Red Squirrel (*Tamiasciurus hudsonicus*) Monitoring and Habitat Analysis on Carson National Forest, New Mexico, 2004

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EXECUTIVE SUMMARY

Purpose

- The purpose of this study was to provide a second year of monitoring of red squirrels on Carson National Forest in order to establish long-term trends in populations and habitat.

Method

- An index of red squirrel density was determined by counting active, primary middens (food caches) on each of two belt transects in a forest stand. One squirrel normally maintains and defends one primary midden. Thus, the density of active primary middens is a conservative estimate of squirrel density.
- Habitat data were collected at two random plots along each belt transect. Habitat variables included: slope, aspect, canopy cover, ground cover (of forbs, grasses, litter, bare, and other), woody understory species and cover, number, size and species of each tree, number and size of snags, and number and size of downed logs.
- Red squirrel midden and habitat data were collected in 59 forest stands. Of these, 33 were repeated from 2003 and 26 were new. Forest stands were identified and mapped by Carson National Forest using geographic information system (GIS). Sampling included the following number of transects: 26 Douglas fir, 23 white fir, 22 blue spruce, 20 Engelmann spruce, 26 spruce-fir, and 1 aspen.

Results

- During 2004, red squirrel density ranged from 0 - 9.44 per acre with an overall mean of 1.04 per acre.
- As in 2003, during 2004 red squirrel densities were relatively low in white fir and Douglas fir stands, and relatively high in Engelmann spruce, blue spruce and spruce-fir stands.
- Based on replicated transects, density of active primary middens was significantly higher in 2004 than in 2003. This was likely due to differences in habitat sampled rather than representative of a population increase. Density of inactive middens did not differ between the years.
- Based on combined 2003 and 2004 data, red squirrel density exhibited a negative relationship with density of white fir and Douglas fir, and are less likely to occur in these cover types.
- Based on combined 2003 and 2004 data, the single best predictor of midden density was the density of large (> 24 inch DBH) Engelmann spruce.
- Within Engelmann spruce and spruce-fir cover types, red squirrel density was positively related with the density of large trees.

- Within blue spruce stands, red squirrel density was positively related with less understory cover and higher canopy cover.

Recommendations

- Annual midden density monitoring of red squirrel should continue long-term.
- Annual midden density monitoring of red squirrels should include a subsample of replicated transects each year to control for inter-stand variation.
- In order to preserve the comparability of year-to-year samples, subsequent monitoring methodology should conform to that developed in 2003.
- Additional studies should be implemented to better address habitat relations of red squirrels in specific stand cover types.
- Additional studies should be implemented that address the impacts of specific forest management strategies.
- Long-term data collection on conifer cone/seed and fungal production should be conducted in conjunction with red squirrel monitoring.
- Increase the number of habitat sampling plots on each transect to better characterize habitat.
- As much as feasible, maintain consistency in field crewmembers to reduce inter-annual and other biases.
- New GIS based maps should be prepared in order to facilitate the selection of new stands for data collection. Stands within 1 mile of all drivable roads should be included.
- Transect 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.

BACKGROUND

The red squirrel (*Tamiasciurus hudsonicus*; also called pine squirrel, spruce squirrel or chickaree) occurs broadly throughout the boreal forest zones of North America with peninsular extensions southward in the Appalachian and Rocky mountains (Hall 1981). It reaches southern range limits in the American Southwest (Hall 1981). Recently, Arbogast et al. (2001) found that populations of red squirrel in the southwestern USA were distinct from other populations and could be recognized as a separate phylogenetic species, *T. fremonti*. This assessment was based on specimens collected from Sandoval Co. (i.e., probably the Jemez Mountains) New Mexico, and Apache Co., Arizona (Arbogast et al. 2001). In contrast, a single specimen from the Southern Rocky Mountains in Colorado was included within the wide-ranging northeastern subspecies *T. h. hudsonicus* (Arbogast et al. 2001). Carson National Forest is located in the southern portion of the San Juan and Sangre de Cristo mountain ranges. These are southern extensions of the large contiguous mountain region known as the Southern Rocky Mountains, which is centered in Colorado. Although it remains unknown to which group animals from the Carson National Forest belong, on a biogeographic basis it seems plausible that they belong to the *T. hudsonicus* group. However, it remains a possibility that extrapolation of results from other geographic areas may not be appropriate.

Red squirrels are primarily associated with various types of conifer forests, although in some areas of eastern North America they also inhabit hardwood and mixed hardwood-evergreen forests (Flyger and Gates 1982). In the Southern Rocky Mountains and Southwest, adiabatic cooling results in distinctive vegetation zones at different elevations. The lowest elevation conifer forests (= lower montane conifer forest) are dominated by ponderosa pine (*Pinus ponderosa*), mid-elevation mixed conifer forests (= upper montane conifer forests) are typically dominated by Douglas fir (*Pseudotsuga menzeisii*), white fir (*Abies concolor*), or blue spruce (*Picea pungens*), while the highest elevation boreal forests (= subalpine forests) are typically co-dominated by Engelmann spruce (*Picea engelmannii*) and corkbark fir (*Abies lasiocarpa* variety *arizonica*; Dick-Peddie 1993). In Colorado and New Mexico, red squirrels are primarily associated with mixed conifer and boreal forests (Bailey 1931, Hatt 1943, Findley 1961, Findley et al. 1975, Fitzgerald et al. 1994). Interlocking canopy within these forests is important for foraging efficiency and escape from predators (Steele 1998). Abert's squirrel (*Sciurus aberti*), rather than red squirrel, typically occupy lower elevation ponderosa pine forests. However, both species can co-occur in the lower portions of the mixed conifer zone (Ferner 1974). Although large stands of mixed conifer or boreal forest seem necessary for red squirrel to maintain populations, red squirrel occasionally occur in ponderosa pine forests, especially in areas adjacent to mixed conifer forest (Finley 1969, Findley et al. 1975). Findley et al. (1975:138) thought that New Mexico red squirrel were especially partial to riparian groves of blue spruce, "to the exclusion of the surrounding conifers". Armstrong (1972) reported them in riparian cottonwood forests. Aspen (*Populus*) is considered a suboptimal habitat type (Steele 1998).

In general, there are very few data available on habitat selection by this species in the Southwest.

Red squirrel eat a wide variety of food including winter terminal buds of evergreens, seeds, bark, fruits, sap, berries, various kinds of fungi, insects, and other animal material (Flyger and Gates 1982, Steele 1998). However, their dietary staple consists of the cones of conifer trees with which they have coevolved (Smith 1970). In New Mexico, all of the dominant conifer trees have cones that mature in the fall and release their seeds. Consequently, red squirrels are larder-hoarders that must harvest the immature "green" cones before they release their seeds and then store them in caches (Smith and Reichman 1984). Cones are usually cached in a single, centrally located midden, typically situated at the base of a large feeding tree (Yeager 1937, Finley 1969, Smith 1970). In some situations, squirrels will also construct smaller, satellite middens and feeding sites. Middens consist of cone scales, cores of eaten cones, and stored uneaten cones. Typically a midden contains enough food to last one or two seasons (Gurnell 1984, M.C. Smith 1968). Middens may be used by many generations of squirrels. This results in very large middens (e.g., 9 m across, 0.5 m deep; Fitzgerald et al. 1994) that endure on the landscape for many years. Midden characteristics, including its location and size, contribute to a cool, moist midden environment; this environment prevents the conifer cones from opening (Smith 1968). Red squirrels are capable of consuming the seeds within the cone by biting through the cone like an ear of corn. Other small mammals may not be able to access the seeds within a closed cone. Thus, by storing the cones in the cool, moist midden environment, the red squirrel is able to prevent its stored seeds from being used by other competitive small mammals (Smith 1968).

In part due to the need to defend cached food supplies, both male and female red squirrels defend exclusive territories centered on the midden (Smith 1968, Kemp and Keith 1970, Rusch and Reeder 1978, Gurnell 1984). Territory size and aggressiveness are related to food availability (Flyger and Gates 1982, Steele 1998). Territorial defense occurs year-round but is most intense in fall when cones are harvested. Regions with conifer species that have serotinous cones (i.e., cones remain closed on trees for several years after they mature), such as lodgepole pine, provide a more consistent cone crop, which results in lowered territorial aggressiveness (Rusch and Reeder 1978, Smith 1968). In addition, it is possible that a more consistently available cone crop might result in more stable populations. In contrast, in regions such as New Mexico that lack serotinous conifers, red squirrel populations are likely to fluctuate in relation to cone crop (Fitzgerald et al. 1994). However, there are very few data on factors influencing red squirrel distribution and abundance and none are available for northern New Mexico.

PURPOSE

Carson National Forest designated the red squirrel as a management indicator species (MIS) for mixed conifer forest in the 1986 Carson Forest Plan. Consequently, information is needed on the species distribution and abundance on the forest, habitat associations, population trends, and how the species is impacted by forest management practices. The main purpose of this study was to provide a second year of monitoring for this species on the Carson National Forest that to provide additional information on habitat and population trends. More specifically, the objectives were to implement monitoring protocols, to determine occurrence and density of red squirrel, to determine the relationship between red squirrel density and habitat characteristics, and to provide a second year of data for a long-term monitoring program.

METHODS

Most studies of red squirrels have concerned their population ecology on relatively small study areas. Consequently, many techniques used in ecological studies (e.g. radio telemetry, trap-mark-resight, etc) are not appropriate for the objectives of this study, which is geared at monitoring the species over a broad geographic area. One notable monitoring program concerns the federally endangered Mount Graham red squirrel (*T. h. grahamensis*). This squirrel occurs in a highly isolated, relatively small area of forest habitat. Because each squirrel maintains and defends one primary midden and because middens are obvious landscape features (e.g., Kilham 1954), Mount Graham red squirrel monitoring has focused on midden activity (Frederick et al. 2003). Currently, this monitoring study involves mapping middens and evaluating changes in midden activity (Frederick et al. 2003). This technique is not possible for monitoring red squirrels on Carson National Forest because it involves identifying the locations of all middens which not feasible in a study area of the extremely large size of Carson National Forest. However, midden density and activity can provide a means for monitoring red squirrels in larger areas. In 2003, Frey developed a method for monitoring red squirrels on the Carson National Forest based on active midden density in belt transects which is used as an estimate of population size. Similar methodology was used to survey Mount Graham red squirrels prior to the development of the more intensive methods based on the specific mapping of middens (Spicer et al. 1985). Similar studies using midden counts have been used for other studies of small areas (e.g., Wolff and Zasada 1975).

Field Methods

Geographic information system (GIS) vegetation cover maps were generated for conifer forest stands on the Carson National Forest. Forest Service GIS cover types included white fir, Douglas fir, blue spruce, Engelmann spruce, and Engelmann spruce-subalpine fir. Only stands within one mile of an established road were included on maps. Original selection of stands for red squirrel monitoring was based on the following criteria: 1) stands were in geographic proximity in order to allow for the survey of an average of approximately 4 stands per day; 2) stands were distributed among five Carson National Forest Districts (Canjilon, El Rito, Questa, Tres Piedras, Camino Real) with relatively more stands surveyed in districts with more red squirrel habitat; 3) survey effort was distributed amongst the stand types; 4) large stands were preferentially selected (minimally, they had to be large enough to contain two 1968 x 33 ft. (= 600 m X 10 m) belt transects; 5) stands were selected to reflect various geographic regions and physiographies; and 6) stands were selected so as to minimize drive time to ensure timely project completion.

Surveys were completed between 6 - 31 July 2004. Red squirrel midden and habitat data were collected in 59 forest stands. Of these, 33 stands were resampled that were originally sampled in 2003, and 26 were new. During 2004, an effort was made to sample a relatively higher proportion of stands dominated

by species of spruce (*Picea* spp.). These habitat types were identified as preferred habitat for red squirrel during the 2003 survey and larger samples were needed to identify habitat relationships within these stand types. The Jicarilla District was not included in this study because red squirrels do not occur there. Once a stand was selected, maps and stand center coordinates were used to determine the general location and direction of two belt transects. Belt transects were 1968 x 33 ft. (= 600 m X 10 m; = 0.6 ha, 1.5 acres). The date, name(s) of persons collecting data, stand location (including district and coordinates of stand center), and cover type as reported by Carson NF were recorded. A transect starting point and bearing was haphazardly selected in such a way to insure that the transect was fully contained within the stand and well away from forest edges (where possible). Coordinates of the starting point was determined with a GPS unit and a compass was used to determine the transect bearing; these data were recorded.

The observer slowly walked the transect, maintaining the bearing, and carefully looked for red squirrel middens. A wire flag was used to mark the observer's position on the transect if the observer had to leave the transect in order to search behind any visual obstructions. Only middens within 16 ft (5 m) on either side of the transect were recorded. The 16 ft was measured with the aid of a retractable "golf ball retriever" pole. For each midden observed on the transect, data on its size, age, activity, and location were recorded. This included any midden that was at least partially within the belt. Midden size included an assessment of whether the midden was a large primary midden or a smaller satellite midden. In the case of a satellite midden, the associated primary midden had to be found in order to verify the satellite status of the observed midden. Age of the midden was assessed by observing the relative state of decay of the midden material. In newly constructed middens, the midden material is fluffy and not compacted or decayed (Fluffy stage). As a midden ages, the midden material becomes compacted (Compacted stage) and eventually begins to decay (Composted stage). Compaction and decay begin at the bottom of the midden. Activity of the midden was assessed by observations of squirrel or sign. An active midden was determined by the presence of a squirrel at the midden or by the presence of fresh cones or feeding remains at the midden. Fresh cone remains have bright coloration. The midden location was the approximate meter location along the transect. Further, a midden could be fully contained within the belt or partially on the belt. Middens only partially in the belt were recorded as < 50% or > 50% within the belt. Midden densities are reported as number of middens per hectare; to convert to middens per acre, divide displayed density by 2.471.

Habitat data were collected at two random points along each transect. Random points were selected by using 1-600 random number tables. Habitat data were collected within a 16.4 ft (= 5 m) radius plot (= 78.5 m^2, = 0.019 acres, = 845 ft^2) at the two random points. Habitat variables were averaged for a transect. All tree, snag, and downed log densities are reported as the mean number within an 845 ft^2 (= 78.5 m^2) area. To calculate the mean density of trees per acre, use the following formula: density = mean number of trees per plot / 0.0194. At each point, location was determined using a GPS unit. Slope

and aspect of the surrounding terrain were visually estimated. Canopy cover was assessed by using a spherical densiometer and taking readings in the four cardinal directions at the point. Percent ground cover was visually estimated on the plot. Ground cover classes included forbs, grasses, litter, bare ground, and other. Percent cover classes included 0-5, 5-25, 25-50, 50-75, 75-95, and 95-100%. Using the same percent cover classes, understory cover of woody shrubs and saplings < 39 in (= 1 m) tall were visually estimated. Dominant understory species were recorded. All trees on the plot were identified and classed into seven size classes based on diameter at breast height 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) was counted for two size classes including < 8 in (= 20 cm) and > 8 in (= 20 cm) DBH. The number of downed trunks (logs) was counted for two size classes including < 8 in (= 20 cm) and > 8 in (= 20 cm) diameter. After completion of the transect, observers sketched a map of the transect location, made notes on the general condition of the stand, and recorded observations of any mammal sign observed.

Statistical Methods

All variables were checked for normality using a one-sample Kolmogorov-Smirnov test. All variables other than elevation, canopy cover, and density of large logs, were non-normal. Thus, where possible, nonparametric tests were performed for non-normal variables. Because of high habitat variation within a stand, both transects within a stand were analyzed separately. In some cases GIS forest service cover types provided by Carson National Forest do not appear to match species associations observed on the ground. Consequently, in addition to the GIS forest cover types, transect habitat was also classified into four general vegetation types based on habitat data. These vegetation types included 1) lower mixed conifer forest (included ponderosa pine, Douglas fir, white fir), 2) upper mixed conifer forest (included Douglas fir, white fir, and Engelmann spruce), 3) boreal forest (included Engelmann spruce and subalpine fir), and 4) blue spruce (blue spruce dominant). These classifications were based on a qualitative assessment of tree composition of the habitat plots. Unless otherwise indicated, all statistics were based on the density of active primary middens on a transect. All statistical analyses were run using SPSS for Windows version 10.0.

Forest-wide analyses.—Kruskal-Wallis tests were used to test whether red squirrel midden density significantly differed by cover type or vegetation type. Wilcoxon signed rank tests were used to test whether the percent of middens in each Forest Service GIS cover type was significantly different from the proportion of each cover type sampled. Simple correlations were assessed between red squirrel midden density estimates and each independent variable. Multiple regression including all independent variables was used to assess the power with which all variables together predicted red squirrel midden density. Stepwise

multiple regression was used to assess the significance of each independent variable for predicting red squirrel midden density.

Based on all available evidence, stands were classified as red squirrels present or absent. Univariate Kolmogorov-Smirnov tests were used to test whether each variable significantly differed in stands where red squirrels were present versus stands where red squirrels were absent. Discriminant function analysis was used to develop statistical models for red squirrel presence or absence in a stand. This model was used to statistically classify stands as either red squirrel present or red squirrel absent.

Cover-type analyses.—Stands within each Forest Service GIS cover type were also analyzed separately in order to evaluate habitat factors that influence red squirrel distribution and abundance within each major cover type. Simple correlations were assessed between red squirrel midden density estimates and each independent variable. Stepwise multiple regressions were used to assess the significance of each independent variable for predicting red squirrel midden density. Discriminant function analyses were used to model habitat characteristics that differed between stands classified as red squirrel present or absent. Univariate Kolmogorov-Smirnov tests were used to test whether each variable significantly differed in stands where red squirrels were present versus stands where red squirrels were absent.

RESULTS

Sampling-2004

A total of 118 transects on 59 forest stands (one more stand than in 2003) was surveyed for red squirrel middens; this was a total sampling area of 175 acres (= 70.8 ha). Of these, 33 were repeated from 2003 and 26 were new. Appendix 1 provides a brief evaluation of the effort and logistics required to complete this inventory. Sampling effort by forest district and forest cover type are presented in Table 1. Elevation of belt transects ranged from 8,064 ft. (= 2,458 m) to 11,329 ft. (= 3,454 m), a wider range than in 2003.

A total of 454 middens were detected. Of these 40.3 % were active primary middens, which formed the basis for most statistical analyses (Table 2). In comparison with 2003, the number of middens detected represented slightly more than twice the number of primary middens and 2.5 times the number of satellite middens.

Table 1. *Number of red squirrel sampling transects on Carson National Forest districts by cover type during July 2004.*

Forest Cover	Camino Real	Canjilon	El Rito	Questa	Tres Piedras	Total
Douglas fir	8	4	2	8	4	26
White fir	2	2	5	8	6	23
Blue spruce	12	0	2	6	2	22
Engelmann spruce	8	0	4	2	6	20
Spruce-fir	10	4	2	8	2	26
Aspen	0	1	0	0	0	1
Total	40	11	15	32	20	118

Table 2. *Number and type of middens detected on belt transects on Carson National Forest in July 2004.*

Midden Activity	Primary	Satellite	Total
Active	183	206	389
Inactive	32	19	51
Uncertain	8	6	14
Total	223	231	454

Forest-wide Patterns 2004

Red squirrel density.—Density of active primary middens varied from 0 - 9.44 per acre (0 - 23.33 per hectare) with an overall mean of 1.04 per acre (2.58 per ha; SD = 4.02). Density of active primary middens varied significantly by Forest Service GIS cover types (Kruskal-Wallis nonparametric test χ^2 = 16.942, *df* = 5, *P* = 0.005; Table 4, Figure 1). Densities were lowest in Douglas fir and white fir, intermediate in Engelmann spruce and blue spruce, and highest in spruce-fir (Table 4). The percentage of each cover type sampled was not significantly correlated with the percentage of middens in each cover type (r_s = 0.377, *P* = 0.461) and the percentage of each cover type sampled did not exhibit a significantly different distribution than percent of middens in each cover type (Wilcoxon signed rank test *Z* = -0.135, *P* = 0.893). These statistics indicate that habitat influences the number of active middens in an area. In comparison with the percent of each cover type sampled, there was a relatively higher percent of middens in blue spruce and spruce-fir forests and a relatively lower percent of middens in white fir and Douglas fir forests.

Table 4. *Density of active, primary red squirrel middens in different Forest Service GIS cover types on Carson National Forest in July 2004.*

	Cover type		Active primary middens			
Forest Service cover type	No. Stands	Percent surveyed	Mean Density (middens/ha)	SE	Range	Percent of Middens
Douglas fir	26	22.0	0.90 (0.36/acre)	0.296	0 – 5.0	7.6
White fir	23	19.5	1.38 (0.56/acre)	0.510	0 – 10.0	10.4
Blue spruce	22	18.6	3.26 (1.32/acre)	0.625	0 – 10.0	23.5
Engelmann spruce	20	16.9	2.58 (1.04/acre)	0.586	0 – 8.3	16.9
Spruce-fir	26	22.0	4.87 (1.97/acre)	1.320	0 – 23.3	41.5
Aspen	1	0.8	0	-	-	0

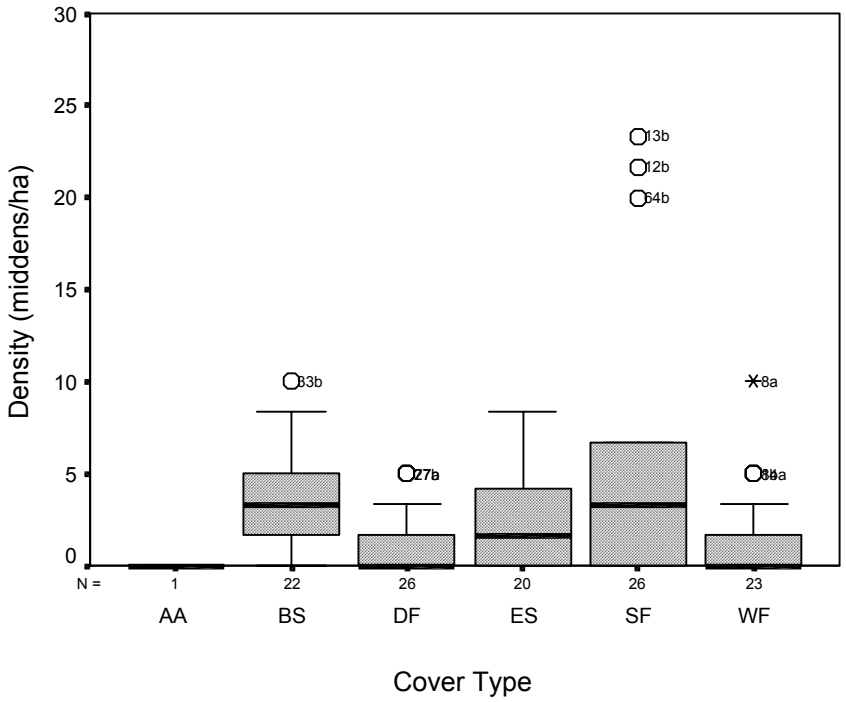

Figure 1. *Density of active, primary red squirrel middens in six Forest Service GIS cover types on Carson National Forest in July 2004. Black bars represent medians, boxes represent quartiles, circles indicate outliers, and the asterisk represents a statistical extreme value. Cover types are Douglas fir (DF), white fir (WF), blue spruce (BS), Engelmann spruce (ES), spruce-fir (SF), and aspen (AA).*

By broad vegetation type, densities of active primary middens were lowest in lower and upper mixed conifer forest, intermediate in blue spruce, and highest in spruce-fir forest (Table 5, Figure 2). Midden density was significantly different by broad vegetation type (Kruskal-Wallis nonparametric test χ^2 = 16.904, df = 3, P = 0.001).

Table 5. *Density of active, primary red squirrel middens in different vegetation types on Carson National Forest in July 2004.*

Vegetation type	No. stands	Mean density (middens/ha)	SE	Range
Blue spruce	9	3.33 (1.35/acre)	1.039	0 – 8.33
Lower mixed conifer	62	1.40 (0.57/acre)	0.266	0 – 8.33
Upper mixed conifer	14	2.74 (1.11/acre)	1.499	0 – 20.00
Spruce-fir	33	4.54 (1.84/acre)	0.932	0 – 23.33

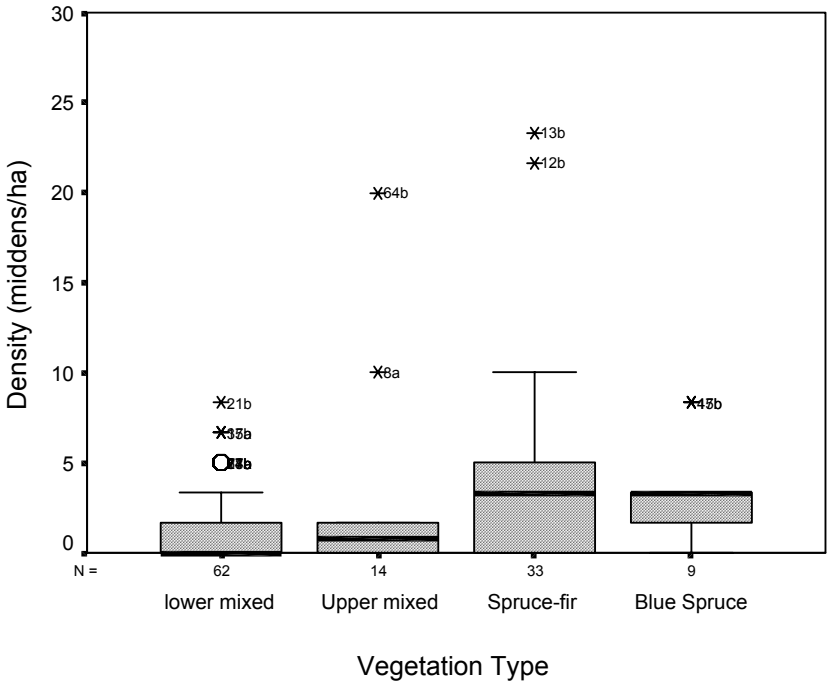

Figure 2. *Density of active, primary red squirrel middens in four vegetation types on Carson National Forest in July 2004. Black bars represent medians, boxes represent quartiles, circles represent outliers.*

Based on simple correlations, density of active primary middens exhibited a significant positive correlation with cover type, vegetation type, total subalpine fir density, large blue spruce and numbers of blue spruce, total Engelmann spruce density, large aspen (20- 24 inches DBH), and total density of all trees (Table 6). In contrast, density of active primary middens exhibited a significant negative correlation with presences of Douglas fir, white fir, sapling aspen and ponderosa pine (< 4 inches DBH), and density and proportion of ponderosa pine (Table 6). A multiple regression of density of active primary middens against all independent variables was significant (r = 0.934, F = 3.309, P = 0.000). A stepwise multiple regression produced eight highly significant models (Table 7). The r^2 change between each model was significant. The single best predictor of midden density was 16-20 inch DBH subalpine fir (Table 7). Additional variables with positive coefficients that improved the model included large Engelmann spruce (12-20 DBH) and blue spruce (16-20 DBH) and 8-12 inch DBH subalpine fir. Additional variables with negative coefficients that improved the model included the percent white fir or other tree species (i.e., Gambel's oak, cottonwood, bristlecone pine, willow) in the stand and the density of very large (>24 inch DBH) subalpine fir. The negative coefficient associated with very large subalpine fir does not indicate that red squirrel densities have a negative relationship with these trees. In fact, there was a significant positive relationship between the density of very large (> 24 in DBH) subalpine fir and the density of red squirrel middens (r = 0.380, F = 19.550, P = 0.000).

Table 6. Significant correlations between density of active red squirrel middens and habitat variables.

Independent variable	r_s	*P*
Cover type	0.296	0.001
Vegetation type	0.354	0.000
Douglas fir		
8-12 DBH	-0.244	0.008
12-16 DBH	-.260	0.004
Total density	-0.289	0.002
% of trees in stand	-0.320	0.000
White fir		
< 4 DBH	-0.249	0.007
4-8 DBH	-0.198	0.031
8-12 DBH	-0.289	0.002
Total density	-0.344	0.000
% of trees in stand	-0.351	0.000
Subalpine fir		
< 4 DBH	0.293	0.001
4-8 DBH	0.208	0.024
8-12 DBH	0.302	0.001
16-20 DBH	0.284	0.002
> 24 DBH	0.196	0.033
Total density	0.319	0.000
% of trees in stand	0.315	0.001
Blue spruce		
16-20 DBH	0.233	0.011
Total density	0.192	0.037
% of trees in stand	0.189	0.040
Engelmann spruce		
4-8 DBH	0.224	0.015
12-16 DBH	0.296	0.001
16-20 DBH	0.223	0.015
20-24 DBH	0.257	0.005
> 24 DBH	0.254	0.005
Total density	0.259	0.005
% of trees in stand	0.261	0.004
Aspen		
< 4 DBH	-0.183	0.047
20-24 DBH	0.227	0.013
Ponderosa pine		
4-8 DBH	-0.228	0.013
Total density	-0.247	0.007
% of trees in stand	-0.247	0.007
Total density all trees	0.213	0.021

Table 7. Statistics for significant (P < 0.001) models produced through stepwise multiple regression of all independent variables against density of active, primary red squirrel middens on Carson National Forest in July 2004. All coefficients are significant (P < 0.05).

Model	r	ANOVA F	Variable	Coefficient	SE
1	0.650	83.948	constant	2.112	0.287
			SF 16-20	15.930	1.739
2	0.702	55.363	constant	2.968	0.345
			SF 16-20	15.618	1.639
			% WF	-0.050	0.013
3	0.733	43.615	constant	2.970	0.331
			SF 16-20	21.921	2.512
			% WF	-0.051	0.012
			SF > 24	-20.787	6.355
4	0.757	37.538	constant	2.477	0.357
			SF 16-20	22.343	2.426
			% WF	-0.040	0.012
			SF > 24	-20.782	6.129
			ES 12-17	1.552	0.504
5	0.769	32.135	constant	2.328	0.357
			SF 16-20	22.526	2.385
			% WF	-40.000	0.012
			SF > 24	-20.846	6.021
			ES 12-17	1.513	0.495
			BS 16-20	1.933	0.859
6	0.781	28.619	constant	2.589	0.369
			SF 16-20	22.292	2.344
			% WF	-0.045	0.012
			SF > 24	-20.835	5.912
			ES 12-17	1.458	0.487
			BS 16-20	1.939	0.843
			% other	-0.069	0.030
7	0.790	25.868	constant	2.412	0.374
			SF 16-20	23.977	2.450
			% WF	-0.043	0.012
			SF > 24	-29.948	7.309
			ES 12-17	1.301	0.486
			BS 16-20	1.949	0.831
			% other	-0.067	0.030
			SF 8-12	1.515	0.734
8	0.799	23.802	constant	2.214	0.381
			SF 16-20	24.330	2.422
			% WF	-0.039	0.012
			SF > 24	-31.026	7.225
			ES 12-17	0.931	0.513
			BS 16-20	2.141	0.825
			% other	-0.066	0.030
			SF 8-12	1.694	0.729
			ES 16-20	1.324	0.651

[1]Abbreviations are subalpine fir (SF), white fir (WF), Engelmann spruce (ES), blue spruce (BS); numbers are DBH size classes.

***Red squirrel presence/absence.*—**No evidence of red squirrels was found on 31.4% of the stands sampled. Red squirrel presence varied by Forest Service GIS stand cover type. Blue spruce stands had the highest proportion of stands with red squirrels present, while Douglas fir and white fir cover types had the highest proportion of stands with red squirrels absent (Figure 3). Based on Kolmogorov-Smirnov tests, a total of eight habitat variables were significantly different in stands where red squirrels were absent as compared with stands where red squirrels were present (Table 8). These variables included forest service cover type, general vegetation type, canopy cover, density of 4-8 DBH Douglas fir, total density of Douglas fir and white fir, and mean percent of stand Douglas fir and white fir. A stepwise discriminant function analysis to model the presence or absence of red squirrels in forest stands resulted in the extraction of one canonical axis (eigenvalue= 0.325, canonical correlation = 0.495, Wilks lambda = 0.755, *df* = 5, *P*= 0.000). The analysis resulted in five models of up to five significant variables. Absence of red squirrels was associated with 8-12 DBH ponderosa pine, 12-16 DBH Douglas fir, 4-8 DBH other tree species (e.g., Gambel's oak), and percent white fir in stand. A total of 72.9 % of the stands were correctly classified according to red squirrel presence or absence. This indicates that the model was good at predicting the presence or absence of red squirrels based on habitat characteristics. Errors in classification were more common in stands where squirrels were not detected but were predicted to occur (32.4 %) as compared with stands where squirrels were observed but they were predicted to be absent (24.7 %). This indicates that most classification errors were probably the result of the field crews occasionally missing sign or other evidence of squirrels in some stands.

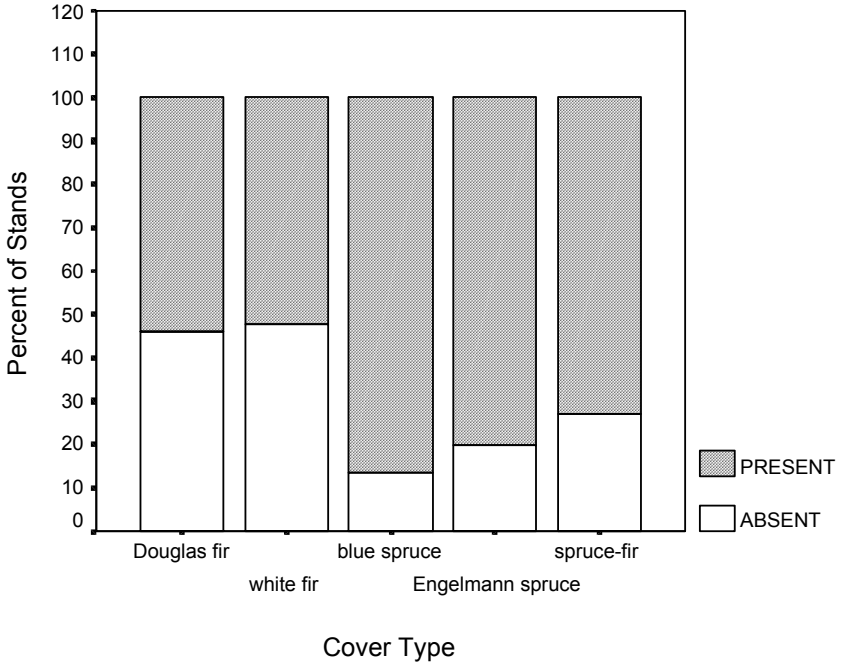

Figure 3. *Percent of total stands in Carson National Forest of each cover type with red squirrels present and absent during July 2004.*

Table 8. *Habitat variables that exhibit significant differences in stands where red squirrels were absent in comparison with stands where red squirrels were present on Carson National Forest. Significance was determined through two-sample Kolmogorov-Smirnov tests.*

	Variable Means		
	absent	present	*P*
Cover type	2.54	3.21	0.020
Vegetation type	1.41	2.14	0.010
Canopy cover	58.31	65.71	0.008
4 – 8 inch DBH Douglas fir	0.51	0.25	0.023
Total density of Douglas fir	2.257	1.426	0.009
Total density of white fir	1.704	1.037	0.048
Mean percent of stand Douglas fir	31.0	19.0	0.003
Mean percent of stand white fir	23.3	11.90	0.015

Inactive Middens.—Density of inactive primary middens varied from 0 – 5.0 per hectare (= 2.0 per acre) with a mean of 0.452 per ha (= 0.18 per acre; Table 9). Density of inactive primary middens did not vary significantly by Forest Service GIS stand cover type (Kruskal-Wallis nonparametric test $P = 0.782$, df = 5, $\chi^2 = 2.461$; Figure 4) or general vegetation type (Kruskal-Wallis nonparametric test $P = 0.771$, df = 3, $\chi^2 = 1.126$). Further, there was a highly significant correlation between the percentage of each cover type sampled and the percentage of inactive middens ($r_s = 0.956$, $P = 0.003$). These statistics suggest that habitat factors did not significant influence midden inactivity.

Table 9. *Occurrence of inactive primary middens in different cover types on Carson National Forest in July 2004.*

	Cover type		Inactive middens		
Forest Service cover type	No. stands	Percent surveyed	Density middens/ha	SD	Percent of middens
Douglas fir	26	22.0	0.577 (0.23/acre)	1.149	28.1
White fir	23	19.5	0.507 (0.21/acre)	1.058	21.9
Blue spruce	22	18.6	0.455 (0.18/acre)	0.760	18.7
Engelmann spruce	20	16.9	0.250 (0.10/acre)	0.250	9.4
Spruce-fir	26	22.0	0.449 (0.18/acre)	0.754	21.9
Aspen	1	0.8	0	0	0.0

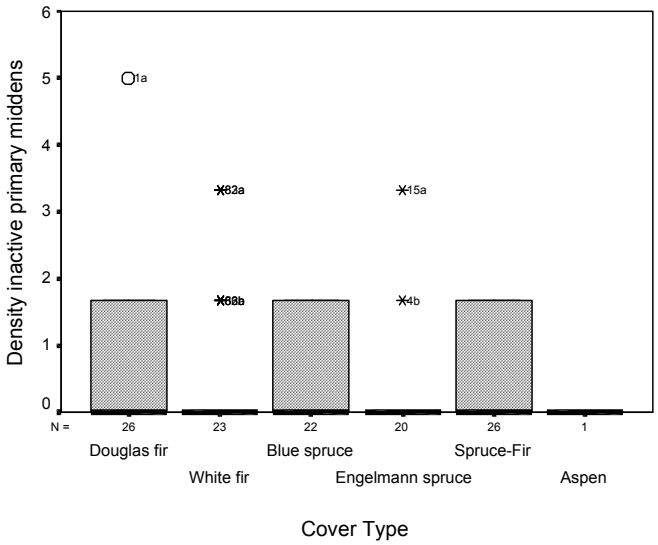

Figure 4. *Density of inactive, primary red squirrel middens in vegetation types on Carson National Forest in July 2004. Black bars represent medians, boxes represent quartiles, circles represent outliers.*

Comparison of 2003 and 2004

In a comparison of stands that were sampled during 2003 and 2004, there was a significantly higher density of active primary middens (Z = 1.393, P = 0.041; Figure 5) and active secondary middens (Z = 1.480, P = 0.025; Figure 6) in 2004 based on two-sample Kolmogorov-Smirnov tests. No significant differences were found in densities of inactive or uncertain activity middens between years.

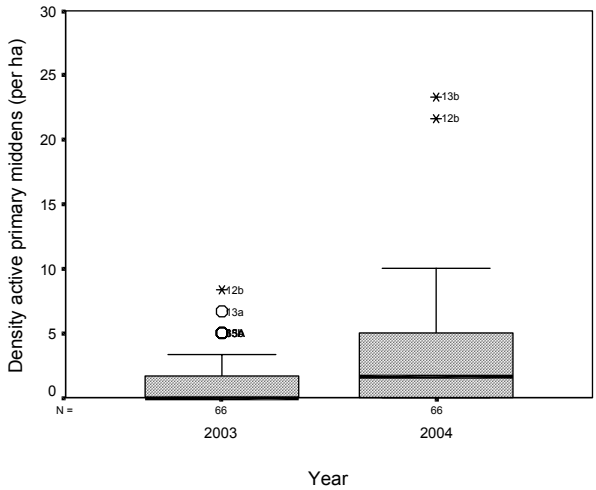

Figure 5. *Comparison of the density of active, primary red squirrel middens during 2003 and 2004 on Carson National Forest. Black bars represent medians, boxes represent quartiles, circles represent outliers.*

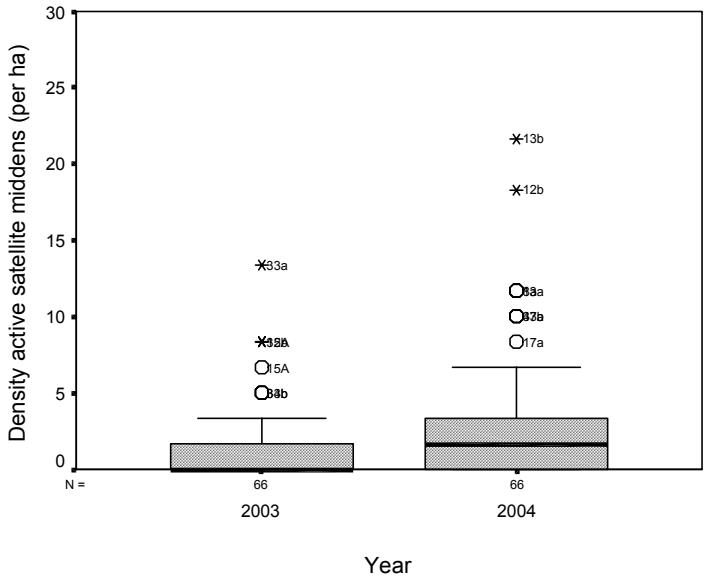

Figure 6. *Comparison of the density of active, satellite red squirrel middens during 2003 and 2004 on Carson National Forest. Black bars represent medians, boxes represent quartiles, circles represent outliers.*

Seventeen habitat variables exhibited significant differences between 2003 and 2004 on the 66 replicated transects (Table 10). Samples collected during 2004 exhibited significantly lower tree density, understory cover, and bare ground than the same transects sampled the previous year. The difference in habitat sampled during 2003 and 2004 is further illustrated by a principal components analysis (Figure 7). A total of 26 principal components (PC) were extracted, which together accounted for 80.4% of the variation in habitats. A scatter plot of the first two components, which together accounted for 17.8 % of the variance, revealed a narrower range of habitat conditions sampled in 2004 as compared to 2003 (Figure 7). Notably, samples from 2004 lacked high positive loadings on both PC 1 and PC 2. High (>0.6) positive scores on component 1 were associated with a high density of small (8-12 in DBH) white fir and total numbers of white fir; the high negative (<-0.6) score on component 1 was the percent Engelmann spruce. High (>0.5) positive scores on component 2 were associated with a high density of sapling and small diameter subalpine fir, total number of subalpine fir, and total number of all trees; the high negative (<-0.5) score on component 2 was the percent blue spruce.

Table 10. *Variables that exhibit significant differences between 2003 and 2004 on Carson National Forest. Significance as determined through two-sample Kolmogorov-Smirnov tests.*

	Year		
	2003	2004	*P*
Density active primary middens	1.11	3.00	0.041
Density active secondary middens	1.26	2.93	0.025
Bare ground cover	1.78	1.23	0.000
Understory density	2.11	1.49	0.000
Density 8-12 inch DBH Douglas fir	0.75	0.28	0.015
Density all sizes Douglas fir	3.20	1.53	0.025
Density <4 inch DBH white fir	1.51	0.22	0.000
Density all size white fir	2.98	1.14	0.015
Density < 4 inch DBH Engelmann spruce	2.01	0.56	0.025
Density 4-8 inch DBH Engelmann spruce	0.66	0.23	0.041
Density 8-12 inch DBH Engelmann spruce	0.79	0.15	0.000
Density 12-16 inch DBH Engelmann spruce	0.69	0.18	0.001
Density all sizes Engelmann spruce	4.47	1.61	0.008
Density 4-8 inch DBH aspen	0.73	0.29	0.003
Density 8-12 inch DBH aspen	1.01	0.31	0.000
Density 12-16 inch DBH aspen	0.91	0.22	0.003
Density all sizes aspen	4.33	1.82	0.003
Total trees	22.05	8.91	0.000
Density small snags	2.78	1.20	0.000

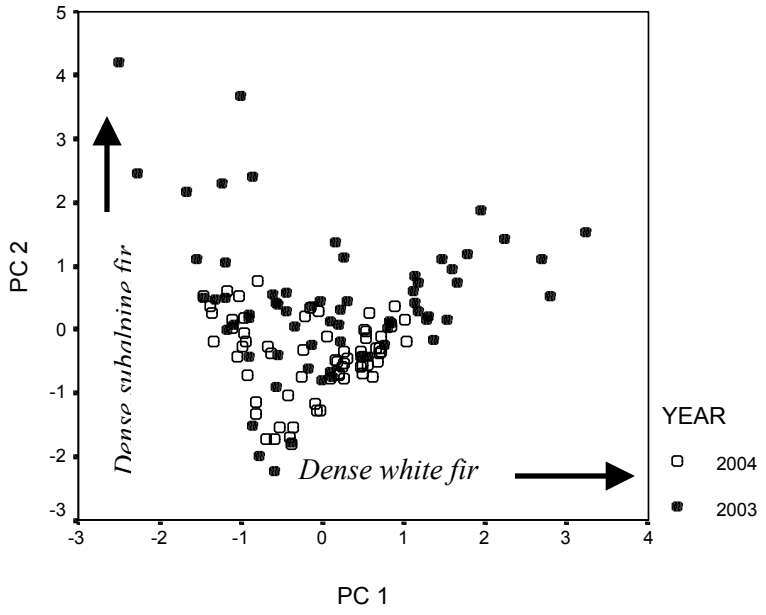

Figure 7. *Scatter plot of habitat characteristics on principal components 1 and 2 for 66 red squirrel transects (i.e., 33 forest stands) sampled in 2003 and 2004 on Carson National Forest.*

Combined 2003-2004 Habitat

A principal components analysis of combined 2003 and 2004 habitat data (234 transects) resulted in the extraction of 26 components, which together accounted for 74.9 % of the variance. The first two components accounted for 16.8 % of the variance. On PC 1 variables with high negative loadings included total density of Engelmann spruce, density of <16 DBH Engelmann spruce, percent of trees in stand that are Engelmann spruce, percent of trees in stand that are subalpine fir, density of 4-8 DBH subalpine fir, and elevation. On PC 1 variables with high positive loadings included density of white fir, Douglas fir and ponderosa pine, and the percent of trees in stand that are Douglas fir or white fir. In contrast, high negative loadings on PC 2 included percent of trees in stand that are blue spruce and density of blue spruce. Variables with high positive loadings on PC 2 included density of all trees and density of Douglas fir. The descriptive gradients for PC1 and PC 2 and a plot of all transects from both years is shown in Figure 8.

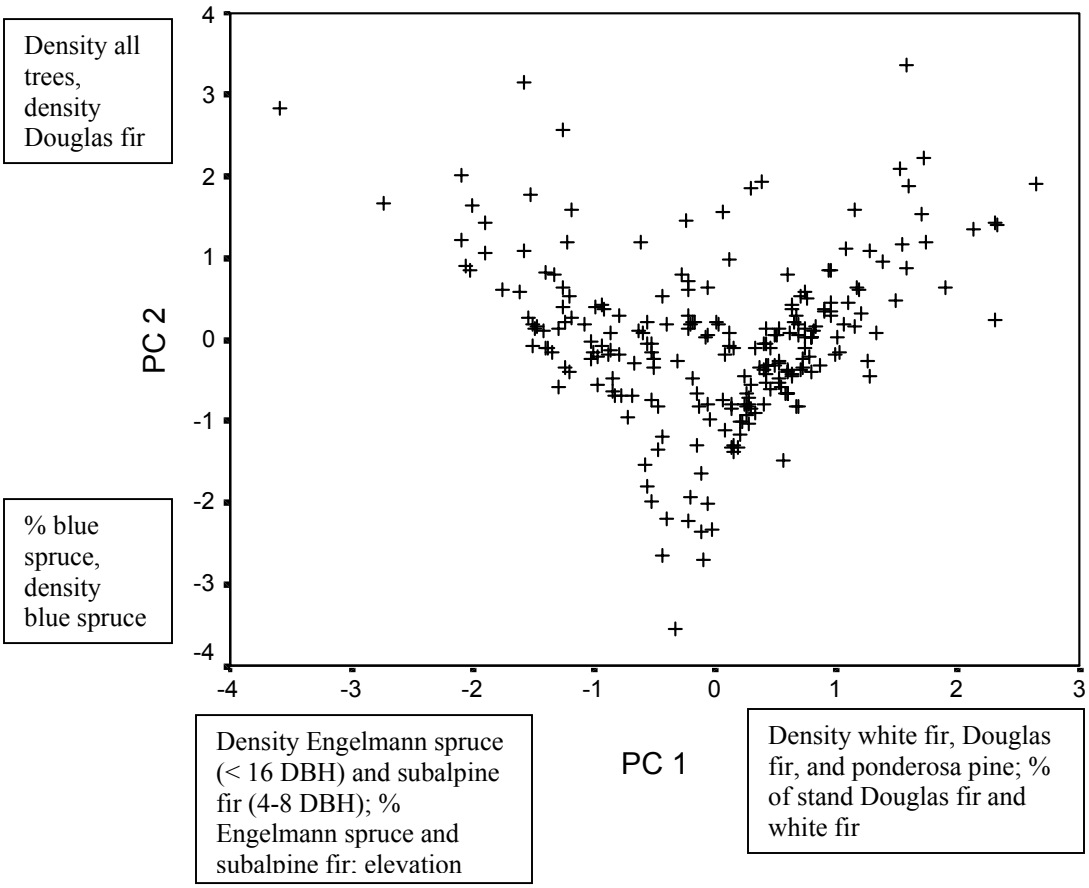

Figure 8. *Scatter plot of habitat characteristics on principal components 1 and 2 for 234 red squirrel transects collected on 84 forest stands during 2003 and 2004 on Carson National Forest. Boxes indicate habitat gradients associated with each axis.*

The scatter plot of each transect on the first two principal components can be used to illustrate the habitat characteristics of stands in each forest service cover type (Figure 9) and general vegetation type (Figure 10). For cover types, white fir and Douglas fir stands tended to overlap with positive scores on PC 1 (Figure 9). Further, these typically lower elevation cover types tend to be separated on PC 1 from cover types that include spruce species. Spruce-fir tends to separate from other cover types with negative scores on PC1; blue spruce tends to separate from other cover types with negative scores on PC2; and Engelmann spruce exhibits broad overlap intermediate to spruce-fir and blue spruce (Figure 9).

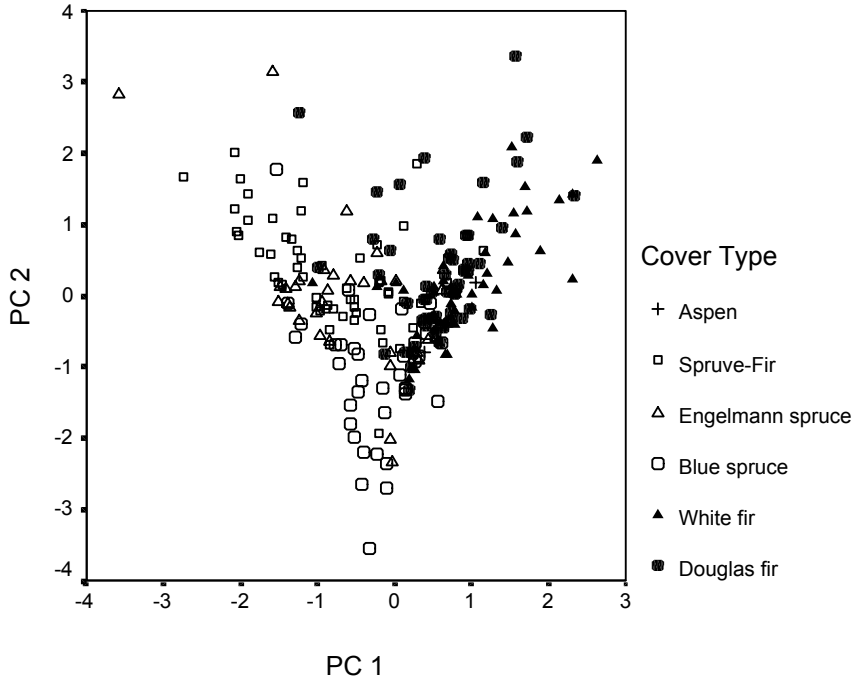

Figure 9. *Scatter plot of habitat characteristics on principal components 1 and 2 for 234 red squirrel transects collected on 84 forest stands during 2003 and 2004 on Carson National Forest.*

Similar patterns are observable when transects are plotted by vegetation type (Figure 10). Lower mixed conifer tends to be well separated from other vegetation types with positive scores on PC1. Blue spruce stands tend to be well separated from other vegetation types with negative scores on PC 2. Spruce-fir stands tend to be well separated from other vegetation types with negative scores on PC 1. Upper mixed conifer exhibits broad overlap with the other three vegetation types.

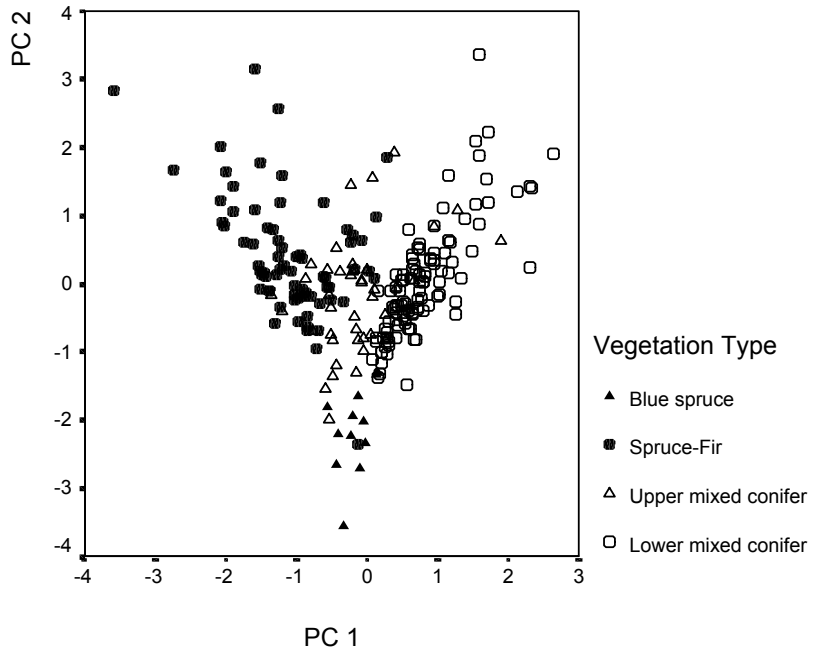

Figure 10. *Scatter plot of habitat characteristics on principal components 1 and 2 for 234 red squirrel transects collected on 84 forest stands during 2003 and 2004 on Carson National Forest.*

There was a significant relationship between density of active primary middens with both PC 1 (r = 0.312, F = 24.953, P = 0.000; Figure 11) and PC 2 (r = 0.147, F = 5.110, P = 0.025; Figure 12) indicating higher densities in spruce-fir and blue spruce forests, respectively. However, there was no significant linear relationship between either component with density of inactive middens.

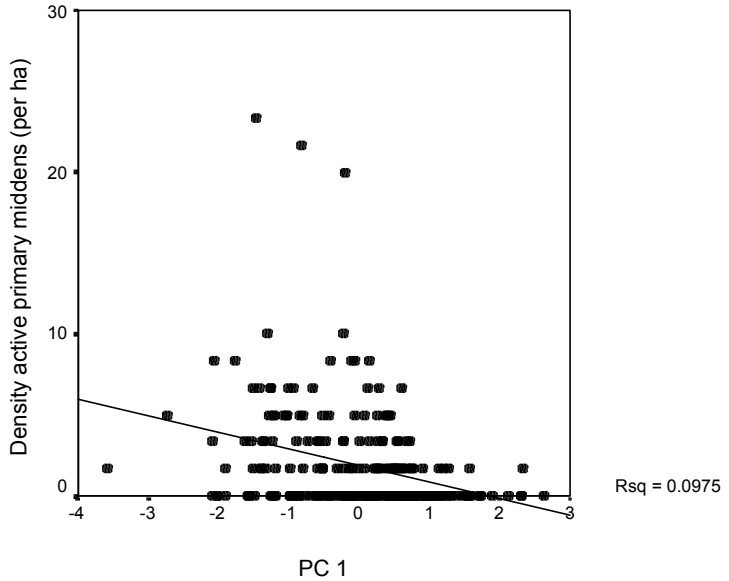

Figure 11. *Relationship between density of active primary middens and PC1.*

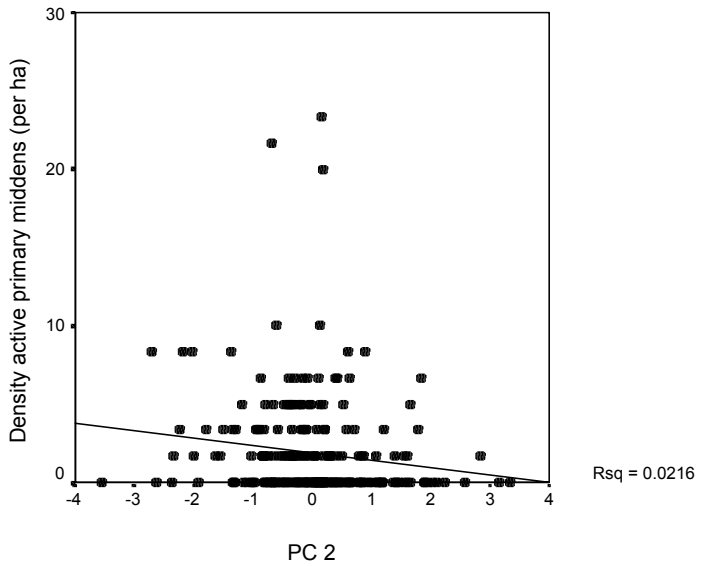

Figure 12. *Relationship between density of active primary middens and PC2.*

A multiple regression of density of active primary middens against all independent variables was significant (r = 0.744, F = 2.312, P = 0.000). A stepwise multiple regression produced ten highly significant models (Table 11). The r^2 change between each model was significant. The single best predictor of midden density was > 24 inch DBH Engelmann spruce (Table 11). Additional variables with positive coefficients that improved the model included 16-20 DBH Subalpine fir, > 24 DBH Subalpine fir, 16-20 DBH blue spruce, 12-16 DBH Engelmann spruce, > 24 DBH blue spruce, < 4 Douglas fir, and 20-24 DBH aspen. Additional variables with negative coefficients that improved the model included the total density of white fir and total density of trees.

The importance of > 24 DBH Engelmann spruce as the best predictor of midden density is largely the result of 3 transects sampled in 2004 with extremely high numbers of middens (Figure 13). When those three transects are removed from the analysis, a simple linear regression between density of > 24 DBH Engelmann spruce and midden density remained significant (r = 0.141, P = 0.032). However, a stepwise multiple regression of all variables revealed that the total density of white fir, which was a negative coefficient, was then the best predictor of midden density (Figure 14). Other variables that improved more complex equations included 12-16 DBH Engelmann spruce, 20-24 DBH aspen, 16-20 DBH blue spruce, total density trees (negative), 12-16 DBH subalpine fir, percent white fir (negative), < 8 inch downed logs (negative), 8-12 DBH subalpine fir (negative).

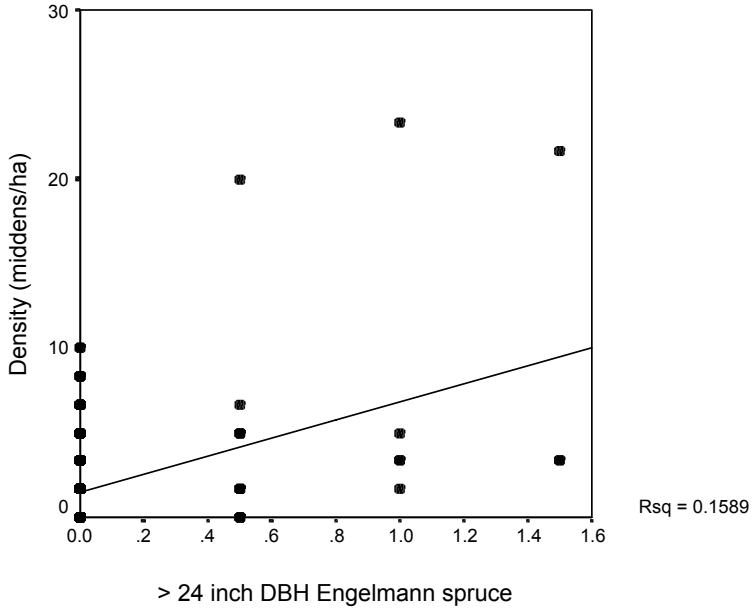

Figure 13. *Relationship between > 24 inch DBH Engelmann spruce and active midden density for 234 red squirrel transects collected on 84 forest stands during 2003 and 2004 on Carson National Forest.*

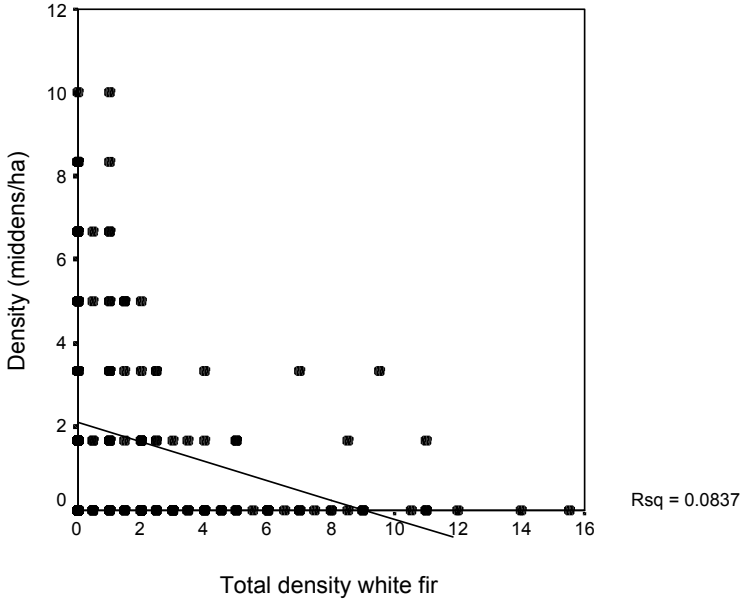

Figure 14. *Relationship between total density of white fir and active midden density for 231 red squirrel transects collected on 84 forest stands during 2003 and 2004 on Carson National Forest (3 outlier transects excluded).*

Table 11. Statistics for significant (P < 0.001) models produced through stepwise multiple regression of all independent variables against density of active, primary red squirrel middens on Carson National Forest in 2003 and 2004. All coefficients are significant (P < 0.05).

Model	r	ANOVA F	Variable	Coefficient	SE
1	0.406	45.649	constant	1.536	0.202
			ES > 24	5.480	0.811
2	0.514	41.327	constant	1.366	0.193
			ES > 24	4.736	0.775
			SF 16-20	5.335	0.957
3	0.553	33.687	constant	1.855	0.229
			ES > 24	4.303	0.763
			SF 16-20	5.352	0.932
			WF total	-0.228	0.061
4	0.576	28.350	constant	1.862	0.225
			ES > 24	4.083	0.754
			SF 16-20	4.009	1.021
			WF total	-0.225	0.060
			SF > 24	12.846	4.314
5	0.597	25.152	constant	1.721	0.227
			ES > 24	4.210	0.743
			SF 16-20	4.123	1.005
			WF total	-0.223	0.059
			SF > 24	12.769	4.244
			BS 16-20	2.117	0.722
6	0.610	22..313	constant	1.420	0.258
			ES > 24	4.331	0.737
			SF 16-20	3.952	0.998
			WF total	-0.185	0.061
			SF > 24	13.536	4.215
			BS 16-20	2.080	0.715
			ES 12-16	0.552	0.234
7	0.625	20.591	constant	1.841	0.302
			ES > 24	4.132	0.732
			SF 16-20	4.307	0.995
			WF total	-0.150	0.062
			SF > 24	12.833	4.170
			BS 16-20	1.934	0.708
			ES 12-16	0.811	0.251
			Total trees	-0.037	0.014
8	0.635	18.871	constant	1.693	0.307
			ES > 24	4.041	0.727
			SF 16-20	4.323	0.987
			WF total	-0.142	0.061
			SF > 24	13.136	4.140
			BS 16-20	1.889	0.703
			ES 12-16	0.832	0.249
			Total trees	-0.035	0.014
			BS > 24	1.935	0.906
9	644	17.571	constant	1.601	0.308
			ES > 24	4.075	0.722
			SF 16-20	40449	0.981
			WF total	-0.162	0.062
			SF > 24	13.177	4.106
			BS 16-20	2.024	0.700
			ES 12-16	0.908	0.250
			Total trees	-0.041	0.014
			BS > 24	1.968	0.899
			DF <4	0.231	0.107
10	652	16.528	constant	1.480	0.311
			ES > 24	3.978	0.718
			SF 16-20	4.392	0.974
			WF total	-0.160	0.061
			SF > 24	13.612	4.085
			BS 16-20	1.990	0.696
			ES 12-16	0.929	0.248
			Total trees	-0.040	0.014
			BS > 24	1.808	0.897
			DF <4	0.254	0.107
			AS 20-24	1.530	0.764

[1]Engelmann spruce (ES), subalpine fir (SF), white fir (WF), blue spruce (BS); aspen (AS); numbers are DBH.

Density Patterns by Cover Type

Habitat features related to red squirrel presence and abundance was investigated within each Forest Service GIS stand cover type. Analyses included each transect from each year in order to increase sample size. However, in most cases sample sizes are still low and these results should be considered preliminary. Much larger sample sizes are required to establish the generality of trends reported.

White fir.—For stands classified as white fir, midden density exhibited a significant positive correlations with > 24 DBH white fir (r_s = 0.346, P = 0.019), < 4 DBH subalpine fir (r_s = 0.432, P = 0.003), 4-8 DBH subalpine fir (r_s = 0.313, P = 0.034), 12-16 DBH subalpine fir (r_s = 0.432, P = 0.003), > 24 DBH subalpine fir (r_s = 0.292, P = 0.049), 4-8 DBH blue spruce (r_s = 0.346, P = 0.018); 12-16 DBH blue spruce (r_s = 0.351, P = 0.017); total density blue spruce (r_s = 0.338, P = 0.022), 16-20 DBH Engelmann spruce (r_s = 0.313, P = 0.034), 20-24 DBH aspen (r_s = 0.361, P = 0.014), and percent blue spruce (r_s = 0.327, P = 0.027). Significant negative correlations were with slope (r_s = -0.313, P = 0.034), 8 - 12 DBH white fir (r_s = -0.460, P = 0.001), total density white fir (r_s = -0.405, P = 0.005), and percent white fir (r_s = -0.351, P = 0.017). Stepwise multiple regression resulted in five significant predictive models for density of active middens. The single best predictor of midden density was 16-20 DBH Engelmann spruce. Additional independent variables included in more complex models included < 4 in. DBH white fir, 12-16 DBH blue spruce, 8-12 DBH blue spruce (negative), and 16-20 DBH blue spruce (negative). Based on two-sample Kolmogorov-Smirnov tests no habitat variables exhibited significant differences in stands where red squirrels were absent in comparison with stands where red squirrels were present.

Douglas fir.—For stands classified as Douglas fir, midden density exhibited a significant positive correlation with canopy cover (r_s = 0.394, P = 0.002), > 8 inch diameter snags (r_s = 0.271, P = 0.040).), and 8-12 in. DBH aspen (r_s = 0.376, P = 0.034). Significant negative correlations were with < 4 in. DBH white fir (r_s = -0.323, P = 0.013), total density white fir (r_s = -0.281, P = 0.033), < 4 in. DBH aspen (r_s = -0.326, P = 0.013), and 12-16 DBH aspen (r_s = -0.263, P = 0.046). Stepwise multiple regression resulted in three significant predictive models for density of active middens. The single best predictor of midden density was total density of white fir, which was a negative relationship. Additional independent variables included in more complex models included canopy cover and 8-12 DBH Douglas fir (negative). Based on two-sample Kolmogorov-Smirnov tests, the number of white fir < 4 in. DBH was the only habitat variable that exhibited a significant difference (P = 0.031) in stands where red squirrels were absent in comparison with stands where red squirrels were present (Figure 15).

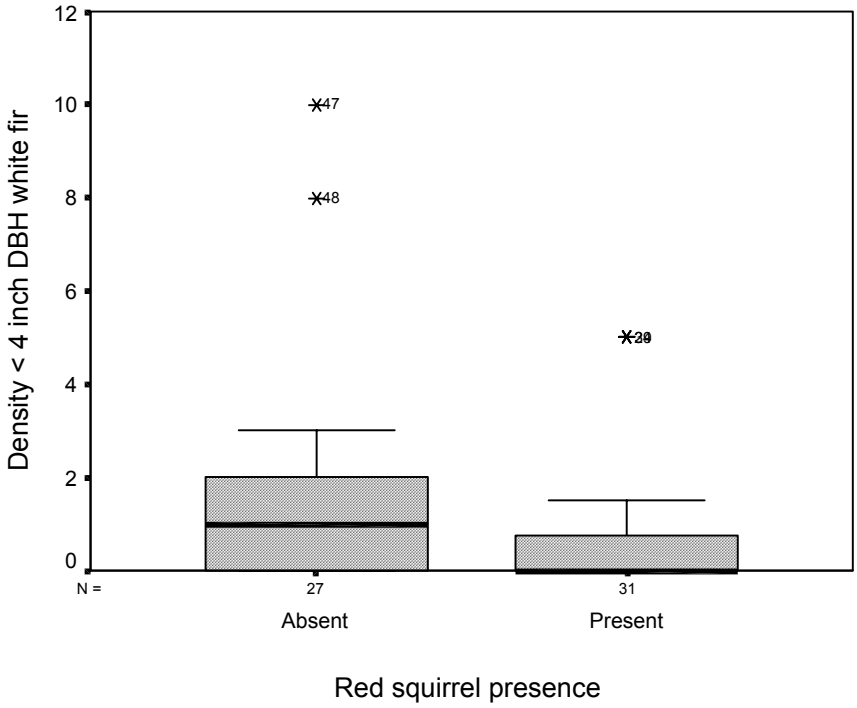

Figure 15. *Number of < 4 in (= 10 cm) DBH white fir present in Douglas fir stands where red squirrels were absent and present. Black bars represent medians, boxes represent quartiles, circles represent outliers, and asterisks represent extreme values. Density of white fir (per acre) of can be calculated by dividing the displayed values by 0.0194.*

Blue spruce.—For stands classified as blue spruce, midden density exhibited a significant negative correlation with understory cover (r_s = -0.378, P = 0.019), density of < 8 inch snags (r_s = -0.438, P = 0.006) and density of > 8 inch diameter snags (r_s = -0.328, P = 0.044). There were no significant positive correlations. A stepwise multiple regression resulted in three significant predictive models for density of active middens. The single best predictor of midden density was understory cover (negative), density of small diameter snags (negative), and density of other species of tree [e.g., Gambel's oak, bristlecone pine, willow] with DBH < 4 inches (negative). Based on two-sample Kolmogorov-Smirnov tests, no habitat variables exhibited significant differences in stands where red squirrels were absent in comparison with stands where red squirrels were present; however, canopy cover was nearly so (P = 0.059; Figure 16).

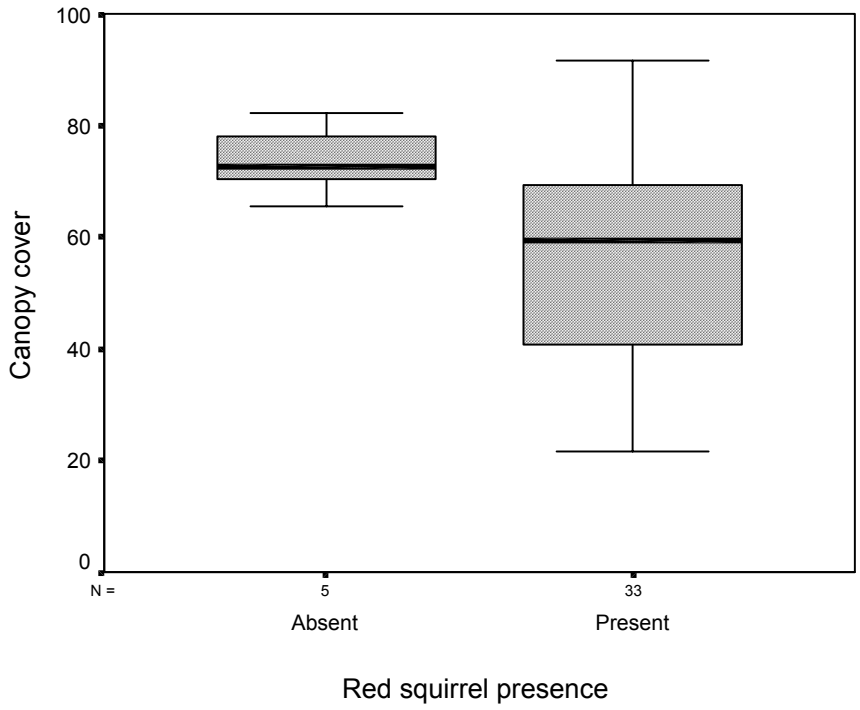

Figure 16. *Index of canopy cover in blue spruce stands where red squirrels are absent and present. Black bars represent medians, boxes represent quartiles, and the circle represents an outlier. Density of blue spruce (per acre) of can be calculated by dividing the displayed values by 0.0194.*

Engelmann spruce.—For stands classified as Engelmann spruce, midden density exhibited a significant negative correlation with elevation (r_s = -0.382, P = 0.026), slope (r_s = -0.360, P = 0.036), bare ground cover (r_s = -0.433, P = 0.011), total density Douglas fir (r_s = -0.423, P = 0.013), and percent Douglas fir in stand (r_s = -0.374, P = 0.029). There were no significant positive correlations. Stepwise multiple regression resulted in nine significant predictive models for density of active middens. The single best predictor of midden density was density of > 24 DBH blue spruce. Additional independent variables included in more complex models included 16-20 DBH Engelmann spruce, total density all sizes subalpine fir (negative), 20-24 DBH Engelmann spruce, 16-20 DBH white fir, 4-8 DBH Engelmann spruce, 12-16 DBH blue spruce, < 8 inch diameter downed logs [negative], and 12-16 DBH Engelmann spruce. Based on two-sample Kolmogorov-Smirnov tests no habitat variables exhibited significant differences in stands where red squirrels were absent in comparison with stands where red squirrels were present.

Engelmann spruce-Subalpine fir.—For stands classified as spruce-fir, midden density exhibited a significant positive correlation with elevation (r_s = 0.405, P = 0.002), 16-20 in. DBH subalpine fir (r_s = 0.443, P = 0.001), > 24 DBH Engelmann spruce (r_s = 0.405, P = 0.002), and percent Engelmann spruce in stand (r_s = 0.441, P = 0.015). There was a significant negative correlation with understory cover (r_s = -0.301, P = 0.024), density < 4 DBH white fir (r_s = -0.324, P = 0.015), total density white fir (r_s = -0.279, P = 0.037), total density aspen (r_s = -0.370, P = 0.005), < 4 DBH other trees (r_s = -0.307, P = 0.021) 4-8 DBH other trees (r_s = -0.307, P = 0.021), total density other trees (r_s = -0.307, P = 0.021), percent white fir (r_s = -0.285, P = 0.033), percent aspen (r_s = -0.395, P = 0.003), percent other trees (r_s = -0.339, P = 0.011), and < 8 inch diameter downed logs (r_s = -0.381, P = 0.004). Stepwise multiple regression resulted in seven significant models. The simplest model only included > 24 DBH Engelmann spruce as a predictor of midden density. Based on data analyzed and reported in 2003, only 0.2 % of Engelmann spruce sampled were of this size. Additional independent variables included in more complex models included 16-20 DBH subalpine fir. < 4 DBH Douglas fir, total density of trees (negative), density 12-16 DBH Engelmann spruce, > 24 DBH white fir (negative) and forb ground cover. Based on two-sample Kolmogorov-Smirnov tests only the density of small diameter (< 8 inches) downed logs exhibited a significant difference (P = 0.032) in stands where red squirrels were absent in comparison with stands where red squirrels were present (Figure 17), although elevation was nearly so (P = 0.52; Figure 18).

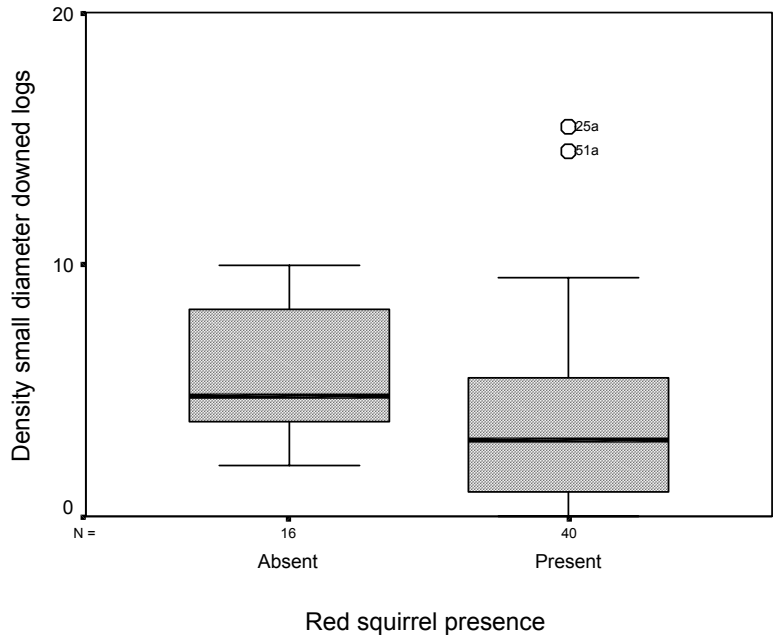

Figure 17. *The density of small diameter downed logs in spruce-fir stands where red squirrels are absent and present. Black bars represent medians, boxes represent quartiles, and the circles represent outliers.*

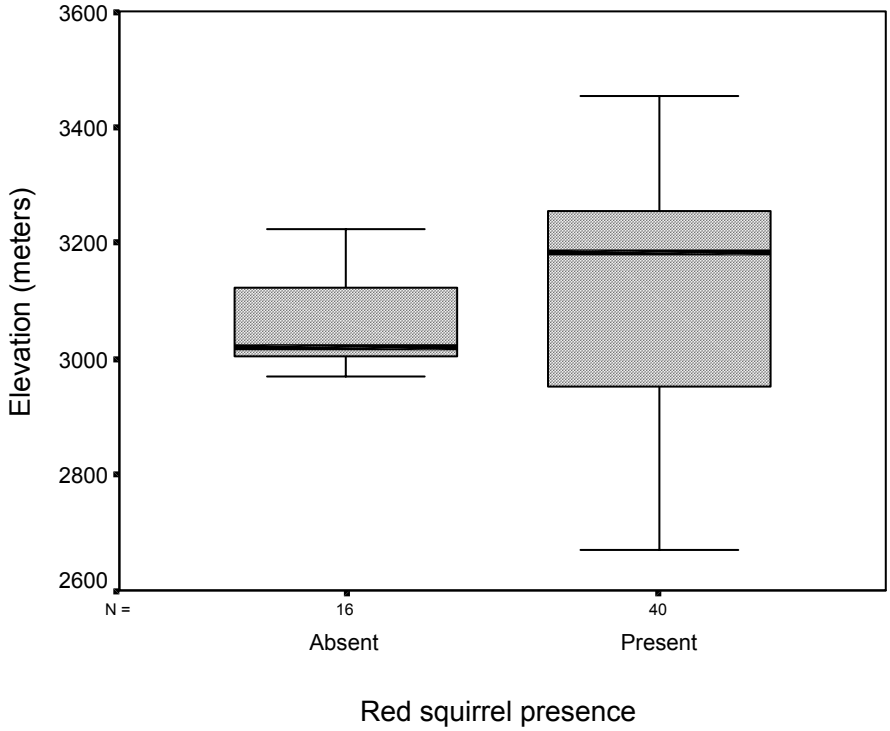

Figure 18. *The elevation of spruce-fir stands where red squirrels are absent nd present. Black bars represent medians, boxes represent quartiles, and the circles represent outliers.*

DISCUSSION

Forest-wide Patterns

Red squirrel density.—Overall mean density of red squirrel middens on Carson National Forest in July 2004 tended to be higher than red squirrel densities found in other studies. Table 12 presents a summary of red squirrel densities found during other studies using a variety of techniques. The relatively higher densities in this study were especially notable for the three stand types containing spruce (blue spruce, Engelmann spruce, spruce-fir). The mean density of red squirrels in these more favored habitats on Carson National Forest were as high, or higher, than the maximum density reported in most previous studies. When the range of variation in density is considered, the density found in some spruce-fir stands on Carson National Forest (e.g., 23.3/ha; = 9.4/acre) greatly exceeded maximum densities reported in Table 12.

Several factors may account for the relatively high estimates of red squirrel density on Carson National Forest. First, this study was somewhat unique in the geographic coverage and habitat variation included. Most previous studies have been conducted in single habitat types or in marginal habitats. Thus, this study may more accurately reflect potential red squirrel density in situations where the species has an opportunity to select many different habitats as a response to high variability in topography, aspect, and stand history. Anecdotal and empirical evidence from previous studies has suggested that red squirrel densities are highest in habitats dominated by spruce (*Picea* spp.). The reason for this is thought to be because spruce trees generally produce large numbers of highly nutritious cones that can be stored efficiently. Several results of this study confirm those previous observations. First, mean midden density was highest in the three cover types where spruce was dominant (blue spruce, Engelmann spruce, spruce-fir; Table 4) and lowest in cover types were spruce was absent or a minor component (Douglas fir, white fir; Table 4). Similarly, across all transects, red squirrel midden density increased with increasing numbers of Engelmann spruce and blue spruce (as well as with subalpine fir), but decreased with increasing numbers of Douglas fir and white fir (Table 6).

Second, during 2004, monitoring focused relatively more intensively on blue spruce and Engelmann spruce stands in order to better assess the response of red squirrels to habitat conditions within these important habitat types. Thus, the overall mean density of red squirrels found in 2004 reflects sampling in these preferred habitats. Third, methods used in this study provide an indirect estimate of red squirrel density based on density of middens. In general, one red squirrel maintains and defends a territory centered on one primary midden; thus midden density is an estimate of red squirrel density. However, in some cases a single red squirrel will maintain more than one midden. This would result in density estimates that are higher than actual. Further, red squirrels often make smaller satellite middens. In some cases, it is difficult to determine if a midden is primary or satellite. This is especially true in instances of presumably exceptional habitat quality where there are many

middens. In these midden complexes, it can be difficult to determine if all midden areas are part of one very large midden or represent multiple smaller middens in very close proximity. For purposes of this study, a midden area was counted if it was separated by even a small gap between it and another midden area. This resulted in extremely high (> 20 / ha) midden densities on three transects in spruce-fir stands during 2004 (transects 12b, 13b, 64b). Consequently, it is likely that red squirrel density estimates were inflated on these and possibly other transects.

Table 12. *Comparison of red squirrel densities reported in previous studies with those observed on Carson National Forest.*

Location	Habitat	Density (per ha)	Reference
Western North America			
Alberta	aspen	0.05 - 0.1	Kemp and Keith 1970
Alberta	spruce	1.6 - 6.8	Rusch and Reeder 1978
	jack pine	0.9 - 2.6	
	aspen	0 - 1.0	
Alaska	white/black spruce	1.2 - 1.6	Wolff and Zasada 1975
	shelterwood	0.5	
	clearcut	0	
Alaska	white spruce	0.6 - 0.8	Smith 1968
	after 2 cone failure	0.2	
Arizona, Mt. Graham	spruce-fir	0.05 - 1.0	Young et al. 1999
	mixed	0.1 - 1.4	
Arizona, Mt. Graham	spruce-fir	0.31	Spicer et al. 1985
	mixed	0.02	
Arizona, west-central	mixed	1.0 - 2.5	Vahle and Patton 1983
British Columbia		1.1 - 2.0	Smith 1965
Colorado	lodgepole pine	0.1	Gurnell 1984
Montana	mixed conifers	0.8 - 2.0	Halvorson 1965
New Mexico	Douglas fir	0.4-0.9	current study
	white fir	0.4-1.4	(mean 2003-mean 2004)
	blue spruce	2.4-3.3	
	Engelmann spruce	1.1-2.3	
	spruce-fir	2.0-4.9	
Eastern North America			
New Brunswick	spruce	2.5	Klugh 1927
New York	spruce	1.1	Fitzwater 1941
multiple studies	various	0.1 - 2.5	cited in Rusch and Reeder 1978

Habitat selection.—Results of sampling in 2004 corroborated patterns of red squirrel habitat selection established on Carson National Forest during 2003. Red squirrels densities generally are low in lower mixed conifer forest, which includes both Douglas fir and white fir stands. Analyses also indicated that red squirrels are more commonly absent from forests dominated by these tree species, especially those of small diameter. In contrast, red squirrel densities are generally high in upper mixed conifer forest and boreal forest. These forest types generally are composed of stands that include spruces (i.e., blue spruce, Engelmann spruce, spruce-fir). Major determinants of the species composition of trees in a forest stand include temperature, moisture, and light intensity. These factors are largely determined by latitude, elevation, and aspect, and hence are not habitat characteristics that are readily managed. Regardless of stand type, red squirrels tended to be more abundant in stands that included large diameter trees. This was especially true for Engelmann spruce, subalpine fir, and blue spruce. In many cases, trees with DBH > 24 inches were identified as important habitat components. Given that "> 24 inches DBH" was the largest category included for data recording, it remains unknown what larger sized tree of each species might be associated with maximal red squirrel densities.

Patterns within Specific Cover Types

White fir.— White fir stands tend to have low red squirrel midden densities and a high proportion of stands where red squirrel are absent (Figures 1 and 3). Red squirrel abundance was lowest in stands with the greatest density or proportion of white fir. However, within these stands, red squirrel abundance increased in relation to the occurrence of blue spruce, subalpine fir, and especially Engelmann spruce. Thus, this suggests that red squirrel preferentially occupy higher elevations and cooler, more mesic sites in white fir cover types.

Douglas fir.—Douglas fir stands also tended to have low red squirrel midden densities and a high proportion of stands where red squirrel are absent (Figures 1 and 3). Within this cover type, red squirrels became less abundant as the density of white fir increased; this was especially true for sapling white firs (< 4 inch DBH). Density of sapling white fir was also the best predictor of red squirrel absence in a Douglas fir stand. Other features associated with higher densities of red squirrel in Douglas fir stands included an increased canopy cover and density of large (> 8 inch diameter) snags. When available, red squirrels will use hollow snags for nest sites.

Blue spruce.—In the blue spruce cover type, red squirrel abundance decreased with increasing understory cover and density of small diameter (< 8 inch) snags. Red squirrels tended to be absent from stands more often when canopy cover was low. Low canopy cover may also be related to high understory cover. Finally, there also was an indication that the density of large diameter snags (> 8 inch DBH) was also associated with reduced numbers of red squirrel.

However, this result is likely a spurious consequence of one transect (68b) with a high number of snags. Although the area was mapped as the blue spruce cover type, the forest was actually dominated by white fir and Douglas fir, two species that are negatively associated with red squirrels. Blue spruce stands are relatively uncommon on Carson National Forest. However, this habitat is important to red squirrels because they reach relatively high densities and they are less likely to be absent from this cover type. Given that blue spruce often occurs along riparian systems into lower mixed conifer forest, these stands may serve as important source populations for red squirrels in adjacent white fir or Douglas fir stands. Increased sample sizes are needed in this cover type to better understand habitat characteristics influencing red squirrel densities.

Engelmann spruce.—In the Engelmann spruce cover type, red squirrels abundance decreased with increasing density of Douglas fir, as well as at higher elevations and steeper slopes. Further, important predictors of higher red squirrel density was the density of large diameter Engelmann spruce, blue spruce, and white fir. These results indicate that red squirrel densities in spruce-fir forest are associated with mature growth stands. In 2003, results indicated a relationship between red squirrel density with an increasing percent grass ground cover. Increased sampling from 2004 demonstrated that that pattern was a spurious result of small sample size.

Engelmann spruce-subalpine fir.—In spruce-fir stands, red squirrel midden density increased with the density of very large Engelmann spruce (> 24 inches DBH) and subalpine fir (16-20 inch DBH). Further, red squirrel density decreased with an increasing understory cover and density of small diameter trees and downed logs. Further, red squirrel densities decreased with increasing density of white fir, aspen, and other trees. These results indicate that red squirrel densities in spruce-fir forest are associated with mature growth stands. Such habitats are likely very important to overall red squirrel densities given that this appears to be the most favored cover type.

Population Trends from 2003 to 2004

Significantly more active red squirrel middens were found on transects replicated in 2004 than in 2003. However, this does not necessarily indicate that the density of squirrels increased. First, the density of inactive middens did not significantly change between the years. Primary middens tend to be enduring landscape features. Consequently, changes in squirrel density is expected to first change the proportion of active to inactive middens, rather than changing the total numbers of primary middens. Second, an analysis of the habitat on the replicated transects indicated that the sampled habitat differed between the years. In particular, in 2004 the transects included areas with less understory cover and density of small diameter trees. These habitat features are negatively associated with red squirrel densities. Thus, it is not unexpected that a higher

density of red squirrel middens was detected in 2004. More important is the difference in habitat sampled on the replicated transects. This may have resulted from several factors. First, GPS technology is not always accurate in areas of high topographic relief and under heavy cloud cover. Thus, it was often not possible to relocate a transect start or to maintain an exact bearing. These small changes in the location of the belt transect can translate into large changes in habitat sampled because of the high habitat heterogeneity in these mountains. Second, it is possible that less experienced field crew tended to avoid stands that were difficult to walk through (high understory and sapling density). One possible means of addressing this in future years is to increase the number of habitat plots on each transect.

CONCLUSIONS

Red squirrel densities observed on Carson National Forest tend to be higher than those reported in other areas. While this may partially be a function of the method, which can overestimate red squirrel densities, it also may reflect the complex nature of habitats available to squirrels in this region. Red squirrel densities tend to be low in lower mixed conifer forest types (i.e., white fir and Douglas fir stands), with squirrels exhibiting a pronounced aversion to white fir, especially those of small diameter. In contrast, densities in spruce dominated habitats (blue spruce, Englemann spruce, spruce-fir stands) tend to be very high. In Engelmann spruce and spruce-fir stands, red squirrel densities are highest in mature growth stands (e.g., > 24 inch DBH). Habitat conditions influencing red squirrel densities in blue spruce stands are less clear, although an increase in canopy cover and decrease in understory cover appears to be associated with higher red squirrel densities. No conclusive trends in population from 2003 to 2004 were detected. This is not surprising given the short duration of the monitoring effort and the species biology (territorial larder-hoarders), which tends to result in more stable population densities.

RECOMMENDATIONS

1) Annual midden density monitoring of red squirrel should continue long-term.

2) Annual midden density monitoring of red squirrels should include a subsample of replicated transects each year to control for inter-stand variation.

3) In order to preserve the comparability of year-to-year samples, subsequent monitoring methodology should conform to that developed in 2003.

4) Additional studies should be implemented to better address habitat relations of red squirrels in specific stand cover types.

5) Additional studies should be implemented that address the impacts of specific forest management strategies.

6) Long-term data on conifer cone/seed and fungal production should be conducted in conjunction with red squirrel monitoring.

7) Increase the number of habitat sampling plots on each transect to better characterize habitat.

8) As much as feasible, maintain consistency in field crewmembers to reduce inter-annual and other biases.

9) New GIS based maps should be prepared in order to facilitate the selection of new stands for data collection. Stands within 1 mile of all drivable roads should be included.

10) Transect 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.

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APPENDIX 1

Monitoring Effort and Logistics

Two to three field crewmembers (23 people-days) were able to complete 59 monitoring sites (= 118 transects) in 13 days, not including travel to and from Carson National Forest. The average number of transects completed during one person-day was 5.1. Although lower than in 2003, this still should be considered an efficient rate. A major reason for the efficiency was because most transects were sampled by a single field crewmember. In future monitoring, it is recommended that field crewmembers work in teams. This will significantly reduce the rate at which monitoring transects can be sampled. Other major reasons for the study efficiency was because field crewmembers camped near monitoring areas, worked long hours and in inclement weather, and were physically fit and able to negotiate rugged terrain at high elevations. Several factors limited the speed by which sampling could be conducted. Fewer transects could be completed on days with longer drive times among sites or on days that required breaking camp and traveling to new monitoring areas. Another major factor that impeded work was inclement weather. The timing of the monitoring coincided with the onset of the monsoon season, which resulted in rain showers virtually every afternoon. Extreme weather conditions (especially due to lightening) resulted in delays. Relative to Abert's squirrel monitoring, red squirrel monitoring is extremely demanding on the field crew. Terrain was generally very rugged, elevation was high, and weather was often bad.

Appendix II. *Transect locations, cover types, and density of active, primary middens sampled on Carson National Forest in August 2003. Latitude and longitude are in decimals of the degree (I.e., site 1a is N 36º 40.435', W 106º 8.694'.*

Date	District	Site	Start Latitude	Start Longitude	Elev.(m)	Bearing	Cover	Density
6-Jul-04	Tres Piedras	1a	36.40.435 N	106.08.694 W	2782	226	DF	1.667
6-Jul-04	Tres Piedras	1b	36.39.970N	106.09.164W	2854	32	DF	0.000
8-Jul-04	Tres Piedras	4a	36.40.961N	106.92.885W	3001	108	ES	0.000
8-Jul-04	Tres Piedras	4b	36.40.900N	106.40.499W	3043	310	ES	1.667
7-Jul-04	Tres Piedras	5a	36.639.607N	106.09.518W	2944	270	SF	0.000
7-Jul-04	Tres Piedras	5b	36.39.661N	106.09.447W	2952	260	SF	0.000
7-Jul-04	Tres Piedras	6a	36.39.566N	106.12.435W	2850	270	BS	0.000
7-Jul-04	Tres Piedras	6b	36.39.571N	106.12.429W	2840	240	BS	1.667
7-Jul-04	Tres Piedras	7a	36.39.889N	106.09.391W	2923	30	WF	0.000
7-Jul-04	Tres Piedras	7b	36.39.881N	106.09.351W	2910	180	WF	0.000
9-Jul-04	Canjilon	8a	36.36.310N	106.22.654W	2857	110	WF	10.000
9-Jul-04	Canjilon	8b	36.36.124	106.22.453	2873	132	WF	5.000
9-Jul-04	Canjilon	9a	36.36.094	106.23.586	2732	110	WF	1.667
9-Jul-04	Canjilon	9b	36.36.068	106.23.607	2742	110	AA	0.000
10-Jul-04	Canjilon	10a	36.33.678	106.23.428	2852	0	DF	0.000
10-Jul-04	Canjilon	10b	36.33.679	106.23.393	2828	45	DF	1.667
10-Jul-04	Canjilon	11a	36.33.399	106.23.766	2811	270	DF	0.000
10-Jul-04	Canjilon	11b	36.33.397	106.23.729	2812	315	DF	0.000
10-Jul-04	Canjilon	12a	36.33.997	106.20.140	3216	350	SF	5.000
10-Jul-04	Canjilon	12b	36.33.979	106.20.028	3208	350	SF	21.667
10-Jul-04	Canjilon	13a	36.34.352	106.20.179	3229	90	SF	5.000
10-Jul-04	Canjilon	13b	36.34.24	106.20.095	3236	30	SF	23.333
10-Jul-04	El Rito	14a	36.28.368	106.17.069	2609	310	WF	5.000
10-Jul-04	El Rito	14b	36.28.376	106.16.989	2732	0	WF	1.667
10-Jul-04	El Rito	15a	36.28.277	106.17.032	2610	270	ES	3.333
10-Jul-04	El Rito	15b	30.28.261	106.17.006	2631	90	ES	8.333
9-Jul-04	El Rito	16a	36.31.884N	106.14.033W	2827	0	DF	1.667
9-Jul-04	El Rito	16b	36.31.830N	106.13.994W	2831	40(350m);280(250m)	DF	3.333
9-Jul-04	El Rito	17a	36.32.210	106.14.066	2836	270	SF	3.333
9-Jul-04	El Rito	17b	36.32.165N	106.14.040W	2836	270	SF	6.667
9-Jul-04	El Rito	21a	36.32.554N	106.14.373W	2865	290	BS	1.667
9-Jul-04	El Rito	21b	36.32.557N	106.14.333W	2910	310	BS	8.333
16-Jul-04	Camino Real	26a	36.08.871	105.32.552	2529	190	WF	1.667
16-Jul-04	Camino Real	26b	36.08.873	105.32.516	2539	240	WF	0.000
16-Jul-04	Camino Real	27a	36.07.850	105.31.936	2620	260	DF	1.667
16-Jul-04	Camino Real	27b	36.08.009	105.31.732	2591	260	DF	5.000
17-Jul-04	Camino Real	28a	36.17.539	105.22.590	2877	280	ES	5.000

17-Jul-04	Camino Real	28b	36.17.543	105.22.599	2873	120	ES	6.667
16-Jul-04	Camino Real	30a	36.07.997	105.31.553	2571	170	ES	1.667
16-Jul-04	Camino Real	30b	36.08.007	105.31.523	2575	140	ES	1.667
17-Jul-04	Camino Real	33a	36.18.763	105.25.564	2698	250	BS	3.333
17-Jul-04	Camino Real	33b	36.18.763	105.25.529	2721	90	BS	10.000
17-Jul-04	Camino Real	34a	36.18.814	105.27.461	2642	250	BS	0.000
17-Jul-04	Camino Real	34b	36.18.818	105.27.403	2638	100	BS	3.333
18-Jul-04	Camino Real	35a	36.21.936	105.23.620	2623	30	BS	6.667
18-Jul-04	Camino Real	35b	36.22.056	105.23.209	2617	320	BS	1.667
18-Jul-04	Camino Real	36a	36.21.911	105.24.626	2799	40	DF	0.000
18-Jul-04	Camino Real	36b	36.21.909	105.24.620	2812	70	DF	0.000
31-Jul-04	Questa	44a	36.47.013	105.10.887	2894	5	WF	0.000
31-Jul-04	Questa	44b	36.47.317	105.10.834	2882	190	WF	0.000
29-Jul-04	Questa	45a	36.45.765	105.12.028	2868	270	DF	0.000
29-Jul-04	Questa	45b	36.45.734	105.12.427	2940	270	DF	0.000
30-Jul-04	Questa	47a	36.47.489	105.15.929	2918	75	BS	3.333
30-Jul-04	Questa	47b	36.47.563	105.15.580	2882	90	BS	8.333
30-Jul-04	Questa	48a	36.47.417	105.11.574	3019	340	SF	0.000
30-Jul-04	Questa	48b	36.47.418	105.11.490	3002	340	SF	0.000
19-Jul-04	Questa	49a	36.45.843	105.22.798	3416	205	ES	5.000
19-Jul-04	Questa	49b	36.45.843	105.22.829	3370	156	ES	3.333
28-Jul-04	Questa	52a	36.44.440	105.25.373	3085	30	SF	0.000
28-Jul-04	Questa	52b	36.44.447	105.25.240	3016	210	SF	0.000
28-Jul-04	Questa	54a	36.45.660	105.22.302	3365	130	SF	0.000
28-Jul-04	Questa	54b	36.45.660	105.22.302	3365	270	SF	5.000
28-Jul-04	Questa	56a	36.43.213	105.24.379	2875	280	WF	0.000
28-Jul-04	Questa	56b	36.43.185	105.24.511	2878	280	WF	0.000
28-Jul-04	Questa	57a	36.44.188	105.26.788	2829	250	BS	3.333
28-Jul-04	Questa	57b	36.44.184	105.26.796	2827	80	BS	0.000
7-Jul-04	Tres Piedras	59a	36.40.159N	106.11.040W	2973	60	DF	1.667
7-Jul-04	Tres Piedras	59b	36.39.116N	106.11.006W	2941	0	DF	0.000
8-Jul-04	Tres Piedras	60a	36.41.413N	106.14.422W	3064	200	ES	0.000
8-Jul-04	Tres Piedras	60b	36.41.406N	106.14.382W	3061	160	ES	1.667
16-Jul-04	Camino Real	61a	36.08.084	105.31.635	2557	200	BS	3.333
16-Jul-04	Camino Real	61b	36.08.079	105.31.626	2590	270	BS	3.333
9-Jul-04	El Rito	62a	36.30.738N	106.13.856W	2779	330	WF	0.000
9-Jul-04	El Rito	62b	36.30.741N	106.13.815W	2798	350	WF	1.667
16-Jul-04	Camino Real	63a	36.06.306	105.29.249	2606	190	BS	0.000
16-Jul-04	Camino Real	63b	36.05.989	105.29.377	2606	210	BS	1.667
16-Jul-04	Camino Real	64a	36.12.948	105.24.037	3282	90	SF	6.667
16-Jul-04	Camino Real	64b	36.12.948	105.24.001	3255	220	SF	20.000

17-Jul-04	Camino Real	65a	36.13.876	105.24.089	3435	340	ES	0.000
17-Jul-04	Camino Real	65b	36.13.874	105.24.115	3442	600	ES	0.000
17-Jul-04	Camino Real	66a	36.15.004	105.23.263	3257	190	SF	5.000
17-Jul-04	Camino Real	66b	36.15.034	105.23.258	3454	270	SF	6.667
16-Jul-04	Camino Real	67a	36.09.254	105.34.553	2463	210	DF	0.000
16-Jul-04	Camino Real	67b	36.09.752	105.34.516	2458	170	DF	0.000
17-Jul-04	Camino Real	68a	36.18.578	105.28.541	2590	240	BS	0.000
17-Jul-04	Camino Real	68b	36.18.578	105.281.541	2590	60	BS	5.000
18-Jul-04	Camino Real	69a	36.19.754	105.23.929	3016	70	SF	6.667
18-Jul-04	Camino Real	69b	36.19.754	105.23.929	3016	250	SF	3.333
17-Jul-04	Camino Real	70a	36.18.851	105.23.464	2968	210	SF	0.000
17-Jul-04	Camino Real	70b	36.18.848	105.23.423	2968	100	SF	0.000
30-Jul-04	Questa	71a	36.47.195	105.11.647	2937	310	BS	1.667
30-Jul-04	Questa	71b	36.47.504	105.11.830	3032	140	BS	5.000
30-Jul-04	Questa	72a	36.46.629	105.12.435	2933	40	DF	0.000
30-Jul-04	Questa	72b	36.46.894	105.12.184	2929	23	DF	0.000
29-Jul-04	Questa	73a	36.45.464	105.12.197	2842	260	WF	0.000
29-Jul-04	Questa	73b	36.45.358	105.12.563	2948	100	WF	0.000
29-Jul-04	Questa	74a	36.44.269	105.11.343	2689	150	DF	0.000
29-Jul-04	Questa	74b	36.43.978	105.11.235	2680	150	DF	0.000
29-Jul-04	Questa	75a	36.43.439	105.15.580	2687	195	WF	0.000
29-Jul-04	Questa	75b	36.43.195	105.11.017	2792	10	WF	0.000
28-Jul-04	Questa	76a	36.43.822	105.24.973	3034	140	SF	0.000
28-Jul-04	Questa	76b	36.43.573	105.24.758	3084	320	SF	3.333
28-Jul-04	Questa	77a	36.44.844	105.26.752	2770	40	DF	5.000
28-Jul-04	Questa	77b	36.45.023	105.26.423	2821	40	DF	1.667
17-Jul-04	Camino Real	78a	36.17.450	105.21.816	2900	100	ES	3.333
17-Jul-04	Camino Real	78b	36.17.410	105.21.418	2959	100	ES	6.667
17-Jul-04	Camino Real	79a	36.18.414	105.22.752	2917	190	DF	0.000
17-Jul-04	Camino Real	79b	36.18.435	105.22.714	3003	70	DF	0.000
18-Jul-04	Camino Real	80a	36.20.544	105.24.188	3022	70	SF	0.000
18-Jul-04	Camino Real	80b	36.20.544	105.23.189	3077	120	SF	5.000
8-Jul-04	Tres Piedras	81a	36.41.037N	106.13.559W	2973	0	ES	3.333
8-Jul-04	Tres Piedras	81b	36.41.029N	106.13.523W	2985	60	ES	0.000
6-Jul-04	Tres Piedras	82a	36.40.435N	106.08.698W	2794	100	WF	0.000
6-Jul-04	Tres Piedras	82b	36.40.408N	106.08.642W	2800	60	WF	1.667
7-Jul-04	Tres Piedras	83a	36.37.980N	106.09.873W	2800	240	WF	3.333
7-Jul-04	Tres Piedras	83b	36.38.035N	106.09.915	2942	250	WF	0.000
9-Jul-04	El Rito	84a	36.30.916N	106.14.836W	2917	10	ES	0.000
9-Jul-04	El Rito	84b	36.31.149N	106.14.684W	2932	180	ES	0.000