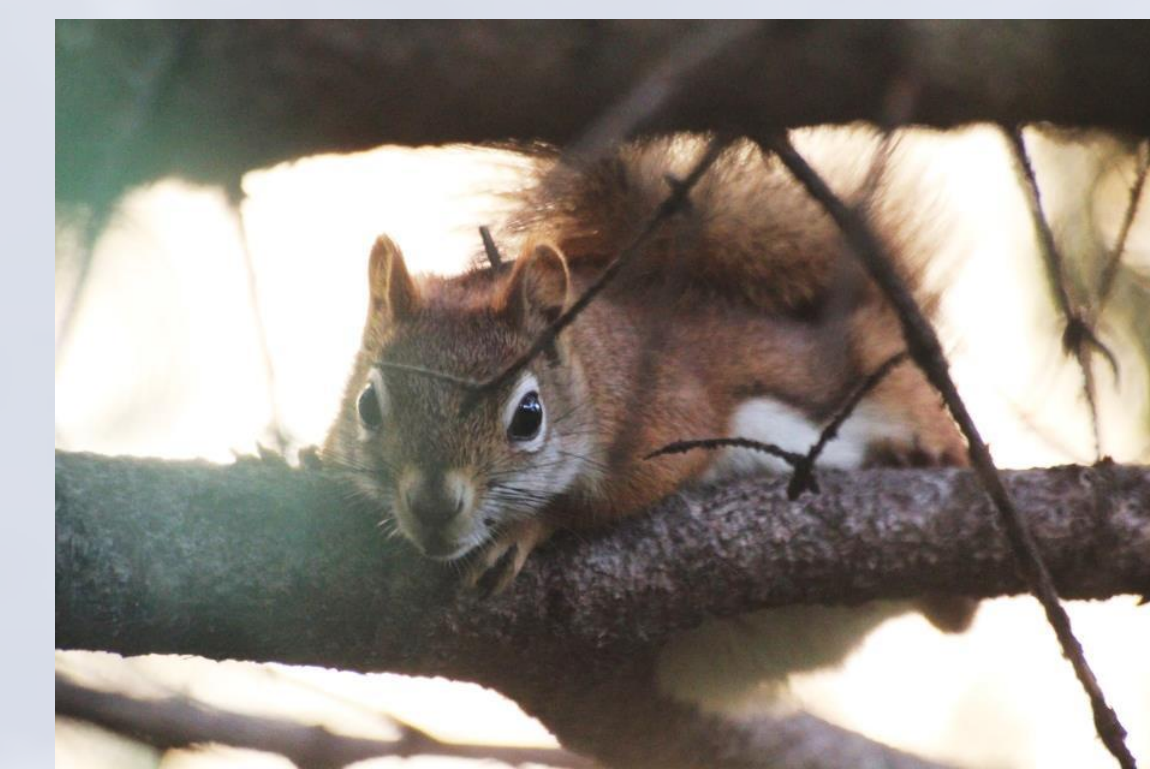




Spatial and Behavioral Interactions between American Red (*Tamiasciurus hudsonicus*) and Eastern Gray (*Sciurus carolinensis*) Squirrels on an Urban College Campus

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Introduction

Squirrels (Order Rodentia, Family Sciuridae) are conspicuous members of the mammal community and have been successful in adapting to the urban landscape. While there are a number of studies examining individual squirrel species in an urban setting (e.g., Bowers and Breland 1996; McCleery et al. 2007), few have focused on multiple species within the same area. In North America, studies of tree squirrel interactions are rare and not well quantified. Studies have focused on interactions between gray squirrels (*Sciurus carolinensis*) and fox squirrels (*S. niger*). Few studies have looked in detail at the American red squirrel (*Tamiasciurus hudsonicus*) and interactions with gray squirrels, particularly in urban environments.

Generally, red squirrels are associated with coniferous forest where they tend to establish territories that they aggressively defend against conspecifics (Riege 1991). However, there is evidence of behavioral plasticity as Gurnell (1987) shows that red squirrels inhabiting deciduous habitats do not establish long-term territories. Gray squirrels are more often associated with deciduous forest (Reige 1991; Nupp and Swihart 2000) and tend to establish a strict dominance hierarchy among conspecific individuals (Thompson 1978).

When occupying the same area, there are anecdotal reports that red squirrels are more aggressive and even displace the substantially larger gray squirrels, but detailed studies fail to support aggressive behaviors between the two species (Ackerman and Weigl 1970). Riege (1991) suggests that a form of indirect competition, exploitation competition, may favor gray squirrels in prime gray squirrel habitat, but that the two species may co-exist in intermediate or mixed habitats where neither species has an advantage.

Concordia College's campus is a unique setting where both the red and gray squirrels are found occupying the same area. The campus habitat may represent a mixed or marginal habitat that enables the two species to co-exist. The goal of this research was to examine in detail how the red and gray squirrels use the habitats present on campus, and how they partition the habitat and resources.



Methods

Tomahawk live traps were set at multiple locations on the Concordia College campus. Traps were baited with peanut butter and were checked every 20 minutes while open. Cloth tarps were placed over traps that captured squirrels to reduce stress.

Each squirrel was identified to species, weighed, and sex was determined. Squirrels were marked with BIOMARK™ passive integrated transponder (PIT) tags for individual identification. (Harper and Batzli 1996; Lebl and Ruf 2010; Gibbons and Andrews 2004). From August 2014 to December 2015 squirrels were injected intramuscularly with the anesthetic Tiletamine (Telazol) and each squirrel was fitted with a collar containing a radio transmitter (Wildlife Materials, Inc.). Starting in January 2016 we began using a squirrel handling cone to handle the squirrels (Koprowski 2002; Arenz 1997). We have found these cones to be safer, quicker, and less stressful on the squirrels. Three or four colored beads unique to each squirrel were placed on the collar to allow for opportunistic identification without the need for telemetry equipment.

Radio telemetry using a Yagi antenna and receiver was used to locate the squirrels on campus and allow for documentation of spatial use of habitat and nesting locations, quantify competition for food and nesting locations, and observe individual behavioral interactions.

All techniques and procedures involving animal handling conform to established American Society of Mammalogists animal handling guidelines (Sikes et al. 2016; Sikes et al. 2011; Gannon et al. 2007) and were conducted in accordance with Minnesota Department of Natural Resources, and Concordia College's IACUC (AUP_BIO_2014.2).

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Results and Discussion

To date we have conducted 22 trapping sessions and have collared 58 different squirrels over three years. We have collected over 691 locations and behavioral observations, 406 of red and 285 of gray squirrels.

Location data indicates that gray squirrels are significantly associated with deciduous trees and red squirrels with coniferous trees ($\chi^2 = 82.45$, $df = 1$, $p < 0.01$) (Fig. 1). Out of the 116 tree locations, 98 of the gray squirrels were in deciduous trees (Fig. 1). Red squirrels were found to be heavily associated with coniferous trees, with 160 of the 247 tree locations in coniferous trees.

Tree usage indicated that red squirrels fluctuated between using primarily coniferous in 2014, to almost equal numbers of deciduous trees in 2015, and then returns to using primarily coniferous trees in 2016. Gray squirrels continued to primarily use deciduous trees throughout the three years (Fig. 2).

In terms of location type, both gray and red squirrels show variability in use of habitats on Concordia College's campus (Fig. 3 and 4). Gray squirrels use primarily deciduous trees, however, they spend much of its time on the ground as well. Red squirrels use primarily coniferous trees, but also heavily use deciduous trees and the ground as well. Red squirrels have also been shown to use underground holes, burrows under sidewalks, and storm drains.

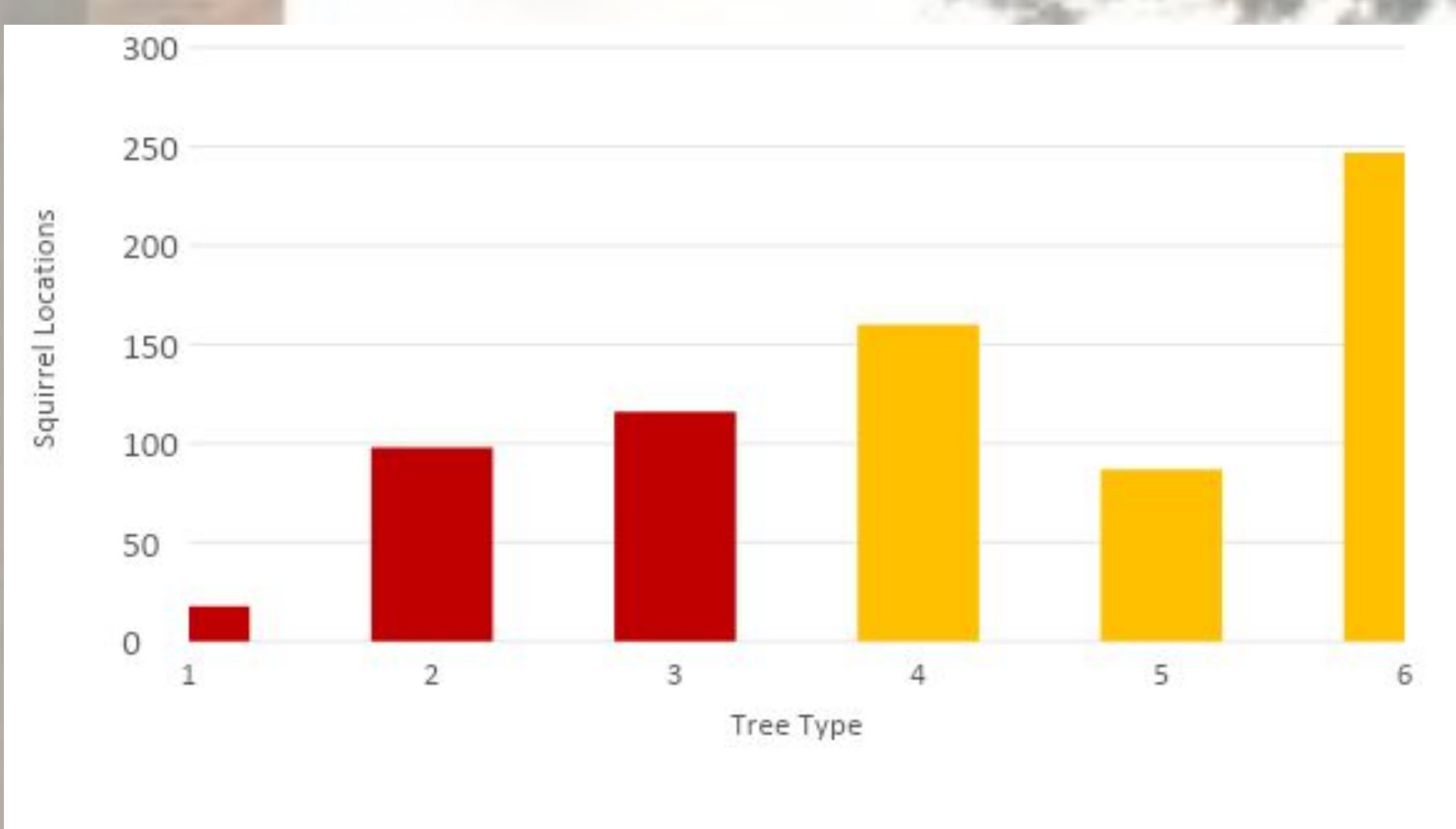


Figure 1. *Sciurus carolinensis* and *Tamiasciurus hudsonicus* locations for all years together based on tree type.

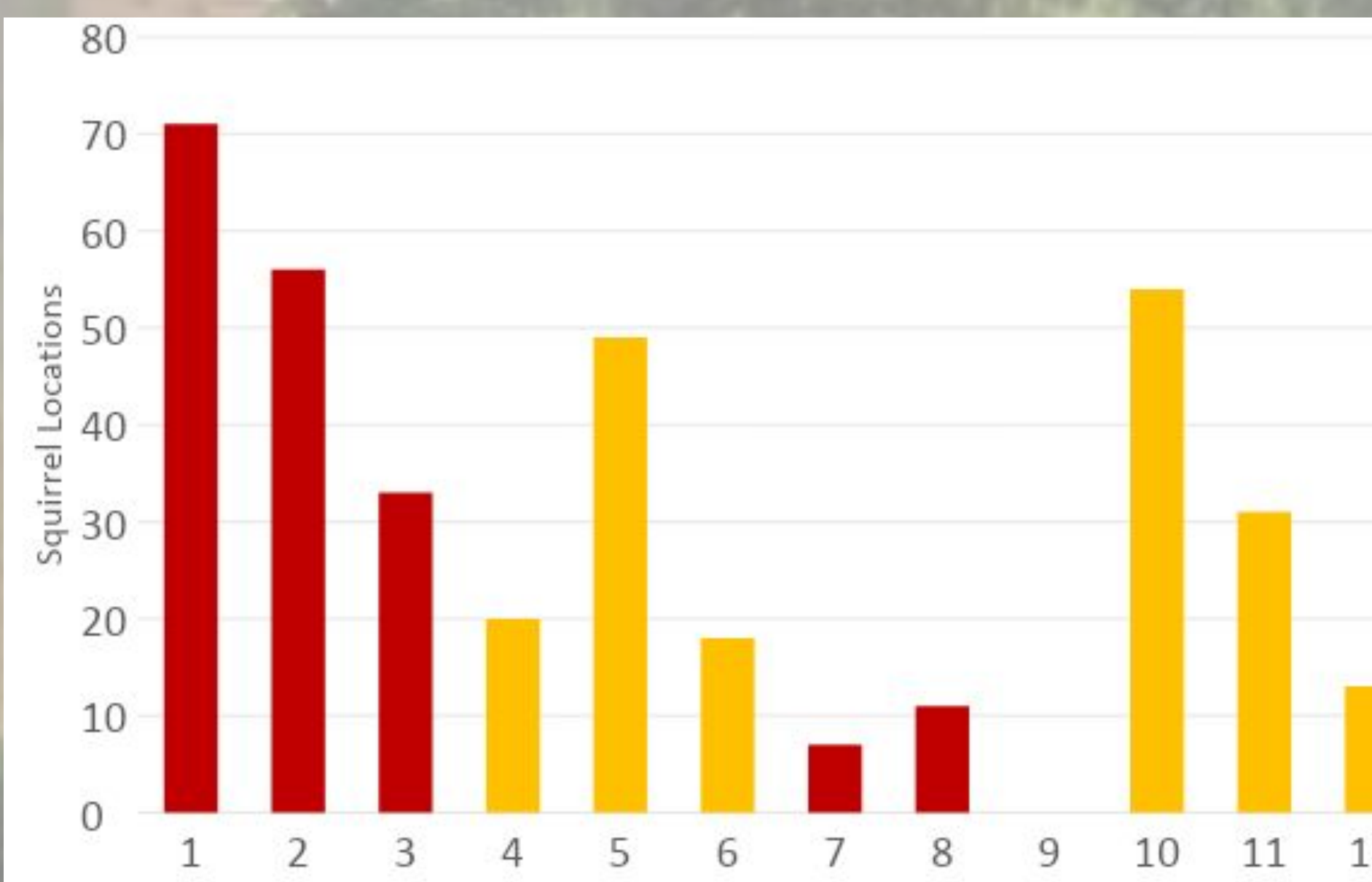


Figure 2. *Sciurus carolinensis* and *Tamiasciurus hudsonicus* locations based on tree type per year.



Figure 3: Distribution of *Sciurus carolinensis* locations from 2014-2016. Locations were grouped in the location types. A total of 212 locations were able to be categorized.

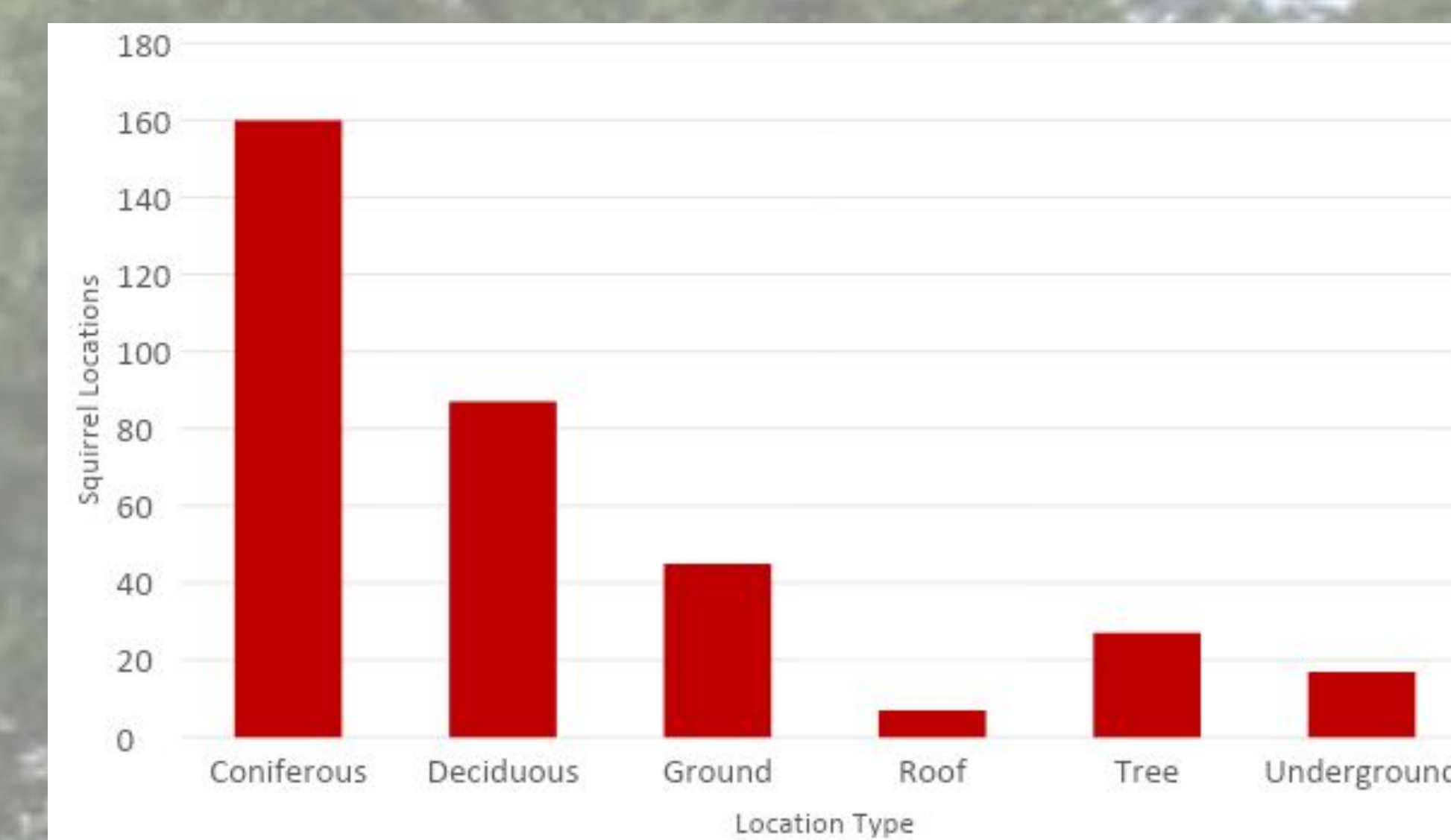


Figure 4: Distribution of *Tamiasciurus hudsonicus* locations from 2014-2016. Locations were grouped in the location types. A total of 343 locations were able to be categorized.



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