



THE UNIVERSITY OF
ARIZONA

**Mt. Graham Red Squirrel Monitoring Program
2008 Annual Report**

Prepared by:

John L. Koprowski, Principal Investigator

Melissa J. Merrick, Wildlife Biologist Sr.

Vicki L. Greer, Wildlife Biologist Sr.

Submitted 22 April 2009

EXECUTIVE SUMMARY

In 2008, the University of Arizona Mt. Graham Red Squirrel Monitoring Program continued efforts to document aspects of red squirrel population biology and food resources in the established study areas around the Mt. Graham International Observatory in the Pinaleno Mountains, Graham County, Arizona. A complete census of the study areas was made in March, June, September, and December 2008.

Overall annual mean mushroom production in 2008 was 1½ times greater than in 2007, and was the sixth highest crop since data collection began in 1994. Seed production for 2007 (1 year delay in reporting due to methodology), was > 65 times lower than in 2006, and the 2007 seed crop ranked 13/15 (15 = lowest seed crop) since data collection began in 1993.

Overwinter survival, calculated as animals surviving from December 2007 to June 2008, was relatively high in TR habitat (78%) and lower in SF habitat (50%). Eight litters were confirmed on or near the monitored areas in 2008. From these 8 litters, 30 juveniles were known to emerge from natal nests and 15 of them were live-trapped and marked.

Squirrel populations in December 2008 (28 Adults) were slightly higher than the previous December (26Ad). The 2008 squirrel populations in TR habitat stayed fairly steady or decreased slightly throughout the year. However in SF habitat, small but steady increases were seen through December, when populations (7Ad on SFC, SFN) were at or near the highest numbers seen in the past four years. If the squirrels near the monitored areas (within 100m) are included, no change in population was seen from December 2007 (33 squirrels) to December 2008 (33 squirrels).

Table of Contents

INTRODUCTION	1
Study Area	1
METHODS	2
Red Squirrel Food Resources	2
<i>Conifer Seed Production</i>	2
<i>Mushroom Production</i>	3
Population Biology	3
<i>Midden Occupancy</i>	3
<i>Overwinter Survival</i>	4
<i>Spatial Distribution</i>	4
Reproductive Activity and Success	5
Trapping and Marking	5
Mapping	5
Weather Data	5
RESULTS	6
Red Squirrel Food Resources	6
<i>2007 Conifer Seed Production</i>	6
<i>2008 Mushroom Production</i>	6
Population Biology	6
<i>Midden Occupancy</i>	6
<i>Overwinter Survival</i>	7
<i>Crude Density</i>	7
<i>Local Density</i>	7
<i>Nearest Neighbor Distance</i>	7
Reproductive Activity and Success	8
Trapping and Marking	8
Mapping	8
Weather Data	8
Insect Outbreaks on Monitored Areas	9
Publications	9
LITERATURE CITED	12

List of Tables

Table 1.	Changes in size of study areas due to construction and fire events, University of Arizona Red Squirrel Monitoring Program, Pinaleño Mountains, Graham County, Arizona.	14
Table 2.	Mushroom genera known to be food resources of Mt. Graham red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>), collected from the food resource plots on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	15
Table 3.	Mean filled conifer seed production, 2007, on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	16
Table 4.	Mean annual mushroom production, 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. .	17
Table 5.	Mean annual mushroom production (wet weight Kg/ha), 2008, of selected mushroom genera known to be food resources for red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>), University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	18
Table 7.	Overwinter survival of Mt. Graham red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>), 2007 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	20
Table 8.	Mean Local Density (# within 100m radius) of middens and Mt. Graham red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>), 2007 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	21
Table 9.	Mean Nearest Neighbor Distance of middens and Mt. Graham red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>), 2007 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	22

List of Figures

Figure 1.	Map of study areas, December 2008, University of Arizona Red Squirrel Monitoring Program, Pinaleño Mountains, Graham County, Arizona.	23
Figure 2a.	Corkbark fir (<i>Abies lasiocarpa</i> var. <i>arizonica</i>) seed fall, 1993 - 2007, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	24
Figure 2b.	Douglas-fir (<i>Pseudotsuga menziesii</i>) seed fall, 1993 - 2007, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	25
Figure 2c.	Engelmann spruce (<i>Picea engelmannii</i>) seed fall, 1993 - 2007, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	26
Figure 3.	Mushroom crops, 1994 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	27
Figure 4.	Quarterly Mt. Graham red squirrel (<i>Tamiasciurus hudsonicus grahamensis</i>) populations (including juveniles), March 2004 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	28
Figure 5.	Summer and winter Mt. Graham red squirrel (<i>Tamiasciurus hudsonicus grahamensis</i>) populations (including juveniles), by habitat, June 1989 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	29

List of Appendices

Appendix A.	Annual conifer seed and mushroom production, 2007, on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	30
Appendix B:	Midden occupancy records, 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	34
Appendix C.	Mt. Graham red squirrel (<i>Tamiasciurus hudsonicus grahamensis</i>) populations (including juveniles at maternal middens), March 2004 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	55
Appendix D:	Quarterly occupancy maps for Mt. Graham red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>) March 2008 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. .	56
Appendix E:	Measures of spatial distribution for middens and Mt. Graham red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>), 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. .	69
Appendix F:	Reproductive success of Mt. Graham red squirrels (<i>Tamiasciurus hudsonicus grahamensis</i>), 2008, on or near University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	74
Appendix G.	Weather information, January - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.	79

INTRODUCTION

The Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) is the southernmost subspecies of the wide-ranging red squirrel and is endemic to the Pinaleño (Graham) Mountains of southeastern Arizona (Hoffmeister 1986). Believed restricted to ≤ 12200 ha of mixed-conifer and spruce-fir forest at elevations > 2360 m (Hatten 2000), Mt. Graham red squirrels were federally protected as endangered in 1987 with critical habitat defined in 1990 and a recovery plan published in 1993 (United States Fish and Wildlife Service 1993). The University of Arizona's Mt. Graham Red Squirrel Monitoring Program (RSMP) was established in 1989 to meet the requirements of the Mount Graham International Observatory (MGIO) Management Plan (USDA Forest Service 1989) by monitoring the population of this endangered species in the highest peaks of the Pinaleño Mountains near the MGIO ($32^{\circ} 42' N$, $109^{\circ} 53' W$). In 2008, the MGIO site consisted of two operating facilities, the Vatican Advanced Technology Telescope (VATT) and the Sub-Millimeter Telescope (SMT), a maintenance and generator building, and a 3.2 km access road (FR 4556). Construction activities at the Large Binocular Telescope (LBT) in 2008 were mainly interior building work. Herein, we report on the monitoring efforts from 1 January to 31 December 2008.

All use of terms *red squirrel* or *squirrel* refers to the Mt. Graham red squirrel unless otherwise noted. No part of this report may be used or reproduced in any form without the written permission of the Monitoring Program Director, Dr. John L. Koprowski, School of Natural Resources, Wildlife Conservation and Management, University of Arizona, Tucson, Arizona, 85721.

Study Area

Four areas were defined in the vicinity of the MGIO to monitor red squirrel populations (Figure 1) and include two forest habitat types: transitional (TR) or mixed conifer forest and spruce-fir (SF) forest. The TR habitat, between 2680 and 3050 m elevation, is composed of Engelmann spruce (*Picea engelmannii*), corkbark fir (*Abies lasiocarpa* var. *arizonica*), Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), southwestern white pine (*P. strobiformis*) and aspen (*Populus tremuloides*). The SF habitat, ≥ 3050 m elevation, is composed of Engelmann spruce and corkbark fir. In each habitat type, an area within 300 m of the telescope sites and access road was defined as the *construction* area (TRC, SFC). For comparison, a *non-construction* area beyond 300 m from the MGIO or the access road was defined in each habitat (TRN, SFN). The size of monitored areas has changed several times due to construction and fire events (Table 1).

METHODS

Red squirrels cache conifer cones in locations known as middens. Middens are easily recognized by presence of cached cones and piles of discarded cone scales. The RSMP defines a midden site as a circular area with 10 m radius surrounding the center of the primary cache site. Because red squirrels are territorial and generally solitary, counts of occupied middens provide a reasonably accurate estimate of population size (Smith 1968; Vahle 1978).

All known midden sites are marked with numbered metal tags, and black and orange striped flagging. During censuses or other monitoring duties, new activity areas that have the potential to become new middens are often located. Feeding sign, caching and squirrels are seen at these areas. These areas are assigned a temporary number and are revisited to assess sign and the presence of a squirrel during the next quarterly census. If conditions warrant, an activity area will be upgraded to a midden and added to the regular quarterly censuses. If no improvement occurs in the two quarterly censuses following initial location, the activity area is removed.

Prior to 2003, at the end of each calendar year, a list of middens to be removed from regular censusing was compiled. If a midden had been censused for at least three years (12 censuses), including at least one good seed crop (better than the mean seed crop over the study period), and was not occupied during that time, the midden was removed from the list for regular censusing and revisited only each December. If any removed middens became re-occupied, the sites are returned to the list for regular census. However, in 2003, because a large number of middens were removed in some areas as a result of insect damage, we began visiting all removed middens during each census. This change was made so as not to leave large parts of the monitored areas unvisited for an entire year. Removed middens, if still unoccupied, are simply checked off a tally sheet, while complete notes are taken on middens considered to be in the regular census.

Red Squirrel Food Resources

Conifer Seed Production

The RSMP began collecting quantitative data in 1993 to determine the abundance of major red squirrel food resources: conifer seeds and mushrooms. In July 2004, 14 of the original seed plots in SFC (7) and SFN (7) were in areas destroyed by the Nuttall Fire. We added 3 new plots in late summer 2004 (SFC - 2, SFN - 1) in remaining unburned areas. Therefore, seed production for 2007 was estimated from 20 seedfall plots distributed among the monitored areas (Figure 1). Three 0.25 m² seed traps were randomly placed within a 10 m x 10 m plot at each location. Seeds from the 2007 crop were collected from the seed traps in June 2008. Conifer seeds contained in each trap were separated by species and individually tested to determine the proportion of seeds that were likely to be viable. A viable seed leaves an oily spot on clean paper when squashed. This method is likely to underestimate total number of viable seeds because some seeds may have been preyed upon within the seed trap. Estimates of seedfall for each tree species were calculated as the average number of viable seeds from all three traps on each plot. Seeds of white pine and ponderosa pine are not readily dispersed by wind due to their large size. As a result, seed crops of these species are

under represented in seed trap samples. Both species may be important local food supplies for red squirrels, but at present no reliable method exists to estimate size of seed crops.

Mushroom Production

As in previous years, mushrooms were collected from plots 1m by 100m (0.01 ha) at two week intervals during periods of mushroom production. Fourteen of 28 food resource plots were destroyed in the Nuttall Fire in July 2004, however, three new plots were established in remaining unburned areas on the SFC and SFN. Mushrooms (epigeous or above-ground fungi) were collected at these 20 sites (Figure 1) from mid-July through late September 2008. Since 2007, mushrooms are collected from east-west oriented plots, instead of north-south as in 2002-2006. We alternate plot collection orientation every five years in order to avoid possible impacts of long-term harvest on plots. Prior to beginning the alternating orientations, we collected mushrooms from both east-west and north-south plots in 2001 and detected no significant differences in weight, number, or diversity of mushrooms between the two orientations. Collections were restricted to genera of mushrooms used by red squirrels on Mt. Graham or in other regions (Table 2). Collected mushrooms were separated by plot and genus, and weighed wet. For most genera, dry weight was calculated by multiplying wet weight by a wet weight/dry weight ratio determined from previous samples on Mt. Graham. Dry weights were measured directly for genera with small numbers of specimens previously collected ($n < 50$).

Because seeds for a given year are not collected and analyzed until the following spring, seed data are delayed by one year. For comparison, the previous year's seed and mushroom data are reported **in addition** to the current year's mushroom data.

Population Biology

Midden Occupancy

Census data were used to determine number and distribution of occupied middens on each monitored area. In March, June, September, and December 2008, all middens were visited at least once to determine occupancy. If a midden appeared to be occupied based upon feeding sign (cone scales, dried mushrooms, and conifer clippings) or caching, every attempt was made on subsequent midden visits to observe the resident and to determine its sex, age, and reproductive condition. In 2008, most animals on or near monitored areas were ear-tagged and many were fitted with radio collars, further assisting census efforts.

All middens on the monitored areas were classified as either occupied, unoccupied, or possibly occupied, with each occupied midden representing one squirrel (except for females with dependent juveniles). A midden was considered unoccupied when no squirrel or squirrel sign was present. A midden was considered possibly occupied when red squirrel sign was found but sign was insufficient to clearly indicate occupancy. Possibly occupied middens were considered to be unoccupied when determining population size. Population size estimates are conservative and represent the minimum number known alive (Krebs 1966). Differences in midden occupancy among

study areas were compared using data from June and December.

Overwinter Survival

Overwinter survival was estimated for squirrels in the monitored areas. During a complete census in December 2007, the number of occupied middens and the identity of resident squirrels were determined. December 2007 occupancy was compared to occupancy for June 2008. For unmarked animals, a squirrel was considered to have survived winter if it was a resident of a midden in December and that same midden was found to be occupied by a squirrel of the same sex in June. In addition, if the midden was listed as occupied based on sign or a squirrel of unknown sex was seen, this was also counted as a surviving individual. For marked squirrels, survival was generally known with a fair degree of certainty using available trapping and telemetry information.

Spatial Distribution

We used three methods to describe spatial distribution of middens and squirrels: crude density, local density, and nearest-neighbor distance. Crude density represents the total number of middens and squirrels per hectare. We made no allowance for differences in habitat quality among monitored areas, and statistical tests are not appropriate.

Local density (LD) is a method of describing local population densities for comparisons among populations in which habitat variables are uncontrolled. For this report, LD is defined as the number of *middens* or *squirrels* within 100 m of a focal *midden* or *squirrel*. Mean LD (\bar{x} LD) of *middens* (all middens, occupied and unoccupied) and *squirrels* (all occupied middens) are compared between areas and habitats. The benefit of using LD is that measurements are not influenced by habitat variables, whereas crude density may include large areas not suitable as squirrel habitat, such as clearings and meadows. The LD method is adapted from distance models of neighborhood modeling used by plant ecologists to describe and compare plant populations (Czárán and Bartha 1992). A circle with a radius of 100 m encloses 3.14 hectares, which is approximately the average home range of Mt. Graham red squirrels (Froehlich 1990, Koprowski et al. 2008) and is also the approximate maximum distance that an observer can recognize and accurately locate a squirrel "chatter" call (P. Young, pers. obs.).

Nearest neighbor distance (NND) is used to describe and compare the spatial distribution of populations and communities of plants and animals (Clark and Evans 1954, Krebs 1989). In this report, NND is the shortest distance (m) from a focal *midden* or *squirrel* to the nearest *midden* or *squirrel*. Mean NND (\bar{x} NND) of middens and squirrels was compared between areas and habitats.

Local density and NND were determined for each midden and squirrel using mapped coordinates and compared among areas and habitats using ANOVA. To determine the LD and NND of some middens and squirrels on the monitored areas, we included off-area middens within 100 m of a focal midden.

Reproductive Activity and Success

In 2008, we recorded breeding condition of adult male and female squirrels, and litter size when observed. By examining the squirrel's condition through trapping efforts or binoculars, we determined reproductive status of females as non-reproductive (small unpigmented teats), reproductive (vulva visibly swollen or appearance of pregnancy), lactating (swollen, elongated teats with surrounding alopecia), recently lactating (elongated black tipped teats), or lactating in past seasons (small black tipped teats). We determined reproductive status of male squirrels during trapping or visual assessment as testes non-scrotal (non-reproductive) or testes scrotal (reproductive).

Trapping and Marking

In accordance with our Federal United States Fish and Wildlife Service Endangered Species and Arizona Game and Fish permits, using accepted methods (Koprowski 2002), we trapped red squirrels using Tomahawk (model 201) wire-mesh box-type live traps, baited with peanuts and/or peanut butter. Once captured, we transferred squirrels to a cloth-handling cone for marks and measurements. We tagged squirrels with small numbered metal ear-tags threaded with colored plastic washers and affixed to ears for easy distance identification. We also fitted adult animals with radio collars. Squirrels were released at the capture site.

Mapping

All middens and other physical features on the monitored areas were previously mapped using GPS with an accuracy of ± 5 m. Universal Transverse Mercator (UTM) coordinates from GPS files were used to compute local densities and nearest neighbor distances. New GPS data (nests, habitat plots, etc.) were collected using a GeoExplorer II system from Trimble Navigation, Inc. Readings were taken within 5 m of the location center. Final GPS locations were based on an average from a minimum of 200 three-dimensional data points. Locations were differentially corrected using base station (Continuously Operating Reference Station, CORS-COT1, Tucson, Arizona). Maps were produced using Arc-View 3.2 (ESRI 1995).

Weather Data

Weather data were collected using two Davis Instruments weather stations. One station was located along the abandoned Forest Service road north of Emerald Peak (32° 42' 14.25"N, 109° 53' 17.06" W) on the SFC; the other was located at the Biology Camp (32° 41' 51.47 N, 109° 54' 20.28"W), adjacent to the TRC. Stations record air temperature (high, low, and average), wind speed, wind direction, rainfall, relative humidity and barometric pressure. Data were averaged at 60-min intervals. Snow depth (cm) was recorded from five snow pole pairs located in SF habitat, one pair at the 3050 m level on the access road, and three snow pole pairs in TR habitat. Each pair consists of a pole in a clearing or canopy opening and a second pole nearby in the forest.

All statistical analyses were conducted using standard tests found in SAS, StatsDirect, or Minitab statistical software. Because sample sizes were sometimes small due to endangered status,

significance for statistical tests was implied when $P \leq 0.05$ and potential biological significance was noted when $P < 0.10$.

RESULTS

Red Squirrel Food Resources

2007 Conifer Seed Production

Data collection for seed crops began in 1993. If years are ranked from highest (1) and lowest (15), the total 2007 seed crop ranked 13/15. Douglas-fir was the most abundant seed in 2007, ranking 10/15. The corkbark fir seed crop ranked 12/15 and Engelmann spruce was the lowest seen in 15 years of data collection. The 2007 overall average seed crop was 71.9 (1000seeds/ha), > 65 times smaller than the seed crop in 2006, 4719.7 (1000seeds/ha); (Table 3, Figures 2a-c, Appendix A).

2008 Mushroom Production

Overall annual mean mushroom production in 2008 was 1½ times greater than in 2007, and was the 6th highest crop since data collection began in 1994. Production generally increased in both TR and SF habitats in 2008 as compared to 2007, except the SFC area, which was slightly lower (Figure 3). In 2008, mushroom production (\bar{x} wet weight) was significantly greater in TR than in SF habitat (Table 4). On TRC, three genera, *Russula*, *Clitocybe*, and *Suillus* accounted for 72% of production. On TRN, *Russula*, *Pholiota*, and *Clitocybe* accounted for 79% of total production. *Russula*, *Clitocybe*, and *Cortinarius* accounted for 75% of the production on SFC. On SFN, *Clitocybe*, *Russula*, and *Cortinarius* accounted for 82% of the total production (Table 5).

Population Biology

Midden Occupancy

Four quarterly censuses (Mar, Jun, Sep, Dec) of all middens on or near monitored areas were made in 2008 (Appendix B). From December 2007 to December 2008, the number of red squirrels decreased, from 26 to 23. On TRC, the highest number of squirrels (11 Ad) was in September 2008, and the lowest number was 7 Ad in December. The highest numbers (8 Ad + 6 J) on TRN were also in September and the lowest was 7 Ad in December. The highest number of squirrels on SFC was in December (7 Ad) with the lowest (3 Ad) in June. On SFN, 7 Ad were resident on the area during December, and 1 squirrel was found in March and June (Figure 4, Appendix B, C, D). The 2008 squirrel populations in TR habitat stayed fairly steady or decreased slightly throughout the year, however in SF habitat, small but steady increases were seen through December, when populations were at or near the highest numbers seen in the past four years (Figure 5).

Two middens on the SFC area, previously removed from regular censusing due to low occupancy, became re-occupied in 2008, and one new midden was located on the TRN area

(Appendix B). In June and December 2008, the proportion of middens occupied did not differ among areas in both TR and SF habitats (Table 6).

Overwinter Survival

The number of squirrels that survived the winter of 2007-2008 did not differ among areas (Table 7); survival was 78% in TR habitat and 50% in SF habitat. For comparison, survival from the previous winter (2006-2007) was 58% in TR habitat and 71% in SF habitat.

Overwinter survival may be overestimated because a midden may be occupied in the spring by a different squirrel of the same sex. This mortality can not be detected among unmarked squirrels. However, this potential overestimate is minimal as most squirrels on the monitored areas are ear-tagged and radio-collared for unique identification.

Crude Density

Between December 2007 and December 2008, crude density of *middens* on all areas except TRC increased slightly, as two previously removed middens became reoccupied, and one new midden was found. (Appendix E1-a). From December 2007 to December 2008, crude density of *squirrels* decreased slightly in TR habitat and increased in SF habitat (Appendix E1-b).

Local Density

The December 2008 overall mean local density (\bar{x} LD \pm SE) of *middens* (3.8 ± 0.32) was nearly the same as December 2007 (3.7 ± 0.24). Local density of middens did not differ for areas within habitats, but TR habitat \bar{x} LD (5.0 ± 0.27) was higher than SF habitat \bar{x} LD (1.9 ± 0.23). The mean \bar{x} LD of *squirrels* (occupied middens) on all areas in December 2008 was 0.8 ± 0.14 , which is a decrease from 1.4 ± 0.22 in December 2007. The \bar{x} LD of *squirrels* also differed among areas, with SFC the lowest \bar{x} LD (0.0 ± 0.0) and TRC the highest (1.1 ± 0.34) (Table 8, Appendix E-2).

Nearest Neighbor Distance

Overall \bar{x} NND \pm SE of *middens* decreased slightly from December 2007 to December 2008 ($56.2\text{m} \pm 3.73$ to $55.7\text{m} \pm 3.62$) (Table 9, Appendix E-2). Nearest neighbor distance of *middens*, as with local density, did not differ in areas within habitats, but SF \bar{x} NND (74.5 ± 8.30) was greater than TR \bar{x} NND (45.0 ± 2.42). The \bar{x} NND of *squirrels* (occupied middens) for all areas changed little from $135.5\text{m} \pm 32.6$ in December 2007 to $136.5\text{m} \pm 25.8$ in December 2008. The \bar{x} NND of *squirrels* differed among areas, with the longest \bar{x} NND on SFC ($181.6\text{m} \pm 28.80$) and the shortest on TRN ($80.2\text{m} \pm 87.70$); (Table 9, Appendix E-2).

Reproductive Activity and Success

In 2008, three possible breeding chases involving squirrels resident on the monitored areas was observed, from late April to late May. In addition, field crews noted in early June, that most middens with a resident female, generally had one or more males in attendance nearby (Appendix F-1). Based on information from census and trapping records, most resident adult males were scrotal from early March through late June (Appendix F-3b).

Most females seen or trapped during June were thought to be either in estrus or pregnant. However, the first lactating female was observed 4 Aug and the latest was on 18 September. During the June census, of the 14 adult females identified as residents (including nearby off-area middens), 9 were reproductive, 2 were non-reproductive, and 1 was unknown. By September, of 12 resident females, 9 were lactating or had been very recently lactating, and the remainder were non-reproductive or unknown (Appendix F-3a). Direct evidence of 8 litters (30 juveniles) was seen on or near the areas during censuses or other activities. Litters were confirmed from mid-August through mid-September, however, some may have emerged slightly earlier as those juveniles were a larger size and roaming further from the nest when first detected (Appendix F-2).

Trapping and Marking

By the end of 2008, nearly all residents on or near monitored areas were fitted with colored ear tags and radio-collared (Appendix B). In addition, 15 of the 30 juveniles produced on or near monitored areas were caught at natal middens and fitted with small numbered metal ear tags to aid in the collection of dispersal information.

Mapping

No significant changes in maps of the monitored areas were made in 2008, as all major features (middens, roads, trails, construction areas, etc.) have been mapped in previous years. New nests or habitat plots were GPS located and added to databases and maps.

Weather Data

Weather data were collected for most of 2008 from two weather stations located at the Biology Camp (TR habitat) and near Emerald Peak (SF habitat). Data from Emerald Peak were sparse in winter months due to several equipment failures. From available data, maximum temperature recorded was 24.4°C in June at the biology camp and the minimum temperature recorded was -15.6°C in January, also at the biology camp. The maximum average monthly temperature was 14.3°C in June at the biology camp and the minimum average monthly temperature was -2.9°C in January at the biology camp (Appendix G-1). The maximum total monthly rainfall was recorded in July on Emerald Peak, at 202.4mm and June was the driest month at 6.4mm at both biology camp and Emerald Peak (Appendix G-1). Snow depth was recorded from nine pairs of

snow poles. The average accumulated snow depth from January - April 2008 ranged from 0.0cm to 93.3cm (Appendix G-2). For comparison, average accumulated snow depths for January - April in 2007 ranged from 10.0cm to 79.3cm, and in February - April 2005-2006, depths ranged from 0.0cm to 47.7cm. Data on wind chill temperatures, wind direction and speed, humidity, and barometric pressure were also collected (Appendix G-1).

Insect Outbreaks on Monitored Areas

Infestations of bark beetles (*Drycoetes confusus* and *Dendroctonus rufipennis*) continued on parts of the monitored areas in 2008, although to a lesser degree than in previous years. Spruce aphid (*Elatobium abietinum*) were seen, but in much reduced numbers. For a detailed report on forest health and continuing research on the insect infestations, please contact the USFS Southwestern Region Entomology and Pathology Office in Flagstaff, AZ.

<http://www.fs.fed.us/r3/resources/health/>

Publications

Books

Sanderson, HR, Koprowski, JL. (eds). 2009. The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment, University of Arizona Press. In press (May 09).

Book Chapters

2008

Palmer, GH, Koprowski, JL and Pernas, T. 2008. Tree squirrels as invasive species: conservation and management implications. Pp 273 - 282 in G. L. Witmer, W. C. Pitt, K.A. Fagerstone (eds.), Managing vertebrate invasive species: proceedings of an international symposium. USDA/APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, Colorado.

2009

- Alanen, MI, Koprowski, JL, Grindler MI, Greer, VL., Coates, CA, Hutton, KA. 2009. Habitat characteristics of the territories of Mt. Graham red squirrels: do sex differences exist? In: Sanderson, HR, Koprowski, JL. (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.
- Bertelsen, SR, Koprowski, JL. 2009. Site characteristics of traditional and newly established middens of the Mount Graham red squirrel. In: Sanderson, HR, Koprowski, JL (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.
- Edelman, AE, Koprowski, JL. 2009. Introduced Abert's squirrels on Mt. Graham: Could they be contributing to the decline of the red squirrel. In: Sanderson, HR, Koprowski, JL. (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.
- Greer, VL, Koprowski, JL. 2009. Time budget of the Mt. Graham red squirrel. In: Sanderson, HR, Koprowski, JL. (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.
- King, SRB, Koprowski, JL. 2009. Effect of human and non-human disturbance on Mt. Graham Red Squirrels. In: Sanderson, HR, Koprowski, JL. (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.
- Koprowski, JL, Snow, T. 2009. A comparison of the census methods used to monitor Mt. Graham red squirrels. In: Sanderson, HR, Koprowski, JL. (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.
- Koprowski, JL, Steidl, RJ. 2009. The dilemma of the small population: potential consequences of the isolation of Mt. Graham red squirrels. In: Sanderson, HR, Koprowski, JL. (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.
- Munroe, KE, Koprowski, JL, Greer, VL. 2009. The social and mating systems of red squirrels: do Mt. Graham red squirrels fit the pattern? In: Sanderson, HR, Koprowski, JL (eds). *The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment*, University of Arizona Press. In press.

Peer-reviewed Articles

2008

- Koprowski, J. L., S. R. B. King, and M. J. Merrick. 2008. Expanded home ranges in a peripheral population: space use by endangered Mt. Graham red squirrels. *Endangered Species Research*, 4:227-232.
- Koprowski, J.L., N. Rajamani. 2008. Global hotspots, centers of diversity, and conservation of the tree and flying squirrels. *Current Science* 95(7): 851-856.
- Lurz, P.W.W., J.L. Koprowski, D.J.Wood. 2008. The use of GIS and modelling approaches in squirrel population management and conservation: a review. *Current Science* 95(7): 918-922.

2009

- Edelman, A.J., J.L. Koprowski. 2009. Does niche overlap for nest sites occur between coexisting native and exotic tree squirrels? *Journal of Mammalogy* 90: 167-174.
- Leonard, K.M., J.L. Koprowski. 2009. A comparison of habitat use and demography of red squirrels at the southern edge of their range. *American Midland Naturalist* 161: In press.
- Leonard, K.M., J.L. Koprowski. 2009. Effects of fire on endangered Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*): responses of individuals with known fates. *Southwestern Naturalist* 53: In press.
- Leonard, K.M., B.S. Pasch, J.L. Koprowski. 2009. *Sciurus pucherani*. *Mammalian Species*, In press.
- Zugmeyer, C.A., J.L. Koprowski. 2009. Severely insect-damaged forest may function as an ecological trap for red squirrels. *Forest Ecology and Management* 257: 464-470.
- Zugmeyer, C.A., J.L. Koprowski. 2009. Unaltered habitat selection after a severe insect infestation: concerns for forest-dependent species. *Journal of Mammalogy* 90: 175-182.

LITERATURE CITED

- Buller, A.H.R. 1920. The red squirrel of North America as a mycophagist. Transactions of the British Mycological Society, 6:355-362.
- Clark, P.J. and F.C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology, 35:445-453.
- Czárán, T. and S. Bartha. 1992. Spatiotemporal dynamic models of plant populations and communities. Trends in Ecology and Evolution, 7:38-42.
- ESRI 1995. ARC View and ARC/Info Users Manuals. Environmental Systems Research Institute. Redlands, CA.
- Froehlich, G.F. 1990. Habitat use and life history of the Mt. Graham red squirrel. M.S. Thesis, Univ. of Arizona, Tucson, 61 pp.
- Hatten, J.R. 2000. A pattern recognition model for the Mount Graham red squirrel. Technical Report 160. Arizona Game and Fish Department, Phoenix, 32 pp.
- Hoffmeister, D.F. 1986. Mammals of Arizona. University of Arizona Press and Arizona Game and Fish Department, Tucson.
- Koprowski, J. L., S. R. B. King, and M. J. Merrick. 2008. Expanded home ranges in a peripheral population: space use by endangered Mt. Graham red squirrels. Endangered Species Research, 4:227-232.
- Krebs, C.J. 1966. Demographic changes in fluctuating populations of *Microtus californicus*. Ecological Monographs 36:239-273.
- Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York.
- Koprowski, J.L. 2002. Handling tree squirrels with an efficient and safe restraint. Wildlife Society Bulletin 30:101-103.
- Smith, C.C. 1968. The adaptive nature of social organization in the genus of three squirrels *Tamiasciurus*. Ecological Monographs 38:31-63.
- Smith, M.C. 1968. Red squirrel responses to spruce cone failure in interior Alaska. Journal of Wildlife Management, 32:305-317.
- States, J.S. 1990. Mushrooms and Truffles of the Southwest. University of Arizona Press, Tucson.
- USDA Forest Service. 1989. Mount Graham International Observatory Management Plan. Coronado National Forest, Tucson, 38 pp.

United States Fish and Wildlife Service, 1993. Mount Graham red squirrel recovery plan. United States Fish and Wildlife Service, Albuquerque, 172 pp.

Vahle, J.R. 1978. Red squirrel use of southwestern mixed coniferous habitat. Master's Thesis, Arizona State University, Tempe, 100 pp.

Uphoff, K.C. 1990. Habitat use and reproductive ecology of red squirrels (*Tamiasciurus hudsonicus*) in central Arizona. M.S. Thesis, Arizona State University, Tempe, 64 pp.

Table 1. Changes in size of study areas due to construction and fire events, University of Arizona Red Squirrel Monitoring Program, Pinaleno Mountains, Graham County, Arizona. All area measures are in hectares.

Event and Date	TRC	TRN	SFC	SFN	All Areas
September 1989	85.19	20.86	88.28	104.81	299.14
LBT Site Expansion 1993	85.19	20.86	100.42	104.81	311.28
After Clark Peak Fire April 1996	51.12	20.85	75.90	104.81	252.68
After Nuttall Fire July 2004	51.12	19.81	58.49	34.14	163.56

TRC = transitional forest in construction zone,
 TRN = transitional forest outside of construction zone,
 SFC = spruce-fir forest in construction zone,
 SFN = spruce-fir forest outside of construction zone.

Table 2. Mushroom genera known to be food resources of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), collected from the food resource plots on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

MUSHROOM GENUS	SOURCE(S)
<i>Amanita</i>	Buller 1920, M.C. Smith 1968
<i>Auricularia</i>	Monitoring Program personal observations
<i>Boletus</i>	Buller 1920, C.C. Smith 1968, M.C. Smith 1968
<i>Clavaria</i>	M.C. Smith 1968
<i>Clitocybe</i>	Monitoring Program personal observations
<i>Cortinarius</i>	C.C. Smith 1968, Froehlich 1990, Uphoff 1990
Gastroid sp.	Monitoring Program personal observations, States 1990
<i>Hydnum</i>	C.C. Smith 1968, M.C. Smith 1968
<i>Lactarius</i>	Buller 1920, C.C. Smith 1968
<i>Leccinum</i>	Monitoring Program personal observations
<i>Lycoperdon</i>	Monitoring Program personal observations
<i>Pholiota</i>	C.C. Smith 1968
<i>Ramaria</i>	Monitoring Program personal observations
<i>Russula</i>	M.C. Smith 1968, C.C. Smith 1968
<i>Suillus</i>	C.C. Smith 1968

Table 3. Mean filled conifer seed production, 2007, on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona. The percent column represents the proportion of each seed species on an individual area.

Area/Habitat	n	<u>Corkbark fir</u>		<u>Douglas-fir</u>		<u>Engelmann spruce</u>	
		\bar{x} 1000 seeds/ha	%	\bar{x} 1000 seeds/ha	%	\bar{x} 1000 seeds/ha	%
TRC	5	2.64	7.1	31.92	85.8	0.00	0.0
TRN	4	10.00	60.2	6.60	39.8	0.00	0.0
SFC	5	2.64	50.0	0.00	0.0	2.64	50.0
SFN	6	0.00	0.0	8.87	50.2	6.60	37.4
TR Habitat	9	5.91	21.1	20.67	73.7	0.00	0.0
SF Habitat	11	1.20	10.0	4.84	40.2	4.80	39.9

Table 4. Mean annual mushroom production, 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Area/Habitat	n	\bar{x} wet weight \pm SE (Kg/ha)	\bar{x} dry weight \pm SE (Kg/ha)
TRC	5	87.0 \pm 17.1	9.6 \pm 1.8
TRN	4	72.6 \pm 19.7	8.2 \pm 2.3
SFC	5	49.7 \pm 9.7	5.5 \pm 1.1
SFN	6	34.8 \pm 15.4	4.6 \pm 2.2
TR Habitat	9	80.6 \pm 12.3	9.0 \pm 1.4
SF Habitat	11	41.6 \pm 9.3	5.0 \pm 1.2

Student's T- Test within TR*:

Wet Weight $t = 0.56$ $P = 0.60$

Dry Weight $t = 0.47$ $P = 0.66$

Student's T- Test within SF*:

Wet Weight $t = 0.78$ $P = 0.45$

Dry Weight $t = 0.34$ $P = 0.74$

Student's T- Test between TR and SF*:

Wet Weight $t = -2.57$ $P = 0.02$

Dry Weight $t = -2.15$ $P = 0.05$

* Data did not deviate from a normal distribution so parametric t-tests were used to compare mushroom production within and between TR and SF habitats.

Table 5. Mean annual mushroom production (wet weight Kg/ha), 2008, of selected mushroom genera known to be food resources for red squirrels (*Tamiasciurus hudsonicus grahamensis*), University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona. The proportions of the three most available genera on each area are in bold.

Genus	<u>TRC</u>		<u>TRN</u>		<u>SFC</u>		<u>SFN</u>	
	\bar{x} Kg/ha	%	\bar{x} Kg/ha	%	\bar{x} Kg/ha	%	\bar{x} Kg/ha	%
<i>Amanita</i>	6.00	6.9	0.00	0.0	1.49	3.0	0.00	0.0
<i>Auricularia</i>	0.01	0.0	2.36	3.3	0.04	0.1	0.00	0.0
<i>Boletus</i>	4.44	5.1	0.00	0.0	0.00	0.0	0.00	0.0
<i>Clavaria</i>	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
<i>Clitocybe</i>	21.09	24.2	12.31	17.0	5.18	10.4	14.72	42.3
<i>Cortinarius</i>	4.56	5.2	5.77	7.9	4.31	8.7	6.74	19.4
Gastroid sp.	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
<i>Hydnum</i>	0.00	0.0	3.67	5.0	0.00	0.0	0.00	0.0
<i>Lactarius</i>	4.95	5.7	1.82	2.5	2.97	6.0	0.47	1.4
<i>Leccinum</i>	0.00	0.0	0.00	0.0	3.74	7.5	0.01	0.0
<i>Lycoperdon</i>	4.22	4.9	1.21	1.7	4.20	8.4	5.84	16.8
<i>Pholiota</i>	0.00	0.0	19.12	26.3	0.00	0.0	0.00	0.0
<i>Ramaria</i>	0.00	0.0	0.75	1.0	0.00	0.0	0.00	0.0
<i>Russula</i>	28.18	32.4	25.57	35.2	27.78	55.9	6.99	20.1
<i>Suillus</i>	13.54	15.6	0.00	0.0	0.00	0.0	0.00	0.0
Total	87.03		72.58		49.69		34.77	

Table 6. Number and percent of available middens occupied by Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Area/Habitat	<u>June</u>			<u>December</u>		
	# middens	# occupied	% occ	# middens	# occupied	% occ
TRC	39	9	23	39	7	18
TRN	29	13	45	30	7	23
SFC	22	3	14	23	7	30
SFN	15	1	7	16	7	44
TR Habitat	68	22	32	69	14	20
SF Habitat	37	4	11	39	14	36
TR + SF	105	26	25	108	28	26

Chi Square:

JUNE

within TR $\chi^2 = 3.595$ df = 1 P = 0.058

within SF* P = 0.633

DECEMBER

within TR $\chi^2 = 0.304$ df = 1 P = 0.581

within SF $\chi^2 = 0.720$ df = 1 P = 0.394

* Fisher's Exact Test was used due to small sample sizes.

Table 7. Overwinter survival of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2007 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Area/Habitat	Number of	Number of	% survival
	Squirrels	Squirrels Surviving	
	Dec 2007 ¹	Jun 2008	
TRC	11	9	82
TRN	12	9	75
SFC	2	1	50
SFN	2	1	50
TR Habitat	23	18	78
SF Habitat	4	2	50

Fisher Exact Test*

within TR* P = 0.730

within SF* P = 1.000

between
habitats* P = 0.311

* Fisher Exact test was used due to the small sample size (any cell with values less than 5).

¹ Of the 27 animals resident on the area in Dec 07, 19 were ear-tagged and/or radio collared thus enabling unique identification and determination of their fate by Jun 08 even if they moved to a different midden or off the area. This large proportion of marked animals in the population increases the accuracy of survival calculations.

Table 8. Mean Local Density (# within 100m radius) of middens and Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2007 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

Area/Habitat	December 2007				December 2008			
	Middens		Squirrels ¹		Middens		Squirrels ¹	
	n	$\bar{x} \pm SE$	n	$\bar{x} \pm SE$	n	$\bar{x} \pm SE$	n	$\bar{x} \pm SE$
TRC	39	5.0 ± 0.41 ^a	11	1.5 ± 0.31 ^a	39	5.0 ± 0.41 ^a	7	1.1 ± 0.34 ^a
TRN	29	4.9 ± 0.29 ^a	11	2.0 ± 0.30 ^a	30	4.9 ± 0.32 ^a	7	0.9 ± 0.14 ^{a,b}
SFC	22	1.8 ± 0.30 ^b	2	0.0 ± 0.00 ^{a,b}	23	1.9 ± 0.32 ^b	7	0.0 ± 0.0 ^b
SFN	15	1.3 ± 0.18 ^b	2	0.0 ± 0.00 ^b	6	1.9 ± 0.31 ^b	7	1.1 ± 0.26 ^a
TR Habitat	68	5.0 ± 0.27	22	1.7 ± 0.22	69	5.0 ± 0.27	14	1.0 ± 0.18
SF Habitat	37	1.6 ± 0.20	4	0.0 ± 0.00	39	1.9 ± 0.23	14	0.6 ± 0.20
TOTAL ¹	105	3.7 ± 0.24	26	1.4 ± 0.22	108	3.8 ± 0.32	29	0.8 ± 0.14

Kruskal-Wallis

LD of Middens

among all areas

LD of Squirrels

among all areas

2007

H = 46.78 df = 3

P < 0.001

2008

H = 41.1 df = 3

P < 0.001

H = 9.14 df = 3

P = 0.027

H = 10.3 df = 3

P = 0.016

a, b, c, d Means within the same category, with the same letter(s), within the same year, are not significantly different.

Table 9. Mean Nearest Neighbor Distance of middens and Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2007 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Area/Habitat	December 2007				December 2008			
	Middens		Squirrels		Middens		Squirrels	
	n	$\bar{x} \pm SE$	n	$\bar{x} \pm SE$	n	$\bar{x} \pm SE$	n	$\bar{x} \pm SE$
TRC	39	43.7 \pm 3.75 ^a	11	80.5 \pm 10.20 ^a	39	43.7 \pm 3.75 ^a	7	116.9 \pm 55.80 ^a
TRN	29	46.2 \pm 2.78 ^a	11	66.8 \pm 5.28 ^a	30	46.7 \pm 2.72 ^a	7	80.1 \pm 8.60 ^{a,b}
SFC	22	76.4 \pm 9.09 ^b	2	654.2 \pm 0.00 ^b	23	73.7 \pm 8.87 ^b	7	181.6 \pm 28.80 ^c
SFN	15	78.3 \pm 17.04 ^b	2	297.7 \pm 0.00 ^b	16	75.7 \pm 16.10 ^b	7	170.0 \pm 87.70 ^{a,d}
TR Habitat	68	44.8 \pm 2.44	22	73.7 \pm 5.82	69	45.0 \pm 2.42	14	98.5 \pm 27.60
SF Habitat	37	77.2 \pm 8.63	4	476.0 \pm 103.0	39	74.5 \pm 8.30	14	175.8 \pm 44.40
TOTAL ¹	105	56.2 \pm 3.73	26	135.5 \pm 32.6	108	55.7 \pm 3.62	29	136.5 \pm 25.80

2007

2008

Kruskal-Wallis:**NND of Middens**

among all areas

H=19.13

df = 3

P < 0.001

H= 20.8

df = 3

P < 0.001**NND of Squirrels**

among all areas

H=6.62

df = 3

P = 0.085

H= 10.8

df = 3

P = 0.013

a,b,c,d Means within the same category, with the same letter(s), of the same year, are not significantly different.

Figure 2a. Corkbark fir (*Abies lasiocarpa* var. *arizonica*) seed fall, 1993 - 2007, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona. Note: scales are different for figures 2a-c.

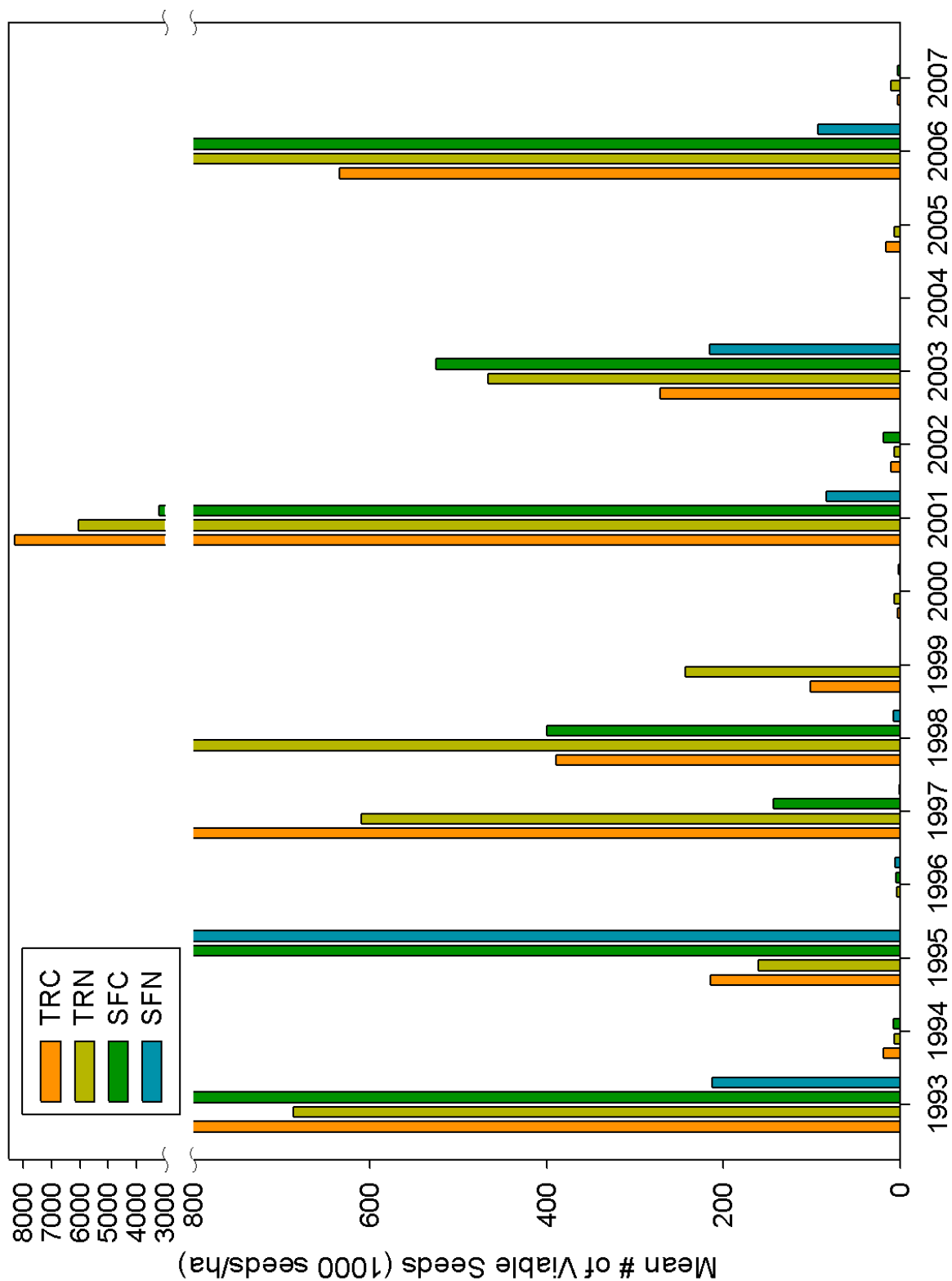


Figure 2b. Douglas-fir (*Pseudotsuga menziesii*) seed fall, 1993 - 2007, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. Note: scales are different for figures 2a-c.

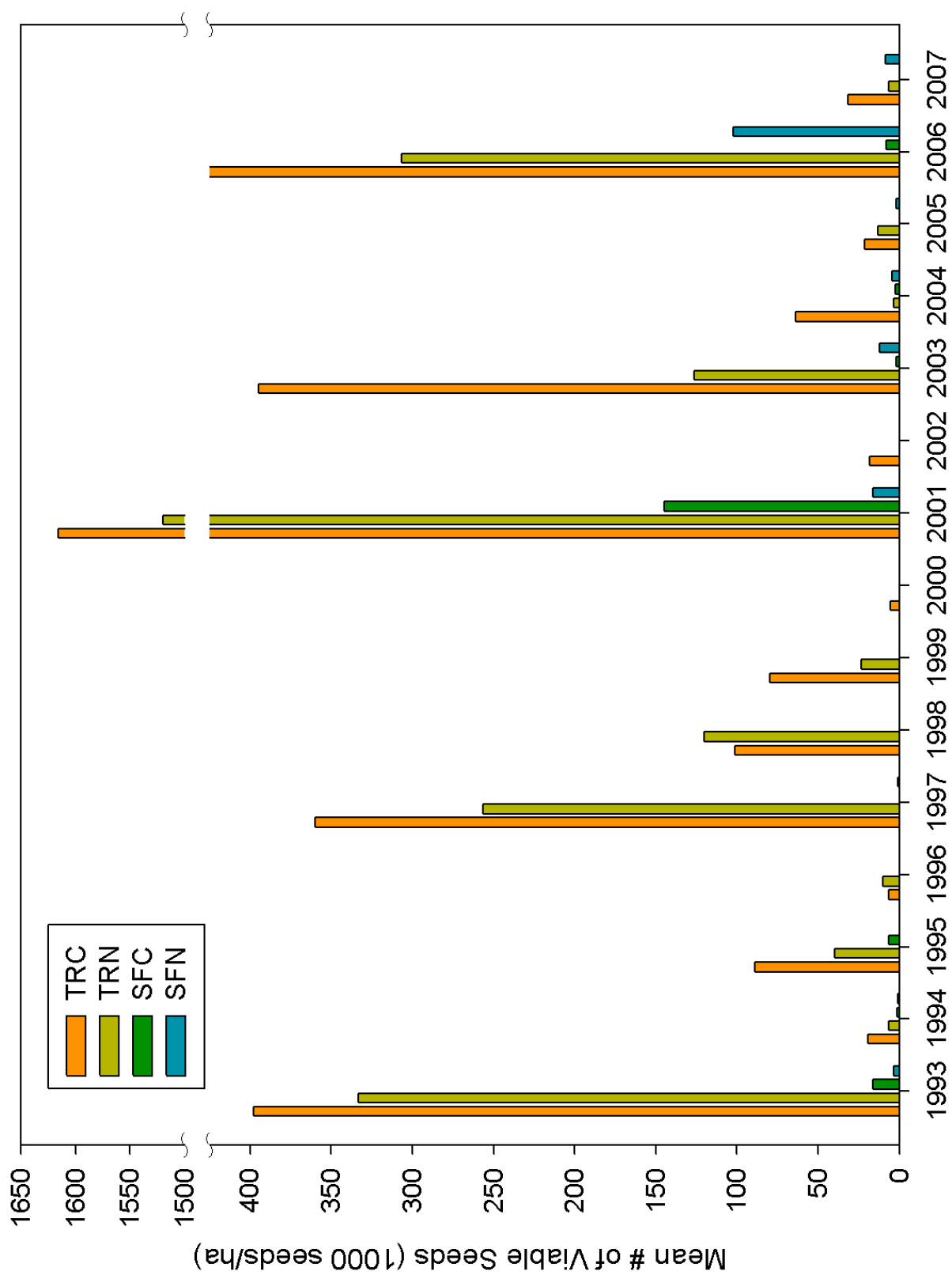


Figure 2c. Engelmann spruce (*Picea engelmannii*) seed fall, 1993 - 2007, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona. Note: scales are different for figures 2a-c.

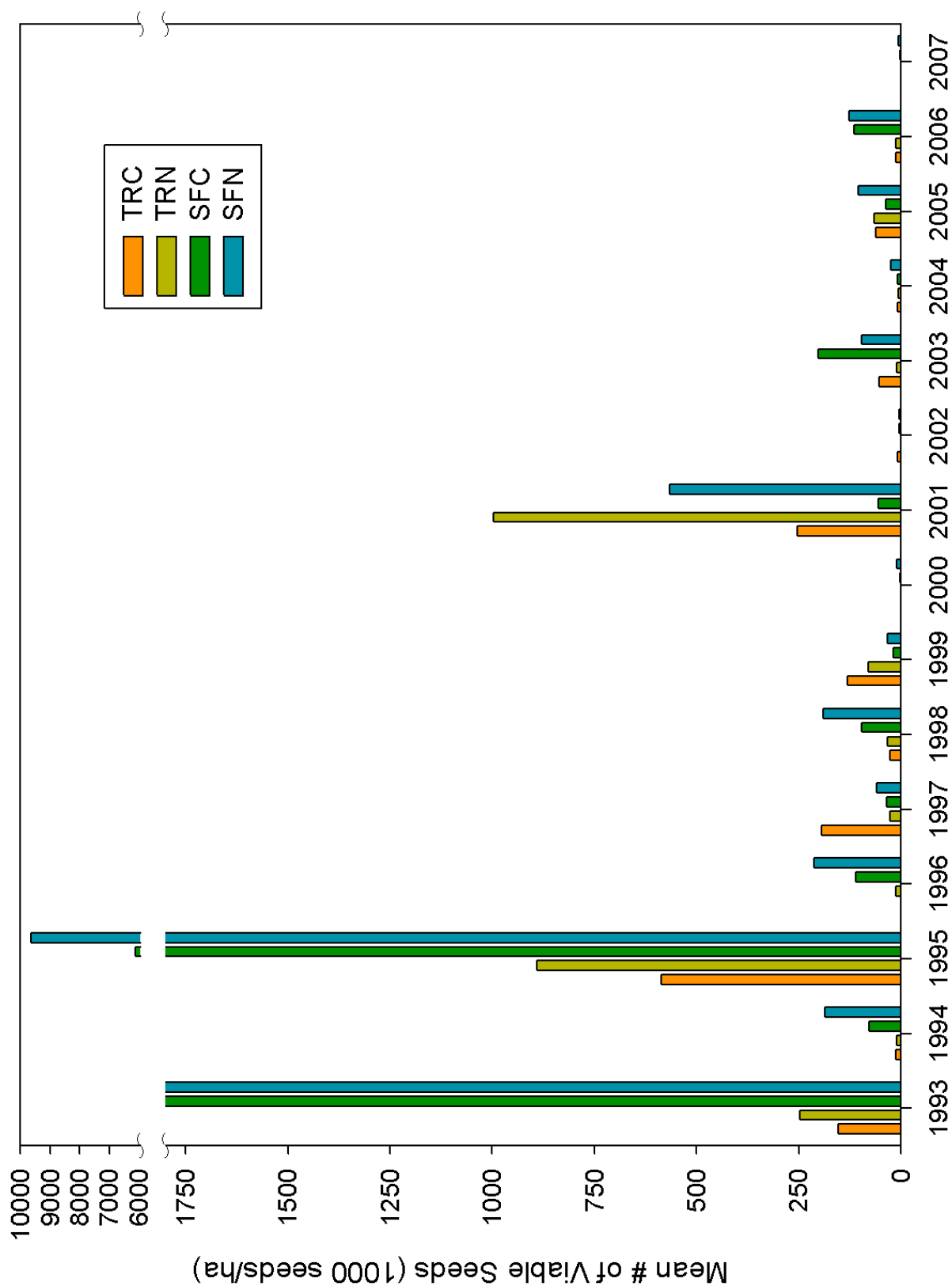


Figure 3. Mushroom crops, 1994 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

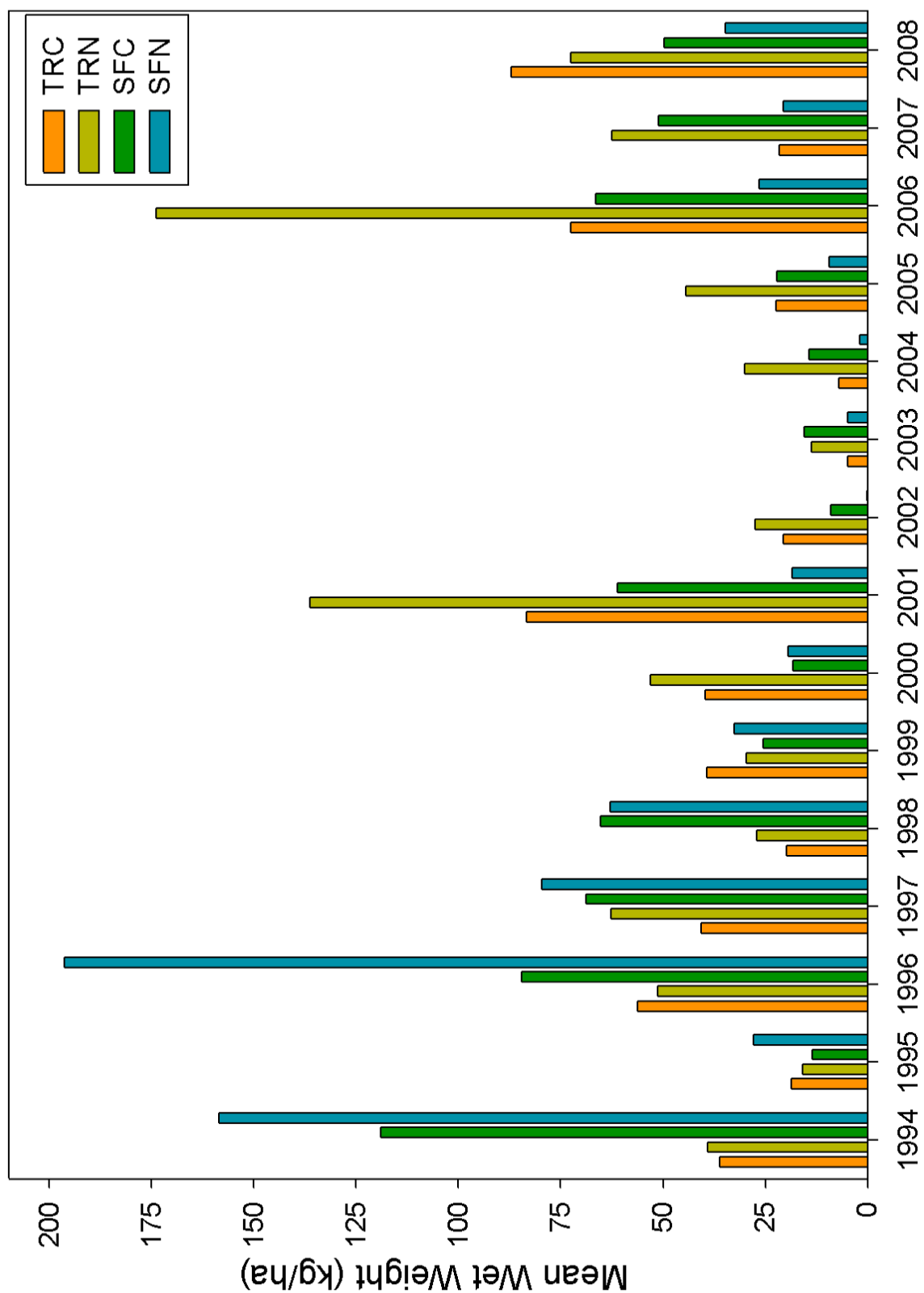


Figure 4. Quarterly Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), March 2004 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

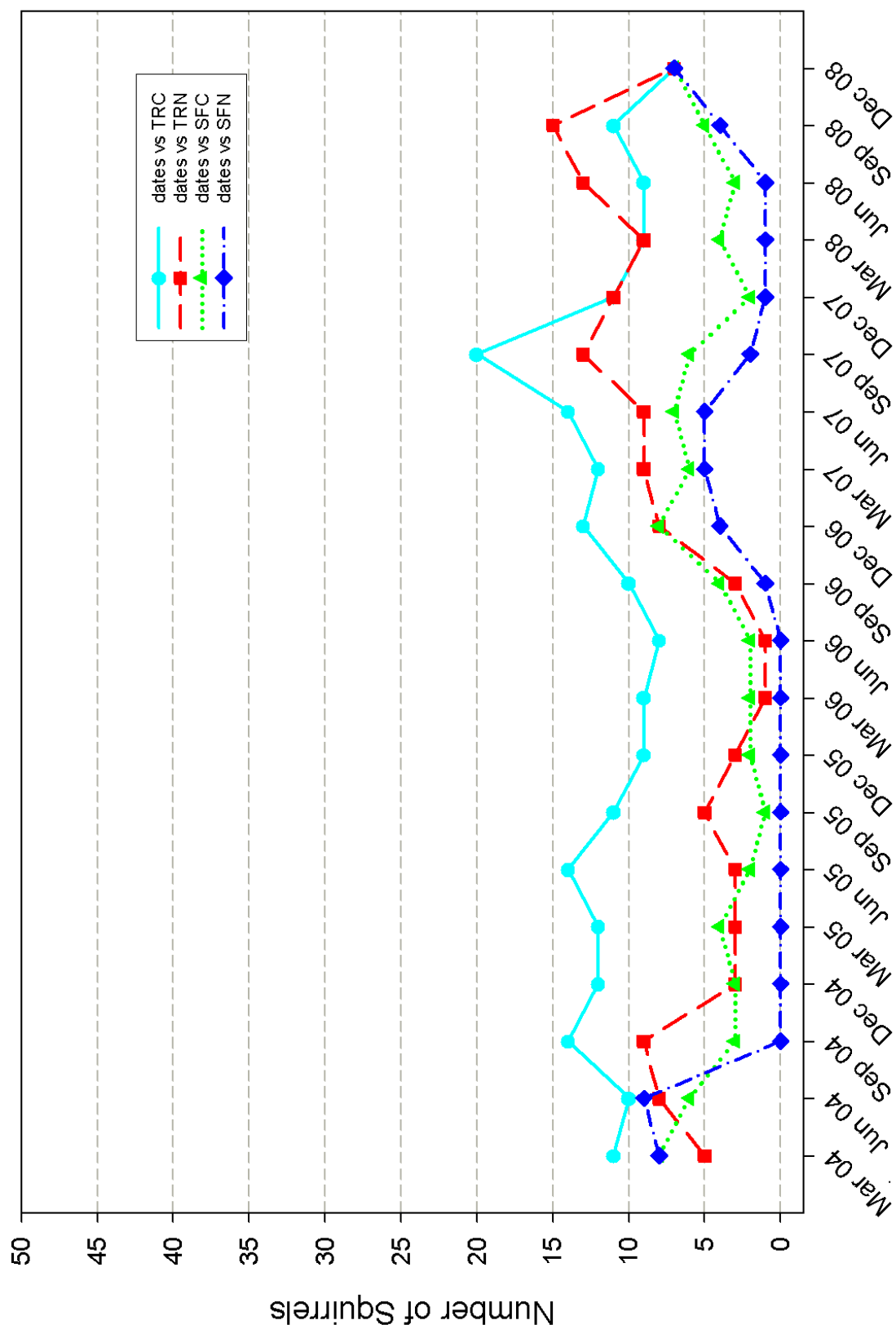
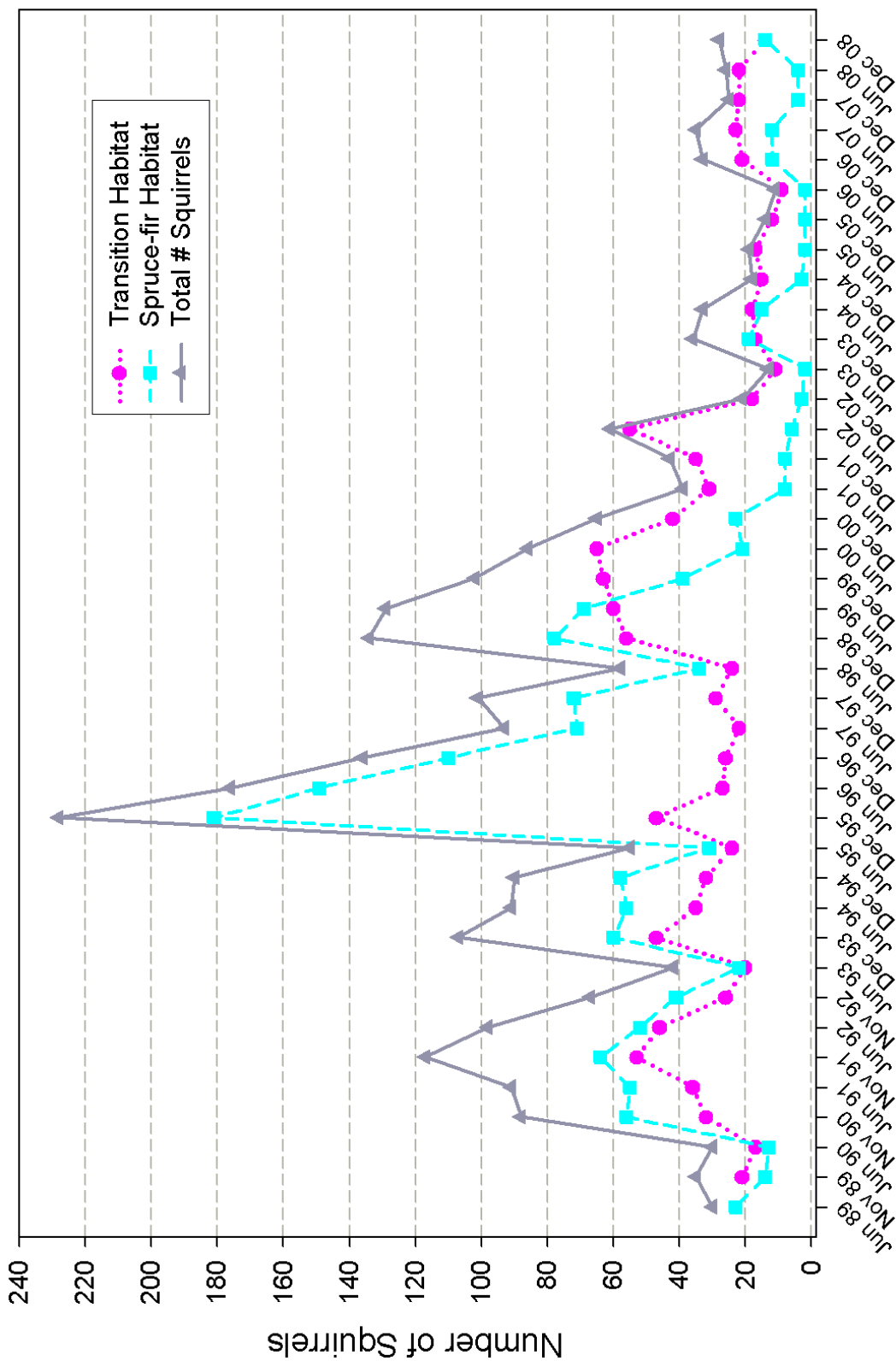


Figure 5. Summer and winter Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), by habitat, June 1989 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.



Appendix A. Annual conifer seed and mushroom production, 2007, on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

A-1: By transect

A-2: By area and habitat

Appendix A-1: Mean number of viable seeds and weights for 2007 seeds and 2007 mushrooms, by transect on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

AREA	TRAN #	Corkbark Fir	Douglas-fir	Englemann Spruce	Total Seeds	Total Mushrooms	
		# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	ww Kg/ha	dw Kg/ha
TRC	1	burned - Clark Peak Fire, 1996					
	2	burned - Clark Peak Fire, 1996					
	3	0.0	80.0	0.0	80.0	18.1	2.1
	4	burned - Clark Peak Fire, 1996					
	5	13.2	0.0	0.0	13.2	17.7	2.3
	6	burned - Clark Peak Fire, 1996					
	7	burned - Clark Peak Fire, 1996					
	8	burned - Clark Peak Fire, 1996					
	9	burned - Clark Peak Fire, 1996					
	10	0.0	0.0	0.0	0.0	35.6	5.1
	11	0.0	53.2	0.0	66.4	17.0	2.0
	12	0.0	26.4	0.0	26.4	19.6	1.2
TRN	1	0.0	0.0	0.0	0.0	42.8	4.9
	2	40.0	13.2	0.0	53.2	59.2	6.6
	3	0.0	0.0	0.0	0.0	102.1	13.7
	4	0.0	13.2	0.0	13.2	46.1	4.9

AREA	TRAN #	Corkbark Fir	Douglas-fir	Englemann Spruce	Total Seeds	Total Mushrooms	
		# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	ww Kg/ha	dw Kg/ha
SFC	1	burned - Nuttall fire, 2004					
	2	burned - Clark Peak Fire, 1996					
	3	burned - Nuttall fire, 2004					
	4	burned - Nuttall fire, 2004					
	5	13.2	0.0	0.0	13.2	27.4	3.1
	6	0.0	0.0	0.0	0.0	97.6	10.5
	7	burned - Clark Peak Fire, 1996, Nuttall fire, 2004					
	8	burned - Clark Peak Fire, 1996, Nuttall fire, 2004					
	9	burned - Clark Peak Fire, 1996, Nuttall fire, 2004					
	10	burned - Clark Peak Fire, 1996, Nuttall fire, 2004					
	11	0.0	0.0	0.0	0.0	50.6	5.5
	12	0.0	0.0	0.0	0.0	27.2	3.4
	13	0.0	0.0	13.2	13.2	52.8	5.4
SFN	1	burned - Nuttall fire, 2004					
	2	burned - Nuttall fire, 2004					
	3	burned - Nuttall fire, 2004					
	4	0.0	0.0	0.0	13.2 white pine	19.1	2.3
	5	0.0	0.0	0.0	0.0	34.7	4.7
	6	13.2	0.0	0.0	13.2	20.1	2.6
	7	burned - Nuttall fire, 2004					
	8	burned - Nuttall fire, 2004					
	9	burned - Nuttall fire, 2004					
	10	burned - Nuttall fire, 2004					
	11	0.0	0.0	0.0	0.0	14.7	1.6
	12	0.0	0.0	26.4	26.4	3.3	0.5
	13	0.0	40.0	13.2	53.2	31.2	4.8

Appendix A-1: Mean number of seeds and weights for 2007 seeds and 2007 mushrooms, by area and habitat on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

AREA	N	Corkbark Fir	Douglas-fir	Englemann Spruce	Total Seeds	Total Mushrooms	
		# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	ww Kg/ha	dw Kg/ha
TRC \bar{x}	5	2.6	31.9	0.0	37.2	21.6	2.7
TRN \bar{x}	4	10.0	6.6	0.0	16.6	62.5	7.5
SFC \bar{x}	5	2.6	0.0	2.6	5.3	51.1	5.6
SFN \bar{x}	6	0.0	8.9	6.6	17.7	20.5	2.8
TR \bar{x}	9	5.9	20.7	0.0	28.0	39.8	4.8
SF \bar{x}	11	1.2	4.8	4.8	12.0	34.4	4.0

Appendix B: Midden occupancy records, 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

KEY

For Midden Numbers:

###^{89*} Midden Number 'Year Found' '*' following year indicates a newly established midden

For Monthly Occupancy cells:

N	Not Occupied
P	Possibly Occupied, Red Squirrel sign found but unsure of residency
Y	Occupied, Red Squirrel sign indicates resident
S	Occupied, Red Squirrel sighted
♀	Occupied, Adult female Red Squirrel
♂	Occupied, Adult male Red Squirrel
J	Occupied, Juvenile Red Squirrel sex unknown
SA	Occupied, Sub-adult Red Squirrel
A	Abert's Squirrel using area, no Red Squirrel present
XX	Remains of Red Squirrel found
* or ^(R/R)	Squirrel is tagged (letters indicate ear tag colors - left ear/right ear, numbers indicate RSMP Animal ID) [B - blue, G - green, M - metal, O - orange, P - pink, R - red, Y - yellow, W - white N - none, - - rip] [tag shape is round unless noted: sq - square, tr - triangle]
NAT	Squirrel is naturally marked - ear notch, short tail, etc.
-	Midden not checked, no data
♀L	Adult female Red Squirrel, lactating
♀+'#'	Adult female Red Squirrel with '#' juveniles
RC	Radio-collared Red Squirrel



Shaded cell indicates a midden that has been renumbered or removed from censusing.

Transition Construction Area (TRC), 2008				
Midden	Mar	Jun	Sep	Dec
1101 ⁸⁹	located off-area, new number - 5101			
1102 ⁸⁹	♂ (M/M RC 748) 2	P ²	P	N
1103 ⁸⁹	♂ (R/B RC 784)	♂ (R/B RC 784) 3	♀ (M/M RC 877) 9	♀ (M/M RC 877)
1104 ⁸⁹	P	P	♀ (Gsq/Psq RC 728) 4	♀ (Gsq/Psq RC 728)
1105 ⁸⁹	burned in Clark Peak fire - April 1996			
1106 ⁸⁹	N	N	N	N
1107 ⁸⁹	burned in Clark Peak fire - April 1996			
1108 ⁸⁹	removed from census - low occupancy ¹			
1109 ⁸⁹	burned in Clark Peak fire - April 1996			
1110 ^{89*}	burned in Clark Peak fire - April 1996			
1111 ⁸⁹	P	N	N	N
1112 ^{89*}	N	N	N	N
1113 ⁸⁹	N	P	P	N
1114 ⁸⁹	located off-area, new number - 5114			
1115 ⁸⁹	N	P	N	N
1116 ⁸⁹	P	♀ (B/M 773) 5	♂ (M/M 854) 5	♂ (M/M 854)
1117 ⁸⁹	burned in Clark Peak fire - April 1996			
1118 ⁸⁹	♂	♂	Y	N
1119 ⁸⁸	burned in Clark Peak fire - April 1996			
1120 ⁸⁹	burned in Clark Peak fire - April 1996			
1121 ^{89*}	♀ (Gsq/Psq 728)	♀ (Gsq/Psq 728) 4	P	P
1122 ⁸⁹	burned in Clark Peak fire - April 1996			
1123 ^{95*}	burned in Clark Peak fire - April 1996			
1124 ^{95*}	burned in Clark Peak fire - April 1996			
1125 ^{95*}	burned in Clark Peak fire - April 1996			
1126 ^{95*}	removed from census - low occupancy ¹			
1130 ⁹⁰	burned in Clark Peak fire - April 1996			
1131 ^{90*}	N	N	♂	N
1132 ^{90*}	removed from census - low occupancy ¹			
1134 ^{91*}	removed from census - low occupancy ¹			
1135 ^{91*}	burned in Clark Peak fire - April 1996			
1136 ^{91*}	burned in Clark Peak fire - April 1996			
1137 ^{91*}	burned in Clark Peak fire - April 1996			
1138 ^{91*}	removed from census - low occupancy ¹			
1139 ^{91*}	burned in Clark Peak fire - April 1996			
1140 ^{91*}	burned in Clark Peak fire - April 1996			

Transition Construction Area (TRC), 2008				
Midden	Mar	Jun	Sep	Dec
1142 ^{91*}	burned in Clark Peak fire - April 1996			
1143 ^{91*}	burned in Clark Peak fire - April 1996			
1144 ^{91*}	N	N	N	P
1145 ^{91*}	located off-area, new number - 5145			
1146 ^{91*}	removed from census - low occupancy ¹			
1147 ^{91*}	N	N	N	♀
1148 ^{91*}	burned in Clark Peak fire - April 1996			
1149 ^{91*}	P	N	N	N
1150 ^{91*}	located off-area, new number - 5150			
1151 ^{91*}	♀ (rip/rip RC 788)	♀ (rip/rip RC 788) 6	N	N
1152 ^{91*}	burned in Clark Peak fire - April 1996			
1153 ^{92*}	P	N	♀ (P/B RC 743) 7	♀ (P/B RC 743)
1154 ^{92*}	N	N	S	P
1155 ^{93*}	located off-area, new number - 5155			
1156 ^{93*}	♀ (P/B RC 743)	♀ (P/B RC 743)	N	N
1157 ^{93*}	located off-area, new number - 5157			
1159 ^{93*}	burned in Clark Peak fire - April 1996			
1160 ^{96*}	Y	S	S	N
1161 ^{96*}	removed from census - low occupancy ¹			
1162 ^{96*}	P	P	P	N
1163 ^{98*}	N	N	N	N
1164 ^{98*}	♀ (B/O 862)	S ⁸	Y	N
1165 ^{98*}	removed from census - low occupancy ¹			
1166 ^{98*}	removed from census - low occupancy ¹			
1167 ^{98*}	N	N	N	N
1168 ^{98*}	N	N	N	N
1169 ^{98*}	N	N	N	N
1170 ^{98*}	♂ (Bsq/Ysq RC 799)	♂ (Bsq/Ysq RC 799)	♂ (Bsq/Ysq RC 799)	♂ (Bsq/Ysq RC 799)
1171 ^{98*}	N	N	N	N
1172 ^{90*}	N	N	N	N
1173 ^{99*}	N	N	N	N
1174 ^{99*}	removed from census - low occupancy ¹			
1175 ^{99*}	removed from census - low occupancy ¹			
1176 ^{99*}	removed from census - low occupancy ¹			
1177 ^{99*}	P	N	N	P

Transition Construction Area (TRC), 2008				
Midden	Mar	Jun	Sep	Dec
1178 ^{99*}	removed from census - low occupancy ¹			
1179 ^{99*}	N	N	N	N
1180 ^{99*}	N	N	N	N
1181 ^{99*}	removed from census - low occupancy ¹			
1182 ^{02*}	N	N	N	N
1183 ^{04*}	N	N	N	N
1184 ^{04*}	N	N	N	N
1185 ^{05*}	N	N	N	N
1186 ^{05*}	N	N	N	N
1187 ^{05*}	N	N	♂	S
# Mid	39	39	39	39
# Occ	9	9	11	7
% Occ	23.1%	23.1%	28.2%	17.9%
# Sq	9	9	11	7

Appendix B - TRC (cont.)

- 1 Middens have been removed from regular censusing due to low occupancy. Removed middens were unoccupied for ≥ 12 consecutive quarterly censuses (three years) prior to removal. After 2003, all of the removed-low occupancy middens are checked each census. Any middens that become reoccupied are added back to regular censusing.
- 2 Male #748 (M/M RC) was resident of midden 1102 in Mar 08, but by June had shifted most activity to midden 5101. The collar for previous resident Male #40 (M/none RC) was signaling from a nest downhill of midden 5101 and he was not seen again, his fate is unknown.
- 3 The collar and tail of Male #784 (R/B RC) were found on the ground near nest 11130 on 29 June 08. He was resident / known alive at midden 1103 during the census period, so he is included in population totals for June 08.
- 4 Females #39 (none/Y RC), #728 (Gsq/Psq RC), and #800 (Gsq/Osq RC), all have overlapping home ranges in the NE part of the TRC area. The three females shifted activity centers / night nests throughout the year. Female #728 moved from midden 1121 to 1104 in September, Female #800 moved from 5221 to 2206 in June, and Female #39 lived at 2219 most of the year. They also co-nested several times in early 2008, in a nest central to their three home ranges. Sometimes all 3 would co-nest, other times various combinations of 2 females.
- 5 Female #773 (B/M) was originally resident at midden 1182, but she was not seen for the December 07 and March 08 censuses. She was resident at midden 1116sh in June 08, her whereabouts in between are unknown. By September 08, Male #854 (M/M) was resident at midden 1116sh, Female #773 was not seen and her fate is unknown.
- 6 Female #788 (none/none RC) was not seen during census observations, but telem points for June 08 showed her moving in the area, with a visual on 22 June 08. A new night nest location was found for her on 29 June 08 near midden 5105. Her last day known to be alive was a 2 July 08 telemetry sighting. The signal remained in the location of the night nest thereafter. A radio collar but no remains or evidence of predation was found on the ground on 20 July 08 (signal was up in tree 2 days earlier).
- 7 Female #743 (P/B RC) was confirmed to have 4 juveniles near midden 1153 on 20 August 08. However, no juveniles were seen during the mid-September census period, so they may have already dispersed.
- 8 An unmarked squirrel (sex unknown) appeared to be resident at midden 1164 by June 08. The fate of previous resident Female #862 (B/O) is unknown.
- 9 Female #877 (M/M RC) was resident at midden 2242 in March and June 08, but by September, she seemed to have moved east up the drainage to midden 1103.

Transition Non-Construction Area (TRN), 2008				
Midden	Mar	Jun	Sep	Dec
2201 ⁸⁹	removed from census - low occupancy ¹			
2202 ⁸⁹	N	N	N	N
2203 ⁸⁹	N	♀ (M/M RC 785) 2	N	N
2204 ⁸⁹	P	P	P	P
2205 ⁸⁹	N	N	N	N
2206 ⁸⁹	P	♀ (Gsq/Osq RC 800) 3	♀ (Gsq/Osq RC 800) 10	♀ (Gsq/Osq RC 800)
2207 ^{89*}	burned in Nuttall fire - July 2004			
2208 ^{89*}	♀ (Ysq/Osq RC 740)	♀ (Ysq/Osq RC 740)	P ⁴	P
2209 ⁸⁹	removed from census - low occupancy ¹			
2210 ⁹⁰	N	N	N	N
2211 ^{90*}	♀ (rip/R RC 776)	♀ (rip/R RC 776)	♀ (rip/R RC 776) + 3J	Y
2212 ⁹⁰	removed from census - low occupancy ¹			
2213 ⁹⁰	removed from census - low occupancy ¹			
2214 ^{90*}	more accurately mapped on TRC, new number - 1172			
2215 ^{90*}	P	N	N	N
2216 ^{90*}	N	N	♀ (M/M RC 785) 2	♀ (M/M RC 785)
2217 ^{90*}	N	N	N	N
2218 ^{91*}	N	N	N	N
2219 ^{91*}	♀ (Y/rip RC 39)	♀ (Y/rip RC 39)	P ⁵	N
2220 ^{91*}	removed from census - low occupancy ¹			
2221 ^{91*}	located off-area, new number - 5221			
2222 ^{91*}	removed from census - low occupancy ¹			
2223 ^{91*}	N	N	N	N
2224 ^{93*}	removed from census - low occupancy ¹			
2225 ⁹⁴	removed from census - low occupancy ¹			
2226 ^{95*}	removed from census - low occupancy ¹			
2227 ^{95*}	N	♂ (R/W RC 744) 6	N	N
2228 ^{95*}	removed from census - low occupancy ¹			
2229 ^{96*}	Y	♂ (M/M 750) 7	N	N
2230 ^{96*}	N	N	N	N
2231 ^{96*}	located off-area, new number - 5231			
2232 ^{96*}	located off-area, new number - 5232			
2233 ^{96*}	removed from census - low occupancy ¹			
2234 ^{97*}	P	Y	♀ (M/M 832)	N

Transition Non-Construction Area (TRN), 2008				
Midden	Mar	Jun	Sep	Dec
2235 ^{98*}	N	N	N	N
2236 ^{98*}	♀ (O/G RC 780)	♀ (O/G RC 780)	♀ (O/G RC 780) + 3J	♀ (O/G RC 780)
2237 ^{98*}	N	N	N	N
2238 ^{98*}	P	P	♀ (Gsq/Bsq RC 778)	♀ (Gsq/Bsq RC 778)
2239 ^{98*}	removed from census - low occupancy ¹			
2240 ^{98*}	removed from census - low occupancy ¹			
2241 ^{98*}	N	P	N	N
2242 ^{98*}	♀ (M/M 877)	♀ (M/M RC 877)	P ⁸	N
2243 ^{98*}	removed from census - low occupancy ¹			
2244 ^{99*}	Y	♂ (rip/Bsq 851)	♂ (rip/Bsq 851)	♂ (rip/Bsq 851)
2245 ^{99*}	removed from census - low occupancy ¹			
2246 ^{99*}	N	N	N	N
2247 ^{99*}	burned in Nuttall fire - July 2004			
2248 ^{99*}	♀ (B/R RC 849) 9	♀ (M/M 875)	P	P
2249 ^{99*}	N	N	N	N
2250 ^{00*}	♀ (Gsq/Bsq RC 778)	♀ (Gsq/Bsq RC 778) 10	N	N
2251 ^{00*}	removed from census - low occupancy ¹			
2252 ^{08*}	new midden Sep 08		♂ (none/Psq RC 750) 7	♂ (none/Psq RC 750)
# Mid	29	29	30	30
# Occ	9	13	8	7
% Occ	31.0%	44.8%	26.7%	23.3%
# Sq	9	13	8 + 6J	7

Appendix B - TRN (cont.)

- 1 Middens have been removed from regular censusing due to low occupancy. Removed middens were unoccupied for ≥ 12 consecutive quarterly censuses (three years) prior to removal. After 2003, all of the removed-low occupancy middens are checked each census. Any middens that become reoccupied are added back to regular censusing.
- 2 Female #785 (M/M RC) moved from midden 2203 to 2216 between the June and September 08 census periods.
- 3 Females #39 (none/Y RC), #728 (Gsq/Psq RC), and #800 (Gsq/Osq RC), all have overlapping home ranges in the NE part of the TRC area. The three females shifted activity centers / night nests throughout the year. Female #728 moved from midden 1121 to 1104 in September, Female #800 moved from 5221 to 2206 in June, and Female #39 lived at 2219 most of the year. They also co-nested several times in early 2008, in a nest central to their three home ranges. Sometimes all 3 would co-nest, other times various combinations of 2 females.
- 4 The radio collar for Female #740 (Ysq/Osq RC) began malfunctioning in June 08, but she was seen several times June-August 08. This female had 3 juveniles confirmed on 24 August at a nest near 2208. Female #740 was not seen during the September census period and midden 2208 did not look very occupied. However, this female was caught in a camera trap on 5 September 08, to the west of 2208 across the road. As we could not determine her midden of residence, she is not included in the September 08 population numbers.
- 5 The collar and remains of Female #39 (Y/rip RC) were found near nest 12101/midden 2204 on 20 August 08. Evidence indicated a raptor kill. This female was first captured as an adult in 2002, so she was at least 7 years old.
- 6 Male #744 (R/W RC) was resident at midden 8007 (southwest of Columbine work center). In early June, he began to move back and forth between 8007 and an area near the Columbine cabins. He consistently nested near midden 2227 in late June and July, though not much feeding sign was noted. He was not seen/heard after late July 08. Note: firewood gatherers cut several snags and logs in close proximity of the night nest in late Jul. It is unknown if this is related to this male's movement/disappearance.
- 7 Male #750 (M/M) was first captured as a sub-adult in December 06 at midden 2219. A radio collar and colored ear tags were fitted in August 08 (he later lost his left ear tag). This male moved to the north edge of the TRN area by September 08 and established a new midden, 2252.
- 8 Female #877 (M/M RC) was resident at midden 2242 in March and June 08, but by September, she seemed to have moved east up the drainage to midden 1103. Note: the previous resident of midden 1103, Male #784, was killed by a raptor in late June 08.
- 9 Signal for Female #849 (B/R RC) coming from nest 12093 in early April, she was not seen thereafter and her fate is unknown.
- 10 Female #778 (Gsq/Bsq RC) shifted residence from midden 2250 to midden 2238 between the June and September 08 censuses.

Spruce-Fir Construction Area (SFC), 2008				
Midden	Mar	Jun	Sep	Dec
3000 ^{95*}	burned in Nuttall fire - July 2004			
3001 ^{95*}	burned in Nuttall fire - July 2004			
3002 ^{95*}	removed from census - low occupancy ¹			
3003 ^{95*}	removed from census - low occupancy ¹			
3004 ^{95*}	burned in Clark Peak fire - April 1996			
3005 ^{95*}	removed from census - low occupancy ¹			
3006 ^{95*}	destroyed by fire suppression in Nuttall fire - July 2004			
3007 ^{95*}	removed from census - too far off area, new # 5307			
3008 ^{95*}	burned in Nuttall fire - July 2004			
3009 ^{95*}	removed from census - low occupancy ¹			
3010 ^{95*}	removed from census - low occupancy ¹			
3011 ^{95*}	located off-area, new number - 5311			
3012 ^{95*}	burned in Clark Peak fire - April 1996			
3013 ^{95*}	removed from census - low occupancy ¹			
3014 ^{95*}	removed from census - low occupancy ¹			
3015 ^{95*}	burned in Clark Peak fire - April 1996			
3016 ^{95*}	burned in Clark Peak fire - April 1996			
3017 ^{95*}	burned in Clark Peak fire - April 1996			
3018 ^{95*}	burned in Clark Peak fire - April 1996			
3019 ^{96*}	removed from census - low occupancy ¹			
3020 ^{96*}	N	N	N	N
3021 ^{96*}	burned in Clark Peak fire - April 1996			
3022 ^{96*}	removed from census - low occupancy ¹			
3023 ^{96*}	burned in Nuttall fire - July 2004			
3024 ^{98*}	removed from census - low occupancy ¹			
3025 ^{98*}	removed from census - low occupancy ¹			
3026 ^{98*}	removed from census - low occupancy ¹			
3027 ^{99*}	removed from census - low occupancy ¹			
3028 ^{99*}	N	N	N	N
3029 ^{99*}	removed from census - low occupancy ¹			
3030 ^{99*}	removed from census - low occupancy ¹			
3031 ^{99*}	removed from census - low occupancy ¹			
3032 ^{99*}	removed from census - low occupancy ¹			
3300 ⁸⁶	burned in Nuttall fire - July 2004			
3301 ^{94*}	burned in Nuttall fire - July 2004			
3302 ^{94*}	located off-area, new number - 5302			

Spruce-Fir Construction Area (SFC), 2008				
Midden	Mar	Jun	Sep	Dec
3303 ^{94*}	N	N	N	N
3304 ^{94*}	removed from census - low occupancy ¹			
3305 ^{94*}	removed from census - low occupancy ¹			
3306 ^{94*}	burned in Nuttall fire - July 2004			
3307 ^{94*}	removed from census - low occupancy ¹			
3308 ^{95*}	burned in Nuttall fire - July 2004			
3309 ^{95*}	removed from census - low occupancy ¹			
3310 ^{95*}	Y	♀ (none/Ysq RC 845) ²	N	N
3311 ^{95*}	N	N	N	P
3312 ^{95*}	N	N	N	N
3313 ^{95*}	located off-area, new number - 5313			
3314 ^{95*}	N	N	N	N
3315 ^{95*}	removed from census - low occupancy ¹			
3316 ^{95*}	burned in Nuttall fire - July 2004			
3317 ^{95*}	removed from census - low occupancy ¹			
3318 ^{95*}	removed from census - low occupancy ¹			
3319 ^{95*}	removed from census - low occupancy ¹			
3320 ^{95*}	removed from census - low occupancy ¹			
3321 ^{95*}	burned in Nuttall fire - July 2004			
3322 ^{95*}	removed from census - low occupancy ¹			
3323 ^{95*}	N	N	♂	♂
3324 ^{95*}	removed from census - low occupancy ¹			
3325 ^{95*}	removed from census - low occupancy ¹			
3326 ^{95*}	removed from census - low occupancy ¹			
3327 ^{95*}	removed from census - low occupancy ¹			
3328 ^{95*}	removed from census - low occupancy ¹			
3329 ^{95*}	removed from census - low occupancy ¹			
3330 ^{95*}	N	N	N	N
3331 ^{95*}	burned in Nuttall fire - July 2004 ³			
3332 ^{95*}	removed from census - low occupancy ¹			
3333 ^{95*}	removed from census - low occupancy ¹			
3334 ^{95*}	burned in Nuttall fire - July 2004			
3335 ^{95*}	removed from census - low occupancy ¹			
3336 ^{95*}	removed from census - low occupancy ¹			
3337 ^{95*}	removed from census - low occupancy ¹			
3338 ^{95*}	burned in Nuttall fire - July 2004			

Spruce-Fir Construction Area (SFC), 2008				
Midden	Mar	Jun	Sep	Dec
3339 ^{95*}	removed from census - low occupancy ¹			
3340 ^{95*}	removed from census - low occupancy ¹			
3341 ^{95*}	N	N	N	N
3342 ^{95*}	removed from census - low occupancy ¹			
3343 ^{95*}	removed from census - low occupancy ¹			
3344 ^{95*}	removed from census - low occupancy ¹			
3345 ^{95*}	removed from census - low occupancy ¹			
3346 ^{95*}	removed from census - low occupancy ¹ , re-occupied Dec 08			♀ (none/Ysq RC 845) ²
3347 ^{95*}	removed from census - low occupancy ¹			
3348 ^{95*}	N	N	N	N
3349 ^{95*}	burned in Nuttall fire - July 2004			
3350 ⁸⁷	removed from census - low occupancy ¹			
3351 ⁸⁷	burned in Nuttall fire - July 2004			
3352 ⁸⁶	removed from census - low occupancy ¹			
3353 ⁸⁷	removed from census - low occupancy ¹			
3354 ⁸⁶	removed from census - low occupancy ¹			
3355 ^{95*}	burned in Nuttall fire - July 2004			
3356 ⁸⁶	burned in Nuttall fire - July 2004			
3357 ⁸⁶	removed from census - low occupancy ¹			
3358 ⁸⁷	burned in Clark Peak fire - April 1996			
3359 ⁸⁷	burned in Clark Peak fire - April 1996			
3360 ⁸⁶	♂ (Psq/Ysq RC 745)	♂ (Psq/Ysq RC 745) ³	♂ (R/G RC 885) ³	♂ ³
3361 ⁸⁶	removed from census - low occupancy ¹			
3362 ⁸⁶	N	N	♀ (none/Ysq RC 845) ²	N
3363 ⁸⁶	removed from census - low occupancy ¹			
3364 ⁸⁶	removed from census - low occupancy ¹			
3365 ⁸⁶	Y	♂ (B/G 856)	Y	Y
3366 ⁸⁶	N	N	♀ (none/R RC 795) ⁴	S
3367 ⁸⁷	removed from census - low occupancy ¹			
3368 ⁸⁶	removed from census - low occupancy ¹			
3369 ⁸⁶	removed from census - low occupancy ¹			
3370 ⁸⁶	N	N	N	N
3371 ⁸⁷	N	N	N	Y
3372 ⁸⁹	N	N	N	N
3373 ⁸⁷	removed from census - low occupancy ¹			
3374 ⁸⁹	Y	N	P ⁵	P

Spruce-Fir Construction Area (SFC), 2008				
Midden	Mar	Jun	Sep	Dec
3375 ⁸⁶	removed from census - low occupancy ¹			
3376 ⁸⁶	located off-area, new number - 5376			
3377 ⁸⁷	located off-area, new number - 5377			
3378 ^{90*}	N	N	P	S
3379 ^{90*}	removed from census - low occupancy ¹			
3380 ^{90*}	removed from census - low occupancy ¹			
3381 ⁹⁰	burned in Nuttall fire - July 2004			
3382 ^{91*}	N	N	N	N
3383 ^{91*}	removed from census - low occupancy ¹			
3384 ^{91*}	burned in Clark Peak fire - April 1996			
3385 ^{91*}	removed from census - low occupancy ¹			
3386 ^{91*}	removed from census - low occupancy ¹			
3387 ^{91*}	burned in Nuttall fire - July 2004			
3388 ^{92*}	located off-area, new number - 5388			
3389 ^{93*}	removed from census - low occupancy ¹			
3390 ^{93*}	removed from census - low occupancy ¹			
3390 ^{93*}	removed from census - low occupancy ¹			
3391 ^{93*}	removed from census - low occupancy ¹			
3392 ^{93*}	removed from census - low occupancy ¹			
3393 ^{93*}	destroyed by fire suppression in Nuttall fire - July 2004			
3394 ^{93*}	N	N	N	N
3395 ^{94*}	removed from census - low occupancy ¹			
3396 ^{94*}	removed from census - low occupancy ¹			
3397 ⁸⁶	burned in Nuttall fire - July 2004			
3398 ⁸⁶	burned in Nuttall fire - July 2004			
3399 ^{94*}	burned in Nuttall fire - July 2004			
# Mid	22	22	22	23
# Occ	4	3	5	7
% Occ	18.2%	13.6%	22.7%	31.8%
# Sq	4	3	5	7

Appendix B - SFC (cont.)

- 1 Middens have been removed from regular censusing due to low occupancy. Removed middens were unoccupied for ≥ 12 consecutive quarterly censuses (three years) prior to removal. After 2003, all of the removed-low occupancy middens are checked each census. Any middens that become reoccupied are added back to regular censusing.
- 2 Female #845 (none/Ysq RC), resident at 3310shift early in 2008, slowly shifted her center of activity uphill over the summer and fall, eventually re-occupying a midden (3346) previously removed from regular censuses due to low occupancy.
- 3 Male #745 (Psq/Ysq RC) was trapped at midden 3360 during the June 08 census. He was not seen or signal heard after June. By August 08, a new male appeared to be resident at 3360, he was trapped and tagged/radio-collared - male #885 (R/G RC).
The remains of male #885 were found near midden 3311, just northeast of 3360 on 17 November 08. Whitewash and plucked fur at the site indicated a raptor kill. By the December 08 census, another unmarked male had moved in to midden 3360.
- 4 Female #795 (rip/Red RC) was last seen/trapped on the SFC area on 27 September 07 at midden 3366. She was found to be occupying midden 3366 again in September 08. Her radio collar was no longer signaling. Her whereabouts in the intervening months were unknown.
- 5 Midden 3374 appeared active during the September 08 census, based on sign. During the census visit, the observer (MJM) witnessed an unknown hawk carrying off a live and barking red squirrel from the area of midden 3374. Later, in a nearby area where barking was heard during the hawk attack, an unmarked lactating female was seen feeding in the trees. It is unknown if the animal carried off was one of her juveniles.

Spruce-Fir Non Construction Area (SFN), 2008				
Midden	Mar	Jun	Sep	Dec
4000 ^{95*}	N	N	N	Y
4001 ^{95*}	burned in Nuttall fire - July 2004			
4002 ^{95*}	removed from census - low occupancy ¹			
4003 ^{95*}	burned in Nuttall fire - July 2004			
4004 ^{95*}	burned in Nuttall fire - July 2004			
4005 ^{95*}	burned in Nuttall fire - July 2004			
4006 ^{95*}	burned in Nuttall fire - July 2004			
4007 ^{95*}	burned in Nuttall fire - July 2004			
4008 ^{95*}	burned in Nuttall fire - July 2004 ⁴			
4009 ^{95*}	burned in Nuttall fire - July 2004			
4010 ^{95*}	N	N	N	N
4011 ^{95*}	removed from census - low occupancy ¹			
4012 ^{95*}	burned in Nuttall fire - July 2004			
4013 ^{96*}	removed from census - low occupancy ¹			
4014 ^{96*}	removed from census - low occupancy ¹			
4015 ^{96*}	burned in Nuttall fire - July 2004			
4016 ^{96*}	N	N	N	P
4017 ^{96*}	burned in Nuttall fire - July 2004			
4018 ^{96*}	burned in Nuttall fire - July 2004			
4019 ^{96*}	burned in Nuttall fire - July 2004			
4020 ^{96*}	removed from census - low occupancy ¹			
4021 ^{96*}	burned in Nuttall fire - July 2004			
4022 ^{98*}	removed from census - low occupancy ¹			
4023 ^{98*}	removed from census - low occupancy ¹			
4024 ^{98*}	removed from census - low occupancy ¹			
4025 ^{99*}	removed from census - low occupancy ¹			
4400 ⁸⁹	N	N	N	P
4401 ^{94*}	burned in Nuttall fire - July 2004			
4402 ^{94*}	burned in Nuttall fire - July 2004			
4403 ^{94*}	removed from census - low occupancy ¹			
4404 ^{95*}	burned in Nuttall fire - July 2004			
4405 ^{95*}	burned in Nuttall fire - July 2004			
4406 ^{95*}	burned in Nuttall fire - July 2004			
4407 ^{95*}	burned in Nuttall fire - July 2004			
4408 ^{95*}	removed from census - low occupancy ¹			
4409 ^{95*}	burned in Nuttall fire - July 2004			

Spruce-Fir Non Construction Area (SFN), 2008				
Midden	Mar	Jun	Sep	Dec
4410 ^{95*}	located off-area, new number - 5410			
4411 ^{95*}	burned in Nuttall fire - July 2004			
4412 ^{95*}	burned in Nuttall fire - July 2004			
4413 ^{95*}	located off-area, new number - 5413			
4414 ^{95*}	burned in Nuttall fire - July 2004			
4415 ^{95*}	burned in Nuttall fire - July 2004			
4416 ^{95*}	burned in Nuttall fire - July 2004			
4417 ^{95*}	N	N	N	N
4418 ^{95*}	burned in Nuttall fire - July 2004			
4419 ^{95*}	burned in Nuttall fire - July 2004			
4420 ⁹⁰	burned in Nuttall fire - July 2004			
4421 ⁸⁶	burned in Nuttall fire - July 2004			
4422 ⁸⁶	burned in Nuttall fire - July 2004			
4423 ⁸⁶	burned in Nuttall fire - July 2004			
4424 ⁸⁶	burned in Nuttall fire - July 2004			
4425 ⁸⁷	burned in Nuttall fire - July 2004			
4426 ⁸⁶	burned in Nuttall fire - July 2004			
4427 ⁸⁶	burned in Nuttall fire - July 2004			
4428 ⁸⁶	burned in Nuttall fire - July 2004			
4429 ⁸⁶	burned in Nuttall fire - July 2004			
4430 ⁸⁶	burned in Nuttall fire - July 2004			
4431 ⁸⁶	burned in Nuttall fire - July 2004			
4432 ⁸⁶	burned in Nuttall fire - July 2004			
4433 ⁸⁷	burned in Nuttall fire - July 2004			
4434 ⁸⁶	burned in Nuttall fire - July 2004			
4435 ⁸⁶	burned in Nuttall fire - July 2004			
4436 ⁸⁶	burned in Nuttall fire - July 2004			
4437 ^{95*}	burned in Nuttall fire - July 2004			
4438 ^{90*}	burned in Nuttall fire - July 2004			
4439 ^{90*}	burned in Nuttall fire - July 2004			
4440 ⁹¹	burned in Nuttall fire - July 2004			
4441 ⁸⁶	burned in Nuttall fire - July 2004			
4442 ^{95*}	burned in Nuttall fire - July 2004			
4443 ⁸⁶	burned in Nuttall fire - July 2004			
4444 ⁸⁶	burned in Nuttall fire - July 2004			
4445 ⁸⁶	burned in Nuttall fire - July 2004			
4446 ⁸⁶	burned in Nuttall fire - July 2004			

Spruce-Fir Non Construction Area (SFN), 2008				
Midden	Mar	Jun	Sep	Dec
4447 ⁸⁶	burned in Nuttall fire - July 2004			
4448 ⁸⁶	burned in Nuttall fire - July 2004			
4449 ⁸⁶	burned in Nuttall fire - July 2004			
4450 ⁸⁶	burned in Nuttall fire - July 2004			
4451 ⁸⁸	burned in Nuttall fire - July 2004			
4452 ⁸⁶	burned in Nuttall fire - July 2004			
4453 ⁸⁶	burned in Nuttall fire - July 2004			
4454 ⁸⁶	removed from census - low occupancy ¹			
4455 ⁸⁶	burned in Nuttall fire - July 2004			
4456 ⁸⁶	burned in Nuttall fire - July 2004			
4457 ⁸⁶	burned in Nuttall fire - July 2004			
4458 ⁸⁶	removed from census - low occupancy ¹			
4459 ⁸⁶	burned in Nuttall fire - July 2004			
4460 ⁸⁷	burned in Nuttall fire - July 2004			
4461 ^{91*}	burned in Nuttall fire - July 2004			
4462 ⁹⁰	burned in Nuttall fire - July 2004			
4463 ⁹⁰	burned in Nuttall fire - July 2004			
4464 ⁹⁰	removed from census - low occupancy ¹			
4465 ^{90*}	N	N	S	♂
4466 ⁸⁷	removed from census - low occupancy ¹			
4467 ⁸⁷	N	N	P	Y
4468 ⁸⁷	removed from census - low occupancy ¹			
4469 ⁸⁷	N	N	N	♂
4470 ⁸⁷	N	N	N	N
4471 ⁸⁷	midden re-occupied Sep 08		♂	S
4472 ⁸⁷	N	N	N	N
4473 ⁸⁷	N	N	S	♂
4474 ⁸⁶	N	N	N	N
4475 ⁸⁷	located off-area, new number - 5405			
4476 ^{95*}	removed from census - low occupancy ¹			
4477 ⁸⁷	N	N	N	N
4478 ^{90*}	removed from census - low occupancy ¹			
4479 ^{90*}	removed from census - low occupancy ¹			
4480 ^{90*}	burned in Nuttall fire - July 2004			
4481 ⁸⁶	removed from census - low occupancy ¹			
4482 ⁸⁶	removed from census - low occupancy ¹			
4483 ⁸⁶	removed from census - low occupancy ¹			

Spruce-Fir Non Construction Area (SFN), 2008				
Midden	Mar	Jun	Sep	Dec
4484 ⁸⁶	N	N	N	P
4485 ⁸⁶	removed from census - low occupancy ¹			
4486 ⁸⁶	removed from census - low occupancy ¹			
4487 ⁸⁶	located off-area, new number - 5487			
4488 ^{91*}	removed from census - low occupancy ¹			
4489 ^{91*}	removed from census - low occupancy ¹			
4490 ^{91*}	burned in Nuttall fire - July 2004			
4491 ^{91*}	Y	S	S	S
4492 ^{91*}	removed from census - low occupancy ¹			
4493 ^{91*}	burned in Nuttall fire - July 2004			
4494 ^{91*}	burned in Nuttall fire - July 2004			
4495 ^{95*}	burned in Nuttall fire - July 2004			
4496 ^{93*}	removed from census - low occupancy ¹			
4497 ^{93*}	burned in Nuttall fire - July 2004			
4498 ^{93*}	burned in Nuttall fire - July 2004			
4499 ^{93*}	burned in Nuttall fire - July 2004			
# Mid	15	15	16	16
# Occ	1	1	4	7
% Occ	6.7%	6.7%	25.0%	43.8%
# Sq	1	1	4	7

Appendix B - SFN (cont.)

- 1 Middens have been removed from regular censusing due to low occupancy. Removed middens were unoccupied for ≥ 12 consecutive quarterly censuses (three years) prior to removal. After 2003, all of the removed-low occupancy middens are checked each census. Any middens that become reoccupied are added back to regular censusing.

Off-Area Midden Occupancy, 2008				
Midden	Mar	Jun	Sep	Dec
TRC Area				
5101 ⁸⁹	P ⁴	♂ (M/M RC 748) 4	♂ (M/M RC 748)	♂ (M/M RC 748)
5102 ^{98*}	♀ (Wsq/Osq 749)	♀ (Wsq/Osq 749)	♀ (Wsq/rip 749)	N ⁵
5103 ^{99*}	N	N	N	P
5104 ^{99*}	N	N	N	N
5105 ^{02*}	N	N	N	N
5106 ⁰²	N	N	N	N
5107 ⁰²	N	N	Y	P
5114 ⁸⁹	removed from census - low occupancy ¹			
5118 ^{94*}	N	N	N	N
5119 ^{89*}	♂ (P/Y RC 730)	♂ (P/Y RC 730) 6	♀	S
5120 ^{89*}	removed from census - too far off area			
5121 ^{89*}	S	♂	P	N
5122 ⁸⁹	removed from census - low occupancy ¹			
5123 ⁸⁹	ROA ² Y	ROA ² ♂ ^(B/B 772)	ROA ² ♂ ^(B/B 772)	ROA ♀ (Wsq/rip 749) 2,5
5124 ^{90*}	removed from census - low occupancy ¹			
5125 ^{89*}	N	N	N	N
5126 ⁹¹	N	N	N	N
5127 ^{95*}	removed from census - low occupancy ¹			
5145 ^{91*}	N	N	N	N
5150 ^{91*}	Y	P	Y	♂ (Psq/Bsq 904)
5155 ^{93*}	N	S	♂	N
5157 ^{93*}	removed from census - low occupancy ¹			
TRN Area				
5200 ^{93*}	♂ (R/P RC 777)	♂ (R/P RC 777)	♂ (R/P RC 777) 7	♀ (M/M 848)
5201 ^{99*}	N	N	N	N
5202 ^{99*}	burned in Nuttall fire - July 2004			
5203 ^{00*}	N	N	N	P
5221 ^{91*}	♀ (Gsq/Osq RC 800) 8	P ⁸	P	N
5231 ^{96*}	N	P	N	N
5232 ^{96*}	N	N	P	P

Off-Area Midden Occupancy, 2008				
Midden	Mar	Jun	Sep	Dec
SFC Area				
5302 ^{94*}	burned in Nuttall fire - July 2004			
5307 ^{95*}	removed from census - too far off area			
5311 ^{95*}	N	N	N	N
5313 ^{95*}	N	N	N	N
5350 ⁸⁶	Y	Y	Y	Y
5351 ^{94*}	burned in Nuttall fire - July 2004			
5352 ^{94*}	burned in Nuttall fire - July 2004			
5353 ^{94*}	removed from census - too far off area			
5354 ^{94*}	burned in Nuttall fire - July 2004			
5355 ^{94*}	burned in Nuttall fire - July 2004			
5356 ^{94*}	burned in Nuttall fire - July 2004			
5357 ^{95*}	removed from census - low occupancy ¹			
5358 ^{95*}	burned in Nuttall fire - July 2004			
5359 ^{95*}	burned in Nuttall fire - July 2004			
5360 ^{96*}	burned in Nuttall fire - July 2004			
5361 ^{96*}	N	N	N	N
5362 ^{96*}	removed from census - low occupancy ¹			
5376 ⁸⁶	removed from census - low occupancy ¹			
5377 ⁸⁷	removed from census - low occupancy ¹			
5388 ^{92*}	removed from census - low occupancy ¹			
SFN Area				
5405 ⁸⁷	N	N	N	N
5410 ^{95*}	removed from census - low occupancy ¹			
5413 ^{95*}	N	N	N	N
5475 ⁸⁶	located on area - new number 4021			
5487 ⁸⁶	removed from census - low occupancy ¹			

Appendix B - Off Area (cont.)

- 1 Middens have been removed from regular censusing due to low occupancy. Removed middens were unoccupied for ≥ 12 consecutive quarterly censuses (three years) prior to removal. After 2003, all of the removed-low occupancy middens are checked each census. Any middens that become reoccupied are added back to regular censusing.
- 2 Midden 5123 is removed from regular censusing as it is $\geq 100\text{m}$ from the monitored area boundary. Information is shown as middens were occupied by marked animals. These animals are NOT included in population totals for the monitored areas.
- 3 The signal for male #40 (M/none RC) was coming from a tree downhill from midden 5101 since February 08. This male was not seen during March 08 census observations and his fate is unknown.
- 4 Male #748 (M/M RC) was resident of midden 1102 in March 08, but by June had shifted most activity to midden 5101. The collar for previous resident Male #40 (M/none RC) was signaling from a tree downhill of midden 5101 and he was not seen again, his fate is unknown.
- 5 Female #749 (Wsq/rip RC) began shifting to the west from midden 5102 in fall 08, eventually settling at midden 5123.
- 6 Male #730 (P/Y RC) was seen and trapped at midden 5119 in June 08, but by July, his signal remained in a nest near midden 5107. Repeated observations of the nest were made during the six weeks following the June census. As no animal was seen and the radio signal did not move, the nest was removed from the tree and examined on 21 July 08. The dried remains of male #730 were found inside and cause of death could not be determined.
- 7 Male #777(R/P RC) was resident at midden 5200 during the September 08 census. But by the end of September, he could not be located, despite several searches of the surrounding area. His fate is unknown. In October 08 and after, Female #848 (M/M) was resident at midden 5200.
- 8 Females #39 (none/Y RC), #728 (Gsq/Psq RC), and #800 (Gsq/Osq RC), all have overlapping home ranges in the NE part of the TRC area. The three females shifted activity centers / night nests throughout the year. Female #728 moved from midden 1121 to 1104 in September, Female #800 moved from 5221 to 2206 in June, and Female #39 lived at 2219 most of the year. They also co-nested several times in early 2008, in a nest central to their three home ranges. Sometimes all 3 would co-nest, other times various combinations of 2 females.

Appendix C. Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles at maternal middens), March 2004 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Date	TRC	TRN	SFC	SFN	TOTAL
Mar 2004	11	5	8	8	32
Jun 2004	8 + 2J	5 + 3J	6	9	28 + 5J
Sep 2004	12 + 2J	4 + 5J	3	0	19 + 7J
Dec 2004	12	3	3	0	18
Mar 2005	12	3	4	0	19
Jun 2005	14	3	2	0	19
Sep 2005	9 + 2J	4 + 1J	1	0	14 + 3J
Dec 2005	9	3	2	0	14
Mar 2006	9	1	2	0	12
Jun 2006	8	1	2	0	11
Sep 2006	10	3	4	1	18
Dec 2006	13	8	8	4	33
Mar 2007	12	9	6	5	32
Jun 2007	14	9	7	5	35
Sep 2007	17 + 3J	13	6	2	38 + 3J
Dec 2007	11	11	2	2	26
Mar 2008	9	9	4	1	23
Jun 2008	9	13	3	1	26
Sep 2008	11	8 + 6J	5	4	28 + 6J
Dec 2008	7	7	7	7	28

Appendix D: Quarterly occupancy maps for Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*) March 2008 - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Appendix E: Measures of spatial distribution for middens and Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

E-1. Crude Density

a) middens

b) Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*)

E-2. Local density and nearest neighbor distances of middens and Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*).

Appendix E-1a: Crude Density (middens/ha) of middens in quarterly censuses, December 2007 through December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

DATE	TRC	TRN	SFC	SFN
Area ¹ (after Jul 04)	51.1 ha	19.8 ha	58.5	34.1
Dec 2007	0.76	1.46	0.38	0.44
Mar 2008	0.76	1.46	0.38	0.44
Jun 2008	0.76	1.46	0.38	0.44
Sep 2008	0.76	1.50	0.38	0.47
Dec 2008	0.76	1.50	0.40	0.47

Appendix E-1b: Crude Density (squirrels/ha; including juveniles at natal middens) of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*) in quarterly censuses, December 2007 through December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

DATE	TRC	TRN	SFC	SFN
Area ¹ (after Jul 04)	51.1 ha	19.8 ha	58.5	34.1
Dec 2007	0.22	0.56	0.03	0.06
Mar 2008	0.18	0.45	0.07	0.03
Jun 2008	0.18	0.66	0.05	0.03
Sep 2008	0.22	0.40	0.09	0.12
Dec 2008	0.14	0.35	0.12	0.21

1 The reduction in the size of the monitored areas after July 2004 was due to the Nuttall Fire. The areas removed were severely burned and are no longer suitable habitat.

Appendix E-2. Local Density and Nearest Neighbor Distances of middens and Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), December 2007 through December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.
Local Density is the number of middens or squirrels (=occupied middens) within 100m radius of a focal midden.

TRC Area										
Middens						Squirrels				
Month	# Mid	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean	# RS	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean
Dec 07	39	5.0	0.41	43.7	3.75	11	1.5	0.31	80.5	10.24
Mar 08	39	5.0	0.41	43.7	3.75	9	0.9	0.26	92.8	11.58
Jun 08	39	5.0	0.41	43.7	3.75	9	0.9	0.26	95.4	10.99
Sep 08	39	5.0	0.41	43.7	3.75	11	1.3	0.27	85.8	14.35
Dec 08	39	5.0	0.41	43.7	3.75	7	1.1	0.34	117.0	55.83

TRN Area										
Middens						Squirrels				
Month	# Mid	Mean local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean	# RS	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean
Dec 07	29	4.9	0.30	46.2	2.78	11	2.0	0.30	66.8	5.28
Mar 08	29	4.9	0.30	46.2	2.78	9	1.3	0.33	71.5	13.56
Jun 08	29	4.9	0.30	46.2	2.78	13	2.2	0.27	62.0	5.48
Sep 08	30	4.9	0.32	46.7	2.72	8	1.0	0.17	81.4	6.63
Dec 08	30	4.9	0.32	46.7	2.72	7	0.86	0.14	80.1	8.60

Appendix E-2 (con't.)

SFC Area										
Middens						Squirrels				
Month	# Mid	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean	# RS	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean
Dec 07	22	1.8	0.31	76.4	9.09	2	0.0	0.0	654.2	0.0
Mar 08	22	1.8	0.31	76.4	9.09	4	0.5	0.29	203.26	101.11
Jun 08	22	1.8	0.31	76.4	9.09	3	0.7	0.33	128.9	96.89
Sep 08	22	1.8	0.31	76.4	9.09	5	0.4	0.24	209.1	79.34
Dec 08	23	1.9	0.32	73.7	8.87	7	0.0	0.0	181.6	28.77

SFN Area										
Middens						Squirrels				
Month	# Mid	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean	# RS	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (m)	Std. Error of the Mean
Dec 07	15	1.3	0.19	78.3	17.04	2	0.0	0.0	297.7	0.0
Mar 08	15	1.7	0.27	74.5	17.18	1	0.0	0.0	1529.6	0.0
Jun 08	15	1.3	0.19	78.3	17.04	1	0.0	0.0	1529.6	0.0
Sep 08	16	1.9	0.31	75.7	16.12	4	1.0	0.41	133.4	54.78
Dec 08	16	1.9	0.31	75.7	16.12	7	1.1	0.26	170.0	87.72

All Areas Combined (including only middens on the monitored areas)										
Middens						Squirrels				
Month	# Mid	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (M)	Std. Error of the Mean	# RS	Mean Local Dens.	Std. Error of the Mean	Mean Nearest Neighbor Dist (M)	Std. Error of the Mean
Dec 07	105	3.8	0.24	56.2	3.73	26	1.5	0.22	135.5	32.59
Mar 08	105	3.8	0.24	55.7	3.71	23	1.0	0.18	166.1	65.02
Jun 08	105	3.8	0.24	56.2	3.73	26	1.5	0.22	137.7	56.81
Sep 08	107	3.9	0.24	56.1	3.66	29	1.0	0.14	112.3	17.64
Dec 08	108	3.9	0.24	55.7	3.62	28	0.8	0.14	137.2	26.70

Appendix F: Reproductive success of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2008, on or near* University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

F-1: Mt. Graham red squirrel breeding chases on or near* the study areas.

F-2: Mt. Graham red squirrel litters seen on or near* the study areas.

F-3: Mt. Graham red squirrel reproductive status and age statistics by census quarter, on or near* the study areas.

* Reproductive success notes for squirrels at middens $\geq 100\text{m}$ from study area boundaries (numbered in 8000s) are included for anecdotal information only. Litters at these middens are not counted in population totals for the Monitoring Program study areas.

Appendix F-1: Breeding Chases Observed - 2008

Descriptions of mating chases observed in 2008 on or near the University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

<u>Date</u>	<u>Midden</u>	<u>Notes</u>
22 Apr 08	2248	Possible breeding chase between Male #851, Female #849, and Female #39. Chases were mainly from the male towards the females and no buzz calls were heard.
10/19 May 08	8008	10 May - Male 876 (resident at 8041) was seen in the vicinity of midden 8008 near resident Female #747, with lots of vocalizations (specific type was not noted). 19 May - an unmarked male was observed chasing Female #747 near her midden, 8008.
28 May 08	1153	Male #799 (resident at midden 1170) was observed in midden 1153 with resident Female #743 chasing up and down trees for about 30 minutes just prior to sunset.
2 Jun 08	TR areas	During this week, the telemetry crew noted that males were making frequent movements away from home middens and that at most middens with resident females, at least one male (up to 3) was seen in the area. No large breeding chases were observed, but several smaller chase events were observed. Of the fourteen resident females trapped on or near the monitored areas in June 08, six appeared to be in estrus, and three appeared to be pregnant.

Appendix F-2: Litters observed in 2008 on or near University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. Only litters on the monitored areas during census months are counted in the quarterly population totals (see Appx. C).

<u>Date</u>	<u>Midden</u>	<u>Notes</u>
19 Aug 08	2208	3 Juveniles were confirmed for Female #740. The first juvenile was seen during a night nest check (maternity nest = 12014). None of the juveniles were trapped.
20 Aug 08	1153	4 Juveniles were confirmed for Female #743. The juveniles were first seen on 20 Aug 08 at maternity nest 11019. None of the juveniles were trapped.
21 Aug 08	2211	3 Juveniles were confirmed for Female #776. The juveniles were larger, when first seen on 21 Aug 08, but clearly still living at maternal midden. All three juveniles were seen entering maternity nest 12002 on that day. Two of the three juveniles were tagged (♀887, ♀889, 1unmk).
22 Aug 08	8044sh	2 Juveniles were confirmed for Female #846. One larger juvenile was seen on 22 Aug 08, and the second seen the next day. The exact maternity nest was not confirmed (poss. 18055). One of the juveniles was tagged (♀888, 1unmk).
23 Aug 08	8040/8041	4 Juveniles were confirmed for Female #847. All 4 juveniles were first seen on 23 Aug 08 near nest 18233 (likely maternity nest, but not confirmed). Two of the juveniles were tagged (♂891, ♀892, 2 unmk).
25 Aug 08	8008	5 Juveniles were confirmed for Female #687. Three of the juveniles were first seen on 25 Aug 08, in an area between nests 18115 and 18126. All five juveniles were trapped and marked with metal ear tags for later identification (♂886, ♂890, ♀893, ♀894, ♂895).
4 Sep 08	2236	3 Juveniles were confirmed for Female #780. All 3 juveniles were first seen on 4 Sep 08 at maternity nest 12004. Two of the juveniles were tagged (♀896, ♀901, 1unmk)
13 Sep 08	18188 area	6 Juveniles were confirmed for Female #898. All 6 juveniles were first seen on 13 Sep 08 at an unmarked maternity nest located 10m 140deg. from 18188. Three of the juveniles were tagged (♀899, ♂900, ♀902, 3 unmk). This is the first litter size of 6 observed since monitoring began in 1989.
13 Sep 08**	18059	3 Juveniles were confirmed for Female #790. All three juveniles were first seen on 13 Sep 08, poking out of holes in the nest tree. The juveniles were small and not ranging far from holes. None of these juveniles were tagged.

**entry missing in original version of AR-08, sent to cooperators, correction not sent, as no impact on study area pops.

Appendix F-3: Reproductive status and age information for Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*) in 2008, on or near University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona. Middens that were determined to be active based on sign alone (Y) are not included. Information gathered on non-resident squirrels is also excluded. Therefore the total number of active middens for a given month may be higher than the totals of the numbers seen here. **Information for off-area middens (5000s) is included in Appx F3a-c.** Information on reproductive condition is taken from trapping records or visual assessment if no trapping data is available.

Appendix F-3a: Female reproductive information

Reproductive Status	March			June			September			December		
	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.
reproductive ²	1			9								
lactating ²							4					
recent lactation ²							5					
past lactation ²										4		
non-reproductive ¹	9			3			2	4/0		1		
unknown	2		1	2			1		1	4		

- 1 J/SA - Juveniles are still living at the maternal midden. Subadult squirrels have dispersed and are living independently. Subadults may be identified by examination during trapping or visual cues: generally smaller size, whiter fur on underside, thinner tail, head may appear slightly large (out of proportion).
- 2 Reproductive may indicate estrus or pregnancy. Lactating indicates current lactation, milk expressed or other visual cues. Recent lactation includes females that have lactated in the current breeding season. Past lactation indicates a female has previously lactated (late in the year it is difficult to tell with certainty whether a female has lactated in the immediate past breeding season (same year).

Appendix F-3b: Male reproductive information.

Reproductive Status	March			June			September			December		
	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.
scrotal	5			11								
partially scrotal												
non-reproductive ¹							5	2/0		4		1
unknown	1		2	4		1	6		1	5		

Appendix F-3c: Age information for final monthly resident females, males, and squirrels of unknown sex combined

March			June			September			December		
Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.	Adult	J/SA ¹	Unkn.
18	0/0	3	30	0/0	0	28	6/0	2	22	0/0	5

1 J/SA - Juveniles are still living at the maternal midden. Subadult squirrels have dispersed and are living independently. Subadults may be identified by examination during trapping or visual cues: generally smaller size, whiter fur on underside, thinner tail, head may appear slightly large (out of proportion).

Appendix G. Weather information, January - December 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

G-1: Monthly weather summaries

G-2: Accumulated snow depths

Appendix G. Monthly weather summaries - January through December, 2008.

Weather station locations:

Biology Camp (32° 41' 51.47 N, 109° 54' 20.28"W)

Emerald Peak (32° 42' 14.25"N, 109° 53' 17.06" W)

Note: Averages are calculated based on the total number of records collected per month. As of 25 September 2000, weather stations are recording data at 1 hour intervals: between approximately 600 and 700 records per month. Data from Emerald Peak are missing for several periods during the year (see footnote 1).

	Month	Biology Camp	Emerald Peak
Temperature (°C) average (max; min)	January	-2.9 (8.1; -15.6)	– ¹
	February	-1.1 (11.9; -13.4)	-0.5 (9.6; -9.3)– ¹
	March	-0.9 (8.4; -12.8)	-3.4 (5.7; -14.7)– ¹
	April	4.8 (15.2; -6.1)	2.9 (13.0; -8.3)– ¹
	May	7.0 (21.4; -3.9)	5.3 (18.1; -5.2)
	June	14.3 (24.4; 1.9)	12.8 (21.3; -0.1)
	July	12.9 (23.4; 8.3)	11.6 (20.5; 7.2)
	August	12.5 (22.2; 6.9)	11.2 (18.8; 6.6)
	September	9.8 (18.3; 4.0)	8.6 (15.7; 3.6)
	October	7.5 (17.2; -2.4)	6.2 (13.9; -3.3)
	November	3.3 (14.0; -6.2)	– ¹
	December	0.9 (9.3; -9.6)	– ¹

	Month	Biology Camp	Emerald Peak
Wind Speed (m/sec), maximum(max. gust)	January	2.2 (8.1)	– ¹
	February	2.7 (9.6)	3.6 (12.9)
	March	1.8 (6.4)	3.1 (11.3)
	April	2.7 (9.6)	3.6 (12.9)
	May	3.1 (11.3)	3.6 (12.9)
	June	2.7 (9.7)	2.7 (9.6)
	July	1.8 (6.4)	3.6 (12.9)
	August	1.3 (4.8)	4.5 (16.1)
	September	1.3 (4.8)	6.3 (22.53)
	October	1.8 (6.4)	4.0 (14.5)
	November	2.7 (9.6)	– ¹
	December	3.1 (11.3)	– ¹
Wind, Most Common Direction	January	E-NE	– ¹
	February	W-SW	N
	March	E	N-NE
	April	W-SW	N
	May	W	N
	June	E	N
	July	E	N
	August	E	N
	September	E-SE	S
	October	N	S-SE
	November	E	– ¹
	December	E	– ¹

	Month	Biology Camp	Emerald Peak
Maximum Snow Depth (cm) Forest/Clearing	January	80,93	81,109
	February	123,142	110,139
	March	74,80	105,130
	April	16.5,0	40,25
	May		
	June		
	July		
	August		
	September		
	October		
	November	1.5,3.5	3,4
	December	48,52	57,59
Rain Fall (mm) Total	January	- ²	- ²
	February	- ²	- ²
	March	- ²	- ²
	April	- ²	- ²
	May	- ²	- ²
	June	6.4	6.4
	July	137.4	202.4
	August	66.0	141.0
	September	28.2	30.8
	October	14.4	19.6
	November	15.4	- ¹
	December	- ³	- ¹ , - ³

	Month	Biology Camp	Emerald Peak
Relative Humidity (%) average (max; min)	January	65.7 (100.0; 19.0)	– ¹
	February	59.8 (100.0; 13.0)	46.8 (93.0; 3.0)– ¹
	March	50.3 (93.0; 0.0)	45.8 (90.0; 7.0)– ¹
	April	32.7 (97.0; 12.0)	27.4 (91.0; 6.0)– ¹
	May	49.0 (100.0; 15.0)	42.6 (99.0; 5.0)
	June	43.3 (96.0; 16.0)	33.5 (88.0; 10.0)
	July	85.5 (100.0; 33.0)	77.4 (100.0; 28.0)
	August	88.2 (100.0; 50.0)	80.2 (100.0; 33.0)
	September	80.9 (100.0; 40.0)	72.2 (99.0; 25.0)
	October	55.3 (100.0; 15.0)	51.9 (100.0; 9.0)
	November	53.4 (100.0; 13.0)	– ¹
	December	59.3 (100.0; 15.0)	– ¹
Dew Point (°C) average (max; min)	January	-9.8 (1.6; -25.0)	– ¹
	February	-8.9 (-2.1; -20.0)	-14.2 (-4.8; -39.2)– ¹
	March	-10.6 (-0.3; -22.8)	-15.0 (-2.7; -32.7)– ¹
	April	-11.5 (-2.2; -24.2)	-15.9 (-4.8; -33.8)– ¹
	May	-4.7 (5.6; -18.4)	-8.8 (4.5; -28.7)
	June	0.9 (13.1; -14.1)	-4.3 (10.3; -22.7)
	July	10.2 (15.9; 3.5)	7.3 (12.6; -0.2)
	August	10.5 (15.8; 5.2)	7.6 (13.0; 0.2)
	September	6.5 (12.8; -2.0)	3.5 (10.8; -9.9)
	October	-1.9 (8.8; -17.8)	-5.0 (7.5; -24.6)
	November	-7.1 (5.5; -24.1)	– ¹
	December	-7.2 (0.4; -20.3)	– ¹

- 1 Emerald Peak Station - intervals with missing data:
 - Jan 08: equipment failure, ice on solar panel caused battery to fail
 - Feb 08: data only for Feb 20 - 29
 - Mar 08: data only for Mar 1 - 19
 - Apr 08: data only for Apr 5 - 30
 - Nov-Dec 08: no data, battery failure
- 2 The rain gauges were disconnected in Dec 07. All moisture during the winter and spring was in the form of snow. The rain gauges were reconnected in June 08.
- 3 The rain gauges were disconnected in Dec 08 and will be reconnected in the spring after the snow melt. Any precipitation in December was snow, so not included here.

Appendix G-2. Monthly maxima, minima and averages for accumulated snow depth. Data are from snow poles in Spruce-Fir (SF) and Mixed Conifer (TR) habitats from locations in the forest (F) and in clearings ©.

Month	Hab	Loc	N ¹	Average snow depth (cm)	Maximum snow depth (cm)	Minimum snow depth (cm)
Jan 2008	TR	C	15	47.9	93.0	0
Jan 2008	TR	F	15	61.0	80.0	43.0
Jan 2008	SF	C	13	68.3	109.0	27.0
Jan 2008	SF	F	13	59.0	81.0	40.0
Feb 2008	TR	C	11	86.9	142.0	45.0
Feb 2008	TR	F	12	78.3	123.0	53.0
Feb 2008	SF	C	10	93.3	139.0	34.0
Feb 2008	SF	F	11	83.2	110.0	58.0
Mar 2008	TR	C	4	49.8	80.0	0
Mar 2008	TR	F	4	53.8	74.0	20.0
Mar 2008	SF	C	9	76.2	130.0	0
Mar 2008	SF	F	9	62.6	105.0	0
Apr 2008	TR	C	2	0	0	0
Apr 2008	TR	F	2	8.3	16.5	0
Apr 2008	SF	C	2	12.5	25.0	0
Apr 2008	SF	F	2	20.0	40.0	0

- 1 N represents the number of snow pole readings in each area per month. There are 9 sets of snow poles (a set = 1 forest and 1 clearing) on the monitored areas: 3 in the TR habitat and 6 in the SF habitat. Not all sets of poles may be read every month.