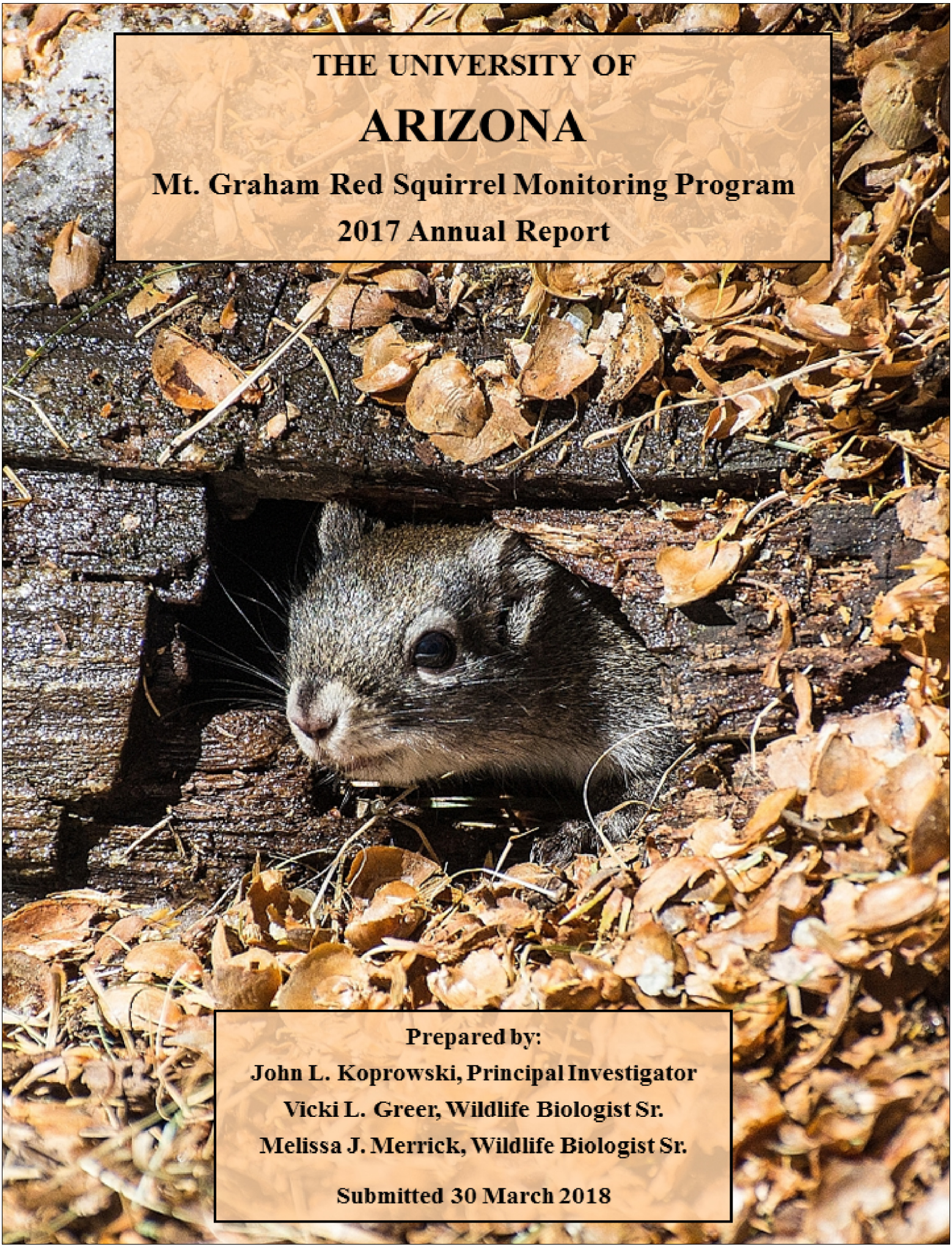

THE UNIVERSITY OF ARIZONA

Mt. Graham Red Squirrel Monitoring Program

2017 Annual Report

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Submitted 30 March 2018

EXECUTIVE SUMMARY

In 2017, the University of Arizona Mt. Graham Red Squirrel Monitoring Program (RSMP) 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.

The Frye Fire began on 7 Jun 17 as a lightning strike on the NE side of the range, by the time the fire was contained in mid July, the total fire perimeter encompassed approximately 19604 hectares (48443 acres), spread over most of the Pinaleño range. USFS Burned Area Response Team (BAER) estimated the damage within the fire perimeter, assigning almost 16% as moderate to severe burn. Many of RSMP activities in the latter half of 2017 were dedicated to assessing impacts to red squirrels and habitats on the monitored and other areas.

Four quarterly censuses (Mar, Jun, Sep, Dec) of all middens on or near monitored areas were conducted in 2017. From December 2016 to December 2017, the number of red squirrels on the monitored areas decreased, from 46 to 8. Each of the four study areas had impacts from the Frye Fire, with several middens sustaining severe burn damage to the understory and canopy, often with few or no live trees remaining in the 10m radius surrounding the midden center. In the September census, immediately following the fire, there were only 4 occupied middens found, however, by December 2017, this number increased to 8 occupied middens.

Through telemetry and observation efforts immediately following the fire, we were able to locate alive 17 of the 21 radio-collared or ear-tagged red squirrels known before the fire on or near the main RSMP study areas and another research area near [Redacted]. We have tracked the fate of these animals throughout 2017 and into early 2018; 9 animals are still alive as of March 2018.

Ten females on or near the monitored areas were noted to be lactating or pregnant from mid May through mid June and 2 litters (6 juveniles total) were confirmed in June. However, no observations were possible from June until August due to the Frye Fire and restricted access to the study areas.

Yearly seed production is reported as the mean number of 1000 *filled* seeds per hectare. The total seed crop in 2016 (one year delay due to methodology) was moderate, ranked 12th of 24 years of data since 1993. The 2016 overall mean seed crop was 666.9 (1000 seeds/ha), larger than the 2015 crop, 164.7 (1000 seeds/ha), but smaller the 2014 crop, 1164.2.

No mushroom data collection occurred in 2017 due to the Frye Fire in June/July 2017 and the restricted access to the study areas until mid August. Few mushrooms were observed in late August/September on the areas while completing other tasks.

Overwinter survival, calculated as animals surviving from December 2016 to June 2017 in

transitional (TR) habitat was 57% (20 of 35 squirrels surviving); the 16th lowest percentage of overwinter survival (28 years of data). In SF habitat, overwinter survival, 27% (3 of 11 squirrels surviving), was lower and ranked 25th of 27 years of data. For comparison, survival from the previous winter, 2015-2016, was 40% (8 of 20 squirrels surviving) in TR habitat and 50% (6 of 12 squirrels surviving) in SF habitat. There were 5 marked squirrels on the monitored areas in December 2016, and by June 2017, 4 were known alive, with 1 unconfirmed mortality (radio collar signaling in nest after April 2017).

[All Map and Location Redacted]

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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° 42' N, 109° 53' W). In 2017, 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 2017.

The Frye Fire began on 7 June 17 as a lightning strike on the NE side of the range, in a burn scarred area from the 2004 Nuttall Complex fire. By the time the fire was contained in mid July, the total fire perimeter encompassed approximately 19604 hectares (48443 acres), spread over most of the Pinaleño range. USFS Burned Area Response Team (BAER) estimated the damage within the fire perimeter, assigning almost 16% as moderate to severe burn. For detailed information about the impacts of the Frye Fire on the monitored and other study areas see Appendices G and H.

All use of terms *red squirrel* or *squirrel* refers to the Mt. Graham red squirrel unless otherwise noted.

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. Three 0.25 m^2 seed traps were randomly placed within a 10 m x 10 m plot at each location. Seeds from the 2016 crop were collected from the seed traps in June 2017. 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) are generally collected at these 20 sites (Figure 1) from late July through late September/early October each year. We alternate plot collection orientation (east-west or north-south) 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).

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 2017, 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 2017, 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).

Overwinter Survival

Overwinter survival was estimated for squirrels on the monitored areas. During a complete census in December 2016, the number of occupied middens and the identity of resident squirrels were determined. December 2016 occupancy was then compared to occupancy for June 2017. 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 2017, 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-2017: SP501610), 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 < 7g). 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

2016 *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 (24), the total 2016 seed crop was moderate, ranked 12 of 24 years of data since 1993. Corkbark fir was the most abundant (in numbers) seed in 2016, and ranked 10 of 24. Engelmann spruce was the second most abundant seed in 2016 and ranked 16 of 24. Douglas-fir was the least abundant seed in 2016, and ranked 17 of 24. The 2016 overall mean seed crop was 666.9 (1000 seeds/ha), larger than the 2015 crop, 164.7 (1000 seeds/ha), but smaller the 2014 crop, 1164.2 (1000 seeds/ha) (Table 3, Figures 2a-c, Appendix A).

2017 *Mushroom Production*

No mushroom data collection occurred in 2017 due to the Frye Fire in June/July 2017 and the restricted access to the study areas until mid August. Few mushrooms were observed in late August/September on the areas while completing other tasks. In 2018, we will fully evaluate damage to the 20 plots that existed prior to the Frye Fire and repair and/or establish new plots on the study areas.

Population Biology

Midden Occupancy

Four quarterly censuses (Mar, Jun, Sep, Dec) of all middens on or near monitored areas were conducted in 2017 (Appendix B). From December 2016 to December 2017, the number of red squirrels on the monitored areas decreased, from 46 to 8. Each of the four study areas had impacts from the Frye Fire, with several middens sustaining severe burn damage to the understory and canopy, often with few or no live trees remaining in the 10m radius surrounding the midden center (Appendix G). In the September census, immediately following the fire, there were only 4 occupied middens found, however, by December 2017, this number increased to 8 occupied middens (Figure 3.)

Overwinter Survival

The number of squirrels that survived the winter of 2016-2017 (December 2016 to June 2017) in TR habitat was 57% (20 of 35 squirrels surviving); the 16th lowest percentage of overwinter survival (28 years of data). In SF habitat, overwinter survival, 27% (3 of 11 squirrels surviving), was lower and ranked 25th of 27 years of data. For comparison, survival from the previous winter, 2015-2016, was 40% (8 of 20 squirrels surviving) in TR habitat and 50% (6 of 12 squirrels surviving) in SF habitat. There were 5 marked squirrels on the monitored areas in December 2016, and by June 2017, 4 were known alive, with 1 unconfirmed mortality (radio collar signaling in nest after April 2017).

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 2017, two breeding chases were observed on the monitored areas and 3 chases were seen on nearby study areas indicating breeding activity during May (Appendix E-1). Based on information from census and trapping records, most resident adult males had testes fully scrotal March through early September and again in December.

From May through August, several females seen or trapped during these months were found to be either pregnant or lactating. The first lactating females were observed in mid May and the latest was observed on 9 August. Direct evidence of 2 litters (6 juveniles emerged from natal nests) was documented on or near the areas during censuses or other activities. Litters were confirmed in mid June, however no observations were possible from then until August due to the Frye Fire and restricted access to the study areas (Appendix E-2).

Trapping and Marking

In 2017, 11 squirrels (4 male, 7 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

All major features (middens, roads, trails, construction areas, etc.) have been mapped in years prior to 2017. New nests or habitat plots were GPS located and added to databases and maps. Fire severity information from USFS BAER team was overlaid on existing RSMP maps to aid in assessments of damage to study areas and middens (Appendix G).

Weather Data

Weather data were collected from January - December 2017 from the Columbine RAWS weather station (TR habitat) due to several equipment failures, some due to the Frye Fire. From available data, maximum temperature recorded was 27.2 °C in June and the minimum temperature recorded was -116.7 °C in January. The maximum average monthly temperature was 15.5 °C in June and the minimum average monthly temperature was -1.1 °C in January (Appendix F-1). The maximum total monthly rainfall was recorded in July, at 308.1 mm (Appendix F-1). Snow depth was recorded from nine pairs of snow poles. The average ***accumulated*** snow depth from December 2016 - April 2017 ranged from 0.0 cm to 65.0 cm (Appendix F-2). For comparison, average accumulated snow depths for the previous winter (November 2015 - April 2016), ranged from 0.0 cm to 98.9 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

Based on information from USFS Forest Health website (see below), activity of bark beetles (*Dryocoetes confusus*, *Dendroctonus rufipennis, D. pseudotsugae*, and *D. brevicomis*) in Graham County was minimal in 2016 (data for 2017 not yet available). 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

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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, 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
After Frye Fire June/July 2017 [2]	50.18	19.74	56.02	32.99	158.93

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.

2 Area sizes were reduced by the number of hectares within each perimeter classified as Severe soil burn by USFS BAER team assessments. Many middens in areas classified as Moderate soil burn had locally heavier damage. However, as the damage was scattered throughout these areas, they were not removed from the total size.

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, **2016**, 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	215.8	77.9	15.9	5.7	45.2	16.3
TRN	4	253.1	83.5	13.3	4.4	36.6	12.1
SFC[1]	4	14.9	26.4	0.0	0.0	41.6	73.6
SFN[1]	5	0.0	0.0	10.6	34.6	19.9	65.3
TR Habitat	9	232.4	80.5	14.8	5.1	41.4	14.3
SF Habitat	9	6.6	15.8	5.9	14.0	29.6	70.3

1 Due to the evacuation in June 2017 for the Frye Fire, one plot each on the SFC and SFN areas was not collected.

Table 4. Number and percent of available middens occupied by Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2017, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

	June			December [1]		
Area/Habitat	# middens	# occupied	% occ	# middens	# occupied	% occ
TRC	56	18	32.1	35	3	8.6
TRN	40	14	35.0	24	3	12.5
SFC	30	3	10.0	8	2	25.0
SFN	23	3	13.0	4	0	0.0
TR Habitat	96	32	33.3	59	6	10.2
SF Habitat	53	6	11.3	12	2	16.7
TR + SF	149	38	25.5	71	8	11.3

1 Middens that had severe fire damage from the Frye Fire and no longer viable squirrel habitat were removed from the totals for December 2017.

Table 5. Overwinter survival of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2016 - 2017, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

	Number of Squirrels	Number of Squirrels Surviving	
Area/Habitat	Dec 2016[1]	Jun 2017	% Survival
TRC	19	11	57.9
TRN	16	9	56.3
SFC	7	1	14.3
SFN	4	2	50.0
TR Habitat	35	20	57.1
SF Habitat	11	3	27.3

[1] Of the 46 animals resident on the areas in Dec 2016, 5 were radio collared and/or ear-tagged thus enabling unique identification. By Jun 2017, 4 of these animals were alive and 1 was unconfirmed dead (collar signaling in a nest after April 2017). The number of marked animals in the population increases the accuracy of survival calculations.

Figure 1. Map of study areas, December 2017 University of Arizona Red Squirrel Monitoring Program, Pinaleño Mountains, Graham County, Arizona. Soil burn severity data is from the USFS BAER assessment team.

[Map Redacted]

Figure 2a. Corkbark fir (*Abies lasiocarpa* var. *arizonica*) seed fall, 1993 - 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. **Scales are different for figures 2a-c**.

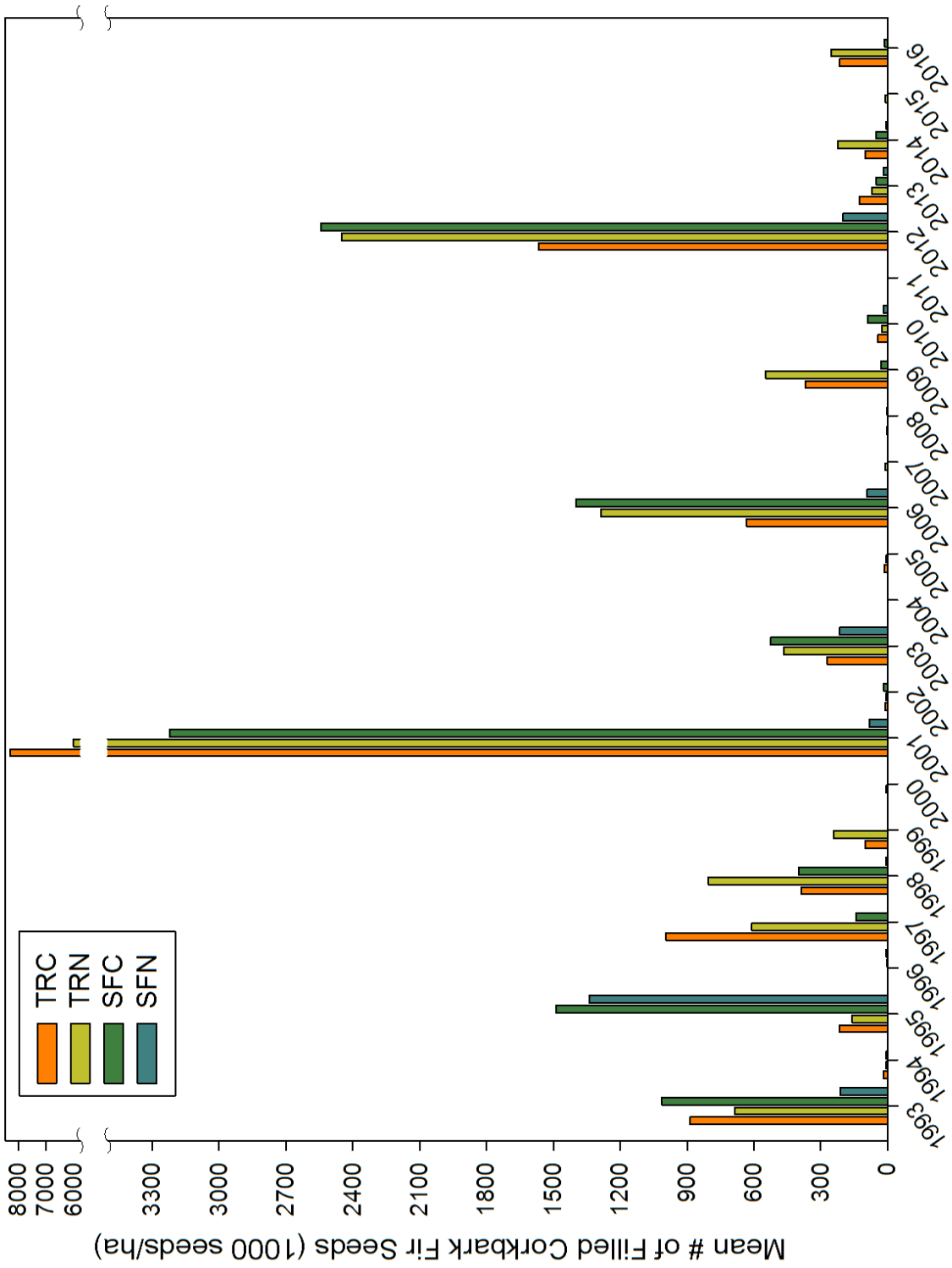


Figure 2b. Douglas-fir (*Pseudotsuga menziesii*) seed fall, 1993 - 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. **Scales are different for figures 2a-c.**

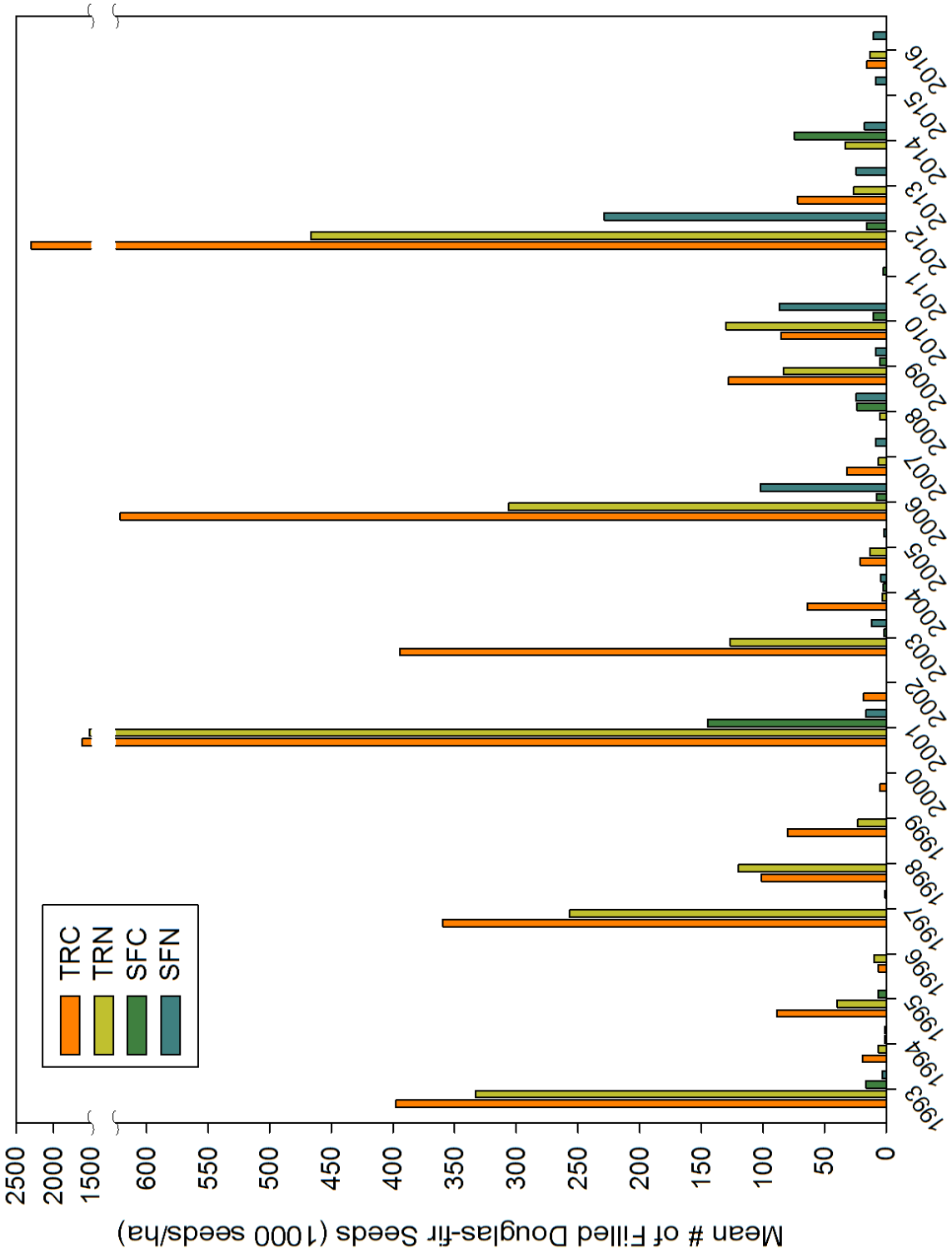


Figure 2c. Engelmann spruce (*Picea engelmannii*) seed fall, 1993 - 2016, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona. **Scales are different for figures 2a-c.**

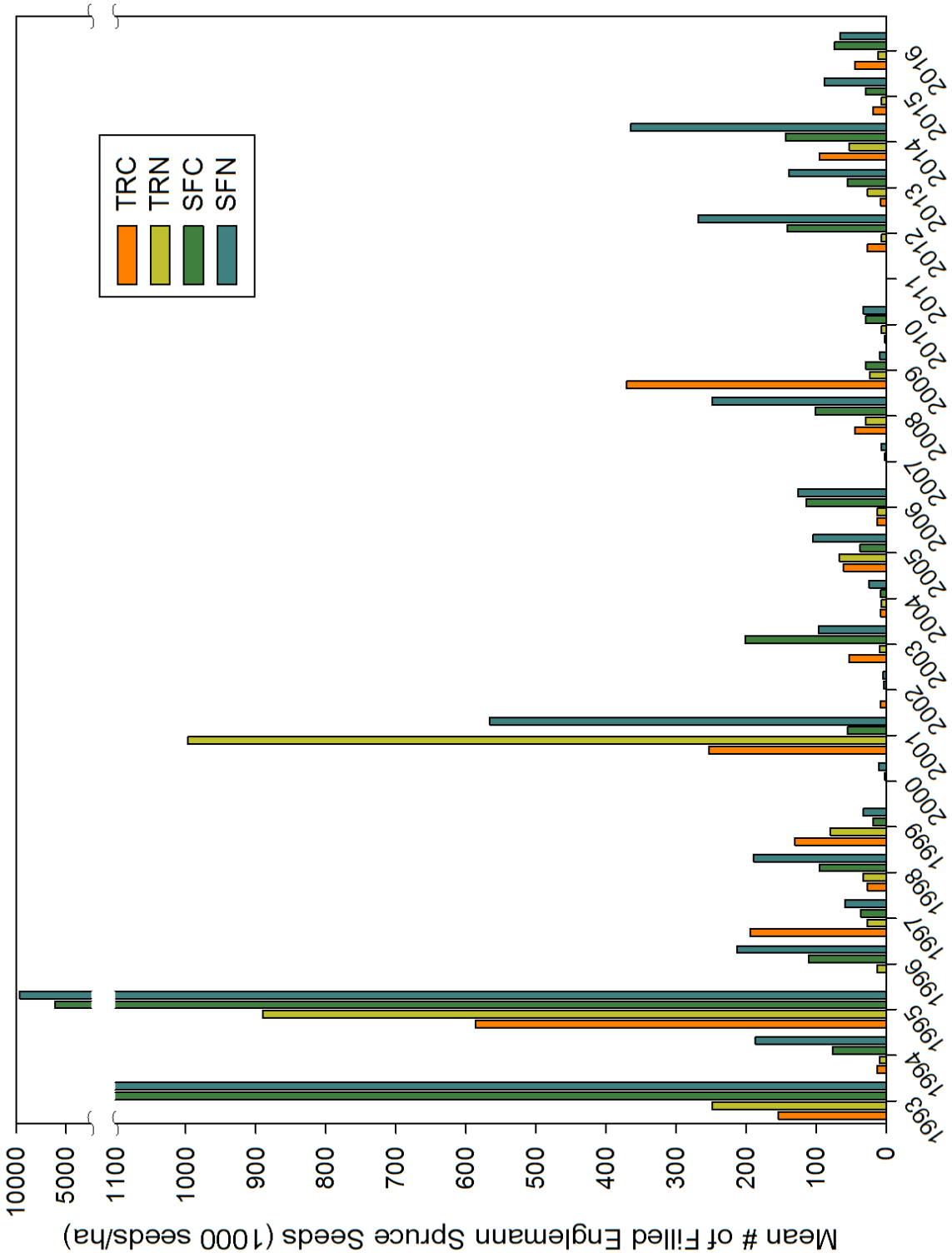


Figure 3. Quarterly Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), March 2013- December 2017, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

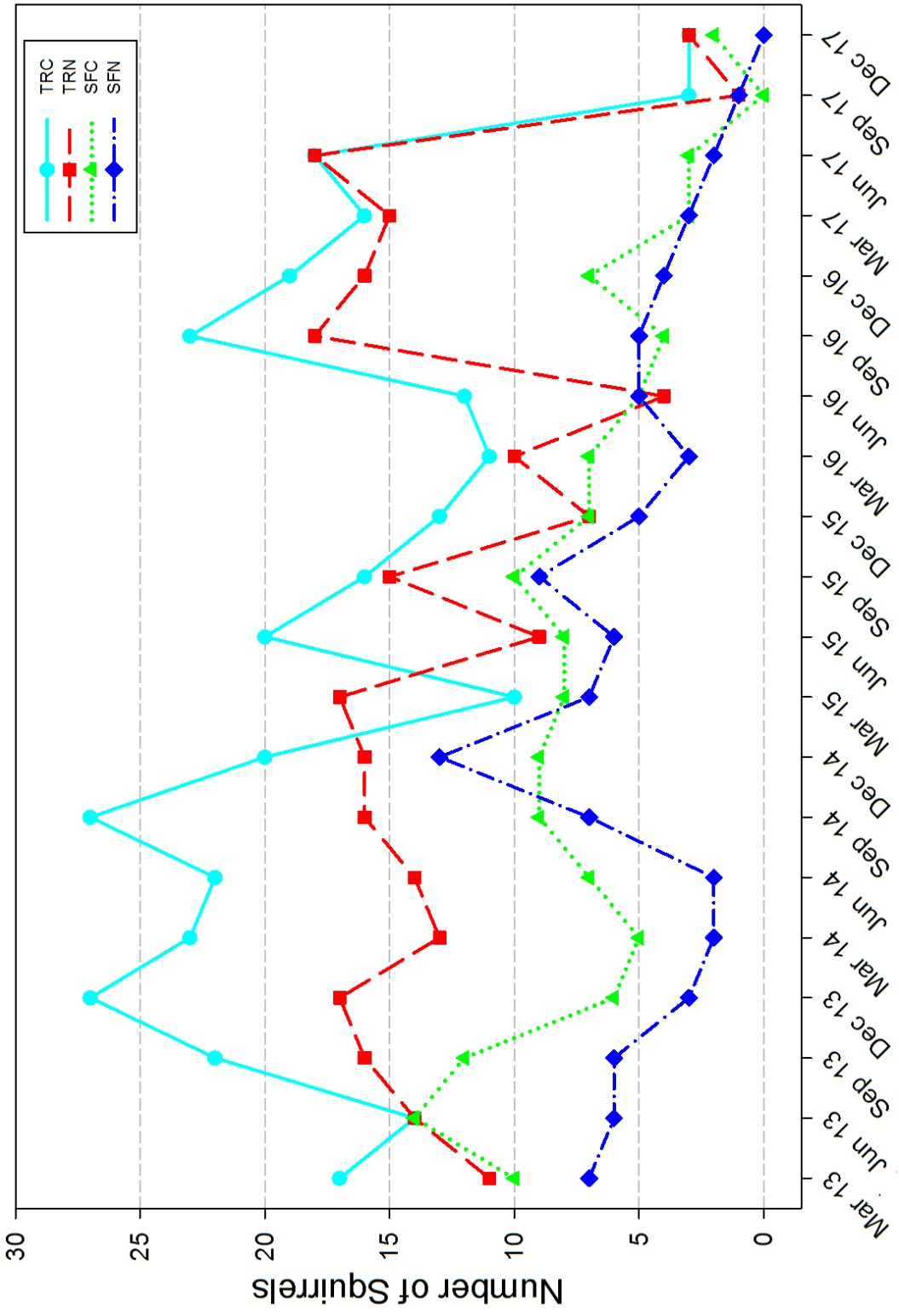
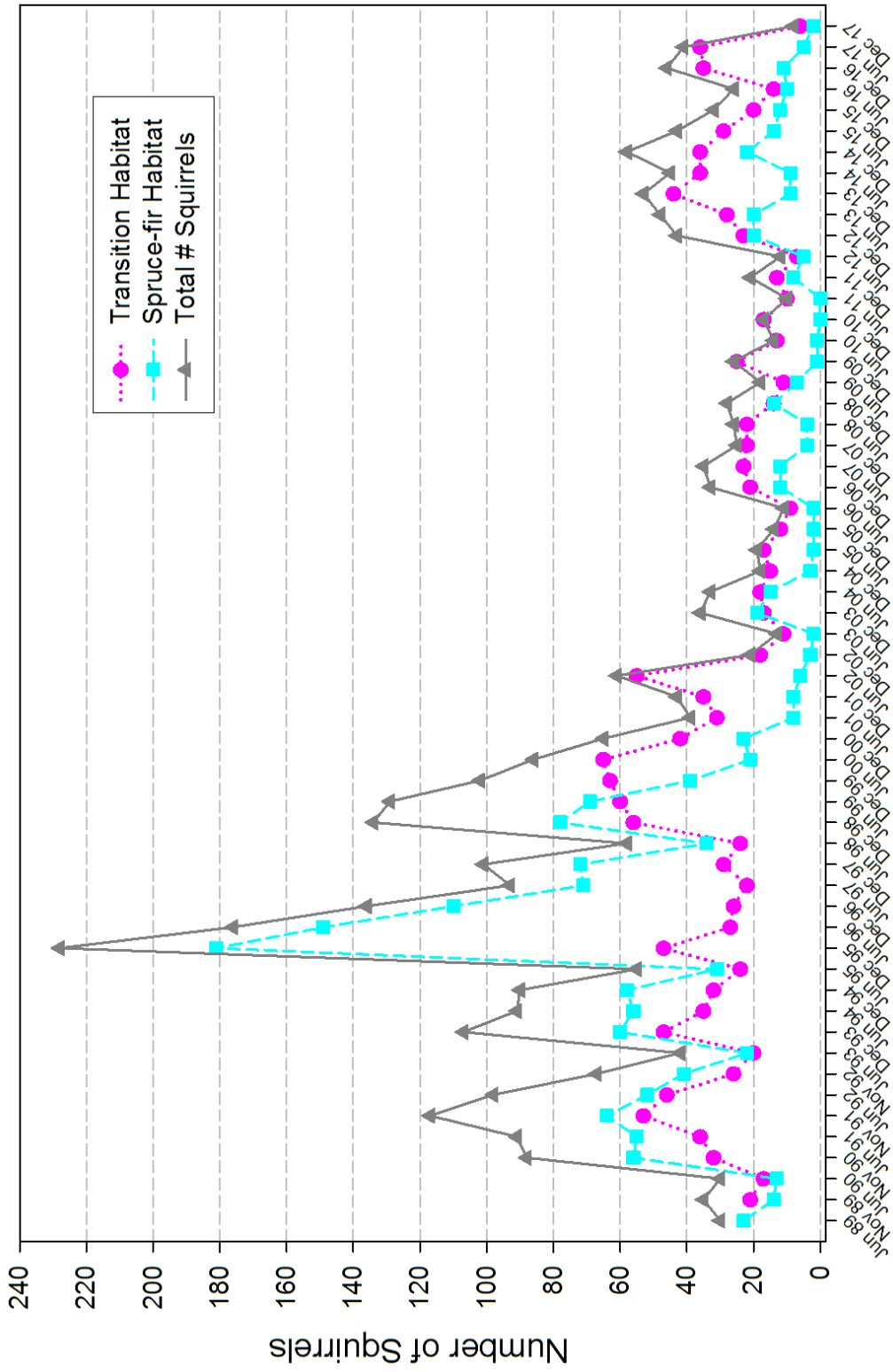


Figure 4. Summer and winter Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles), by habitat, June 1989 - December 2017, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.



Appendix A. Mean number of seeds (filled) for **2016** and mushrooms (wet weight) for **2016**, 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	215.8	15.9	45.2	276.9	37.5
TRN	4	253.1	13.3	36.6	303.0	114.2
SFC	5	14.9	0.0	41.6	56.5	47.4
SFN	6	0.0	10.6	19.9	30.5	45.0
TR	9	234.5	14.6	40.9	290.0	78.9
SF	11	7.5	5.3	30.8	43.5	46.2

Appendix B: Midden occupancy records, 2017, 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

Transition Construction Area (TRC), 2017				
Midden	Mar	Jun	Sep	Dec
1102[89]	N	♀	Burned in Frye Fire [1]	
1103[89]	♂	♂	Burned in Frye Fire	
1104[89]	♀	♀	Burned in Frye Fire	
1111[89]	N	N	Burned in Frye Fire	
1112[89*]	P	N	Burned in Frye Fire	
1113[89]	N	N	Burned in Frye Fire	
1115[89]	N	N	Burned in Frye Fire	
1116[89]	N	N	Burned in Frye Fire	
1118[89]	♂ (O/O RC 1161)	♂ (O/O RC 1161)	♂ (O/O RC 1161)	♂ (O/O RC 1161)
1121[89*]	♀	♀	N	N
1127[14*]	Y	♀	N	N
1128[15*]	Y	P	♂	P
1131[90*]	♂ (Bsq/Ysq RC 1197)	♂ (Bsq/Ysq RC 1197)	Burned in Frye Fire	
1134[91*]	N	N	N	N
1144[91*]	N	N	N	N
1147[91*]	N	N	N	N
1149[91*]	N	N	N	N
1151[91*]	N	N	N	N
1153[92*]	N	N	Burned in Frye Fire	
1154[92*]	N	N	N	N
1156[93*]	♂	♂	P	N
1160[96*]	N	N	N	N
1162[96*]	N	N	Burned in Frye Fire	
1163[98*]	N	N	N	N
1164[98*]	♀ (Wsq/Ysq RC 1196)	♀ (Wsq/Ysq RC 1196)	P	N
1167[98*]	N	N	N	N
1168[98*]	N	N	Burned in Frye Fire	
1169[98*]	N	N	Burned in Frye Fire	
1170[98*]	♂	♂	Burned in Frye Fire	
1171[98*]	N	N	Burned in Frye Fire	
1172[90*]	N	N	Y	N
1173[99*]	N	N	N	N
1174[99*]	S	P	N	N
1175[99*]	N	Y	N	N

Transition Construction Area (TRC), 2017				
Midden	Mar	Jun	Sep	Dec
1176[99*]	Y	Y	Burned in Frye Fire	
1177[99*]	♂ (R/Y 1188)	♂ (R/Y 1188)	N	N
1179[99*]	N	N	Burned in Frye Fire	
1180[99*]	N	N	Burned in Frye Fire	
1182[02*]	N	N	N	N
1183[04*]	N	N	N	N
1184[04*]	N	N	Burned in Frye Fire	
1185[05*]	N	N	N	N
1186[05*]	N	♀ (P/P RC 1218)	N	N
1187[05*]	N	N	N	N
1188[10*]	N	N	N	N
1189[10*]	♂	♀	P	♀
1190[10*]	N	N	N	N
1191[10*]	N	N	N	N
1192[11*]	Y	♀	P	♀
1193[12*]	N	N	N	N
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	♀	Burned in Frye Fire	
1199[14*]	♀ (W/O RC 1130)	Y	Burned in Frye Fire	
# Mid	56	56	35	35
# Occ	16	18	3	3
% Occ	29%	32%	9%	9%
# Sq	16	18	3	3

1 Middens marked as “Burned in Frye Fire” had severe damage to the understory and canopy with few to no live trees in the area within 10m radius of the tag tree/activity area.

Transition Non-Construction Area (TRN), 2017				
Midden	Mar	Jun	Sep	Dec
2202[89]	N	N	N	N
2203[89]	S	S	Burned in Frye Fire [1]	
2204[89]	N	N	P	N
2205[89]	N	N	N	N
2206[89]	♂	♂	Burned in Frye Fire	
2208[89*]	Y	P	Burned in Frye Fire	
2210[90]	N	N	N	N
2211[90*]	S	♀	♀ (B/B RC 1219)	♀ (B/B RC 1219)
2215[90*]	N	N	N	N
2216[90*]	N	N	N	N
2217[90*]	N	N	N	N
2218[91*]	N	N	N	P
2219[91*]	S	Y	Burned in Frye Fire	
2223[91*]	S	N	Burned in Frye Fire	
2227[95*]	N	N	N	N
2229[96*]	N	N	Burned in Frye Fire	
2230[96*]	N	N	N	N
2234[97*]	N	N	Burned in Frye Fire	
2235[98*]	N	N	N	N
2236[98*]	S	S	N	♂
2237[98*]	N	N	N	N
2238[98]	N	N	N	N
2239[98]	N	♀	N	N
2240[98]	S	N	Burned in Frye Fire	
2241[98*]	N	N	Burned in Frye Fire	
2242[98*]	N	N	Burned in Frye Fire	
2244[99*]	♀	♀	P	N
2246[99*]	N	N	Burned in Frye Fire	
2248[99*]	Y	Y	N	N
2249[99*]	N	N	Burned in Frye Fire	
2250[00*]	S	Y	N	N
2252[08*]	S	S	Burned in Frye Fire	
2253[09*]	S	S	Burned in Frye Fire	
2255[11*]	N	N	N	N

Transition Non-Construction Area (TRN), 2017				
Midden	Mar	Jun	Sep	Dec
2256[12*]	♀	N	N	N
2257[13*]	N	N	N	N
2258[14*]	N	N	Burned in Frye Fire	
2259[16*]	♀	Y	Burned in Frye Fire	
2260[14*]	N	♀ + 4J	N	Y
2261[17*]	S	♀	Burned in Frye Fire	
2262[17*]	new midden			N [2]
# Mid	38	38	23	24
# Occ	15	14	1	3
% Occ	40%	37%	4%	12%
# Sq	15	14 + 4J	1	3

1 Middens marked as "Burned in Frye Fire" had severe damage to the understory and canopy with few to no live trees in the area within 10m radius of the tag tree/activity area.

2 This location was a hot spot with some squirrel signs seen earlier in the year. Designated as a midden for future censuses as there was minimal fire damage.

Spruce-Fir Construction Area (SFC), 2017				
Midden	Mar	Jun	Sep	Dec
3002[95*]	N	N	Burned in Frye Fire [1]	
3020[96*]	♀	P	N	S
3022[96*]	N	NC [2]	Burned in Frye Fire	
3028[99*]	N	♀	Burned in Frye Fire	
3033[12*]	N	N	N	N
3034[12*]	P	N	Burned in Frye Fire	
3035[13*]	N	N	Burned in Frye Fire	
3036[13*]	N	N	Burned in Frye Fire	
3037[17*]	new midden			♀
3303[94*]	N	N	Burned in Frye Fire	
3310[95*]	♀	P	Burned in Frye Fire	
3311[95*]	N	NC	Burned in Frye Fire	
3312[95*]	N	N	N	N
3314[95*]	N	N	N	N
3323[95*]	N	P	Burned in Frye Fire	
3328[95*]	N	N	Burned in Frye Fire	
3330[95*]	N	NC	Burned in Frye Fire	
3341[95*]	N	NC	Burned in Frye Fire	
3346[95*]	N	NC	Burned in Frye Fire	
3348[95*]	N	N	Burned in Frye Fire	
3360[86]	Y	S	Burned in Frye Fire	
3362[86]	N	N	Burned in Frye Fire	
3365[86]	N	N	N	N
3366[86]	N	N	N	P
3370[86]	N	NC	Burned in Frye Fire	
3371[87]	N	NC	Burned in Frye Fire	
3372[89]	N	NC	Burned in Frye Fire	
3374[89]	N	NC	Burned in Frye Fire	
3378[90*]	N	NC	Burned in Frye Fire	
3382[91*]	N	♂	N	N
3394[93*]	N	NC	Burned in Frye Fire	
# Mid	30	30	7	8
# Occ	3	3	0	2
% Occ	10%	10%	0%	25%
# Sq	3	3	0	2

1 Middens marked as “Burned in Frye Fire” had severe damage to the understory and canopy with few to no live trees in the area within 10m radius of the tag tree/activity area.

2 Middens marked with “NC” in June were not censused due to mandatory fire evacuation of the study area before they could be visited.

Spruce-Fir Non Construction Area (SFN), 2017				
Midden	Mar	Jun	Sep	Dec
4000[95*]	N	N	Burned in Frye Fire [1]	
4010[95*]	N	N	Burned in Frye Fire	
4023[98*]	N	N	Burned in Frye Fire	
4026[09*]	N	N	S	Y
4027[12*]	N	N	Burned in Frye Fire	
4028[14*]	N	N	N	P
4029[15*]	N	N	Burned in Frye Fire	
4400[89]	N	N	Burned in Frye Fire	
4417[95*]	N	N	N	N
4465[90*]	N	N	N	N
4466[87]	Y	P	Burned in Frye Fire	
4467[87]	N	N	Burned in Frye Fire	
4469[87]	N	N	Burned in Frye Fire	
4470[87]	N	N	Burned in Frye Fire	
4471[87]	N	N	Burned in Frye Fire	
4472[87]	N	N	Burned in Frye Fire	
4473[87]	N	N	Burned in Frye Fire	
4474[86]	N	N	Burned in Frye Fire	
4477[87]	N	N	Burned in Frye Fire	
4484[86]	N	N	Burned in Frye Fire	
4488 [91*]	Y	♀	Burned in Frye Fire	
4491[91*]	Y	S	Burned in Frye Fire	
4492[91*]	N	N	Burned in Frye Fire	
# Mid	23	23	4	4
# Occ	3	2	1	0
% Occ	13%	9%	25%	0%
# Sq	3	2	1	0

1 Middens marked as “Burned in Frye Fire” had severe damage to the understory and canopy with few to no live trees in the area within 10m radius of the tag tree/activity area.

Off-Area Midden Occupancy, 2017				
Midden	Mar	Jun	Sep	Dec
TRC Area				
5101[89]	S	♂	N	N
5102[98*]	N	N	Burned in Frye Fire [1]	
5103[99*]	N	N	N	N
5104[99*]	N	N	N	N
5105[02*]	N	N	Burned in Frye Fire	
5106[02]	N	N	Burned in Frye Fire	
5107[02]	N	N	Burned in Frye Fire	
5118[94*]	N	N	Burned in Frye Fire	
5119[89*]	S	S	N	N
5121[89*]	♀(R/W RC 1177)	N	Burned in Frye Fire	
5125[89*]	N	N	Burned in Frye Fire	
5126[91]	N	N	Burned in Frye Fire	
5145[91*]	N	N	Burned in Frye Fire	
5150[91*]	♀(P/G RC 1171)	♀(P/G RC 1171)	Burned in Frye Fire	
5155[93*]	N	N	Burned in Frye Fire	
5157[93*]	Y	P	Burned in Frye Fire	
5159[12]	N	N	Burned in Frye Fire	
5161[16*]	♀(B/B RC 1168)	♀(B/B RC 1168)	Burned in Frye Fire	
TRN Area				
5200[93*]	S	N	N	N
5201[99*]	N	N	Burned in Frye Fire	
5203[00*]	N	N	N	N
5221[91*]	♂	♂	N	N
5231[96*]	N	N	Burned in Frye Fire	
5232[96*]	♂(Rsq/Psq RC 1179)	♂	Burned in Frye Fire	
SFC Area				
5311[95*]	P	NC [2]	Burned in Frye Fire	
5313[95*]	N	NC	Burned in Frye Fire	
5350[86]	N	N	Burned in Frye Fire	
5361[96*]	N	N	Burned in Frye Fire	
5377[87]	N	NC	Burned in Frye Fire	
SFN Area				
5405[87]	N	N	Burned in Frye Fire	
5413[95*]	N	N	Burned in Frye Fire	

1 Middens marked as “Burned in Frye Fire” had severe damage to the understory and canopy with few to no live trees in the area within 10m radius of the tag tree/activity area.

2 Middens marked with “NC” in June were not censused due to mandatory fire evacuation of the study area before they could be visited.

Appendix C. Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) populations (including juveniles at maternal middens), March 2013 - December 2017, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

Date	TRC	TRN	SFC	SFN	TOTAL
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
Mar 2017	16	15	3	3	37
Jun 2017	18	14 + 4 Juv	3	2	37 + 4 Juv
Sep 2017	3	1	0	1	4
Dec 2017	3	3	2	0	8

Appendix D: Quarterly occupancy maps for Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), March, June, September, and December 2017, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

[12 Maps Redacted]

Appendix E: Reproductive success of Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), 2017 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.

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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 - 2017

Breeding chases observed on or near the University of Arizona Red Squirrel Monitoring Program study areas in 2017. 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
15 May 17	1164	Marked males 1161 and 1197 were observed several times during the week in the midden of marked female 1196.
17 May 17	5150	Marked males 1161 and 1197 were also observed at this midden where marked female 1171 was resident.
19 May 17	8050	Unmarked female resident was in estrous based on visual cues, at least 2 unmarked males observed chasing in the area. A few buzz calls were heard.
23 May 17	8017	Marked male 1170 was observed in a mating chase with the resident unmarked female and another unmarked male. Male 1170 attempted a copulation with the female. The chase lasted until about 1950 hours, then male 1170 returned to his midden (8044sh) and nested there.
26 May 17	8060	Resident squirrel was an unmarked female. At least 5 males were observed in the midden, marked males 1170, 1194, 1195, 1213, and one unmarked male.

Appendix E-2: Litters and reproductive status observed in 2017 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
unmk ♀	2260/15211	13 Jun 17	4 juveniles
1217	8057/18139	14 Jun 17	2 juveniles
Total	2 litters		6 juveniles

Reproductive status for females where no litters were detected. No observations were possible between mid June and mid August due to the Frye Fire and restricted access to the study areas.

Female ID	Midden	Date	Notes
1168	5161	16 May 17	lactating
1172	8034	18 May 17	lactating
1173	8043	14 Jun 17	pregnant
1192	8036	26 May 17	pregnant
1196	1164	9 Aug 17	lactating
1218	1186	14 Jun 17	lactating
unmk	8060	25 May 17	lactating
unmk	2211	25 May 17	lactating

Appendix F. Weather information, 2017, University of Arizona Red Squirrel Monitoring Program study areas, Pinaleño Mountains, Graham County, Arizona.

F-1: Monthly weather summaries*

F-2: Accumulated snow depths

* In 2017, the weather station at the biology camp had several periods with no data collection due to equipment problems and the Frye Fire. The weather summary data is from the RAWS (remote automated weather station) site at Columbine Ranger Station, Mt. Graham, Coronado National Forest. The Raws station is located approximately 2 km north of the biology camp at a similar elevation.

https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?azACOL

Appendix F-1: Monthly weather summaries - 2017, Columbine Ranger Station RAWS.

	Mean Wind Speed	Mean Wind Direction	Maximum Wind Gust	Average Air Temperature					Average Relative Humidity			Precipitation
Date	m/s	Deg	m/s	Deg C					%			mm
mm/yyyy	Ave.	Vector Ave.	Max.	Ave.	Ave. Daily Max.	Max.	Ave. Daily Min.	Min.	Ave.	Max.	Min.	Total
Jan-17	1.958	212.5	16.54	-1.14	5.44	60.00	-6.59	-16.66	69.88	100	8	31.50
Feb-17	2.495	216.3	15.20	2.35	8.69	60.00	-3.61	-9.99	58.86	100	5	24.89
Mar-17	2.101	204.6	15.20	3.91	11.13	16.67	-2.15	-11.66	51.70	100	11	15.75
Apr-17	2.596	220.8	15.20	6.00	12.31	17.78	-0.26	-10.55	38.77	100	4	6.35
May-17	2.262	211.8	16.99	8.10	14.98	20.56	1.60	-4.44	45.02	100	13	7.62
Jun-17	1.622	201.5	12.52	15.55	22.72	27.22	8.48	2.22	34.17	100	7	9.14
Jul-17	0.960	91.9	9.84	14.50	20.66	25.56	9.50	7.22	72.91	100	12	308.10
Aug-17	0.992	140.6	12.96	13.59	19.95	22.22	8.15	5.00	70.89	100	26	72.14
Sep-17	2.062	198.0	12.07	11.70	17.52	22.78	6.83	0.56	63.26	100	24	9.14
Oct-17	2.056	205.5	12.96	9.68	16.38	22.78	4.16	-2.22	45.38	100	7	2.03
Nov-17	1.902	211.7	12.96	7.30	13.91	20.56	1.91	-3.89	40.32	100	2	3.30
Dec-17	1.431	168.6	15.20	1.35	8.07	15.00	-3.92	-13.88	47.49	100	3	12.45

Appendix F-2: ***Accumulated*** snow depths on the monitored areas for Winter 2016 - 2017.

Snow Depth Summary

Snow Year	*Month*	*Habitat*	*Location*	*Avg Depth (cm)*	*Min Depth (cm)*	*Max Depth (cm)*	*Avg. % Cover*	*# of Readings for Avg.*
2016-2017								
2016	Dec	Spruce-fir	Clearing	10.3	0	16	75.0	3
2016	Dec	Spruce-fir	Forest	2.7	0	6	66.7	3
2016	Dec	Transition	Clearing	15.8	13	20	92.5	4
2016	Dec	Transition	Forest	20.3	15	29	100.0	3
2017	Jan	Transition	Clearing	63.8	30	90	100.0	5
2017	Jan	Transition	Forest	65.0	15	92	100.0	5
2017	Feb	Transition	Clearing	64.3	58	68	100.0	3
2017	Feb	Transition	Forest	59.3	57	61	95.0	3
2017	Mar	Spruce-fir	Clearing	58.7	15	91	100.0	3
2017	Mar	Spruce-fir	Forest	64.0	42	76	95.0	3
2017	Mar	Transition	Clearing	30.8	20	44	62.5	4
2017	Mar	Transition	Forest	33.7	23	48	68.3	3
2017	Apr	Transition	Clearing	6.0	6	6	20.0	1
2017	Apr	Transition	Forest	0.0	0	0	0.0	1
		Averages for Snow Year		35.3	21.0	46.2	76.8	***Sum # Readings***
			Std Dev	26.18				44
			SE of Mean	3.95				

Appendix G: Impacts of Frye Fire, June - July 2017, on Mt. Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*), middens, and RSMP study area size, Pinaleño Mountains, Arizona.

The Frye Fire began on 7 June 17 as a lightning strike on the NE side of the range, in a burn scarred area from the 2004 Nuttall Complex fire. By the time the fire was contained in mid July, the total fire perimeter encompassed approximately 19604 hectares (48443 acres), spread over most of the Pinaleño range. USFS Burned Area Response Team (BAER) estimated the damage within the fire perimeter, assigning almost 16% as moderate to severe burn. For more detailed information on the Nuttall Fire Complex over the whole Pinaleño range, see the following website: https://inciweb.nwcg.gov/incident/5221/

Appendix G-1: Fire effects on Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) **middens** and RSMP study area size.

During the September 2017 quarterly census, each midden on the monitored areas was visited and assessed for fire damage to the substrate, vegetation, and canopy strata within a 10m radius of the tag tree, using the matrix below (adapted from Nature Conservancy/National Park Service/USFS BAER methods). This coding system was used to match previous fire assessments on UA monitored areas done after the 1996 Clark Peak Fire and 2004 Nuttall Complex Fire. Some middens/tag trees could not be located in the severely burned areas, therefore assessments were made at estimated locations.

	0 Unburned	1 Scorched	2 Lightly Burned	3 Moderately Burned	4 Heavily Burned	N/A Not Applicable
S Substrate (litter/duff)	not burned	litter partially blackened; duff nearly unchanged wood/leaf structures unchanged	litter charred to partially consumed; upper layer of duff burned; wood/leaf structure charred but recognizable	litter mostly to entirely consumed; leaching coarse light colored ash; duff deeply burned; wood/leaf structures unrecognizable	litter and duff consumed, leaving fine white ash; mineral soil visibly altered; often reddened or glazed	inorganic (rock)
V Vegetation Understory brush/herbs (<2.5m tall)	not burned	foliage scorched and attached to supporting twigs	foliage and smaller twigs partially to completely consumed	foliage, twigs, and small stems consumed	all plant parts consumed, leaving some or no major stems/trunks	not present prior to fire
Tree/Canopy Strata	no change from pre-fire conditions	some of bole and needles, lower on tree with light scorch, few red needles	bole with heavier burn damage, more red needles	some charring on bole, some needles consumed, a few red needles remain	heavy charring on bole, limbs and needles may be entirely consumed	not present prior to fire

Appendix G-1a: Damage to Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) **middens** on the monitored areas by fire, Frye Fire, June-July 2017.

	TRC	TRN	SFC	SFN	Off-Area[2]	Total
# Mids pre Frye Fire [1]	66	55	94	47	48	310
# Mids severe burn damage, removed	29	24	77	39	38	207

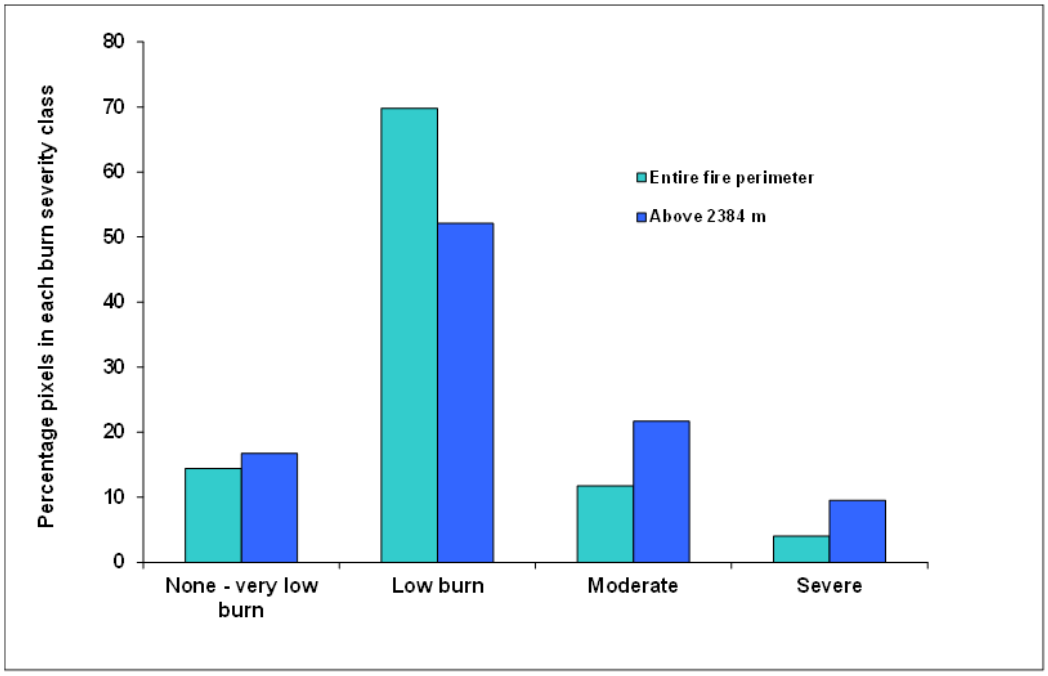
1 The number of known middens on each area prior the Frye Fire. This includes middens previously designated as "Removed Low Occupancy", removed from regular censusing due to historical non-occupied status.

2 Middens just outside the boundaries of the monitored areas that are censused for additional population and density data. This number includes middens around all 4 of the other areas.

Appendix G-1b: Number of hectares in BAER burn severity classes from the Frye Fire on each of the monitored areas.

(size in hectares)	TRC	TRN	SFC	SFN	Total
areas pre-Frye Fire	51.12	19.81	58.59	34.14	163.56
No burn	8.21	2.08	3.43	0.57	14.29
Low burn	36.29	15.72	31.29	19.42	102.72
Moderate	5.68	1.95	21.34	12.99	41.96
Severe	0.95	0.07	2.43	1.15	4.60

Appendix G-1c: Relative percentage of pixels in each BAER burn severity class within the entire perimeter of the Frye Fire, and percentage of pixels in the severity classes above 2384m (elevation of lowest known red squirrel midden in the Pinaleño Mountains).



Appendix G-2: Frye Fire effects on Mt. Graham red **squirrels** (*Tamiasciurus hudsonicus grahamensis*) on RSMP study areas.

The effects of the Frye Fire on red squirrels on the monitored areas are less defined than direct fire impacts to middens. Indeed, the effects may not be fully understood for years as the impact of the major loss of potential squirrel habitat becomes more clear. We were able however, to glean some information on red squirrel response and survival after the Frye Fire from the quarterly census data for June and September 2017 with additional information from telemetry studies.

Appendix G-2a: Number of occupied middens/squirrels on the monitored areas during 4 census months in 2017. These numbers include unmarked and radio collared/ear tagged squirrels.

Date	TRC	TRN	SFC	SFN	TOTAL
Mar 2017	16	15	3	3	37
Jun 2017	18	14 + 4 Juv	3	2	37 + 4 Juv
Sep 2017	3	1	0	1	4
Dec 2017	3	3	2	0	8

Appendix G-2b: Accounts of marked Mt. Graham red **squirrels** (*Tamiasciurus hudsonicus grahamensis*) on and near RSMP study areas, Pinaleño Mountains, Arizona, before and after the Frye Fire, June/July 2017. Animals that are still alive as of March 2018 are highlighted in gray.

ID	Midden	Sex	status
1161	1118	M	**survived fire**; alive Mar 18
1168	5160	F	**survived fire**; collar only found Aug 17, fate unknown
1170	8044	M	signal not heard after fire, fate unknown
1171	5150	F	**survived fire**, signal not heard after Oct 17, fate unknown
1172	8075	F	**survived fire**, moved to new midden(8046); alive Mar 18
1173	8073	F	**survived fire**, collar and tail found Dec 17
1180	8001	M	**survived fire**, signal not heard after Nov 17, fate unknown
1192	8036	F	**survived fire**, collar and remains found Aug 17
1195	8015	M	**survived fire**, (had ear tags only before fire, collared in Sep 17), collar and remains found Feb 18
1196	1164	F	**survived fire**, collar only found Sep 17, fate unknown
1197	1131	M	**survived fire**, midden completely burned, moved to new midden near [REDACTED]. Collar only found Sep 17, fate unknown
1198	8046	F	**survived fire**, collar and remains found Mar 18
1200	8640 G	F	**survived fire**, still alive Mar 18
1201	8695 G	M	**survived fire**, still alive Mar 18
1203	8694 G	F	**survived fire**, still alive Mar 18
1206	8696 G	F	**survived fire**, still alive Mar 18
1207	8638 G	M	**survived fire**, still alive Mar 18
1209	9210 G	F	**survived fire**, still alive Mar 18
1216	8048	F	signal not heard after fire, fate unknown
1217	8057	F	Female and 4 juveniles seen in Jun 17. Midden severely burned, collar signaling near nest tree, remains of female found 27 July. No juveniles were observed post-fire.
1218	1186	F	**survived fire**, signal not heard after Sep 17, but found alive without collar Mar 18, re-collared.

1 Middens with "G" are located near[REDACTED]. Squirrels were previously marked in this area for another research project.

Appendix H: Results of Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) surveys by the Red Squirrel Monitoring Program in other research areas in the Pinaleño (Graham) Mountains of southeastern Arizona.

The Red Squirrel Monitoring Program (RSMP) has conducted research projects outside the original monitored areas to examine aspects of red squirrel ecology such as potential competition with Abert's squirrels, juvenile dispersal, and effects of previous fires. As a result, these areas are generally surveyed once per year to determine squirrel populations.

Appendix H-1: List of occupied middens found in Fall 2017 in areas surveyed by RSMP, including marked and unmarked animals on [location information REDACTED]

UA Mid #	AZGFD Name	Study Area	Month Surveyed	Animal ID	Notes
1118			Dec	♂ 1161	
1192			Dec	♀ unmk	
2211			Dec	♀ 1219	
2236			Dec	♂ unmk	
3020			Dec	squirrel unmk	
5120			Dec	♂ unmk	
8015			Dec	♂ 1195	
8046			Dec	♀ 1198	
8075			Dec	♀ 1172	new midden found Aug 2017
3037			Dec	squirrel unmk	new midden found Dec 2017
8623			Dec	♂ 1207	
8640			Dec	♀ 1200	
8645			Dec	♂ unmk	
8694			Dec	♀1203	
8696			Dec	♀ 1206	
8695			Dec	♂ 1201	
9209			Dec	squirrel unmk	
9210			Dec	♀ 1209	
9208			Sep	♂ unmk	New midden found in [REDACTED]. Relocated ♂ 1197 there after fire (Aug 17), but at last check, occupied by unmk male.
8432			Oct	not seen	occupied based on signs
8447			Oct	not seen	occupied based on signs
8458			Oct	squirrel unmk	
8465			Oct	not seen	occupied based on signs
8601			Oct	squirrel unmk	
8606			Oct	not seen	occupied based on signs
8607			Oct	not seen	occupied based on signs
8616			Oct	not seen	occupied based on signs
8637			Dec	squirrel unmk	[REDACTED]. Flagged a new shift about 20m N-NE of tag tree. Fresh feeding signs and caches found, squirrel chattered.

Appendix H-1: Map of original RSMP monitored areas and other research areas in the Pinaleño (Graham) Mountains of southeastern Arizona.

[Map Redacted]