DOCUMENTING DISTRIBUTION AND HABITAT ATTRIBUTES FOR NORTHERN FLYING SQUIRREL IN TETON COUNTY, WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Northern Flying Squirrel

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ABSTRACT

The northern flying squirrel (*Glaucomys sabrinus*) is a secretive and nocturnal mammal that can be difficult to detect. The Wyoming Game and Fish Department classifies the northern flying squirrel as a Species of Greatest Conservation Need because statewide population trends are unknown and the species is at risk from habitat loss due to natural and anthropogenic disturbances. Between 4 June and 22 July 2014, we used remote infrared cameras and enclosed bait tubes at 12 plots to estimate occupancy and update the current distribution of northern flying squirrels in Teton County. Additionally, we evaluated important components of habitat that could be used to predict presence of flying squirrels. We recorded 13 unique detections (i.e., photographs of flying squirrel >1 hr apart) on 7 plots. Understory cover varied among sites, although saplings were found most frequently in occupied plots ($\bar{X}$ = 2.95% ± 0.25) and less frequently in unoccupied plots ($\bar{X}$ = 0.25% ± 0.75; t_{10} = 3.72; P = 0.003). Conversely, we detected a greater amount of shrubs in unoccupied plots ($\bar{X}$ = 66.50% ± 2.73) than in occupied plots ($\bar{X}$ = 33.36% ± 4.78; t_{10} = -3.08, P = 0.005). Both lichen and witches' broom were present only in occupied plots. We recommend that future monitoring should employ cameras and enclosed bait tubes and be conducted in the late summer and fall seasons to optimize detections of flying squirrels. We also recommend that future surveys consider characterizing availability of mycorrhizal fungi, which may affect occupancy of flying squirrels.

INTRODUCTION

The northern flying squirrel (*Glaucomys sabrinus;* flying squirrel) generally occupies boreal and north temperate conifer, mixed conifer-hardwood, and northern hardwood forests of the northern United States and Canada (Weigl 2007). These cool and moist habitats support old-growth and mature forests that have a well-developed canopy and an abundance of snags, downed wood, and organic materials. Old-growth stands provide the most suitable habitats for the flying squirrel, such stands provide structure to facilitate locomotion and nesting, and wood-borne fungi and lichens for foraging (Carey et al. 1999). The flying squirrel is important to ecosystem processes since it consumes and transports fungal spores (Wells-Gosling and Heaney 1984, Gabel et al. 2010). Consequently, because of their dependence on and importance to forest ecosystems, flying squirrels can serve as excellent indicators of forest health (Carey 2000). The flying squirrel is also an important prey base for nocturnal raptors and mammalian carnivores associated with old-growth forests (Martin et al. 1994). In Wyoming, the flying squirrel occurs primarily in montane and subalpine forests of the western mountain ranges, although there are isolated populations in the xeric and lower montane forests of the Black Hills and Sweetwater County (WGFD 2010). In Wyoming, habitat loss is the most limiting factor for populations of flying squirrels (WGFD 2010). The species is susceptible to declines as a result of large-scale habitat manipulation projects that destroy or remove suitable habitat (e.g., logging, prescribed fire) with both short- and long-term consequences (Holloway and Smith 2011). The flying squirrel is also vulnerable to habitat loss due to climate change (e.g., mountain pine beetle kill, drought, fire) which may cause their range to contract or fragment (WGFD 2010). Because their habitat is naturally patchy and susceptible to natural and anthropogenic disturbances, the flying squirrel is classified as a Species of Greatest Conservation Need by the Wyoming Game and Fish Department (Department; NSS 4, Tier 2; WGFD 2010).

In 2012 and 2013, Department biologists developed a baseline occupancy model to monitor trends for flying squirrels in the Wyoming Range as part of a long-term monitoring program (Van Fleet et al. 2014). Although surveys were conducted in the Wyoming Range, other areas in the northwest were not surveyed due to time restraints and limited equipment. This left a dearth of information on flying squirrel occupancy in other areas of northwestern Wyoming, including Teton County. Our objectives were to follow established guidelines and use remote cameras (PC800 Reconyx, Holmen, WI) and enclosed bait tubes to document flying squirrels and establish a baseline for long-term surveillance in Teton County. Additionally, we evaluated important components of habitat that could be used to predict presence of flying squirrels. Work in Teton County was made possible through a grant from the Meg and Bert Raynes Wildlife Fund, a nonprofit located in Jackson, WY.

METHODS

Our study area was located in the Bridger-Teton National Forest in northwestern Wyoming (Fig. 1). Dominate forest trees included Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*), and sub-alpine fir (*Abies lasiocarpa*), with elevation ranging from 2049 m to 2367 m. Specifically, we conducted our surveys within the Fall Creek and Shadow Mountain areas.

We completed surveys between 4 June and 22 July 2014. We used camera-trapping protocols established by Van Fleet and Grenier (2012) and Cudworth et al. (2013) to conduct surveys. We used GIS (ArcGIS 10.1, ESRI, Redlands, CA) to randomly select 4-ha survey plots from suitable habitat (i.e., spruce-fir and lodgepole-pine forests) and ≥200 m from a road. If a pre-selected plot was not accessible due to impassable or closed roads, we selected a suitable replacement site within the same drainage. Each plot contained 16 survey stations (i.e., 1 enclosed bait tube and 1 camera) set in a 4 × 4 array with 50 m between stations and a 50 m buffer zone between the outer perimeter of the plot and survey stations. This distance accounted for home range overlap between flying squirrels and maximized detection opportunities (Hough and Dieter 2009).

At each survey station, we affixed a camera to a tree with a bungee cord approximately 1.5 m above ground. We attached an enclosed bait tube to a tree ≤2 m from the camera, baited with a mixture of oatmeal, peanut butter, and bacon grease to lure flying squirrels within camera range. We re-baited enclosed bait tubes at each station in the late afternoon for five consecutive days. We programmed cameras to take pictures 24 hrs a day and 3 photos every 10 sec each time the camera was triggered. At each station we recorded the UTM location, species of tree, diameter at breast height (DBH), and approximate height of each bait tree. At the end of the fifth night, we retrieved the enclosed bait tubes and cameras, downloaded pictures to a laptop, and erased each memory card. We distinguished photos of flying squirrels from red squirrels (*Tamiasciurus hudsonicus*) and chipmunks (*Neotamias sp*.) by the presence of a patagium, large eyes, and a square, flat tail. We recorded all locations for flying squirrels and non-target species.

In conjunction with the camera surveys, we randomly selected 3 survey stations within each 4-ha survey plot and collected data for several habitat variables based on published studies of northern flying squirrels (Wells-Gosling and Heaney 1984; Rosenberg and Anthony 1991; Waters and Zabel 1995, Pyare and Longland 2002). We used 7-m radius circular plots at each location with the bait tree as our center point. In each cardinal direction, we placed one transect, 7 m in length, dividing each habitat-sampling plot into quadrants (i.e., northwest, northeast, etc.). Along each transect at 4m from the bait station we recorded the percentage of overstory cover using a convex densiometer (Forestry Suppliers Inc., Jackson, MS). In each 7-m quadrant we visually estimated the percent, type, and distance of primary understory (i.e., shrub, seedling, and sapling) ≤2 m in height and recorded if mushrooms were present (Pyare and Longland 2002). Within 360° of the bait tree, we determined the basal area factor (BAF) of trees (>10 cm DBH) using a wedge prism (BAF 10; Forestry Suppliers Inc., Jackson, MS) and recorded presence of lichen, witches broom, and natural or excavated tree cavities within the plot. All dead standing trees were assigned to a snag class from 1 to 5 (Ganey and Vojka 2007, Pyare and Longland 2002). We also recorded the total number of logs (≥20 cm DBH) and number of "class 3", or heavily decayed CWD, within the 7-m radius plot (Ganey and Vojta 2010). Finally, to account for the influence of microtopography on flying squirrels, we measured slope, aspect, and elevation at each bait tree. We summarized all data for each plot and provide averages ± standard error for each value per plot. We used t-tests to compare habitat variables between occupied and unoccupied plots.

RESULTS

We surveyed 12 plots for a total of 960 camera nights (Fig. 1). We recorded 13 unique detections (i.e., photographs of flying squirrel >1 hr apart) on 7 plots. Presence of flying squirrels was greater in the Fall Creek area along the western slopes of the Jackson valley (Fig.

1). On average, plots occupied by flying squirrels had a predominantly southeastern aspect of 148°, while unoccupied plots had a western aspect of 268°. All observations of flying squirrels and non-target species were entered into the Department's Wildlife Observation System (Table 1).

We did not observe any flying squirrel mortalities, and none of our enclosed bait tubes were damaged or destroyed. One camera, however, sustained a puncture in the lens from a grizzly bear (*Ursus arctos*). Since this incident happened during the last morning of the survey, the total number of camera nights was not affected.

We sampled 332 live trees and 71 snags at 37 stations within 12 plots (one plot contained 4 habitat survey stations). Although our sample size was relatively small, occupied sites tended to be characterized by live trees with larger DBH and lower basal area and included some element of Engelmann spruce (Table 2). Understory cover varied among sites, although saplings were found more frequently in occupied plots ($\bar{X}$ = 2.95% ± 0.25) than unoccupied plots ($\bar{X}$ = 0.25% ± 0.75; t_{10} = 3.72; P = 0.003). Conversely, we detected a greater amount of shrubs in unoccupied sites ($\bar{X}$ = 66.50% ± 2.73) than in occupied sites ($\bar{X}$ = 33.36% ± 4.78; t_{10} = -3.08, P = 0.005). Other ground cover (mushrooms, grass, and CWD) and habitat (slope, canopy cover, and tree cavities) components did not differ significantly between occupied and unoccupied sites, potentially due to small sample size. Other habitat components were not significant.

Occupied sites appeared positively associated with the presence of lichen and witches' broom on trees within the plots. On the 7 occupied sites, lichen was observed at 6 sites (86%) while witches' broom was observed at 4 sites (57%). The five unoccupied plots contained no lichen or witches' broom. Observations of mushrooms were similar between occupied (n = 3) and unoccupied (n = 2) plots.

DISCUSSION

Flying squirrels detected during our surveys seemed to have no aversion to entering the enclosed bait tubes. We also observed several squirrels perching on top of the enclosed bait tube while consuming the bait, thus increasing our opportunity for proper identification. Our survey method has proven highly successful at detecting flying squirrels (>80%) in other areas of Wyoming (Van Fleet et al. 2014). Our lower detection rate in the Jackson valley may be attributed to the time of year the survey was conducted. Krueger (2004) and Vernes (2004) reported low live-capture success in May and June with greater success occurring in summer and fall months. In 2012 and 2013, we also observed lower detection rates for flying squirrels during late-spring and early-summer compared to late-summer and early-fall surveys (Van Fleet et al. 2014). This time period coincides with females having young, which may cause them to be more cautious, preferring to forage closer to the nest tree (Krueger 2004). Additionally, females with young forage less often and typically only leave the nest for short intervals during this season (Wells-Gosling 1985). Therefore, we recommend that future monitoring should be conducted in the late summer and fall seasons to optimize detections of flying squirrels.

We failed to detect a significant difference in stand characteristics between sites that were occupied by flying squirrels and those that were not. Although we had a small sample size, results suggest that flying squirrels may be selecting for stands with lower basal area of live trees and larger DBH of live trees and snags. Results are similar to surveys the Department conducted in the Wyoming Range, where stands typically consisted of larger, older trees in late succession (Van Fleet et al. 2014). Older trees provide greater thermal insulation, denning sites, reduced predation risk, and greater biomass of lichen important for flying squirrels (Meyer et al. 2005, Smith 2007). Flying squirrels were detected in several plots that contained some quantity of Engelmann spruce, which occur in areas favored by adequate soil moisture, cool temperature, and shade (NCRS 2000). Perhaps flying squirrels are not only selecting for larger, older trees, but also for the micro-climate these areas provide rather than Engelmann spruce itself.

Flying squirrels were found in plots that contained more saplings and fewer shrubs than unoccupied plots, similar to studies conducted by Holloway and Malcom (2007). This is contradictory to several investigators who suggest that flying squirrels utilize understory cover with a higher density of shrubs to avoid predators or to feed on other food items (e.g., insects, buds, and seeds–Pyare and Longland 2002, Smith 2007). While opinions differ on the composition of understory needed for flying squirrels, the diversity and abundance of lichen and mycorrhizal fungi may be a limiting factor and may explain the lack of agreement on ground cover. Lichen, or bearded tongue, was found consistently on trees in occupied sites. Lichen is not only an important winter food item, but may also be used as cavity nest material (Maser et al. 1985, 1986; Hayward and Rosentreter 1994). We also detected witches' broom at several occupied sites, which flying squirrels use for both caching and denning sites (Garnett et al. 2006, Mowry 2008). Perhaps flying squirrels are selecting for cool micro-habitats within the forests that promote lichen and organic soils which are important for fungal growth (Gomez et al. 2005, Meyer et al. 2005, Weigl 2007). Gomez et al. (2005) found a direct correlation between flying squirrel density and abundance of mycorrhizal fungi. Due to time constraints and limited personnel, we were unable to quantify availability of this important food item. We recommend that future surveys consider characterizing availability of mycorrhizal fungi, which may affect occupancy of flying squirrels.

Initially, we intended on using program PRESENCE (Hines 2010) to evaluate occupancy and develop an encounter history for each plot, however our sample size was too small to statistically evaluate occupancy. This method is in place however, and can easily be incorporated with previous work from the Wyoming Range. We recommend incorporating a subset of these plots with future trend monitoring in the Wyoming Range.

We consider our results to be a success in the Jackson valley by enhancing our knowledge of this secretive species. We continue to adjust our habitat data techniques to better evaluate important components of habitat that could be used to predict presence of flying squirrels. Although the flying squirrel appears to be more common than previously believed (WGFD 2010), it is still vulnerable to population declines due to fire, logging, and pine beetle kill that removes mature trees.

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Table 1. Number of detections (i.e., photographs >1 hr apart) for northern flying squirrel (*Glaucomys sabrinus*) and non-target species from remote cameras and enclosed bait tubes. Surveys were conducted during June and July 2014 in the eastern and western mountains of the Jackson valley, Bridger-Teton National Forest, Teton County, Wyoming.

Species	Drainage Eastern	Drainage Western	Total	Proportion of total detections
Black bear (*Ursus americanus*)	0	2	2	0.12
Chipmunk (*Tamius sp.*)	5	21	26	0.15
Coyote (*Canis latrans*)	0	1	1	0.01
Downy woodpecker (*Picoides sp.*)	0	1	1	0.01
Elk (*Cervus canadensis*)	1	4	5	0.03
Grizzly bear (*Ursus arctos*)	1	0	1	0.01
Moose (*Alces alces*)	0	13	13	0.08
Mouse (*Peromyscus sp.*)	2	1	3	0.02
Mule deer (*Odocoileus hemionus*)	12	37	49	0.29
Northern flying squirrel (*Glaucomys sabrinus*)	2	11	13	0.08
Red fox (*Vulpes vulpes*)	0	1	1	0.01
Red squirrel (*Tamiasciurus hudsonicus*)	32	19	51	0.30
Unknown species	2	1	3	0.02
Total	57	112	169	1.10

Table 2. Species of live trees and snags measured for all a) occupied plots and b) unoccupied plots surveyed for northern flying squirrels (*Glaucomys sabrinus*) from June - July 2014 (n = 12) in Teton County, Wyoming. We present total number of live trees and snags, and mean number diameter at breast height (DBH; cm), basal area factor (BAF), and standard error (SE) per species for plots. Mean BAF of all live trees and snags were significantly different for occupied sites and those where we failed to detect flying squirrels ($P < 0.001$).

a)

Tree species	*n*	DBH (cm)	SE	BAF	SE
Subalpine fir (*Abies lasiocarpa*)	41	21.36	2.77	7.68	1.59
Lodgepole pine (*Pinus contora*)	144	25.86	1.54	8.26	1.55
Engelmann Spruce (*Picea engelmannii*)	52	26.07	3.13	8.37	1.54
Unknown	2	29.35	0.96	5.00	0
All live trees	239	25.66	1.81	7.33	1.26

b)

Tree species	*n*	DBH (cm)	SE	BAF	SE
Subalpine fir (*Abies lasiocarpa*)	13	24.62	2.85	9.62	1.18
Lodgepole pine (*Pinus contora*)	161	23.03	2.57	8.17	1.55
Engelmann Spruce (*Picea engelmannii*)	0	0	0.00	0.00	0.00
Unknown	0	0	0.00	0.00	0.00
All live trees	174	23.83	1.06	8.90	1.01

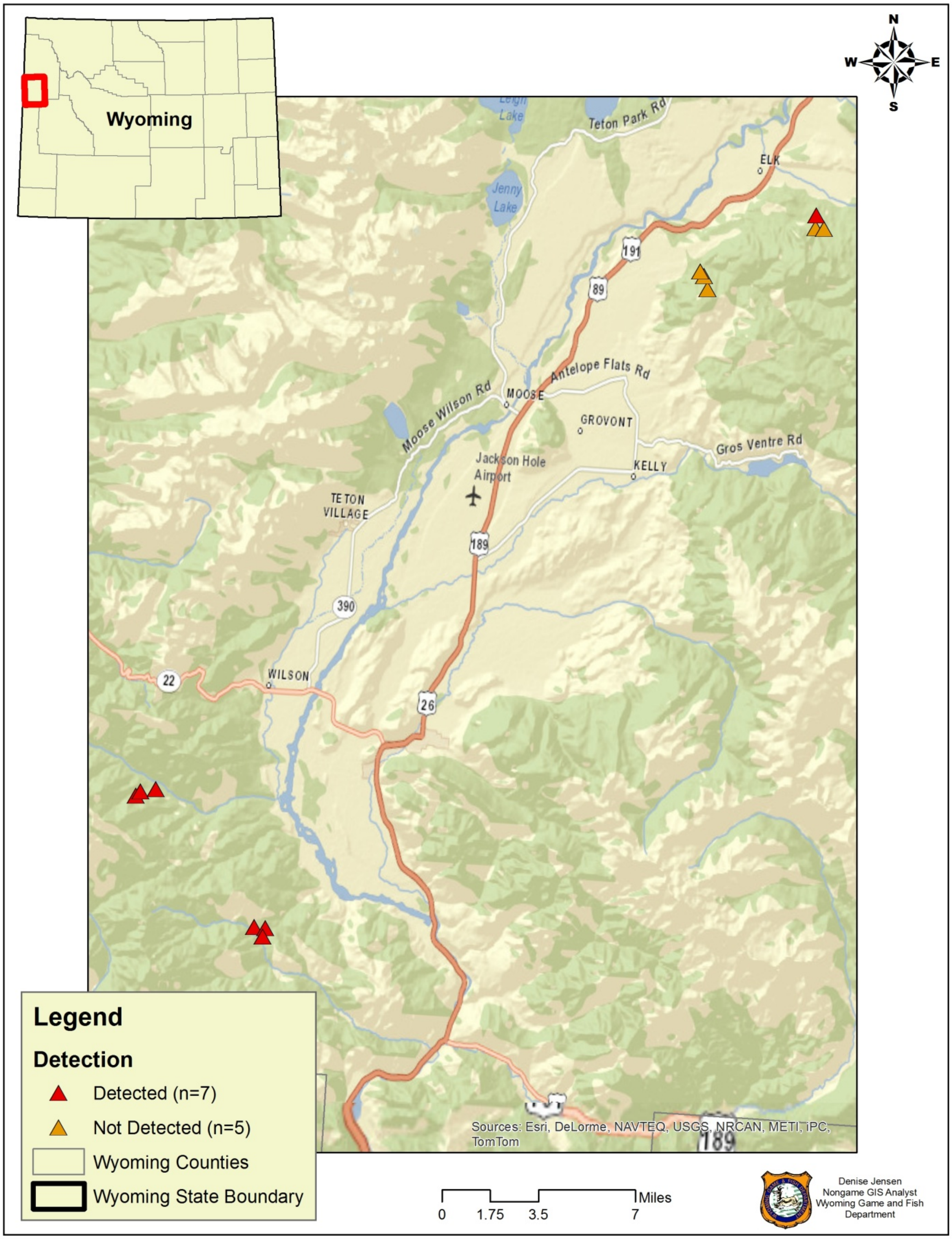

Figure 1. Study area, locations of survey plots, and detections of northern flying squirrels (*Glaucomys sabrinus*). Surveys were conducted from 4 June to 22 July 2014 in Bridger Teton National Forest, Teton County, Wyoming.