



**THE UNIVERSITY OF
ARIZONA**

**Mt. Graham Red Squirrel Monitoring Program
2009 Annual Report**

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Submitted 2 April 2010

EXECUTIVE SUMMARY

In 2009, 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 2009.

Overall annual mean mushroom production in 2009 was nearly 3 times greater than in 2008, ranked 12th lowest crop of 15 years since data collection began in 1994. Seed production for 2008 (1 year delay in reporting due to methodology), was nearly 7 times greater than in 2007, and the 2008 seed crop ranked 4th highest of 16 years since data collection began in 1993.

Overwinter survival, calculated as animals surviving from December 2008 to June 2009, was relatively high in TR habitat (64%) and much lower in SF habitat (28%). Four litters were confirmed on or near the monitored areas in 2008. From these 4 litters, 10 juveniles were known to emerge from natal nests and 3 were live-trapped and marked.

Squirrel populations in December 2009 (26 Adults/Subadults) were slightly lower than the previous December (28Ad/SA). The 2009 squirrel populations in TR habitat increased throughout the year, from 8Ad in March to 25Ad/SA in December. However in SF habitat, decreases were seen through December, when populations (1Ad on SFC, 0Ad on SFN) were the lowest numbers seen since June 2006. If the squirrels near the monitored areas (within 100m) are included, nearly the same population numbers were seen from December 2008 (33 Ad/SA) to December 2009 (32 Ad/SA).

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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 2009, 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 2009 were mainly interior instrument installation. Herein, we report on the monitoring efforts from 1 January to 31 December 2009.

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 & the Environment, 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. Activity 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 the early 1990s, to determine the abundance of major red squirrel food resources: conifer seeds (1993) and mushrooms (1994). 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 2008 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 2008 crop were collected from the seed traps in June 2009. Conifer seeds contained in each trap were separated by species and individually tested to determine the proportion of seeds that were “filled” (most likely to be viable). A filled 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 2009. 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 2009, 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 2009, 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 2008, the number of occupied middens and the identity of resident squirrels were determined. December 2008 occupancy was compared to occupancy for June 2009. 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.

Reproductive Activity and Success

In 2009, 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 permits issued by United States Fish and Wildlife Service Endangered Species (TE041875-0) and Arizona Game and Fish Department (SP575549), using accepted methods (Koprowski 2002), we trapped red squirrels using wire-mesh box-type live traps (Tomahawk Co., model 201), 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 (National Band & Tag Co., #1 Monel) threaded with colored plastic washers (National Band & Tag Co., 3/8" diameter) and affixed to ears for easy distance identification. We also fitted adult animals with radio collars (Wildlife Materials Inc., SOM2190). 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. 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 ArcView 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.

Statistical Analyses

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

2008 Conifer Seed Production

Data collection for seed crops began in 1993. If years are ranked from highest (1) and lowest (16), the total 2008 seed crop ranked 9 of 16. Engelmann spruce was the most abundant seed in 2008, ranking 4 of 16. The Douglas-fir crop ranked 10 of 16, while the corkbark fir crop (15 of 16) was nearly the lowest seen since 1993. The 2008 overall average seed crop was 489.3 (1000seeds/ha), nearly 7 times greater than the seed crop in 2007, 71.9 (1000seeds/ha); (Table 3, Figures 2a-c, Appendix A).

2009 Mushroom Production

Overall annual mean mushroom production in 2009 was nearly 3 times lower than in 2008, and ranked 12th lowest of 15 years since data collection began in 1994. Production decreased in both TR and SF habitats in 2009 as compared to 2008, except the SFC area, which was slightly higher (Figure 3). In 2009, mushroom production (\bar{x} wet weight) did not differ within TR habitat or between habitats, however, SFC had significantly greater production than SFN (Table 4). On TRC, three genera, *Russula*, *Amanita*, and *Cortinarius* accounted for 95% of production. On TRN, *Russula*, *Leccinum*, and *Cortinarius* accounted for 85% of total production. *Russula*, *Auricularia*, and *Cortinarius* accounted for 90% of the production on SFC. On SFN, *Russula*, *Auricularia*, and *Clitocybe* accounted for 92% 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 2009 (Appendix B). From December 2008 to December 2009, the number of red squirrels decreased slightly, from 28 to 26. On TRC, the highest number of squirrels (19 Ad/SA) was in December 2009, and the lowest number was 3 Ad in March. The highest numbers (7 Ad) on TRN were in September and the lowest was 5 Ad in March and June. The highest number of squirrels on SFC was in March (7 Ad) with the lowest (1 Ad) in September and December. On SFN, 5 Ad were resident on the area during March, and no squirrels were found in September and December (Figure 4, Appendix B, C, D). The 2009 squirrel populations in SF habitat decreased throughout the year, however in TR habitat, steady increases were seen through the year, especially by December, when populations were some of the highest seen in the past five years (Figure 5, Appendix C).

In 2009, one new midden was located on the TRN area (Appendix B). In June 2009, the proportion of middens occupied did not differ within areas in both TR and SF habitats. However, in December 2009, TRC had a significantly greater proportion of middens occupied than TRN (Table 6).

Overwinter Survival

The number of squirrels that survived the winter of 2008-2009 did not differ among areas (Table 7); survival was 64% in TR habitat and 28% in SF habitat. For comparison, survival from the previous winter (2007-2008) was 78% in TR habitat and 50% 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.

Reproductive Activity and Success

In 2009, two breeding chases involving squirrels resident on or near the monitored areas were observed, from early April to mid May. In addition, field crews noted in early April, several males making regular forays to areas of female middens (Appendix E-1). Based on information from census and trapping records, most resident adult males were scrotal from early February through late June.

Most females seen or trapped during June were thought to be either in estrus or pregnant. The first lactating female was observed 19 June and the latest was on 2 October. Direct evidence of 4 litters (10 juveniles) was seen on or near the areas during censuses or other activities. Litters were confirmed from mid-August through late-September (Appendix E-2). Based on trapping and field observations, a few females who were lactating or pregnant in early summer, may have lost first litters, as they were detected lactating or pregnant again later in the fall.

Trapping and Marking

By the end of 2009, the majority of resident squirrels on or near monitored areas were fitted with colored ear tags and radio-collared (Appendix B). In addition, 3 of the 10 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 2009, 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 2009 from two weather stations located at the Biology Camp (TR habitat) and near Emerald Peak (SF habitat). Data from Emerald Peak were sparse due to several equipment failures. From available data, maximum temperature recorded was 23.7°C in August at the biology camp and the minimum temperature recorded was -12.8°C in February, also at the biology camp. The maximum average monthly temperature was 14.5°C in July at the biology camp and the minimum average monthly temperature was -4.4°C in December at the biology camp (Appendix F-1). The maximum total monthly rainfall was recorded in August on Emerald Peak, at 104.6 mm and October was the driest month at 1.6 mm at the biology camp (Appendix F-1). Snow depth was recorded from nine pairs of snow poles. The average accumulated snow depth from November 2008 - March 2009 ranged from 1.3 cm to 104.8 cm (Appendix F-2). For comparison, average accumulated snow depths for the previous winter (January - April 2008)

ranged from 0 cm to 93.3 cm. Data on wind chill temperatures, wind direction and speed, humidity, and barometric pressure were also collected (Appendix F-1).

Insect Outbreaks on Monitored Areas

Infestations of bark beetles (*Drycoetes confusus* and *Dendroctonus rufipennis*) continued on parts of the monitored areas in 2009, 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, H. R., and J. L. Koprowski, editors. 2009. The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment, University of Arizona Press, Tucson.

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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, 2008, 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 (i.e. the proportions add across rows).

Area/Habitat	# plots	<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	5.3	10.4	0.0	0.0	45.3	89.6
TRN	4	0.0	0.0	5.0	14.3	29.9	85.7
SFC	5	5.3	4.0	24.0	18.3	101.3	77.6
SFN	6	0.0	0.0	24.4	8.9	248.8	91.1
TR Habitat	9	2.9	6.7	2.2	5.1	38.4	88.2
SF Habitat	11	2.4	1.2	24.2	11.6	181.8	87.2

Table 4. Mean annual mushroom production, 2009, 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	13.1 \pm 4.5	1.4 \pm 0.5
TRN	4	18.5 \pm 5.9	1.9 \pm 0.6
SFC	5	51.9 \pm 14.6	5.3 \pm 1.5
SFN	6	1.6 \pm 0.3	0.2 \pm <0.1
TR Habitat	9	15.5 \pm 3.5	1.6 \pm 0.4
SF Habitat	11	24.5 \pm 10.1	2.5 \pm 1.0

Wilcoxon test within TR:

Wet Weight $Z = 0.86$ $P = 0.39$

Dry Weight $Z = 0.61$ $P = 0.54$

Wilcoxon test within SF:

Wet Weight $Z = 1.92$ $P = \mathbf{0.06}$

Dry Weight $Z = 1.74$ $P = \mathbf{0.08}$

Wilcoxon test between TR and SF:

Wet Weight $Z = 0.99$ $P = 0.32$

Dry Weight $Z = 0.99$ $P = 0.32$

Table 5. Mean annual mushroom production (wet weight Kg/ha), 2009, of selected mushroom genera known to be food resources for red squirrels (*Tamiasciurus hudsonicus grahamensis*), University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. The percentages of the three most available genera on each area are in red.

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>	1.50	11.5	0.00	0.0	3.35	6.5	0.00	0.0
<i>Auricularia</i>	0.06	0.5	0.13	0.7	4.48	8.6	0.27	16.7
<i>Boletus</i>	0.00	0.0	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>	0.47	3.6	0.77	4.2	0.04	0.1	0.15	9.2
<i>Cortinarius</i>	0.69	5.3	1.32	7.1	3.69	7.1	0.08	4.9
<i>Gastroid sp.</i>	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
<i>Hydnum</i>	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
<i>Lactarius</i>	0.11	0.8	0.32	1.8	1.17	2.3	0.00	0.0
<i>Leccinum</i>	0.00	0.0	2.74	14.8	0.34	0.7	0.00	0.0
<i>Lycoperdon</i>	0.06	0.4	0.57	3.1	0.07	0.1	0.05	3.0
<i>Pholiota</i>	0.00	0.0	0.62	3.3	0.00	0.0	0.00	0.0
<i>Ramaria</i>	0.00	0.0	0.30	1.6	0.00	0.0	0.00	0.0
<i>Russula</i>	10.17	77.9	11.77	63.5	38.70	74.6	1.08	66.3
<i>Suillus</i>	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Total	13.06		18.54		51.85		1.63	

Table 6. Number and percent of available middens occupied by Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2009, 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	6	15.4	39	19	48.7
TRN	30	5	16.7	31	6	19.4
SFC	24	3	12.5	24	1	4.2
SFN	17	4	23.5	17	0	0
TR Habitat	69	11	15.9	70	25	35.7
SF Habitat	41	7	17.1	41	1	2.4
TR + SF	110	18	16.4	111	26	23.4

Chi Square:

JUNE

within TR $\chi^2 = 0.021$ df = 1 P = 0.885

within SF* P = 0.422

DECEMBER

within TR $\chi^2 = 6.49$ df = 1 **P = 0.011**

within SF* P = 1.000

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

Table 7. Overwinter survival of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2008 - 2009, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Area/Habitat	Number of Squirrels	Number of Squirrels Surviving	% survival
	Dec 2008 ¹	Jun 2009	
TRC	7	4	57.1
TRN	7	5	71.5
SFC	7	2	28.6
SFN	7	2	28.6
TR Habitat	14	9	64.3
SF Habitat	14	4	28.6

Fisher's Exact Test*

within TR* P > 0.999

within SF* P > 0.999

between
habitats* P > 0.128

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

¹ Of the 28 animals resident on the areas in Dec 08, 12 were ear-tagged and/or radio collared thus enabling unique identification and determination of their fate by Jun 09 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.

Figure 2a. Corkbark fir (*Abies lasiocarpa* var. *arizonica*) seed fall, 1993 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. Note: scales are different for figures 2a-c.

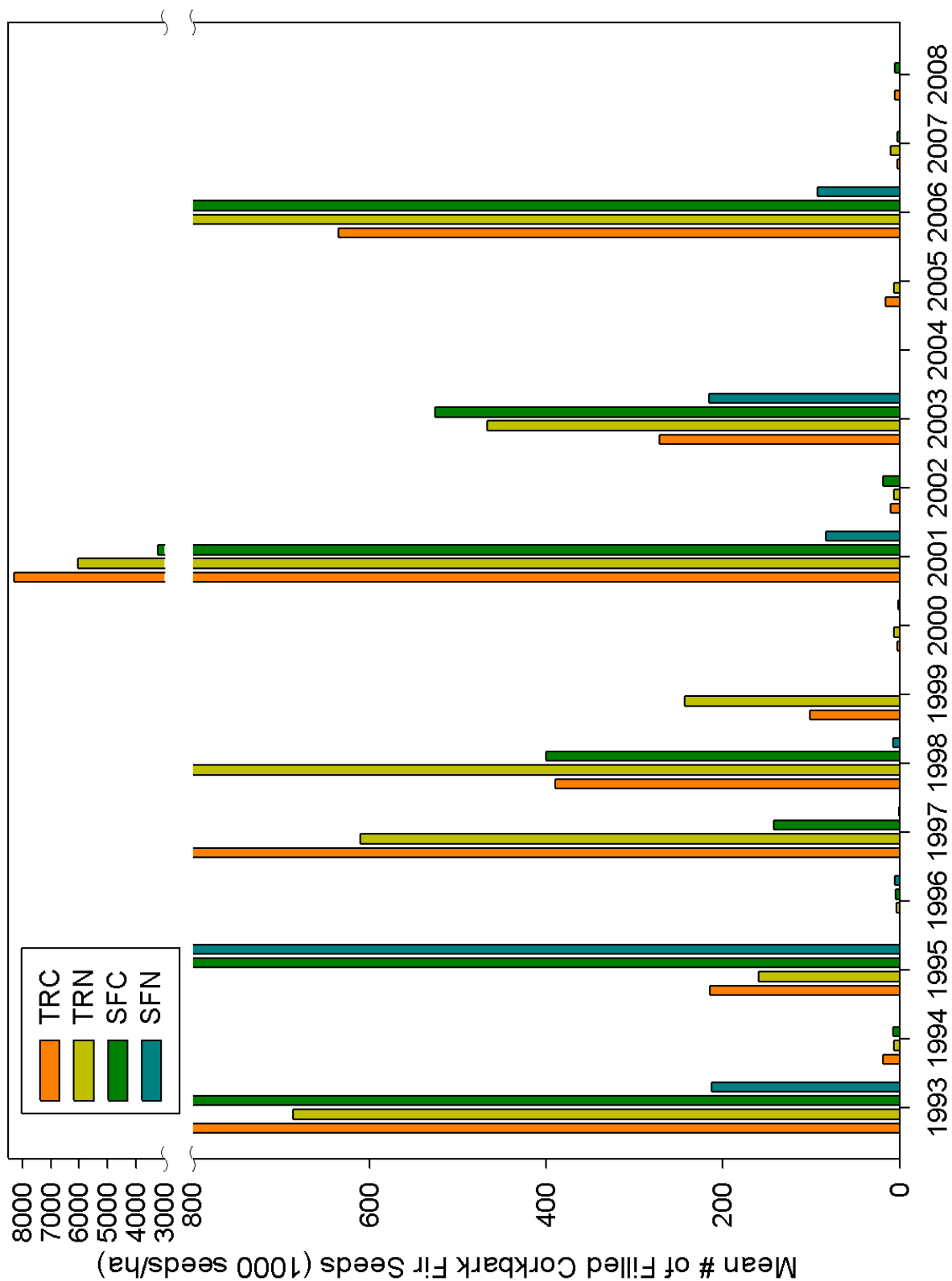


Figure 2b. Douglas-fir (*Pseudotsuga menziesii*) seed fall, 1993 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona. Note: scales are different for figures 2a-c.

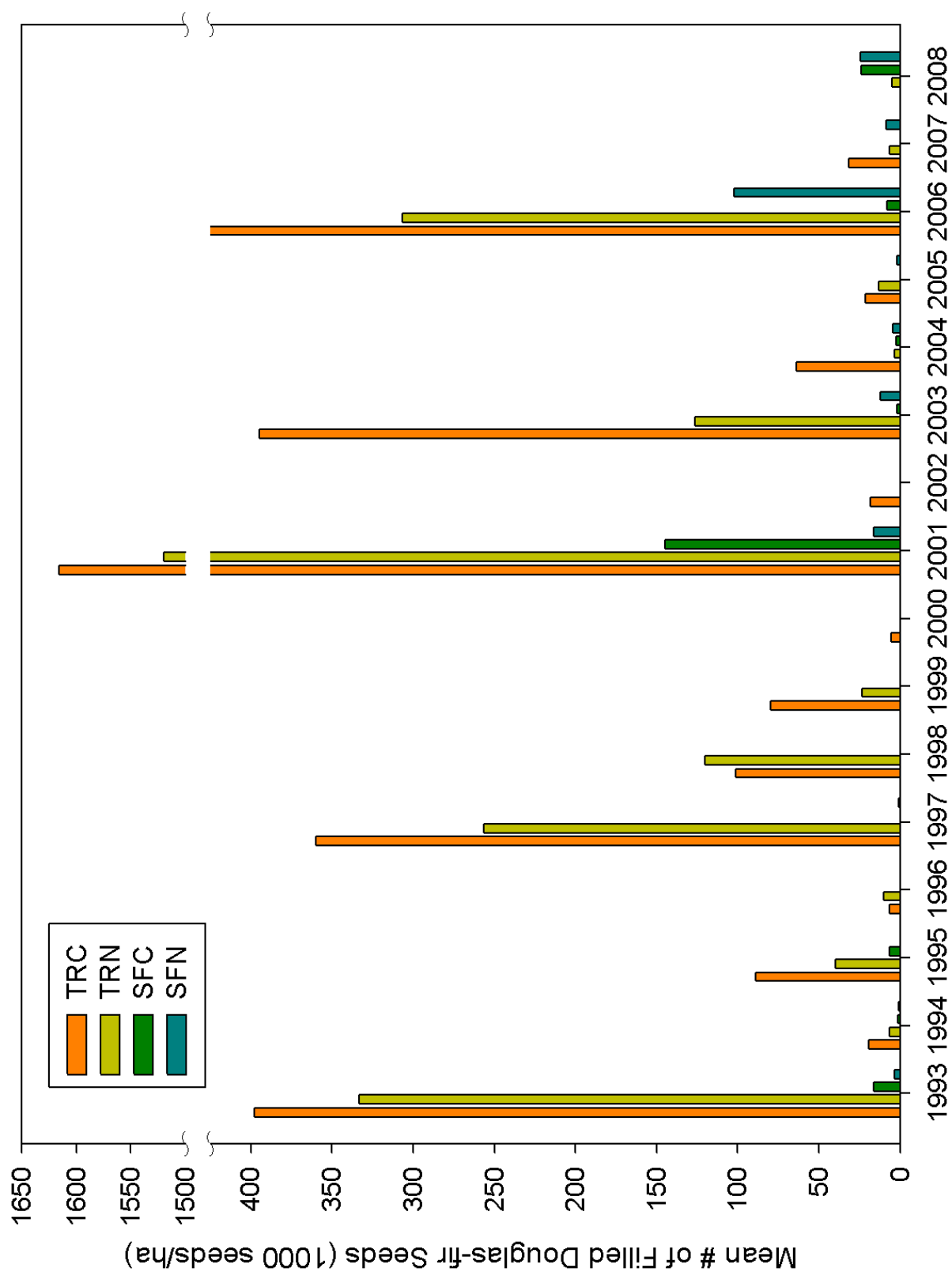


Figure 2c. Engelmann spruce (*Picea engelmannii*) seed fall, 1993 - 2008, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona. Note: scales are different for figures 2a-c.

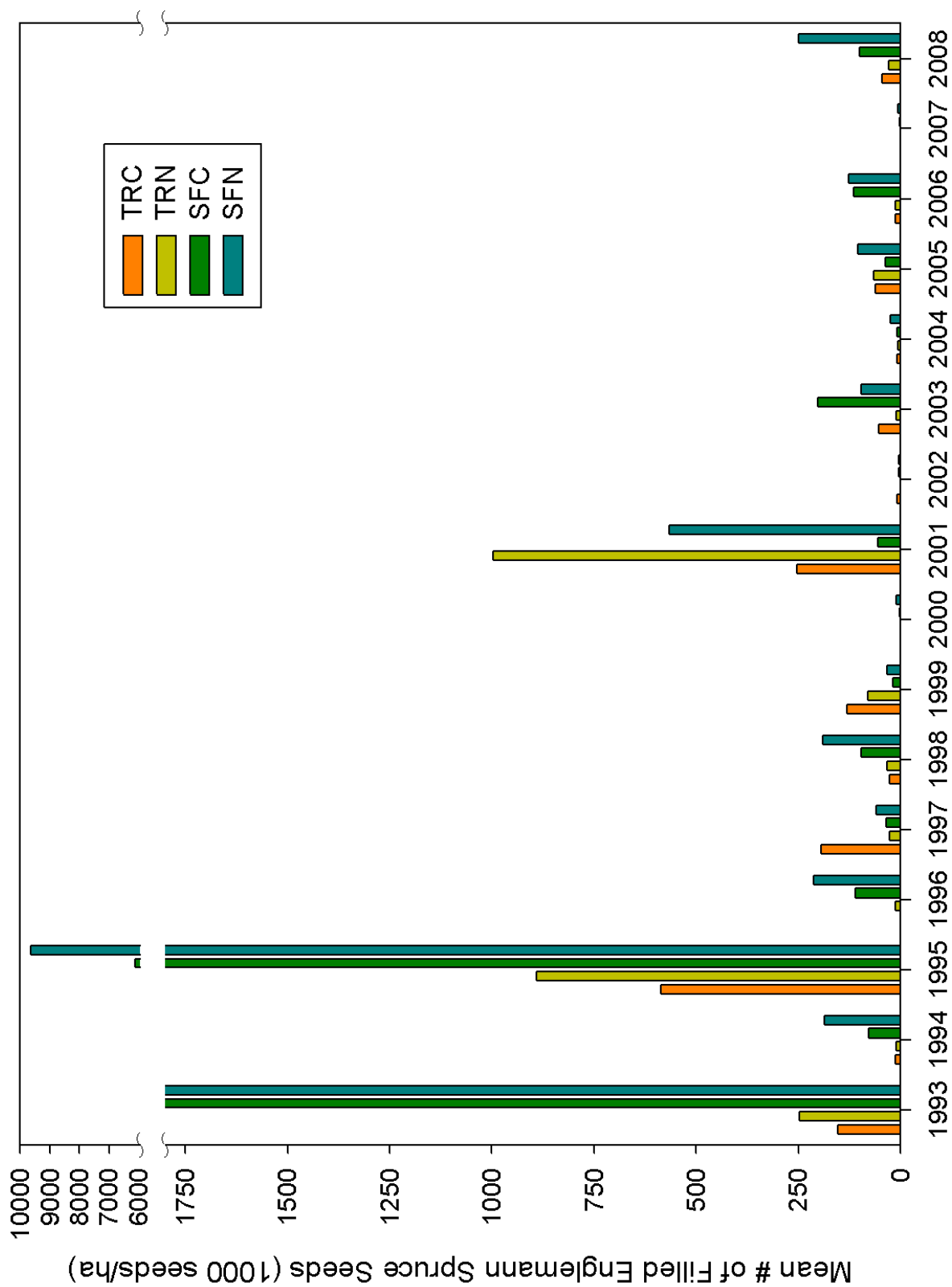


Figure 3. Mushroom crops by habitat, 1994 - 2009, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

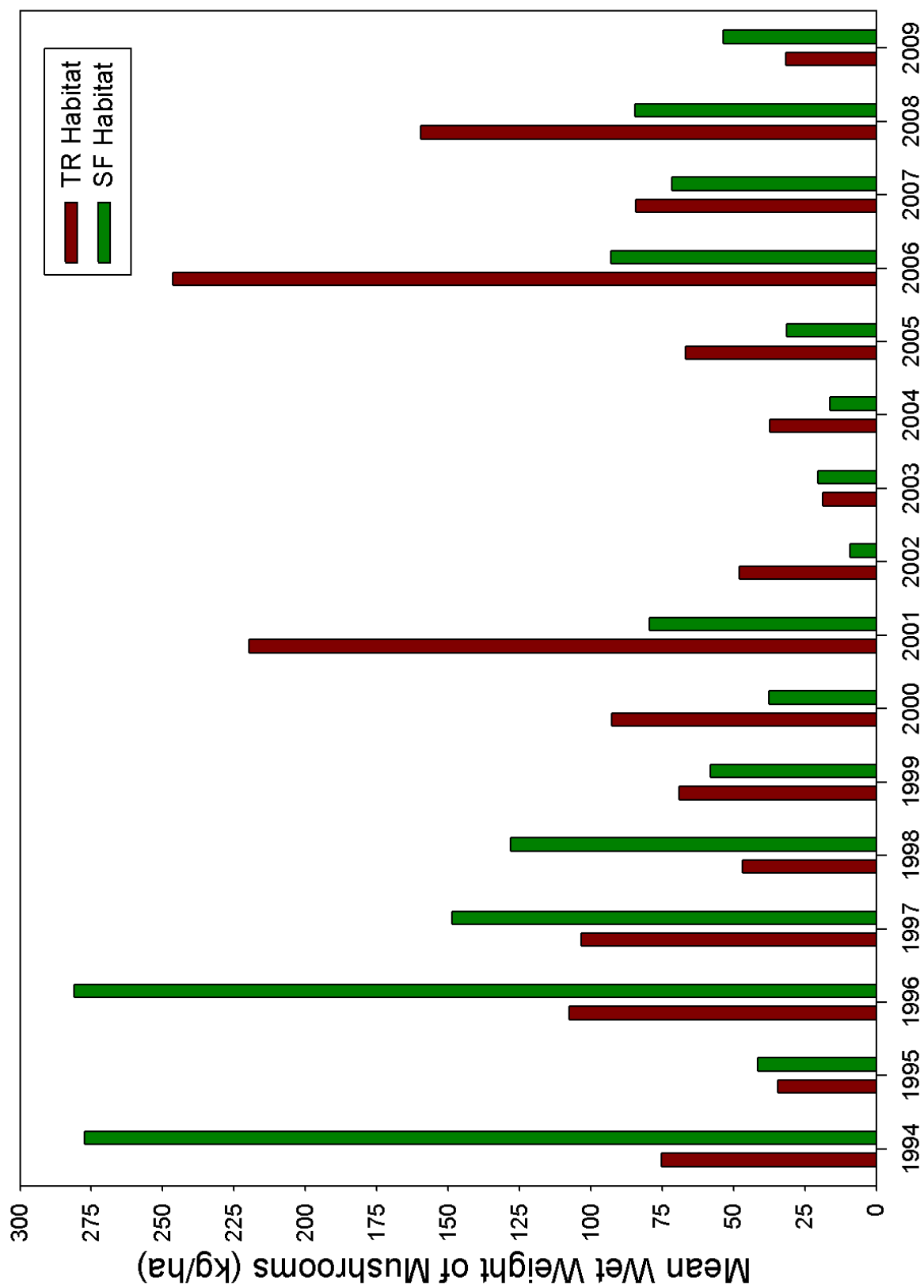


Figure 4. Quarterly Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), March 2005 - December 2009, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

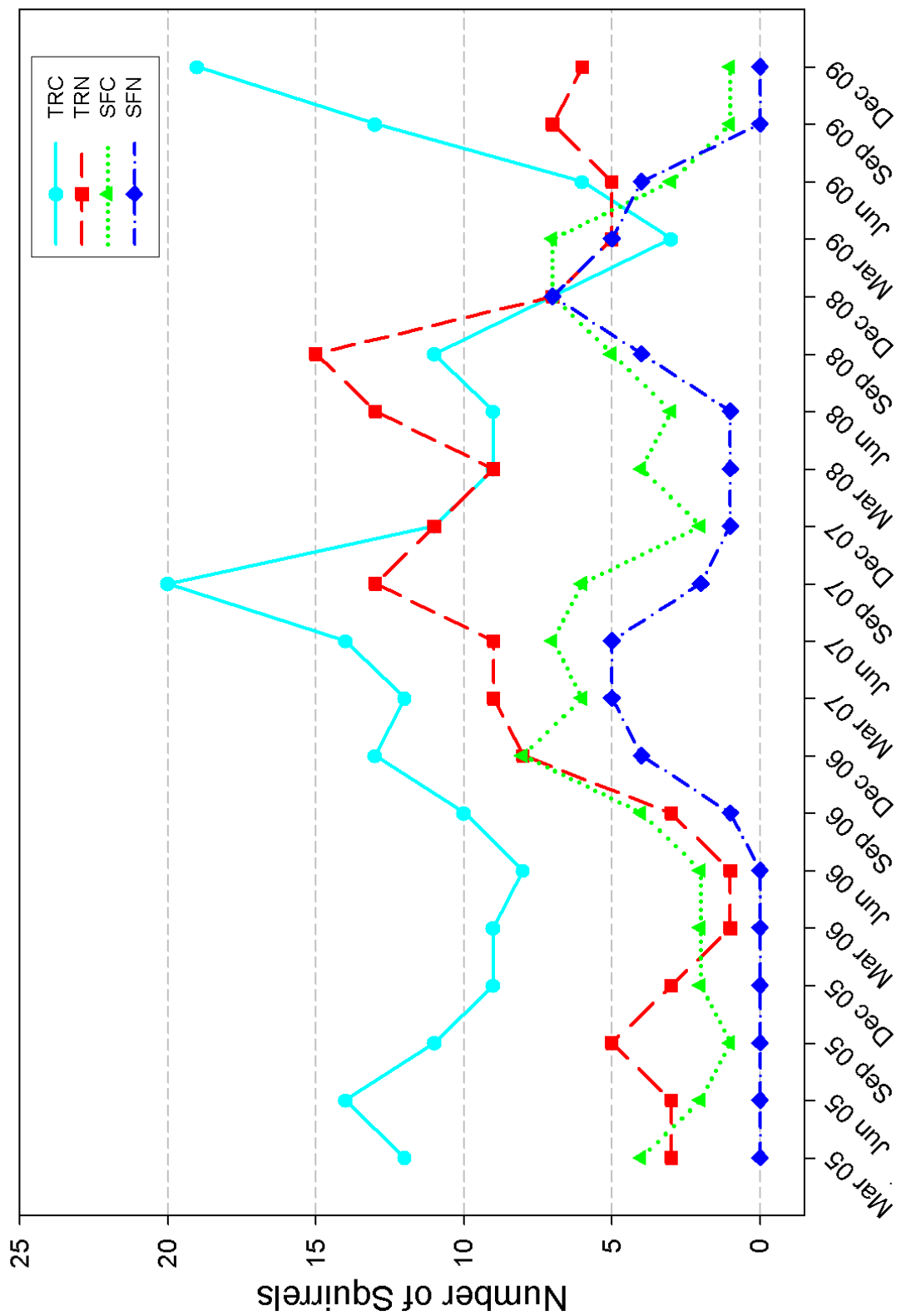
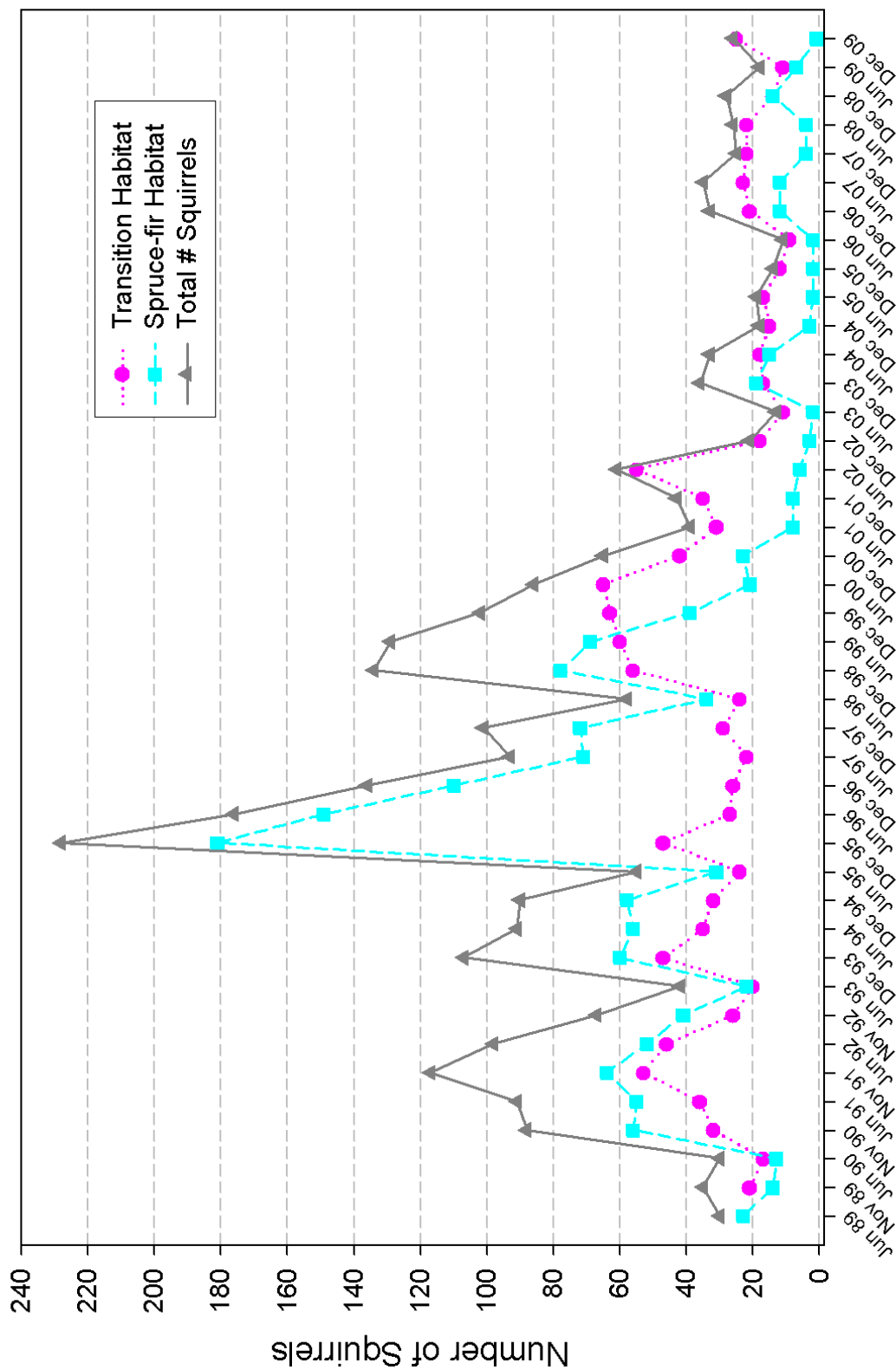


Figure 5. Summer and winter Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), by habitat, June 1989 - December 2009, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.



Appendix A. Annual conifer seed and mushroom production, 2008, on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Appendix A-1: Mean number of seeds (filled) and weights for 2008 seeds and 2008 mushrooms, by area and habitat on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

		Corkbark Fir	Douglas-fir	Englemann Spruce	Total Seeds	Total Mushrooms	
AREA	N	# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	# 1000 seeds/ha	ww Kg/ha	dw Kg/ha
TRC \bar{x}	5	5.3	0.0	45.3	50.6	87.0	9.6
TRN \bar{x}	4	0.0	5.0	29.9	34.9	72.6	8.2
SFC \bar{x}	5	5.3	24.0	101.3	130.6	49.7	5.5
SFN \bar{x}	6	0.0	24.4	248.8	273.2	34.8	4.6
TR \bar{x}	9	2.9	2.2	38.4	43.6	80.6	9.0
SF \bar{x}	11	2.4	24.2	181.8	208.4	41.6	5.0

Appendix B: Midden occupancy records, 2009, 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
♀ (R/R RC 101)	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] [RC = radio collar] [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

Note: Beginning with this 2009 Annual Report, middens that have been removed from regular censusing due to permanent fire damage or low occupancy, are no longer listed in Appendix B. Please refer to the 2008 Annual Report for a complete list of these middens.

Transition Construction Area (TRC), 2009				
Midden	Mar	Jun	Sep	Dec
1102 ⁸⁹	N	N	S	S
1103 ⁸⁹	N	P	S	♂ (G/none RC 916)
1104 ⁸⁹	N ¹	P	P	Y
1106 ⁸⁹	N	N	N	N
1111 ⁸⁹	N	N	N	N
1112 ^{89*}	N	N	N	N
1113 ⁸⁹	N	P	N	♂
1115 ⁸⁹	N	N	N	N
1116 ⁸⁹	P	♂ (M/M 854) 2	♂ (M/M 854) 2	♀
1118 ⁸⁹	N	♂	♂ (P/P RC 916) 3	♂ (P/P RC 916)
1121 ^{89*}	N	N	P	N
1131 ^{90*}	N	N	♂	♂ (O/W RC 929)
1144 ^{91*}	N	N	P	S
1147 ^{91*}	P	P	N	N
1149 ^{91*}	N	N	N	S
1151 ^{91*}	N	N	P	N
1153 ^{92*}	♀ (P/B RC 743)	♀ (P/B RC 743)	♀ (P/B RC 743)	♀ (P/B RC 743)
1154 ^{92*}	P	P	N	S
1156 ^{93*}	N	N	♂ (O/R RC 911) 4	♂ (O/R RC 911)
1160 ^{96*}	P	♀ NAT 5	♂	♂ (Y/O RC 930)
1162 ^{96*}	N	N	N	N
1163 ^{98*}	N	P	S	♂
1164 ^{98*}	N	P	S	S
1167 ^{98*}	N	N	N	N
1168 ^{98*}	N	N	N	N
1169 ^{98*}	N	N	N	N
1170 ^{98*}	♂ (Bsqq/Ysq RC 799)	♂ (Bsqq/Ysq RC 799) 6	S	♂ (R/R 931)
1171 ^{98*}	N	N	N	N
1172 ^{90*}	N	N	N	N
1173 ^{99*}	N	N	N	N
1177 ^{99*}	P	N	♂	S
1179 ^{99*}	N	N	N	N
1180 ^{99*}	N	N	N	S

Transition Construction Area (TRC), 2009				
Midden	Mar	Jun	Sep	Dec
1182 ^{02*}	N	N	N	N
1183 ^{04*}	N	P	P	P ⁷
1184 ^{04*}	N	N	N	N
1185 ^{05*}	N	N	N	N
1186 ^{05*}	N	N	N	N
1187 ^{05*}	1S	♀ (Y/Y RC 914)	♀ (Y/Y RC 914)	♀ (Y/Y RC 914)
# Mid	39	39	39	39
# Occ	3	6	13	19
% Occ	7.7%	15.4%	33.3%	48.7%
# Sq	3	6	13	19

- 1 The resident of midden 1104, ♀728, was not seen in 2009. Her collar was signaling from a ground nest (11152) near midden 1104 since late Dec 2008. Her fate is unknown.
- 2 The new resident of midden 1116shift, ♂854, was first tagged in 2007 as a juvenile. He was captured again as an adult in Jun 09 and a radio collar was fitted.
9 Oct 09 - the remains (jawbone, vertebrae) and radio collar of ♂854 were found on the ground ~150m N-NW of midden 1116shift, across the drainage.
- 3 ♂916 was first captured in Jun 09, as a roaming male, near midden 1103. Contact was lost with him, as the radio collar apparently malfunctioned. He was relocated in mid-Sep 09 as the new resident of midden 1118, in the S of the study area, and the bad radio collar was replaced.
- 4 Between Jun and Sep 09, ♂911 changed residency from midden 8046shift (W of the study area) to midden 1156, a distance of approx. 525m.
- 5 The unmarked female resident of 1160 in Jun 09, had an injured left rear hip or leg, movement seemed only slightly impaired.
- 6 The collar and tail of ♂799 were found ~175m S of his midden 1170, near midden 1146, in the evening of 10 Jul 09. He was known to be moving by telemetry signal earlier in the same day.
- 7 Some squirrel sign was found at midden 1183 during several 2009 censuses. It was believed that the resident of nearby midden 1160, may have been feeding in the area of 1183. No other resident squirrel was confirmed during several observations.

Transition Non-Construction Area (TRN), 2009				
Midden	Mar	Jun	Sep	Dec
2202 ⁸⁹	N	N	N	N
2203 ⁸⁹	N	N	P	N
2204 ⁸⁹	P	N	N	N
2205 ⁸⁹	N	N	N	N
2206 ⁸⁹	♀ (Gsq/Osq RC 800)	♀ (Gsq/Osq RC 800)	♀ (Gsq/Osq RC 800)	P ¹
2208 ^{89*}	N	N	N	N
2210 ⁹⁰	N	N	N	N
2211 ^{90*}	N	N	N	N
2215 ^{90*}	N	N	N	N
2216 ^{90*}	♀ (M/M RC 785)	♀ (M/M RC 785)	P ²	P
2217 ^{90*}	N	N	♀ (M/M RC 785) ²	N
2218 ^{91*}	N	N	N	N
2219 ^{91*}	P	N	N	N
2223 ^{91*}	N	N	♀ (M/G RC 780) ³	♀ (M/G RC 780) ³
2227 ^{95*}	N	N	N	N
2229 ^{96*}	N	N	P	P
2230 ^{96*}	N	N	N	N
2234 ^{97*}	N	N	♂ (M/M 918) ⁴	Y
2235 ^{98*}	N	N	N	N
2236 ^{98*}	♀ (O/G RC 780)	♀ (O/G RC 780)	N ³	Y
2237 ^{98*}	N	N	N	N
2238 ⁹⁸	♀ (Gsq/Bsq RC 778)	♀ (Gsq/Bsq RC 778)	N ⁵	N
2241 ^{98*}	N	N	N	N
2242 ^{98*}	N	P	P	N
2244 ^{99*}	P	N	♂ (none/Psq RC 750) ⁶	♂ (none/Psq RC 750)
2246 ^{99*}	N	N	N	N
2248 ^{99*}	P	N	S	N
2249 ^{99*}	N	N	N	N
2250 ^{00*}	N	N	N	N
2252 ^{08*}	♂ (none/Psq RC 750)	♂ (none/Psq RC 750)	P ⁶	♀
2253 ^{09*}	new midden Aug 09 ⁵		♀ (Gsq/Bsq RC 778)	♀ (Gsq/Bsq RC 778)
# Mid	30	30	31	31
# Occ	5	5	7	6
% Occ	16.7%	16.7%	22.6%	19.4%
# Sq	5	5	7	6

Appendix B - TRN (cont.)

- 1 The last telemetry points and observations for ♀800 were in early Oct 09. Her signal could not be detected on 16 Oct 09. Observations were made that day at her last known night nest, 15211, where 3 Juvenile red squirrels were observed, ♀800 was not seen. We observed again at the nest on 6 Nov 09, when the 3 Juveniles were seen, and a possible sighting of ♀800, but could not be positive as just a glimpse of a collared squirrel in the twilight. Neither female 800 nor the juveniles were observed anywhere in the area during the Dec 09 census. Female 800 was likely alive into mid-Nov 09, as the 3 juveniles remained in the nest area, however her fate is unknown after that time.
- 2 Female 785 shifted her residency from midden 2216 to 2217 between late Aug and early Sep 09. (she had 1 known juvenile near 2216 shift in mid-Aug). The collar and tail of ♀ 785 were found under the snow on 5 Dec 09, ~225m S-SE from midden 2217.
- 3 Between Jun and Sep 09 censuses, ♀780 changed her midden from 2236 to a shift near midden 2223. When she was trapped for weight and repro check in Sep 09, some old wounds on her haunches were discovered. They were very likely talon marks, as there was one on each hip. The wounds were scabbed over and healing, but the female was moving stiffly on the back legs, “hopping” up the tree. When female was captured for Dec 09 checks, we discovered she had lost most of her tail, with the vertebrae only about 2.5cm long. There was no open wound and the end of the tail looked scabbed over. The female was moving around nearly normal with her rear legs by this time. This is one lucky squirrel!
- 4 Male 918 is the offspring of female 778, who had two juveniles in August at a nearby maternity nest. This young male moved into this midden near his mother and they were observed vocalizing back and forth several times.
- 5 Female 778 regularly used a night nest (12026) up the hill from her midden (2238) throughout the winter of 08-09. In Aug 09, she had 2 juveniles in this nest. After Aug, ♀778 stayed in the area, feeding and caching cones. This nest area was upgraded to a midden by the Sep 09 census.
- 6 Male 750 moved from midden 2252 to midden 2244 between the Jun and Sep 09 censuses.

Spruce-Fir Construction Area (SFC), 2009				
Midden	Mar	Jun	Sep	Dec
3020 ^{96*}	N	N	N	N
3028 ^{99*}	N	N	N	N
3303 ^{94*}	N	N	N	N
3310 ^{95*}	N	N	♀	S
3311 ^{95*}	N	N	N	P
3312 ^{95*}	N	N	N	N
3314 ^{95*}	N	N	N	N
3323 ^{95*}	♂	P	N	N
3328 ^{95*}	Y ¹	Y	P	N
3330 ^{95*}	N	N	N	N
3341 ^{95*}	N	N	N	N
3346 ^{95*}	S	N	N	N
3348 ^{95*}	N	N	N	N
3360 ⁸⁶	S	Y	P	P
3362 ⁸⁶	N	N	N	N
3365 ⁸⁶	♂	S	N	N
3366 ⁸⁶	Y	P	N	N
3370 ⁸⁶	N	N	N	N
3371 ⁸⁷	N	N	P	N
3372 ⁸⁹	N	N	N	N
3374 ⁸⁹	P	P	P	N
3378 ^{90*}	♂	P	N	N
3382 ^{91*}	N	N	N	N
3394 ^{93*}	N	N	P	N
# Mid	24	24	24	24
# Occ	7	3	1	1
% Occ	29.2%	12.5%	41.7%	41.7%
# Sq	7	3	1	1

1 Midden 3328 was previously removed from censusing in 2003, due to low occupancy. The midden became re-occupied in Mar 09 and was added back to the census list.

Spruce-Fir Non Construction Area (SFN), 2009				
Midden	Mar	Jun	Sep	Dec
4000 ^{95*}	Y	Y	N	N
4010 ^{95*}	N	N	N	N
4016 ^{96*}	N	N	N	N
4026 ^{09*}	S ¹	Y	P	N
4400 ⁸⁹	N	N	N	N
4417 ^{95*}	N	N	N	N
4465 ^{90*}	P	P	N	N
4467 ⁸⁷	S	P	N	N
4469 ⁸⁷	P	P	N	N
4470 ⁸⁷	N	N	N	N
4471 ⁸⁷	Y	Y	P	N
4472 ⁸⁷	N	N	N	N
4473 ⁸⁷	Y	P	N	N
4474 ⁸⁶	N	N	N	N
4477 ⁸⁷	N	N	N	N
4484 ⁸⁶	N	N	P	N
4491 ^{91*}	P	Y	N	N
# Mid	17	17	17	17
# Occ	5	4	0	0
% Occ	29.4%	23.5%	0%	0%
# Sq	5	4	0	0

- 1 Midden 4026 was added to regular censusing in Mar 09. It was discovered in summer 2008 as a hotspot, then upgraded to a midden, as a resident squirrel and signs persisted into 2009.

Off-Area Midden Occupancy, 2009				
Midden	Mar	Jun	Sep	Dec
TRC Area				
5101 ⁸⁹	♂ (M/M RC 748)	♂ (M/M RC 748)	♂ (M/M RC 748)	♂ (M/M RC 748)
5102 ^{98*}	N	N	N	N
5103 ^{99*}	N	N	N	N
5104 ^{99*}	N	N	N	N
5105 ^{02*}	N	N	N	N
5106 ⁰²	N	N	N	N
5107 ⁰²	N	N	N	N
5118 ^{94*}	N	N	P	N
5119 ^{89*}	N	♀ (P/W 917)	♀ (P/W 917)	♂
5121 ^{89*}	N	Y	N	N
5123 ⁸⁹	<i>ROA</i> ¹ ♀ (Wsq/rip 749)	<i>ROA</i> ¹ ♀ (Wsq/rip 749)	<i>ROA</i> ¹ ♀ (Wsq/rip 749)	<i>ROA</i> ¹ P ²
5125 ^{89*}	N	N	N	N
5126 ⁹¹	N	N	N	N
5145 ^{91*}	N	N	N	N
5150 ^{91*}	P	P	♂ (Psq/Bsq 904) ³	♂ (Psq/Bsq 904)
5155 ^{93*}	N	P	♂	Y
TRN Area				
5200 ^{93*}	♀ (M/M 848)	P	♂	♂
5201 ^{99*}	N	N	N	N
5203 ^{00*}	N	N	N	P
5221 ^{91*}	N	N	♂	♂
5231 ^{96*}	N	N	N	N
5232 ^{96*}	N	N	N	N
SFC Area				
5311 ^{95*}	N	N	N	N
5313 ^{95*}	N	N	N	N
5350 ⁸⁶	♂	P	N	N
5361 ^{96*}	P	N	N	N
SFN Area				
5405 ⁸⁷	N	N	N	N
5413 ^{95*}	N	N	N	N

Appendix B - Off Area (cont.)

- 1 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.
- 2 Female 749, resident at midden 5123, was last seen on 20 Oct 03. Her collar was found on the ground in a grassy area about 10m from the 5123 tag tree. No signs of predation were found. Her fate is unknown.
- 3 Male 904 was first captured in Sep 08 near midden 5150. He was not seen again until Jun 09, traveling through midden 1118. By Sep 09, he was resident at midden 5150sh#2 (=nest 15109), and he was fitted with a radio collar in Dec 09.

Appendix C. Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles at maternal middens), March 2005 - December 2009, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Date	TRC	TRN	SFC	SFN	TOTAL
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
Mar 2009	3	5	7	5	20
Jun 2009	6	5	3	4	18
Sep 2009	13	7	1	0	21
Dec 2009	19	6	1	0	26

Appendix D: Quarterly occupancy maps for Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*) March 2009 - December 2009, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

Appendix E: Reproductive success of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2009, on or near* University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

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

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

* Reproductive success notes for squirrels at middens $\geq 100\text{m}$ from study area boundaries (numbered in 5000s and 8000s) are included for anecdotal information only. Litters at these middens are not counted in population totals for the Monitoring Program study areas.

Appendix E-1: Breeding Chases Observed - 2009

Descriptions of mating chases observed in 2009 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>
15 Apr 09	near 8048	Breeding chase between Male #786 and Female #898. Chases were mainly from the male towards the female and buzz calls were heard.
14 May 09	near 2206	Female 800, resident at midden 2206, was chased by 5 males; Male #750, Male #799, Male #748, and 2 unmarked males. Many buzz calls were heard during the observation. The chase was observed for about 1.5 hours before sunset, when activity stopped and squirrels dispersed.

Other possible breeding movements were noted during field activities in late March 09: Male #748 making movements to the SW away from his home midden 5101 towards female #749 (midden 5123). Male #750 was also making movements away from his midden (2252) up and down the drainage in the direction of female #800 (5221/2206 area).

Appendix E-2: Litters observed in 2009 on or near University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno 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>
12 Aug 09	2216sh	1 Juvenile was confirmed for Female #785 during observations at maternity nest 12113. Unknown if there were more in the litter, as the juvenile seen was larger and possibly dispersed shortly after the sighting. This juvenile was not trapped.
16 Aug 09	2253	2 Juveniles were confirmed for Female #778 during observations at maternity nest 12026. One of the juveniles was trapped (Male #918).
17 Aug 09	8006	4 Juveniles were confirmed for Female #898 during observations at maternity nest 18177. One of the juveniles was trapped (Female #927).
28 Sep 09	5221/2206	3 Juveniles were confirmed for Female #800 during observations at maternity nest 15211. None of the juveniles were trapped. Note: these juveniles were not included in the monitored area population totals as they and their mother were mostly in the areas just outside the TRN.

Appendix F. Weather information, January - December 2009, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleno Mountains, Graham County, Arizona.

F-1: Monthly weather summaries

F-2: Accumulated snow depths

Biology Camp Weather Summary

Date: Jan 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-12.100	698.900	11.000	-26.300	0.000	0.000	-13.900	0.000
Avg	-0.233	709.020	58.204	-8.741	0.461	1.707	-0.682	
Max	9.900	715.700	100.000	4.100	2.200	8.050	9.900	3.200
Total								27.200
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: East

Date: Feb 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-12.800	692.600	15.000	-25.400	0.000	0.000	-16.200	0.000
Avg	-0.104	707.615	49.705	-10.761	0.477	1.783	-0.413	
Max	10.900	716.300	100.000	1.700	1.800	6.440	10.900	2.000
Total								11.800
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: West South West

Date: Mar 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-5.300	700.400	17.000	-16.000	0.000	0.000	-6.900	0.000
Avg	3.180	709.137	49.590	-7.424	0.480	1.798	2.962	
Max	13.900	714.800	100.000	-0.400	2.200	8.050	13.900	0.000
Total								0.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: West South West

Biology Camp Weather Summary

Date: Apr 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-8.700	700.800	19.000	-15.100	0.000	0.000	-9.200	0.000
Avg	4.919	709.098	41.229	-8.195	0.392	1.482	4.778	
Max	15.700	715.900	96.000	-1.900	2.700	9.660	15.700	0.000
Total								0.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: North
South West

Date: May 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	2.800	706.900	18.000	-13.300	0.000	0.000	2.800	0.000
Avg	10.102	711.722	52.238	-0.589	0.311	1.199	10.095	
Max	20.500	716.800	100.000	9.600	1.800	6.440	20.500	3.000
Total								32.800
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: North

Date: Jun 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	3.300	707.400	23.000	-12.400	0.000	0.000	3.300	0.000
Avg	11.132	711.821	59.907	2.728	0.362	1.371	11.129	
Max	20.600	716.100	100.000	14.800	1.300	4.830	20.600	3.200
Total								25.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: West South West

Biology Camp Weather Summary

Date: Jul 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	8.300	712.500	33.000	1.600	0.000	0.000	8.300	0.000
Avg	14.561	716.063	76.841	10.164	0.269	1.011	14.561	
Max	23.200	719.800	100.000	16.000	1.300	4.830	23.200	14.800
Total								90.400
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: East

Date: Aug 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	6.300	711.700	33.000	-3.100	0.000	0.000	6.300	0.000
Avg	13.549	714.862	68.616	7.339	0.199	0.757	13.549	
Max	23.700	717.700	100.000	15.100	1.300	4.830	23.700	11.200
Total								84.800
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: East South East

Date: Sep 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	1.900	709.500	42.000	-4.800	0.000	0.000	1.900	0.000
Avg	9.936	712.583	82.122	6.780	0.141	0.534	9.934	
Max	18.400	715.900	100.000	13.500	1.300	4.830	18.400	7.200
Total								54.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: North

East

Biology Camp Weather Summary

Date: Oct 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-11.800	689.300	13.000	-22.800	0.000	0.000	-14.600	0.000
Avg	5.070	706.926	60.540	-2.884	0.559	2.078	4.776	
Max	17.400	715.200	100.000	8.300	2.700	9.660	17.400	0.800
Total								1.600
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: East

Date: Nov 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-6.300	699.100	12.000	-25.600	0.000	0.000	-9.400	0.000
Avg	3.420	709.193	53.336	-6.895	0.234	0.886	3.322	
Max	15.600	716.600	100.000	3.500	2.700	9.660	15.600	0.000
Total								0.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: North

Date: Dec 2009 Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-11.300	690.500	15.000	-25.100	0.000	0.000	-13.200	0.000
Avg	-4.360	702.499	73.632	-9.367	0.702	2.578	-5.185	
Max	2.300	708.000	100.000	-2.100	2.700	9.660	2.300	0.000
Total								0.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: East South East

Emerald Peak Weather Summary ***

Date: Jun 2009

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	3.800	701.900	33.000	-5.400	0.000	0.000	3.800	0.000
Avg	11.550	706.456	68.509	5.547	0.401	1.477	11.497	
Max	18.200	710.100	96.000	12.100	4.000	14.480	18.200	2.200
Total								8.400
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South

Date: Jul 2009

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	7.800	706.600	27.000	-2.900	0.000	0.000	7.800	0.000
Avg	13.471	710.706	66.222	6.770	0.237	0.887	13.471	
Max	20.300	714.400	99.000	13.300	1.800	6.440	20.300	15.000
Total								36.600
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: East

Date: Aug 2009

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	6.000	707.100	25.000	-8.400	0.000	0.000	4.700	0.000
Avg	12.432	710.379	57.839	3.491	0.651	2.404	12.344	
Max	19.800	713.300	99.000	11.600	4.000	14.480	19.800	13.600
Total								104.600
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: North West

Emerald Peak Weather Summary

Date: Sep 2009

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-0.100	705.000	27.000	-10.500	0.000	0.000	-2.200	0.000
Avg	8.765	709.047	72.543	3.763	0.420	1.562	8.705	
Max	15.400	712.200	98.000	9.500	2.200	8.050	15.400	8.600
Total								80.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: North West

*** There were several technical issues at the Emerald Peak weather station, causing lost data.

F-2: Accumulated snow depths on the monitored areas for Winter 2008-2009.

<i>Snow Year</i>		<i>Habitat</i>	<i>Location</i>	<i>Avg Depth (cm)</i>	<i>Min Depth (cm)</i>	<i>Max Depth (cm)</i>	<i>Avg. % Cover</i>	<i># of Readings for Avg.</i>
<i>Year</i>	<i>Month</i>							
<i>2008-2009</i>								
2008	11	Spruce-fir	Clearing	3.1	2.5	4	76.7	6
2008	11	Spruce-fir	Forest	2.4	1.5	3	65.8	6
2008	11	Transition	Clearing	2.0	1	3.5	41.7	3
2008	11	Transition	Forest	1.3	1	1.5	55.0	3
2008	12	Spruce-fir	Clearing	40.8	19	59	89.6	18
2008	12	Spruce-fir	Forest	37.3	20	57	77.5	18
2008	12	Transition	Clearing	38.0	20	52	82.8	9
2008	12	Transition	Forest	33.0	15	48	72.8	9
2009	1	Spruce-fir	Clearing	104.8	64	125	98.8	6
2009	1	Spruce-fir	Forest	94.8	84	110	81.7	6
2009	1	Transition	Clearing	88.7	83	99	81.7	3
2009	1	Transition	Forest	82.3	73	94	75.0	3
2009	2	Transition	Clearing	91.0	85	97	100.0	2
2009	2	Transition	Forest	75.0	60	90	100.0	2
2009	3	Spruce-fir	Clearing	60.4	0	107	80.0	5
2009	3	Spruce-fir	Forest	49.8	0	77	83.3	6
2009	3	Transition	Clearing	62.4	17	88	90.0	5
2009	3	Transition	Forest	48.8	30	72	100.0	5
<i>Averages for Snow Year</i>				50.9	32.0	65.9	80.7	<i>Sum # Readings</i>
<i>Std Dev</i>				34.24				115
<i>SE of Mean</i>				3.19				