THE UNIVERSITY OF ARIZONA

Mt. Graham Red Squirrel Monitoring Program

2016 Annual Report

Prepared by:

John L. Koprowski, Principal Investigator

Vicki L. Greer, Wildlife Biologist Sr.

Melissa J. Merrick, Wildlife Biologist Sr.

Submitted 28 March 2016

EXECUTIVE SUMMARY

In 2016, 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 Pinaleño Mountains, Graham County, Arizona.

Overall annual mushroom production (sum of $\bar{x}$ wet weight for all areas) in 2016 was 244.1 kg/ha, smaller than in 2015 (483.0 kg/ha). The 2016 mushroom crop ranked 10 of 23 years since data collection began in 1994.

Yearly seed production is reported as the mean number of 1000 *filled* seeds per hectare. The total seed crop in 2015 (one year delay due to methodology) ranked 18th lowest of 23 years of data since 1993. The 2015 overall mean seed crop was 164.7 (1000 seeds/ha), considerably smaller than the 2014 crop, 1164.2 (1000 seeds/ha), and the 2013 crop, 622.9 (1000 seeds/ha).

Overwinter survival, calculated as animals surviving from December 2015 to June 2016, was 40% (8 of 20 squirrels surviving) in transitional (TR) habitat and 50% (6 of 12 squirrels surviving) in spruce-fir (SF) habitat. Overwinter survival was mixed compared to other winters; the proportion of squirrels surviving in TR habitat was nearly the lowest (ranked 25th of 27 years of data). In SF habitat, the proportion surviving ranked near the middle (15th of 26 years of data). In December of 2015 there were 5 radio collared and/or ear-tagged squirrels on or near the monitored areas. By June 2016, 4 of these animals were alive and 1 was unconfirmed dead (animal not seen after March census).

A complete census of the study areas was made in March, June, September, and December 2016. Squirrel populations in December 2016 (46 adults/subadults) were higher than the previous December (32 adults/subadults). In both TR and SF habitats, the number of squirrels was generally highest in the fall. Eight litters were confirmed on or near the monitored areas in 2016. From these 8 litters, 15 juveniles were known to have emerged from natal nests.

Table of Contents

List of Tables

List of Figures

List of Appendices

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° 42' N, 109° 53' W). In 2016, the MGIO site consisted of three operating facilities, the Vatican Advanced Technology Telescope (VATT), the Sub-Millimeter Telescope (SMT), and the Large Binocular Telescope (LBT), a maintenance and generator building, and a 3.2 km access road (FR 4556). Herein, we report on the monitoring efforts from 1 January to 31 December 2016.

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 m 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 (C.C. 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 reoccupied, 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 is estimated from 20 seedfall plots distributed among the monitored areas (Figure 1). Three 0.25 m^2 seed traps were randomly placed within a 10 m x 10 m plot at each location. Seeds from the 2014 crop were collected from the seed traps in June 2015. 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 1 m by 100 m (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 (2) and SFN (1). Mushrooms (epigeous or above-ground fungi) were collected at these 20 sites (Figure 1) from late July through mid September 2016. Mushrooms in 2016 were collected on north-south transects. 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 to the nearest 0.1 g. 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 ($n < 100$).

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 (Appendix A) in addition to the current year's mushroom data (Tables 4, 5).

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 2016, 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 2016, many 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 on the monitored areas. During a complete census in December 2015, the number of occupied middens and the identity of resident squirrels were determined. December 2015 occupancy was then compared to occupancy for June 2016. 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 the following 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 2016, 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) and Arizona Game and Fish Department (SCL-2016: SP735657), 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., style 1005-1) threaded with colored plastic washers (National Band & Tag Co., ⅜" diameter, style 1842) and affixed to ears for easy distance identification. Radio collars (Wildlife Materials Inc., model SOM2190) were fitted on some adult (collar weight ~7 g). Squirrels were released at the capture site.

Mapping

All middens and most other physical features on the monitored areas were previously mapped using GPS with an accuracy of ± 5 m. Any new GPS data (middens, nests, etc.) were collected using GeoXM or GeoXT units 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 3.3 (ESRI 2002).

Weather Data

Weather data were collected using a Weather Monitor II station (Davis Instruments, www.davisnet.com) located at the Biology Camp (32" 41' 51.47 N, 109" 54' 20.28 W), adjacent to the TRC. The station records air temperature, wind speed, wind direction, rainfall, relative humidity and barometric pressure. Data are averaged at 60 min intervals and minimum, maximum and mean values are recorded. 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 IBM SPSS statistical software (Ver. 19, www.spss.com). 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

2015 *Conifer Seed Production*

Data collection for seed crops began in 1993 and yearly production is currently reported as the mean number of 1000 *filled* seeds per hectare. If years are ranked from highest (1) and lowest (23), the total 2015 seed crop overall was comparatively low, ranked 18 of 23 years of data since 1993. Engelmann spruce was the most abundant (in numbers) seed in 2015, and ranked 16 of 23. Corkbark fir was the second most abundant seed in 2015 and ranked 19 of 23. Douglas-fir was the least abundant seed in 2015, and ranked 21 of 23. The 2015 overall mean seed crop was 164.7 (1000 seeds/ha), considerably smaller than the 2014 crop, 1164.2 (1000 seeds/ha), and the 2013 crop, 622.9 (1000 seeds/ha) (Table 3, Figures 2a-c, Appendix A).

***2016** Mushroom Production*

Overall annual mushroom production (sum of $\bar{x}$ wet weight for all areas) in 2016 was 244.1 kg/ha, smaller than in 2015 (483.0 kg/ha). The 2016 mushroom crop ranked 10 of 23 years since data collection began in 1994. Production decreased in both TR and SF habitats in 2016 as compared to 2015 (Figure 3). In 2016, mushroom production ($\bar{x}$ wet weight) did not differ on study areas within each habitat or between habitats (Table 4). On TRC, three genera, *Russula, Lactarius,* and *Cortinarius* accounted for 73% of production. On TRN, *Pholiota*, *Russula*, and *Auricularius* accounted for 84% of total production. *Amanita, Russula,* and *Cortinarius* accounted for 76% of the production on SFC. On SFN, *Russula, Lactarius,* and *Cortinarius* accounted for 70% 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 conducted in 2016 (Appendix B). From December 2015 to December 2016, the number of red squirrels on the monitored areas increased, from 32 to 46. On TRC, the highest number of squirrels (19 adults + 4 juveniles) was in September 2016, and the lowest number was 11 adults in March. The highest numbers on TRN were in September (18 adults) and the lowest was 4 adults in June. The highest number of squirrels on SFC was in March and December (7 adults) and the lowest was 4 adults in September. On SFN, the highest number (5 adults) was in June and September and the lowest was 3 adults in March (Figure 4, Appendix B, C, D). On all areas, in both TR and SF habitats, the number of squirrels was generally higher in the latter half of the year (Figure 5).

In 2016, one new midden each was located in TR habitat (Appendix B). In both June and December of 2016, the proportion of middens occupied did not differ within TR and SF habitats (Table 6).

Overwinter Survival

The number of squirrels that survived the winter of 2015-2016 did not differ within or between areas (Table 7). Survival in TR habitat was 40% (8 of 20 squirrels surviving); the third lowest percentage of overwinter survival (25th of 27 years of data). In SF habitat, overwinter survival, 50% (6 of 12 squirrels surviving), was somewhat higher and ranked 15th of 26 years of data. For comparison, survival from the previous winter, 2014-2015, was 25% (9 of 36 squirrels surviving) in TR habitat and 36.4% (8 of 22 squirrels surviving) in SF habitat. There were 5 marked squirrels on the monitored areas in December 2015, and by June 2016, 4 were known alive, with 1 unconfirmed mortality (animal not seen after March 2016).

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

Reproductive Activity and Success

In 2016, one breeding chase was observed on the monitored areas and 2 chases were seen on nearby study areas indicating breeding activity from at least late May through late June (Appendix E-1). Based on information from census and trapping records, most resident adult males had testes fully scrotal March through August and again in December.

From May through September, several females seen or trapped during these months were found to be either pregnant or lactating. The first lactating females were observed in mid June and the latest was observed on 5 October. Direct evidence of 8 litters (15 juveniles emerged from natal nests) was documented on or near the areas during censuses or other activities. Litters were confirmed from late July through early October (Appendix E-2).

Trapping and Marking

In 2016, 15 squirrels (7 male, 8 female), on or near monitored areas, had radio-collars and/or colored ear tags (Appendix B). These animals were located several times each month using radio telemetry to track home ranges, reproduction and survival.

Mapping

No significant changes in maps of the monitored areas were made in 2016, 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 from January - December 2016 from the Biology Camp weather station (TR habitat). From available data, maximum temperature recorded was 27.1 °C in June and the minimum temperature recorded was -17.2 °C in February. The maximum average monthly temperature was 14.8 °C in July and the minimum average monthly temperature was -1.8 °C in January (Appendix F-1). The maximum total monthly rainfall was recorded in September, at 137.2 mm (Appendix F-1). Snow depth was recorded from nine pairs of snow poles. The average ***accumulated*** snow depth from November 2015 - April 2016 ranged from 0.0 cm to 98.9 cm (Appendix F-2). For comparison, average accumulated snow depths for the previous winter (November 2014 - April 2015), ranged from 0.0 cm to 42.8 cm. Data on wind chill temperatures, wind direction and speed, humidity, and barometric pressure were also collected (Appendix F-1). Weather data are also collected near the monitored areas in the TR habitat from a Remote Automatic Weather Station (RAWS), located at Columbine Ranger Station. Weather data and reports can be found at: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?azACOL

Insect Outbreaks on Monitored Areas

Based on information from USFS Forest Health websites (see below), activity of bark beetles (*Dryocoetes confusus*, *Dendroctonus rufipennis, D. pseudotsugae*, and *D. brevicomis*) in Graham County was minimal in 2016. For detailed information on forest health and continuing research on insect infestations, please contact the USFS Southwestern Region Entomology and Pathology Office in Flagstaff, AZ.
http://www.fs.usda.gov/main/r3/forest-grasslandhealth
and
http://foresthealth.fs.usda.gov/portal

RECENT PUBLICATIONS

Peer-reviewed Journal Articles - 2016

Chen, H. L. and J. L. Koprowski. 2016. Barrier effects of roads on an endangered forest obligate: influences of traffic, road edges, and gaps. Biological Conservation. 199: 33-40.

Chen, H. L. and J.L. Koprowski. 2016. Differential effects of roads and traffic on space use and movements of native forest-dependent and introduced edge-tolerant species. PLoS one. 11(1): e0148121.

Doumas, S. L., J. L. Koprowski, and W. O. Noble. 2016. Landscape-level assessment of Abert's squirrel and red squirrel in mixed conifer forest. The Southwestern Naturalist. 60:240-246.

Gwinn, R. N., and J. Koprowski. 2016. Differential response to fire by introduced and endemic species complicates endangered species conservation. Hystrix. 27(2).

Kilanowski, A. L. and J. L. Koprowski. 2016. Female-biased sexual size dimorphism: ontogeny, seasonality, and fecundity of the cliff chipmunk (*Tamias dorsalis*). Journal of Mammalogy 98:204-210.

Kilanowski, A. L., and J. L. Koprowski. 2016. Communal denning of cliff chipmunks (*Tamias dorsalis*). The Southwestern Naturalist, 61(3), 248-251.

Merrick M. J., and J. L. Koprowski. 2016. Evidence of natal habitat preference induction within one habitat type. Proceedings of the Royal Society B. 283: 20162106.

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.

ESRI 2002. ARC View 3.3. Environmental Systems Research Institute. Redlands, CA.

Froehlich, G. F. 1990. Habitat use and life history of the Mt. Graham red squirrel. Thesis, University of Arizona, Tucson, USA.

Hatten, J. R. 2000. A pattern recognition model for the Mount Graham red squirrel. Technical Report 160. Arizona Game and Fish Department, Phoenix, USA.

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press and Arizona Game and Fish Department, Tucson, USA.

Koprowski, J. L. 2002. Handling tree squirrels with an efficient and safe restraint. Wildlife Society Bulletin 30: 101-103.

Krebs, C. J. 1966. Demographic changes in fluctuating populations of *Microtus californicus*. Ecological Monographs 36: 239-273.

Smith, C. C. 1968. The adaptive nature of social organization in the genus of three *(sic)* 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, USA.

United States Fish and Wildlife Service. 1993. Mount Graham red squirrel recovery plan. United States Fish and Wildlife Service, Albuquerque, New Mexico, USA.

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

USDA Forest Service. 1989. Mount Graham International Observatory Management Plan. Coronado National Forest, Tucson, USA.

Vahle, J. R. 1978. Red squirrel use of southwestern mixed coniferous habitat. Thesis, Arizona State University, Tempe, USA.

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. All area measures are in hectares.

	Transition habitat		Spruce-fir habitat		
Event and Date	Construction [1]	Non-construction	Construction	Non-construction	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

1 Construction areas are ≤ 300 m from Mt. Graham International Observatory or access road. Non-construction areas are sites outside this boundary established for comparison.

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.

Genus	Source
Amanita	Buller 1920, M.C. Smith 1968
Auricularia	Monitoring Program personal observations
Boletus	Buller 1920, C.C. Smith 1968, M.C. Smith 1968
Clavaria	M.C. Smith 1968
Clitocybe	Monitoring Program personal observations
Cortinarius	C.C. Smith 1968, Froehlich 1990, Uphoff 1990
Gastroid sp.	Monitoring Program personal observations, States 1990
Hydnum	C.C. Smith 1968, M.C. Smith 1968
Lactarius	Buller 1920, C.C. Smith 1968
Leccinum	Monitoring Program personal observations
Lycoperdon	Monitoring Program personal observations
Pholiota	C.C. Smith 1968
Ramaria	Monitoring Program personal observations
Russula	M.C. Smith 1968, C.C. Smith 1968
Suillus	C.C. Smith 1968

Table 3. Mean *filled* conifer seed production, **2015**, on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. The percent column represents the proportion of each seed species on an individual area (proportions add across rows).

		Corkbark fir		Douglas-fir		Engelmann spruce	
Area/Habitat	# plots	$\bar{x}$ 1000 seeds/ha	%	$\bar{x}$ 1000 seeds/ha	%	$\bar{x}$ 1000 seeds/ha	%
TRC	5	2.6	12.5	0.0	0.0	18.6	87.5
TRN	4	10.0	60.2	0.0	0.0	6.6	39.8
SFC	5	0.0	0.0	0.0	0.0	29.3	100.0
SFN	6	0.0	0.0	8.9	9.1	88.7	91.0
TR Habitat	9	5.9	30.9	0.0	0.0	13.2	69.1
SF Habitat	11	0.0	0.0	4.8	7.3	61.7	92.7

Table 4. Mean annual mushroom production, **2016**, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

Area/Habitat	# transects	$\bar{x}$ wet weight ± SE (kg/ha)
TRC	5	37.5 ± 9.7
TRN	4	114.2 ± 60.1
SFC	5	47.4 ± 9.9
SFN	6	45.0 ± 11.0
TR Habitat	9	71.6 ± 28.4
SF Habitat	11	46.1 ± 7.1

Kruskal-Wallis test within TR:

Wet Weight $\chi^2 = 2.16$ df = 1 P = 0.14

Kruskal-Wallis test within SF:

Wet Weight $\chi^2 = 0.03$ df = 1 P = 0.86

Kruskal-Wallis test between TR and SF:

Wet Weight $\chi^2 < 0.01$ df = 1 P = 0.97

Table 5. Mean annual mushroom production (wet weight kg/ha), **2016**, 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 (proportions add down columns).

	TRC		TRN		SFC		SFN	
Genus	$\bar{x}$ kg/ha	%	$\bar{x}$ kg/ha	%	$\bar{x}$ kg/ha	%	$\bar{x}$ kg/ha	%
Amanita	2.18	5.8	4.53	4.0	20.38	42.9	7.14	15.9
Auricularia	1.10	2.9	7.96	7.0	2.19	4.6	0.05	0.1
Boletus	2.66	7.1	0.00	0.0	0.00	0.0	0.00	0.0
Clavaria	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Clitocybe	1.33	3.5	2.39	2.1	1.23	2.6	0.08	0.2
Cortinarius	8.19	21.8	5.41	4.7	6.04	12.7	7.92	17.6
Gastroid sp.	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Hydnum	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Lactarius	4.68	12.5	0.28	0.2	4.61	9.7	8.33	18.5
Leccinum	0.00	0.0	3.04	2.7	1.27	2.7	5.09	11.3
Lycoperdon	0.90	2.4	0.57	0.5	2.00	4.2	0.70	1.5
Pholiota	0.00	0.0	57.44	50.3	0.00	0.0	0.00	0.0
Ramaria	1.84	4.9	2.49	2.2	0.00	0.0	0.43	0.9
Russula	14.66	39.1	30.08	26.3	9.72	20.5	15.13	33.6
Suillus	0.00	0.0	0.00	0.0	0.00	0.0	0.11	0.2
Total	37.54		114.17		47.43		44.98	

Table 6. Number and percent of available middens occupied by Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

	June			December		
Area/Habitat	# middens	# occupied	% occ	# middens	# occupied	% occ
TRC	56	12	21.4	56	19	33.9
TRN	38	4	10.5	39	16	41.0
SFC	30	5	16.7	30	7	23.3
SFN	23	5	21.7	23	4	17.4
TR Habitat	94	16	17.0	95	35	36.8
SF Habitat	53	10	18.9	53	11	20.8
TR + SF	147	26	17.7	148	46	31.1

Comparison of midden occupancy within habitats on RSMP study areas, June and December 2016.

JUNE	
Fisher's exact test*	
within TR	P = 0.26
within SF	P = 0.73
DECEMBER	
Fisher's exact test*	
within TR	P = 0.52
within SF	P = 0.74

* Fisher's exact test used due to small sample sizes.

Table 7. Overwinter survival of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2015 - 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

	Number of Squirrels	Number of Squirrels Surviving	
Area/Habitat	Dec 2015[1]	Jun 2016	% Survival
TRC	13	6	46.2
TRN	7	2	28.6
SFC	7	5	71.4
SFN	5	1	20.0
TR Habitat	20	8	40.0
SF Habitat	12	6	50.0

Comparison of overwinter survival within and between habitats on RSMP study areas.

within TR*			P = 0.64
within SF*			P = 0.24
between habitats	$\chi^2 = 0.19$	df = 1	P = 0.66

* Fisher's exact test used due to small sample sizes.

[1] Of the 32 animals resident on the areas in Dec 2015, 5 were radio collared and/or ear-tagged thus enabling unique identification. By Jun 2016, 4 of these animals were alive and 1 was unconfirmed dead (animal not seen after March 2016). The number of marked animals in the population increases the accuracy of survival calculations.

Figure 1. Map of study areas, December 2016, University of Arizona Red Squirrel Monitoring Program, Pinaleño Mountains, Graham County, Arizona.

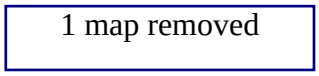


Figure 2a. Corkbark fir (*Abies lasiocarpa* var. *arizonica*) seed fall, 1993 - 2015, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. **Scales are different for figures 2a-c**.

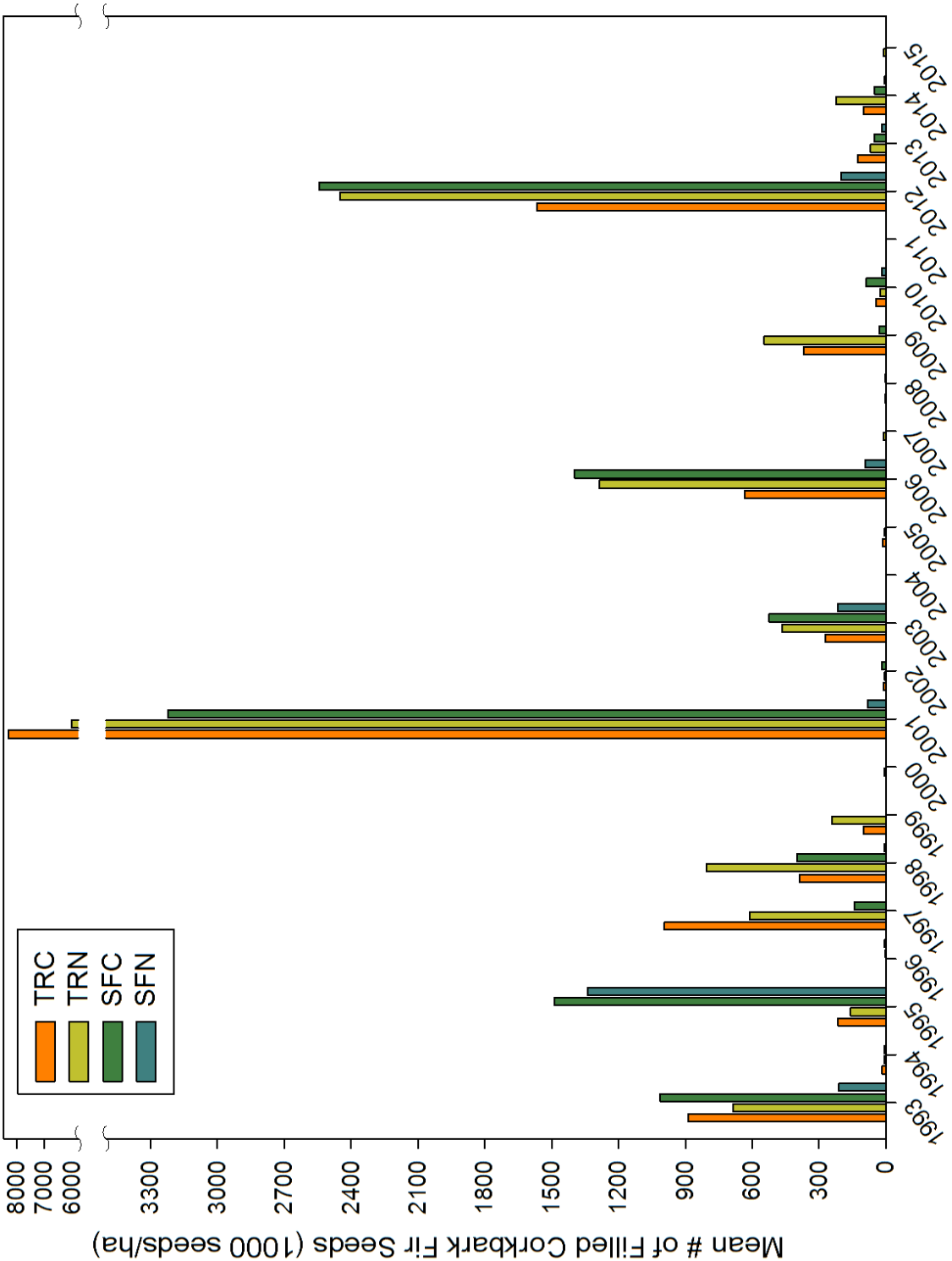


Figure 2b. Douglas-fir (*Pseudotsuga menziesii*) seed fall, 1993 - 2015, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. **Scales are different for figures 2a-c.**

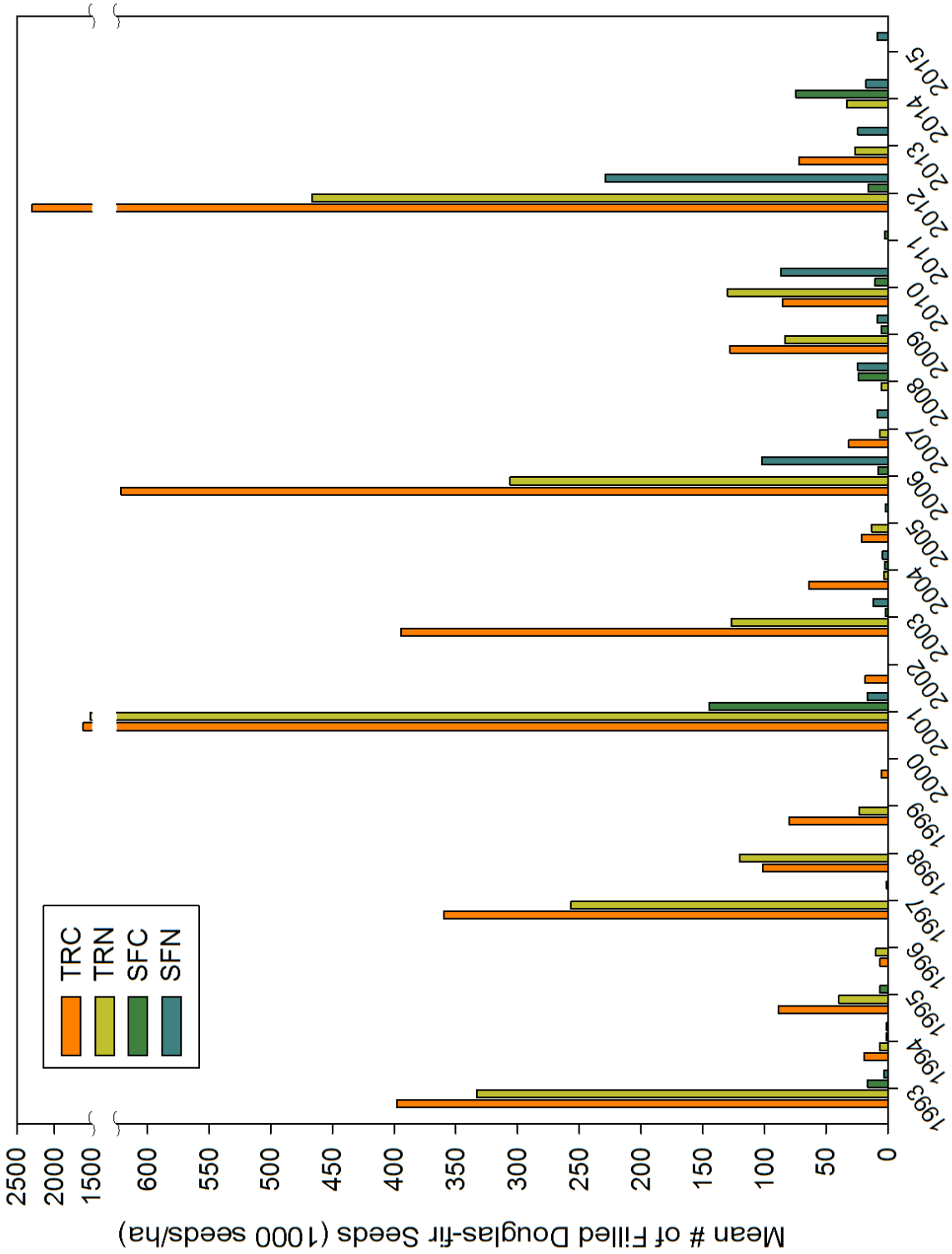


Figure 2c. Engelmann spruce (*Picea engelmannii*) seed fall, 1993 - 2015, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. **Scales are different for figures 2a-c.**

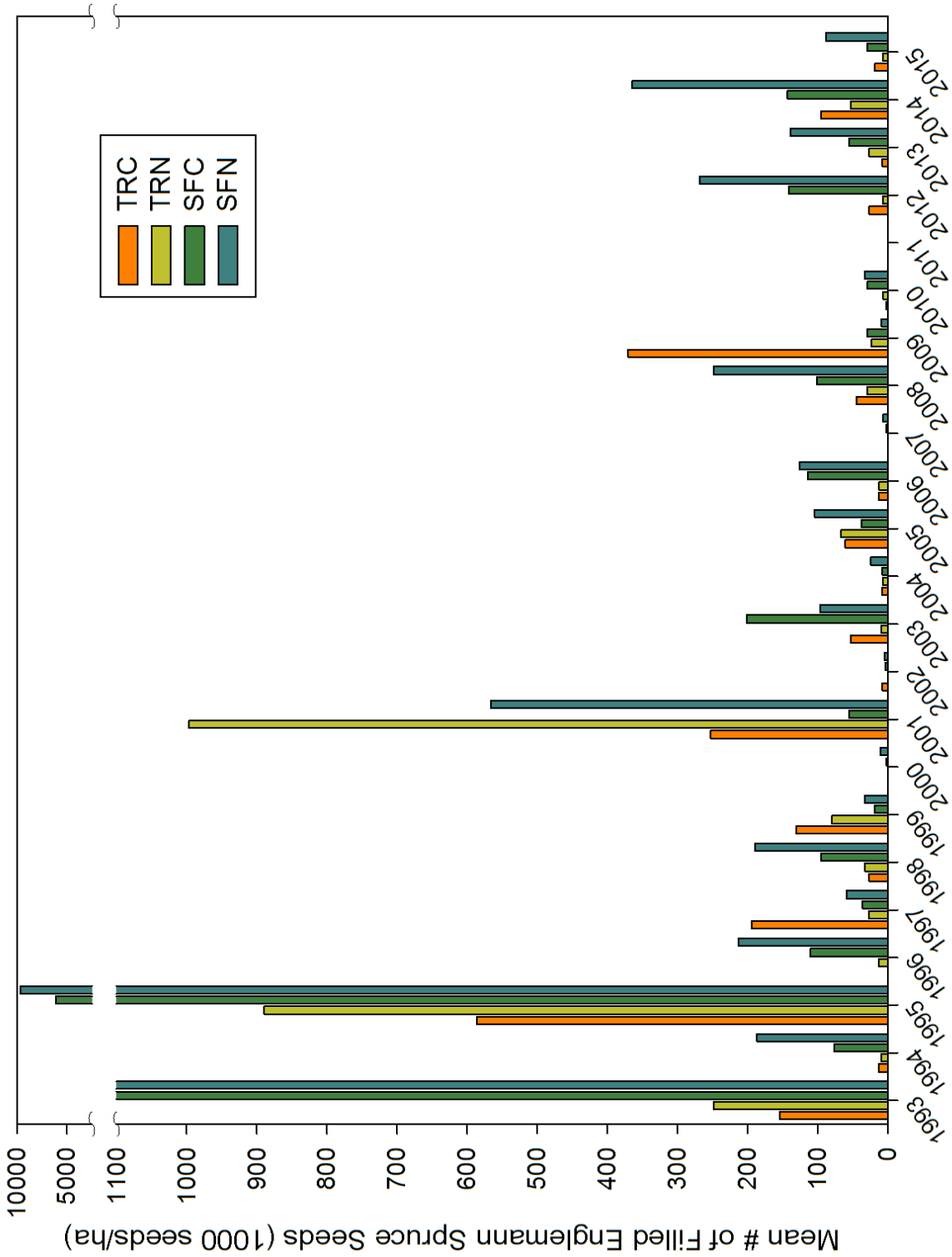


Figure 3. Mushroom crops by habitat, 1994 - 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

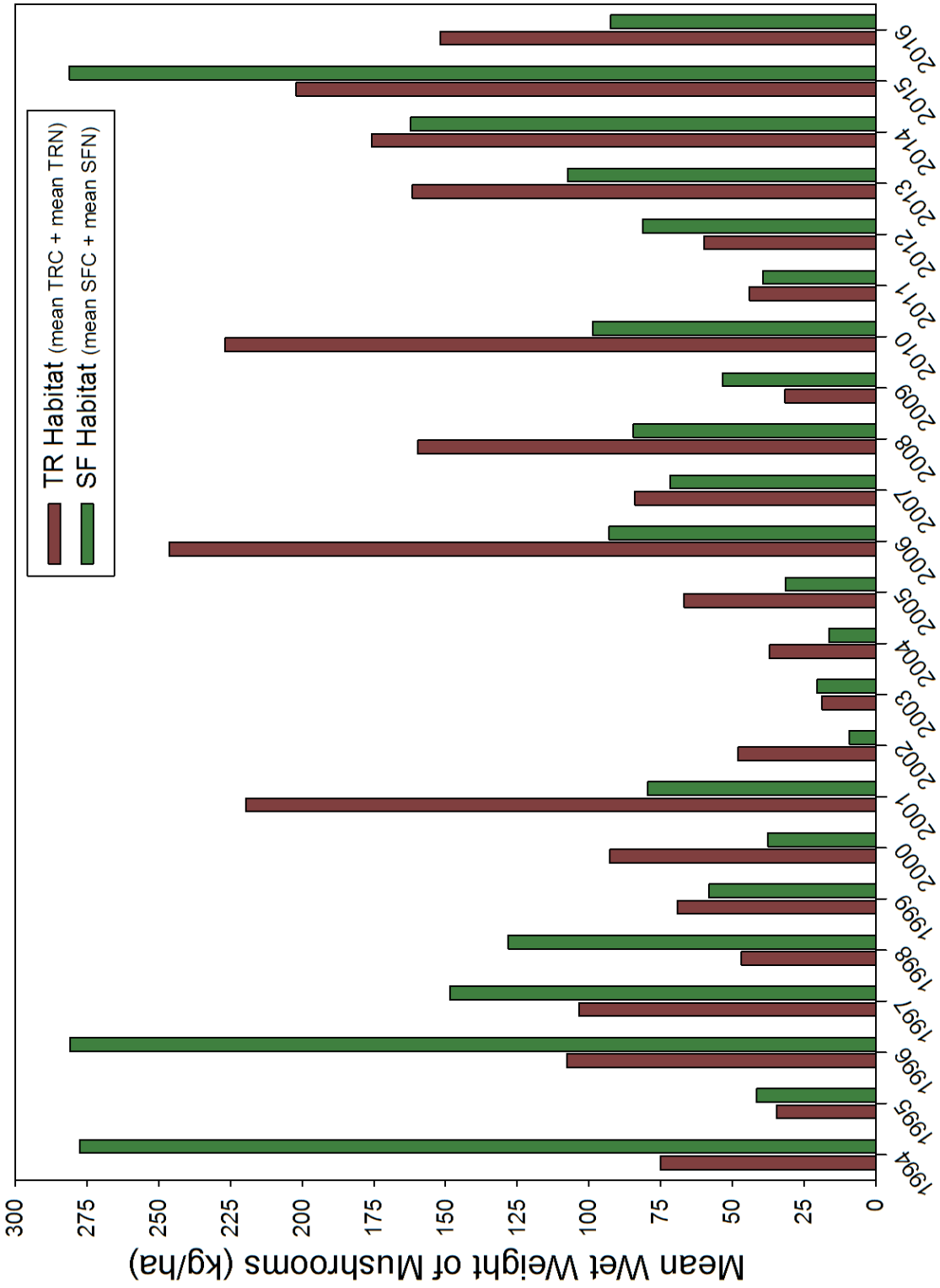


Figure 4. Quarterly Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), March 2012- December 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

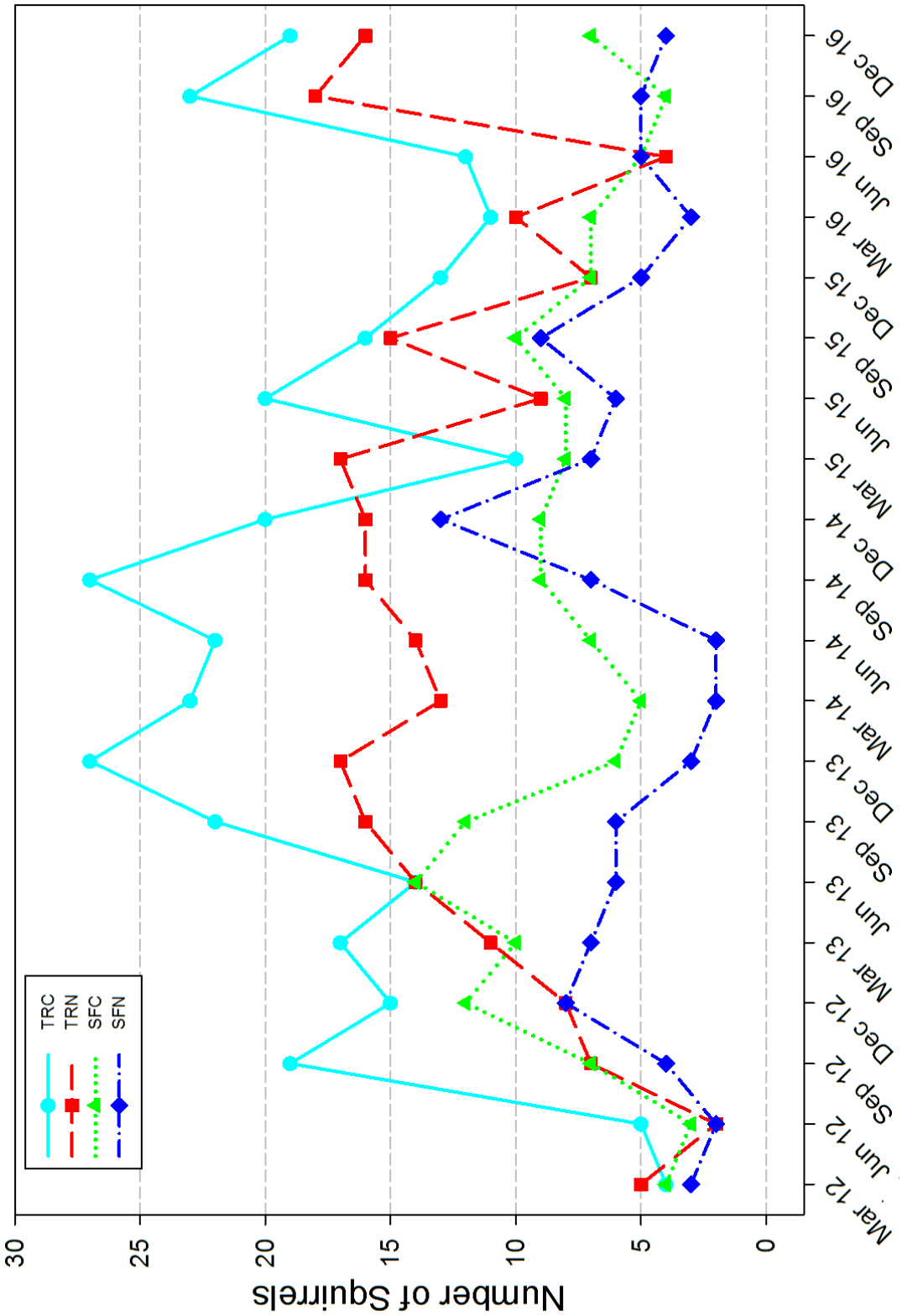
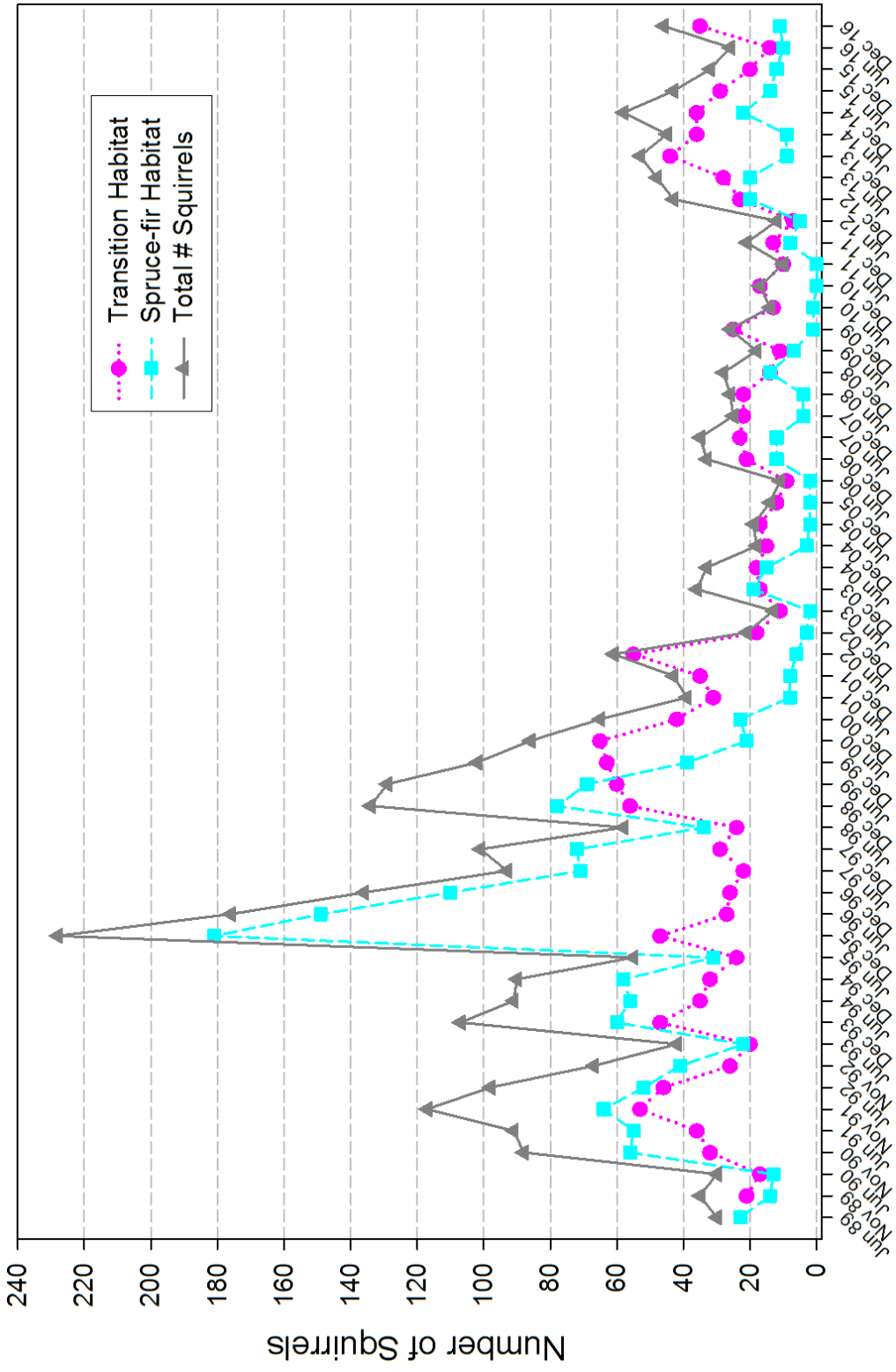


Figure 5. Summer and winter Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), by habitat, June 1989 - December 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.



Appendix A. Mean number of seeds (filled) for **2015** and mushrooms (wet weight) for **2015**, by area and habitat on University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

		Corkbark Fir	Douglas-fir	Englemann Spruce	Total Seeds	Total Mushrooms
AREA	# transects	$\bar{x}$ 1000 seeds/ha	$\bar{x}$ 1000 seeds/ha	$\bar{x}$ 1000 seeds/ha	$\bar{x}$ 1000 seeds/ha	$\bar{x}$ ww kg/ha
TRC	5	2.6	0.0	18.6	21.2	72.2
TRN	4	10.0	0.0	6.6	16.6	129.8
SFC	5	0.0	0.0	29.3	29.3	163.8
SFN	6	0.0	8.9	88.7	97.6	117.2
TR	9	5.9	0.0	13.2	19.1	97.8
SF	11	0.0	4.8	61.7	66.5	138.4

Appendix B: Midden occupancy records, 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño 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, subadult 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 the 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), 2016				
Midden	Mar	Jun	Sep	Dec
1102[89]	N	N	♀	N
1103[89]	S	♂	♂	♂
1104[89]	N	N	S	♂
1111[89]	N	N	N	N
1112[89*]	N	N	N	N
1113[89]	N	N	N	Y
1115[89]	N	N	N	N
1116[89]	N	N	N	N
1118[89]	♂ (O/O RC 1161)	♂ (O/O RC 1161)	♂ (O/O RC 1161)	♂ (O/O RC 1161)
1121[89*]	N	S	♂	S
1127[14*]	S	P	♀	S
1128[15*]	N	♂ (R/Y 1188)	S	S
1131[90*]	♀ (W/W RC 1162)	♀ (W/W RC 1162)	N	♂ (Bsq/Ysq RC 1197)
1134[91*]	N	N	N	N
1144[91*]	N	N	N	N
1147[91*]	N	N	P	N
1149[91*]	N	N	N	N
1151[91*]	N	N	N	N
1153[92*]	P	P	♂	P
1154[92*]	N	N	♀ (W/W RC 1162) + 1J	P
1156[93*]	Y	♀ (G/Y RC 1186)	♂	♂
1160[96*]	N	N	N	N
1162[96*]	N	N	N	N
1163[98*]	N	N	N	N
1164[98*]	P	P	♂	♀ (Wsq/Ysq RC 1196)
1167[98*]	♀ (W/O RC 1130)	♀ (W/O RC 1130)	P	P
1168[98*]	N	N	N	N
1169[98*]	N	N	N	N
1170[98*]	S	♀ (W/B RC 1184)	♀ (W/B RC 1184)	♂
1171[98*]	N	N	N	N
1172[90*]	N	N	N	♂
1173[99*]	N	N	N	N
1174[99*]	♂NAT 1	♀	S	S

Transition Construction Area (TRC), 2016				
Midden	Mar	Jun	Sep	Dec
1175[99*]	N	N	N	P
1176[99*]	Y	Y	S	♂
1177[99*]	N	N	♂ (R/Y 1188)	♂ (R/Y 1188)
1179[99*]	N	N	N	N
1180[99*]	N	N	N	N
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	N	N
1188[10*]	N	N	N	N
1189[10*]	N	P	♂	♀
1190[10*]	N	P	N	N
1191[10*]	N	N	N	N
1192[11*]	♀	♀	S	♀
1193[12*]	N	♀	N	Y
1194[13*]	N	N	N	N
1195[13*]	N	N	N	N
1196[13*]	N	N	N	N
1197[13*]	N	N	N	N
1198[13*]	♂	N	♀	N
1199[14*]	N	N	♀ (W/O RC 1130) + 3J	♀ (W/O RC 1130)
# Mid	56	56	56	56
# Occ	11	12	19	19
% Occ	20%	21%	34%	34%
# Sq	11	12	19 + 4J	19

1 The resident male at midden 1174 has a natural mark, a triangle shaped notch on the back of his left ear.

Transition Non-Construction Area (TRN), 2016				
Midden	Mar	Jun	Sep	Dec
2202[89]	N	N	S	♂
2203[89]	♂	♂ (Bsq/Wsq 1187)	♂	♂
2204[89]	N	N	♀	N
2205[89]	N	N	♀	N
2206[89]	S	N	♂	S
2208[89*]	P	N	S	♀
2210[90]	N	N	N	N
2211[90*]	♂ (W/G RC 1176)	♂ (W/G RC 1176)	♂	♀
2215[90*]	N	N	N	N
2216[90*]	N	N	S	♀
2217[90*]	N	N	N	N
2218[91*]	♂	N	P	N
2219[91*]	Y	N	♂	S
2223[91*]	Y	N	N	N
2227[95*]	N	N	N	N
2229[96*]	N	N	N	N
2230[96*]	N	N	N	N
2234[97*]	N	N	P	N
2235[98*]	N	N	N	N
2236[98*]	S	♂ (Y/P 1189)	♂	S
2237[98*]	N	N	N	N
2238[98]	N	N	P	N
2239[98]	N	N	N	♀
2240[98]	S	N	N	N
2241[98*]	N	N	N	N
2242[98*]	N	N	N	N
2244[99*]	N	N	♂	♀
2246[99*]	N	N	S	♂
2248[99*]	♂	♀	N	N
2249[99*]	N	N	N	N
2250[00*]	N	N	♂	♀
2252 [08*]	N	N	♀	N
2253 [09*]	♂	N	S	♂
2255 [11*]	N	N	N	N

Transition Non-Construction Area (TRN), 2016				
Midden	Mar	Jun	Sep	Dec
2256 [12*]	N	N	Y	♀
2257 [13*]	N	N	P	N
2258 [14*]	N	N	♀	N
2259 [16*]	new midden		Y	Y
2260 [14*]	N	N	N	Y
# Mid	38	38	39	39
# Occ	10	4	18	16
% Occ	26%	11%	46%	41%
# Sq	10	4	18	16

Spruce-Fir Construction Area (SFC), 2016				
Midden	Mar	Jun	Sep	Dec
3002[95*]	N	N	N	N
3020[96*]	N	P	P	Y
3022[96*]	Y	Y	N	N
3028[99*]	N	P	N	P
3033[12*]	N	N	N	N
3034[12*]	S	P	N	N
3035[13*]	N	N	N	N
3036[13*]	N	N	N	N
3303[94*]	N	N	N	N
3310[95*]	Y	Y	♂	Y
3311[95*]	P	N	N	N
3312[95*]	N	N	N	N
3314[95*]	N	N	N	N
3323[95*]	S	Y	N	Y
3328[95*]	N	N	N	N
3330[95*]	N	N	N	N
3341[95*]	N	N	N	N
3346[95*]	Y	P	S	N
3348[95*]	S	♀	P	Y
3360[86]	N	N	♀	S
3362[86]	N	N	N	N
3365[86]	N	N	N	S
3366[86]	N	N	N	N
3370[86]	N	N	N	N
3371[87]	N	N	P	N
3372[89]	N	N	N	N
3374[89]	N	N	N	N
3378[90*]	Y	Y	S	Y
3382[91*]	N	N	N	N
3394[93*]	N	N	N	N
# Mid	30	30	30	30
# Occ	7	5	4	7
% Occ	23%	17%	13%	23%
# Sq	7	5	4	7

Spruce-Fir Non Construction Area (SFN), 2016				
Midden	Mar	Jun	Sep	Dec
4000[95*]	N	N	N	N
4010[95*]	N	N	N	N
4023[98*]	N	N	N	N
4026[09*]	N	N	♂	Y
4027[12*]	N	N	N	N
4028[14*]	P	N	N	N
4029[15*]	Y	N	N	N
4400[89]	N	N	N	N
4417[95*]	N	N	N	N
4465[90*]	N	S	N	N
4466[87]	N	♀	S	N
4467[87]	N	N	N	N
4469[87]	N	♂	N	N
4470[87]	N	♀	Y	P
4471[87]	Y	N	N	Y
4472[87]	N	N	N	N
4473[87]	N	N	N	N
4474[86]	N	N	N	N
4477[87]	N	N	N	N
4484[86]	N	P	N	N
4488[91*]	P	N	♂	Y
4491[91*]	Y	S	♀	♂
4492[91*]	N	N	N	N
# Mid	23	23	23	23
# Occ	3	5	5	4
% Occ	13%	22%	22%	17%
# Sq	3	5	5	4

Off-Area Midden Occupancy, 2016				
Midden	Mar	Jun	Sep	Dec
TRC Area				
5101[89]	S	♂	Y	♀ + SA
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	N	N
5119[89*]	♀ (R/W RC 1177)	N	S	♂
5121[89*]	Y	♀ (R/W RC 1177)	♀ (R/W RC 1177)	♀ (R/W RC 1177)
5125[89*]	N	N	N	N
5126[91]	N	N	N	N
5145[91*]	N	N	N	N
5150[91*]	♀ (P/G RC 1171)	♀ (P/G RC 1171)	♀ (P/G RC 1171)	♀ (P/G RC 1171)
5155[93*]	P	P	P	P
5157[93*]	Y	P	S	♂
5159[12]	N	N	N	N
5161	new midden			♀ (B/B RC 1168)
TRN Area				
5200[93*]	♂	N	N	N
5201[99*]	N	N	N	S
5203[00*]	N	N	N	♀
5221[91*]	N	N	N	S
5231[96*]	N	N	N	N
5232[96*]	S	S	Y	♂ (Rsq/Psq RC 1179)
SFC Area				
5311[95*]	N	N	N	N
5313[95*]	N	N	N	N
5350[86]	S	N	N	Y
5361[96*]	N	N	N	N
5377[87]	N	N	N	N
SFN Area				
5405[87]	N	N	N	N
5413[95*]	N	N	N	N

Appendix C. Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles at maternal middens), March 2012 - December 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

Date	TRC	TRN	SFC	SFN	TOTAL
Mar 2012	4	5	4	3	16
Jun 2012	5	2	3	2	12
Sep 2012	11 + 8 Juv	7	3 + 4 Juv	4	25 + 12 Juv
Dec 2012	15	8	12	8	43
Mar 2013	17	11	10	7	45
Jun 2013	14	10 + 4 Juv	14	6	44 + 4 Juv
Sep 2013	22	16	12	6	56
Dec 2013	27	17	6	3	53
Mar 2014	23	13	5	2	43
Jun 2014	19 + 3 Juv	14	7	2	42 + 3 Juv
Sep 2014	21 + 6 Juv	16	9	7	53 + 6 Juv
Dec 2014	20	16	9	13	58
Mar 2015	10	17	8	7	42
Jun 2015	17 + 3 Juv	9	8	6	40 + 3 Juv
Sep 2015	16	15	10	9	50
Dec 2015	13	7	7	5	32
Mar 2016	11	10	7	3	31
Jun 2016	12	4	5	5	26
Sep 2016	19 + 4 Juv	18	4	5	46 + 4 Juv
Dec 2016	19	16	7	4	46

Appendix D: Quarterly occupancy maps for Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), March, June, September, and December 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

12 maps removed, pages 36-47

Appendix E: Reproductive success of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2016 on or near [1] University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño 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.

---

1 Reproductive success notes for squirrels at middens ≥ 100 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 - 2016

Breeding chases observed on or near the University of Arizona Red Squirrel Monitoring Program study areas in 2016. Information on breeding chases in other areas of the Pinaleño Mountains is included here to provide a general time frame for red squirrel breeding activity.

Date	Location	Notes
26 May 16	5123	Marked female 1168 appeared to be in estrus based on examination during trapping. Several males, including two radio-collared males were observed around her midden during this week.
14 Jun 16	8020	Two unmarked squirrels observed in copulation.
16 Jun 16	8053	Several squirrels in the area chasing, one copulation was observed

Appendix E-2: Litters observed in 2016 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 Appendix C).

Mother ID	Midden/Nest	Date Litter 1st Seen	Notes
1130	1153/11050	12 Aug 16	3 juveniles
1162	1154/11041	16 Aug 16	1 juvenile
1171	5150/15105	5 Oct 16	1 juvenile
1173	8043/18384	5 Oct 16	3 juveniles
1184	1115/11272	5 Oct 16	2 juveniles
1185	8068/18087	24 Aug 16	1 juvenile
1190	8022/18533	21 Jul 16	2 juveniles
1192	8036/18538	14 Sep 16	2 juveniles
Total	8 litters		15 juveniles

Appendix F. Weather information, 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

F-1: Monthly weather summaries*

F-2: Accumulated snow depths

*Due to various hardware and software problems, complete data is missing for some months.

Additional weather data for RSMP study areas can be obtained from the RAWS (remote automated weather station) at the Columbine ranger station. Please consult the Western Regional Climate Center webpage at www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?azACOL

Appendix F-1: Monthly weather summaries - 2016, Biology Camp.

Biology Camp Weather Summary

Date: Jan 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-16.100		5.000		0.000	0.000		
Avg	-1.807		54.299		1.702	4.435		
Max	14.440		100.000		6.259	17.430		
Total								
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South West

Date: Feb 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-17.210		5.000		0.000	0.000		
Avg	1.567		39.318		1.277	3.531		
Max	18.330		100.000		8.941	18.330		
Total								
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South East

Date: Mar 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-7.777		5.000		0.000	0.000		
Avg	2.988		41.453		2.403	5.771		
Max	13.890		100.000		8.047	18.330		
Total								
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South West

Date: Apr 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-6.300	706.000	19.000	-16.400	0.000	0.000	-8.200	0.000
Avg	3.289	715.813	58.544	-5.332	0.556	2.053	3.057	
Max	15.800	724.200	100.000	3.400	2.200	8.050	15.800	0.000
Total								0.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South East

Appendix F-1 (cont.):

Biology Camp Weather Summary

Date: May 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-3.600	708.800	18.000	-15.100	0.000	0.000	-3.600	0.000
Avg	7.249	717.454	50.794	-3.440	0.558	2.062	7.169	
Max	19.000	724.800	100.000	6.800	1.800	6.440	19.000	0.000
Total								0.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: West

Date: Jun 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	5.100	717.600	13.000	-8.200	0.000	0.000	5.100	0.000
Avg	14.436	723.479	52.108	3.045	0.340	1.279	14.435	
Max	27.100	727.600	100.000	14.000	1.300	4.830	27.100	6.000
Total								44.000
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South East

Date: Jul 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	8.300	720.500	34.000	1.700	0.000	0.000	8.300	0.000
Avg	14.794	723.983	72.890	9.554	0.200	0.762	14.794	
Max	23.400	727.200	100.000	16.600	1.300	4.830	23.400	12.200
Total								86.200
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South East

Date: Aug 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	5.900	719.100	47.000	2.000	0.000	0.000	5.900	0.000
Avg	11.681	721.698	86.785	9.361	0.127	0.485	11.679	
Max	19.800	724.300	100.000	15.000	2.200	8.050	19.800	15.000
Total								84.400
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South East

Appendix F-1 (cont.):

Biology Camp Weather Summary

Date: Sep 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	0.556	716.400	19.000	-6.100	0.000	0.000	3.500	0.000
Avg	10.238	720.641	78.993	7.279	0.795	2.193	10.675	
Max	21.110	725.500	100.000	15.000	4.917	10.730	19.100	12.800
Total								137.200
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South West

Date: Oct 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-1.110	717.000	26.000	-11.200	0.000	0.000	4.500	0.000
Avg	8.895	720.964	62.038	1.395	0.956	2.426	9.524	
Max	16.670	724.600	100.000	8.800	5.812	11.620	15.200	1.200
Total								2.800
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: North

South South West

Date: Nov 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-12.500	703.900	10.000	-25.800	0.000	0.000	-14.200	0.000
Avg	2.512	717.251	63.318	-5.082	0.588	2.180	2.159	
Max	14.200	723.500	100.000	5.800	1.800	6.440	14.200	1.600
Total								11.600
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: West

Date: Dec 2016

Recording Interval: 60min

	Outside Temperature	Barometric Pressure	Relative Humidity	Dew Point	Wind Speed	Max Wind Speed	Wind Chill	Rain
Min	-12.770	707.100	9.000	-23.800	0.000	0.000	-7.000	0.000
Avg	0.542	715.281	67.955	-7.368	1.425	3.749	1.005	
Max	14.440	721.800	100.000	1.800	8.047	19.220	10.800	0.400
Total								3.600
	C	millibars	%	C	meters/sec	meters/sec	C	millimeters

Predominant Wind Direction: South West

F-2: ***Accumulated*** snow depths on the monitored areas for Winter 2015 - 2016.

Snow Depth Summary

Snow Year Year	*Month*	*Habitat*	*Location*	*Avg Depth (cm)*	*Min Depth (cm)*	*Max Depth (cm)*	*Avg. % Cover*	*# of Readings for Avg.*
2015-2016								
2015	Nov	Spruce-fir	Clearing	7.5	5	10	100.0	2
2015	Nov	Spruce-fir	Forest	5.5	2	9	100.0	2
2015	Nov	Transition	Clearing	1.0	1	1	25.0	1
2015	Nov	Transition	Forest	0.0	0	0	5.0	1
2015	Dec	Spruce-fir	Clearing	8.5	0	21	37.5	4
2015	Dec	Spruce-fir	Forest	4.5	0	10	20.0	4
2015	Dec	Transition	Clearing	24.1	3	35	91.2	10
2015	Dec	Transition	Forest	25.3	2	46	90.5	10
2016	Jan	Transition	Clearing	98.9	90	112	100.0	6
2016	Jan	Transition	Forest	92.0	70	116	100.0	6
2016	Feb	Transition	Clearing	71.8	31.5	92	96.7	6
2016	Feb	Transition	Forest	67.4	46	96	100.0	5
2016	Mar	Spruce-fir	Clearing	48.7	0	96	61.7	3
2016	Mar	Spruce-fir	Forest	35.0	0	60	73.3	3
2016	Mar	Transition	Clearing	33.1	0	59	66.3	4
2016	Mar	Transition	Forest	13.0	0	52	43.8	4
2016	Apr	Transition	Clearing	2.7	0	16	24.8	6
2016	Apr	Transition	Forest	3.1	0	5.5	36.2	6
		Averages for Snow Year		30.1	13.9	46.5	65.1	***Sum # Readings***
			Std Dev	32.45				83
			SE of Mean	3.56				