

INTERACTIONS BETWEEN PREDATORS AND MT. GRAHAM RED SQUIRRELS
(*TAMIASCIURUS HUDSONICUS GRAHAMENSIS*)

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Predation in populations of small mammals is a rarely observed event (Pearson, 1985); however, the role of predators in population regulation often is considered to be important. Documentation and assessment of mortality factors are especially critical when considering the population dynamics of threatened or endangered species. Herein, we document interactions of the endangered Mt. Graham red squirrel with potential predators.

The Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) is an isolated subspecies found only on the highest peaks of the Pinaleno Mountains, Graham Co., Arizona (Hoffmeister, 1986). The squirrel is slightly smaller in body size and has a slightly narrower skull (United States Fish and Wildlife Service, 1993) than other red squirrels found in North America. Genetic evidence also supports the distinctiveness of this geographically isolated subspecies (Sullivan and Yates, 1994). The squirrel was reported to be extinct in the 1960s (Minckley, 1968) but was rediscovered in 1972 (Spicer et al., 1985) and listed as endangered in 1987. In fall 2000, the total population of the Mount Graham red squirrel was estimated at approximately 470 individuals (T. Snow, Arizona Department of Game and Fish, pers. comm.).

Mount Graham red squirrels inhabit spruce-fir and mixed conifer forests (United States Fish and Wildlife Service, 1993). Red squirrels larderhoard seed cones into piles known as middens, typically near the center of their territory (Steele, 1998). Preferred midden locations include areas of thick foliage, dense canopies, and high stem densities (Smith and Mannan, 1994). Depending on season and availability, the squirrels feed mainly on conifer seeds, fungi, bone, and conifer twigs (Colorado National Forest, 1988). Nest sites typically

are located in large decaying snags (Froehlich and Smith, 1990).

Our monitored area, approximately 250 ha, incorporates both mixed conifer forest dominated by Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), corkbark fir (*Abies lasiocarpa* var. *arizonica*) and southwestern white pine (*Pinus strobiformis*) and spruce-fir forest composed principally of Englemann spruce (*Picea engelmannii*) and corkbark fir.

During the course of other investigations (Young, 1994), observations of potential predators were recorded nearly monthly from 1989 until 1996 and quarterly thereafter. A minimum of 41,000 h of field observation, including 3,269 h of focal animal observations, was expended.

Eighty-three observations of predators were made during monitoring periods (Table 1). Eight species of potential predators (6 avian, 2 mammalian) were observed. Five predation attempts, 1 successful and 4 unsuccessful, were recorded. Evidence of 6 possible predation attempts was documented and 5 potential predator species were observed in or near middens but did not attempt predation.

On 19 October 1989, 2 juvenile red squirrels (presumed siblings) chased each other as a Mexican spotted owl (*Strix occidentalis lucida*) unsuccessfully attacked at 1354 h MST. After 1 min the squirrel chase resumed and the owl looked on from a perch 15 m away. Eight min later the owl made a second, and this time successful, attempt. Carrying the squirrel by the neck, the owl flew 30 m east, perched in a tree for a few minutes and then left the area. Immediately after the attack the second squirrel chattered and entered the nest snag.

On 27 September 1989, the first of 4 unsuccessful predation attempts was recorded. A red squirrel was observed caching cones for ap-

TABLE 1—Potential predators of *Tamiasciurus hudsonicus* observed, 1989–2000.

Potential predators		Observations	Number of predation attempts
Common name	Scientific name		
Northern goshawk	<i>Accipiter gentilis</i>	31	3—Unsuccessful Attempts
Cooper's Hawk	<i>Accipiter cooperii</i>	9	
Sharp-shinned hawk	<i>Accipiter striatus</i>	3	
Red-tailed hawk	<i>Buteo jamaicensis</i>	5	1—Successful Attempt
Mexican spotted owl	<i>Strix occidentalis lucida</i>	3	
Great-horned owl	<i>Bubo virginianus</i>	2	20
Unknown raptor			
Bobcat	<i>Lynx rufus</i>	7	1—Unsuccessful Attempt
Gray fox	<i>Urocyon cinereoargenteus</i>	3	6—Predator unknown
Red squirrel body parts found		6	

proximately 10 min when a bobcat (*Lynx rufus*) approached from the southwest and crouched along a downed log. The squirrel appeared to detect and then approach the cat but eventually moved away over a series of downed logs and up a tree. The bobcat, sinking further into a crouch, bobbed its head to watch the squirrel before pouncing over the logs and onto the tree. After climbing about 1.5 m, the bobcat retreated. The squirrel barked when the bobcat was about 50 m away. Neighboring squirrels and 1 Abert squirrel (*Sciurus aberti*) barked shortly thereafter.

The 3 remaining unsuccessful predation attempts were made by northern goshawks (*Accipiter gentilis*). On 4 October 1990, a red squirrel was observed running the length of a log and caching cones when a goshawk flew 1.5 m above ground into the midden area and directly towards the squirrel. The squirrel squeaked and retreated. The goshawk landed on the log and perched for <1 min before flying away. A few minutes later the squirrel ran to the nest snag and sat on a limb barking for approximately 2.5 min before feeding on an Engelmann spruce cone. The second unsuccessful attempt by a goshawk was made on 9 September 1995 when an adult female squirrel was running around the trunk of a tree for approximately 30 sec prior to the attack. The squirrel barked for approximately 1 min after the hawk flew away. A third attempt by a goshawk was recorded on 11 June 2000 but no further details were available for this observation.

On separate occasions researchers found evidence of apparent raptor predation on red

squirrels. On 1 occasion only the fur, intestinal tract, and parts of the skull remained; on another, blood and tufts of fur were found on snow without prints of a terrestrial predator. Two tails were found together at the base of a snag, possibly a favorite feeding spot for a raptor. A third tail was found in close proximity to a known raptor nest and the fourth tail was found in an open meadow adjacent to a forested midden area.

Five potential predator species, not attempting predation, were observed during field visits. Nine Cooper's hawks (*Accipiter cooperii*), 3 sharp-shinned hawks (*A. striatus*), 5 red-tailed hawks (*Buteo jamaicensis*), 2 great-horned owls (*Bubo virginianus*), and 3 gray foxes (*Urocyon cinereoargenteus*) were observed near middens. On separate occasions, a red-tailed hawk, a sharp-shinned hawk, and a gray fox provoked long barks from resident squirrels.

Documentation of predation is important to understanding the ecological pressures that sensitive species face. Mt. Graham harbors resident populations of bobcats, gray fox (Hoffmeister, 1956), and several species of raptors. Raptors composed 88%, and mammals 12%, of all predator observations made during the monitoring periods. Mexican spotted owls, even though nocturnal, are successful red squirrel predators (Seamans and Gutierrez, 1999). Spotted owls are known also to feed heavily on northern flying squirrels and an array of small mammals (Thraillkill and Bias, 1989).

The bobcat, a known predator of red squirrels (Hamilton and Hunter, 1939), was the only mammal observed actively preying on the

squirrel. However, gray foxes, known predators of tree squirrels (Fritzell and Haroldson, 1982), were observed traveling through midden areas on 3 occasions. In a study conducted by Hatfield (1939), red squirrels and eastern gray squirrels made up 3% of the stomach contents of the gray fox.

Cooper's hawks, great-horned owls, sharp-shinned hawks, and red-tailed hawks, known red squirrel predators (Steele, 1998), were observed 47 times. The northern goshawk, however, was the most frequently observed predator throughout the study and accounted for a third of all observations recorded. Red squirrels composed 37% of goshawks' diet in a study conducted by Meng (1959). Raptors were the main cause of mortality during a study of juvenile dispersal in Mount Graham red squirrels in which juveniles appeared to be more susceptible to predation due to exploration of unknown areas with unfamiliar escape routes, as well as from being preoccupied with avoiding resident squirrels (Kreighbaum and Van Pelt, 1996). Successful predation attempts on the Mt. Graham red squirrel appear to be low; 1 successful attempt was observed during 41,000 h of field work. Future studies are still needed, however, to determine the frequency of predation, its significance on population regulation, and the susceptibility of age classes to predation.

Resumen—La ardilla *Tamiasciurus hudsonicus grahamensis* es una subespecie aislada que se encuentra sólo en los picos más altos de las Montañas Pinaleno, en el condado Graham, Arizona, USA. Mientras se monitoreaba esta subespecie (de 1989 al 2000), se registraron observaciones de depredadores potenciales durante 41,000 h de observaciones de campo. Se hicieron 83 observaciones de depredadores. Se observaron 8 especies de depredadores potenciales (6 de aves y 2 de mamíferos): los buhos *Strix occidentalis lucida* y *Bubo virginianus*, los gavilanes *Accipiter gentilis*, *A. cooperii*, *A. striatus* y *Buteo jamaicensis*, el zorro *Urocyon cinereoargenteus* y el gato montés *Lynx rufus*. Se registraron 5 intentos de depredación, 1 éxito y 4 fracasos.

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