# PERSPECTIVES ON RED SQUIRREL *(TAMIASCIURUS HUDSONICUS)* AND EASTERN CHIPMUNK *(TAMIAS STRIATUS)* DISTRIBUTION AND DETECTABILITY IN NEWFOUNDLAND FROM CITIZEN SCIENCE AND OCCUPANCY MODELING

by

Heather E. Spicer



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The undersigned certify that they have read, and recommend to the School of Science and Environment for acceptance, a thesis entitled "Perspectives on red squirrel *(Tamiasciurus hudsonicus)* and eastern chipmunk *(Tamias striatus)* distribution and detectability in Newfoundland from citizen science and occupancy modelling" submitted by Heather E. Spicer in partial fulfillment of the requirements for the degree of Bachelor of Science, Honours.

____________________________

Dr. Erin Fraser (Supervisor)

____________________________

Dr. Ian Warkentin

____________________________

Dr. Lakshman Galagedara

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# Abstract

Red squirrels (*Tamiasciurus hudsonicus*) and eastern chipmunks (*Tamias striatus*) are both introduced species on the island of Newfoundland. There is evidence that *T. hudsonicus* have contributed to significant changes in the ecology of several native animal and plant species. Little is known about the ecological implications of the introduction of *T. striatus.* The full extent of both the *T. hudsonicus* and *T. striatus* ranges across insular Newfoundland and the nearshore islands have not been described. *Tamiasciurus hudsonicus* reliably respond to broadcasts of recorded conspecific territorial vocalizations, both through calling back and approaching the speaker. However, variation in the responsiveness of *T. hudsonicus* to call broadcasts (detectability) over time is not well understood. I investigated *T. hudsonicus* and *T. striatus* distribution across Newfoundland ecoregions and *T. hudsonicus* detectability in Newfoundland through a two-part study. First, I recruited elementary school students to participate in a citizen science investigation. Participants submitted data about *T. hudsonicus* and *T. striatus* presence at locations across Newfoundland, including the results of surveys using call broadcasts, observations made while walking in the woods, and qualitative data from student interviews with family/friends. I received data from 50 teachers and 899 elementary school students affiliated with 29 schools around the island of Newfoundland. This included 43 class point count/call broadcast surveys (including a total of 85 point counts), as well as 159 individual walks in the woods, and 142 interviews with family and friends. The proportion of sites with *T. hudsonicus* present did not vary significantly among ecoregions ($\chi^2$= 0.725, df=5, $p$>0.05), however, the proportion of sites with *T. striatus* did ($\chi^2$=12.61, df=5, $p$<0.05), suggesting that *T. striatus* are more restricted in their range than *T. hudsonicus.* Second, I investigated how *T. hudsonicus* detection probability varied over time and during silent and playback treatments by conducting monthly point count/call broadcasts along standardized survey routes at two locations on the west coast of Newfoundland. Probability of detection estimates steadily declined from autumn to winter and detection probability was always higher during playback treatments than during silent treatments. This demonstrates the efficacy of using call broadcasts during point count surveys for *T. hudsonicus,* and suggests that call broadcasts are most effectively used for this purpose in the summer and early fall.

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# Summary of Project

This honours thesis project is made up of three distinct parts: (i) a literature review summarizing red squirrel *(Tamiasciurus hudsonicus)* and eastern chipmunk *(Tamias striatus)* biology and the impact of these two non-native species on Newfoundland ecosystems, (ii) a citizen science documentation of *T. hudsonicus* and *T. striatus* distribution in insular Newfoundland and the nearshore islands, and (iii) a study of monthly point count/call broadcast surveys to quantify the probability of detection of *T. hudsonicus* in western Newfoundland and to investigate whether their level of responsiveness changes over time. Parts (ii) and (iii) are written in scientific article format as two separate chapters, as each part involved independent data collection, analyses, and interpretation.

# Literature Review

*Study species*

North American red squirrels *(Tamiasciurus hudsonicus)*

North American red squirrels *(Tamiasciurus hudsonicus)* are small-bodied tree squirrels (Family Sciuridae) that are found across much of Canada and the United States, from Alaska to Newfoundland in the north, and southward to encompass a region aligning with the Cascade, Rocky, and Appalachian mountain ranges (Steele 1998). They have a reddish back and a white stomach with dark coloured lines along their sides that become more defined in the summer months. Their tails are smaller and flatter than other tree squirrels and can be yellowish-gray or rusty red. *Tamiasciurus hudsonicus* go through two molts of their body hair in a year, but only once a year for hair in their tail. *Tamiasciurus hudsonicus* weigh 200 to 250 g, and are 270 to 385 mm long. In general, body size of tree squirrels increases with latitude, but *T. hudsonicus* are an exception. According to Bergmann's rule, body size of warm-blooded animals is typically large in cold climates in order to retain heat (Ashton et al. 2000), and yet, *T. hudsonicus* is the smallest species of tree squirrel found in the coldest climate (Steele 1998). Their smaller size, about 30% less than the gray squirrel, *Sciurus carolinensis*, may result from selection pressures to better forage and move around in the smaller branches of trees where they live (Wheatley 2007).

*Tamiasciurus hudsonicus* have a high affinity for coniferous forest areas (Rusch and Reeder 1978), therefore, as the boreal forest becomes sparsely populated by coniferous vegetation at the southern border of the biome, squirrel populations also become considerably fragmented or patchy. *Tamiasciurus hudsonicus* are primarily granivorous (Steele 1998), which means their main source of food comes from grains and seeds. An indicator of squirrel activity is often the presence of piles of seeds dropped during feeding that are scattered throughout the territory of a squirrel (Posthumus et al. 2015). Density of *T. hudsonicus* is greatest in old-growth conifer stands where mature trees produce large cone crops each year (Thompson et al. 1989; Fisher and Bradbury 2006). The availability of seeds and cones from conifers can fluctuate from year to year, so *T. hudsonicus* must also be opportunistic in these times of food shortage (Steele 1998). *Tamiasciurus hudsonicus* will feed on secondary resources including tree buds and flowers, berries, insects, fungi, and even nestlings of birds and other mammals (Willson et al. 2003). In the winter and early spring, bark stripping and tree girdling is common, whereby strips of bark are removed from the entire circumference of the tree in order for the squirrel to gain access to the sugary sap underneath (Steele 1998).

Scatterhoarding and larderhoarding are two broad classifications to describe the way squirrels store food (Smith and Reichman 1984). Scatterhoarding is the scattering of small food caches throughout a home range or territory, and larderhoarding is the concentration of food in a centralized location within an individual's territory (Hurly and Lourie 1997). *Tamiasciurus hudsonicus* are usually described as larderhoarders because they mainly focus on caching conifer cones in a single, protected site called a midden (Rusch and Reeder 1978; Benhamou 1996; Posthumus et al. 2015). A midden can be a storage site, such as a hollow log, that stays relatively cool and moist in order to prevent hoarded cones from opening and releasing seeds (Hurly and Lourie 1997). Depending on the availability of food, middens may contain enough food to last multiple seasons (Steele 1998; Posthumus et al. 2015), and reach up to 13 m in diameter and 50 cm in depth (Patton and Vahle 1986). The size of these middens varies with location, but middens are often inherited with the establishment of new territories (Hurly and Lourie 1997).

*Tamiasciurus hudsonicus* are highly territorial and in order to protect their middens, individuals will aggressively defend a territory against other *T. hudsonicus* (Rusch and Reeder 1978; Digweed and Rendall 2010; Shonfield et al. 2012). *Tamiasciurus hudsonicus* emit a range of alarm calls to defend their cache of food (Kemp and Keith 1970). A primary factor that influences the size and shape of an individual territory is the availability and distribution of food (Steele 1998). There is an inverse relationship between food availability and territory size (Haughland and Larsen 2004). In areas with less favourable habitat and less food, *T. hudsonicus* will occupy larger territories. Estimates of territory sizes usually range from 0.24-0.98 hectares (Steele 1998). As a territory becomes larger, it is increasingly difficult for a single squirrel to successfully monitor and maintain the entire boundary of the territory from intrusion (Shonfield et al. 2012).

*Tamiasciurus hudsonicus* depend on vocalizations to secure their territories and find mates (Steele 1998; Dantzer et al. 2013). Researchers have divided the vocalizations made by *T. hudsonicus* into five broad categories which include: chirps, rattles, screeches, growls, and buzz calls (Steele 1998). Chirps (1-2 kHz) are alarm calls emitted in the presence of other squirrels. A rattle call (0.5-2 kHz) is also a type of alarm call that is used to establish an individual territory and threaten intruders (Lair 1990). These rattles may also be used in combination with the third type of call, screeches, which add to the aggressive rattle call and scare away intruders. Intrusions rarely lead to physical chases or fights (Dantzer et al. 2013). The last two calls, growls

(0.5-2 kHz) and buzz calls (5-6.5 kHz) are associated with calls made during mating seasons when males and females approach each other (Steele 1998).

Eastern chipmunks *(Tamias striatus)*

Eastern chipmunks *(Tamias striatus)* are small, heavy-set ground squirrels (Family Sciuridae) with grayish-brown fur and distinctive stripes on their backs (Snyder 1982). They are found across eastern North America, from Lake Manitoba eastward to Quebec in Canada, and all the way to the southern states of the United States that border the Gulf of Mexico. *Tamias striatus* weigh 80 to 125 g, and are 225 to 268 mm long. They use simple and complex burrowing systems to store food and hide from predators. *Tamias striatus* live in primarily deciduous or mixed deciduous/coniferous wooded areas. Their diet consists of seeds and nuts that they collect and store in their burrows overwinter (Baack and Switzer 2000). Like *T. hudsonicus, T. striatus* also rely on other food resources, particularly insects, fungi, and occasionally other small animals when there is low availability of more typical food sources (Synder 1982).

*Tamias striatus* produce a variety of chips, trills, and chucks which function as alarm signals in response to threats (Snyder 1982; Burke da Silva et al. 2002). Frequencies of these calls range from 1 kHz (high-pitched chips and trills) to 11 kHz (low-pitched chucks). Groups are known to call at the same time as a chorus to warn nearby relatives of approaching predators (Snyder 1982; Weary and Kramer 1995). After hearing an alarm call, individuals may delay their emergence from burrows or alter their foraging behaviour to run shorter, more direct routes to feeding stations (Baack and Switzer 2000). *Tamias striatus* also respond to conspecific playback, but rather than calling back and approaching the speaker in the way that *T. hudsonicus* do, they assume an upright or crouched alert posture to reduce the chance of being seen or heard by a predator (Weary and Kramer 1995).

*Impact of Tamiasciurus hudsonicus and Tamias striatus on Newfoundland ecosystems*

In Newfoundland, suitable abiotic conditions and fewer predators have led to successful introductions for 11 out of 12 non-native mammal species. *Tamiasciurus hudsonicus* are not native to insular Newfoundland, Canada, but, were successfully introduced by humans starting in 1963 (Steele 1998; Benkman et al. 2008; Whitaker 2015). The first documented attempt of *T. hudsonicus* introduction occurred in 1955 in St. John's, but this attempt failed. Eight years later in 1963, members of the public brought squirrels over from Quebec and Labrador and successfully established a local population on the Northern Peninsula in Roddickton and Main Brook (Strong and Leroux 2014; Whitaker 2015). *Tamiasciurus hudsonicus* were later introduced to Camel Island in Notre Dame Bay, and by the 1970s, translocations made by locals and the Newfoundland Wildlife Service helped to colonise *T. hudsonicus* in suitable habitat throughout insular Newfoundland (Whitaker 2015), but the full extent of their range on nearshore islands has not been described. At present day, estimates of squirrel densities on Newfoundland are higher than some areas on the mainland where these squirrels are native (Benkman et al. 2008). Differences in the dynamics of island and mainland populations may help to explain how there is a higher survivorship and stability of small mammals on islands (Koprowski 2005). Newfoundland has suitable habitats, a lack of predators, and an abundance of food and nesting spaces, which all have contributed to the success of the species (Fisher and Wilkinson 2005).

Recent evidence suggests that the introduction and subsequent spread of *Tamiasciurus hudsonicus* in Newfoundland has had major impacts on several species of local plants and animals, including balsam fir *(Abies balsamea)* (Gosse et al. 2011), red crossbill *(Loxia curvirostra percna)* (Benkman et al. 2008), and gray-cheeked thrush *(Catharus minimus minimus)* (Whitaker et al. 2015). Predation by *T. hudsonicus* on conifer cones reduces a large fraction of conifer seed crop in Newfoundland (Whitaker 2015) and can significantly impact the rate of overall boreal forest regeneration (Gosse et al. 2011). Every year, *T. hudsonicus* harvest and store cones which can prevent some conifers, such as *Abies balsamea*, from reproducing at previously normal rates. Over time, as squirrel activity effectively removes cones from an area of forest, this leads to lower recruitment of seedlings for later years (Gosse et al. 2011).

*Tamiasciurus hudsonicus* are seed predators and will compete with other animals that eat cones, such as the endangered red crossbill *(Loxia curvirostra percna)*, a subspecies only found in Newfoundland (Benkman et al. 2008). *Tamiasciurus hudsonicus* are strong competitors for seeds, but this subspecies of *L. curvirostra* did not co-evolve with *T. hudsonicus* in Newfoundland, therefore, these birds were not prepared to compete for food. Less than 30 years after the introduction of *T. hudsonicus* to the island, the *L. curvirostra percna* population rapidly declined to a point of near extinction (Benkman et al. 2008).

Recently, it has been hypothesized that *T. hudsonicus* may be negatively impacting another threatened local bird species, the gray-cheeked thrush *(Catharus minimus minimus)* (Whitaker et al. 2015; Whitaker 2015). *Tamiasciurus hudsonicus* may prey on eggs and nestlings (Willson et al. 2003), potentially including those of *C. minimus minimus* (Whitaker et al. 2015). Since 1975, there has been an estimated 95% decline in *C. minimus minimus* in low-lying areas in Newfoundland. At higher elevations, decline is not as pronounced, and this may be because *T. hudsonicus* are infrequent or absent from mountainous and elevated regions. Currently, both *L. curvirostra percna* and *C. minimus minimus* are listed as species at risk in Newfoundland and Labrador, so it is important to understand how *T. hudsonicus* are impacting these species year after year.

There are comparatively few studies investigating the impacts of *Tamias striatus* in Newfoundland, therefore, introductions of closely related species elsewhere in the world may help to provide some insight into potential impacts of this species. Non-native Siberian chipmunks (*Tamias sibiricus*), have been accidently or intentionally released into forests in Europe since the 1960s (Vourc'h et al. 2007; Marmet et al. 2009) and there is some concern that they may act as new hosts to amplify the circulation of pathogens and bacteria, such as *Borrelia burgdorferi,* which later gives rise to serious illnesses, including Lyme disease (Marsot et al. 2013). Siberian chipmunks (*Tamias sibiricus*) in Europe are suspected of carrying a wider range of infections than native bank voles (*Myodes glareolus*) and wood mice (*Apodemus sylvaticus*), consequently contributing to higher emergence of disease in Europe (Marsot et al. 2013). In Newfoundland, it is unknown whether *T. striatus* have a similar capacity to spread disease amongst native and non-native species.

# **Chapter 1:** Citizen science investigation of red squirrel *(Tamiasciurus hudsonicus)* and eastern chipmunk *(Tamias striatus)* distribution among ecoregions in Newfoundland

## Introduction

Red squirrels *(Tamiasciurus hudsonicus)* and eastern chipmunks *(Tamias striatus)* are both non-native species that have been introduced to Newfoundland. There is evidence suggesting that *T. hudsonicus* have had major impacts on some native animals and plants in Newfoundland (Benkman et al. 2008; Gosse et al. 2011; Whitaker et al. 2015), and little is known about the ecological implications of the introduction of *T. striatus*. Species distribution and abundance of *T. hudsonicus and T. striatus a*re currently not well documented in Newfoundland and it is important to gain information about the extent of these two species across insular Newfoundland and the nearshore islands.

Newfoundland has been divided into nine distinct ecoregions based on differences in climate, vegetation, and soil (Damman 1983). Seven ecoregions were surveyed in this project and these regions include: Western Newfoundland Forest (WNF) (mixed coniferous-deciduous forests dominated by balsam fir *(Abies balsamea));* Central Newfoundland Forest (CNF) (mainly hardwood forests dominated by white birch *(Betula papyrifera)* and aspen *(Populus tremuloides));* North Shore Forest (NSF) (continuous forests of black spruce *(Picea mariana)* and balsam fir *(Abies balsamea)* with a rocky coastline); Northern Peninsula Forest (NPF) (forests of black spruce *(Picea mariana)* interspersed with bogs and softwood scrub); Avalon Forest (AF) (mixed coniferous-deciduous forests of balsam fir *(Abies balsamea)*, white birch *(Betula papyrifera)*, and yellow birch *(Betula alleghaniensis))*; Strait of Belle Isle Barrens (IB) (patches of dwarfed white spruce *(Picea glauca)* interspersed with arctic-alpine vegetation); and the Maritime Barrens (MB) (rocky barrens broken up by heathland and stunted balsam fir *(Abies balsamea))* (Ecoregions of Newfoundland 2017). While *T. hudsonicus* and *T. striatus* are known to prefer coniferous and mixed deciduous-coniferous forests, respectively, a comparison of presence/abundance of both species amongst ecoregions in Newfoundland has not been investigated to date.

Citizen science projects are designed for scientists to connect with members of the community, collect scientific data, and answer research questions (Lukyanenko at al. 2016). These types of projects are becoming increasingly prevalent in recent literature (Holck 2008) since they can achieve similar objectives as other research methods in a more cost effective way (Danielsen et al. 2007). Citizen science projects are appropriate in circumstances where the goal is to address research questions related to a large geographical area and require a large quantity of data to be collected (Snäll et al. 2011; Callaghan and Gawlik 2015). In turn, the citizen scientists may also develop a better understanding and appreciation for their local environment because of their active participation in the scientific process (Cooper et al. 2007; Danielsen et al. 2007; Holck 2008; Snäll et al. 2011).

The objective of this study was to use a citizen science approach to investigate variation in abundance/presence of *T. hudsonicus* and *T. striatus* among ecoregions in insular Newfoundland and the nearshore islands. Based on what we know about the history and habitat preferences of squirrels and chipmunks in Newfoundland (e.g. Whitaker 2015), I predicted that *T. hudsonicus* would be found across all of insular Newfoundland and many of the nearshore islands, but *T. striatus* would be found only in areas with mixed deciduous-coniferous forests on the main island.

## Methods

### *Data collection*

Between June and September 2016, teachers and schools from the Newfoundland and Labrador English School District (NLESD) were contacted by phone and e-mail and invited to participate in the 'red squirrel and eastern chipmunk citizen science project'. Schools located in remote areas or on nearshore islands were particularly targeted in an attempt to broaden the geographical range of the project. Each participating school received a package containing a written guide for each teacher (Appendix A), a speaker for conducting call broadcasts, data sheets, letters to parents, and supplies for hands-on educational activities to relate each grade's science curriculum to *T. hudsonicus* and *T. striatus* biology. To align with best practices for conducting citizen science surveys, data sheets were simplified and standardized, using checklists and short answer questions that ideally reduced inter-observer variation (Holck 2008; Snäll et al. 2011; Lewandowski and Specht 2015). Because citizen science volunteers are more likely to stay involved with projects when researchers regularly communicate with them by offering feedback and research progress (Lewandowski and Specht 2015), project updates were regularly e-mailed to participating classes over the course of the data collection period. All packages were sent out on or before October 14, 2016 and data sheets were returned by December 2, 2016.

All work was conducted with permission from the Newfoundland and Labrador English School District school board (NLESD approval; Appendix B), as well as with necessary provincial permitting for conducting wildlife research (Scientific research permit #:WLR2016-18; Appendix A) and approval from the Memorial University of Newfoundland animal care committee (Animal care approval #16-05EF; Appendix B).

Participating classes were given the option to collect data in any or all of the three following ways: (i) class point count/call broadcast survey, (ii) individual walk in the woods, and (iii) interviews with family and friends. The citizen scientists filled out the relevant provided data sheets for each data collection component. During (i) class point count/call broadcast surveys students and their teachers visited a local forested area as a group and played recordings of *T. hudsonicus* territorial calls at one or more point counts (point counts separated by 300 m to avoid surveying individual squirrels more than once). At each point count, citizen scientists had a four minute quiet observation period followed by four minutes of call broadcasts of recorded *T. hudsonicus* territorial calls. Vocalizations were broadcast using XTREME Audiopod portable Bluetooth speakers working wirelessly with teachers' personal smartphones or laptop computers/tablets. The recorded *T. hudsonicus* territorial calls were obtained from Cornell sound library Macaulay Library at the Cornell Lab of Ornithology and edited by D. Whitaker (ML Catalogue #numbers:100916, 136185). Citizen scientists recorded specific details about the location of their survey, date and time, distance travelled, general habitat description of the survey location, and the number and type of responses (auditory and visual) from *T. hudsonicus* and *T. striatus.*

Data collection parts (ii) and (iii) were designed for individual or small group out-of-school participation. During (ii) individual walk in the woods, students completed a survey for *T. hudsonicus* and *T. striatus* by going for a short walk in a forest near their home and recording all observations as well as associated information about the study site. During (iii) interviews with family and friends, students interviewed an adult (perhaps a parent, grandparent, or friend in their community) who had a cabin in a forested area on Newfoundland or the surrounding nearshore islands. Interviewees reported whether or not *T. hudsonicus* and/or *T. striatus* were ever present at their cabin, how often both species were seen, and at what point in the past they first noticed each species in the area around their cabin. Participating teachers returned all completed data sheets in prepaid envelopes to Grenfell Campus. Updates to the participating classes were sent out as new information became available and appropriate recognition for their work was given in presentations throughout the whole project (Elbroch et al. 2011).

*Statistical analyses*

Statistical analyses were conducted manually and using R version 3.3.1. Each class point count/call broadcast survey, individual walk in the woods, and cabin identified through interviews with family and friends was mapped in Google Maps using the descriptions provided by the citizen scientists and coordinates were obtained based on these points. Each point was assigned to an ecoregion based on a visual examination of an ecoregion layer in ArcGIS (ArcMap 10.4) (Ecoregions of Newfoundland and Labrador 2007).

Species presence and abundance was compared among ecoregions using two statistical approaches. To compare the mean number of *T. hudsonicus* detected at each point count during (i) class point count/broadcast surveys, a Kruskal-Wallis test was used to examine across ecoregion differences. The mean numbers of *T. hudsonicus* detected during quiet observations and call broadcast periods were pooled for analyses. Chi-square tests for homogeneity were used to test for variation in the proportions of sites where *T. hudsonicus* and *T. striatus* were present (based on data from (ii) individual walks in the woods and (iii) cabins identified through interviews with family and friends). When Chi-square results indicated that the proportion of sites with *T. hudsonicus* and *T. striatus* differed among ecoregions, further paired-comparisons were conducted using a Marascuilo procedure. All data was reported as mean ± standard error, unless otherwise stated, and an α-level of 0.05 was used for all statistical tests.

## Results

Data were received from 50 teachers and 899 elementary school students affiliated with 29 schools around the island of Newfoundland. Citizen scientists completed 43 class point count/call broadcast surveys which included a total of 85 point counts (Figure 1.1). Several classes reported detections of *T. striatus* audibly (but not visually) in response to the call broadcast portions of their surveys. Given that participants were not explicitly trained to recognize the calls of *T. striatus* and given that the typical response of *T. striatus* to predator alarm calls is to assume an upright and alert posture (and not to call back) (Weary and Kramer 1995), these reports were considered to be unlikely, and only visual reports of *T. striatus* were included in subsequent analyses.

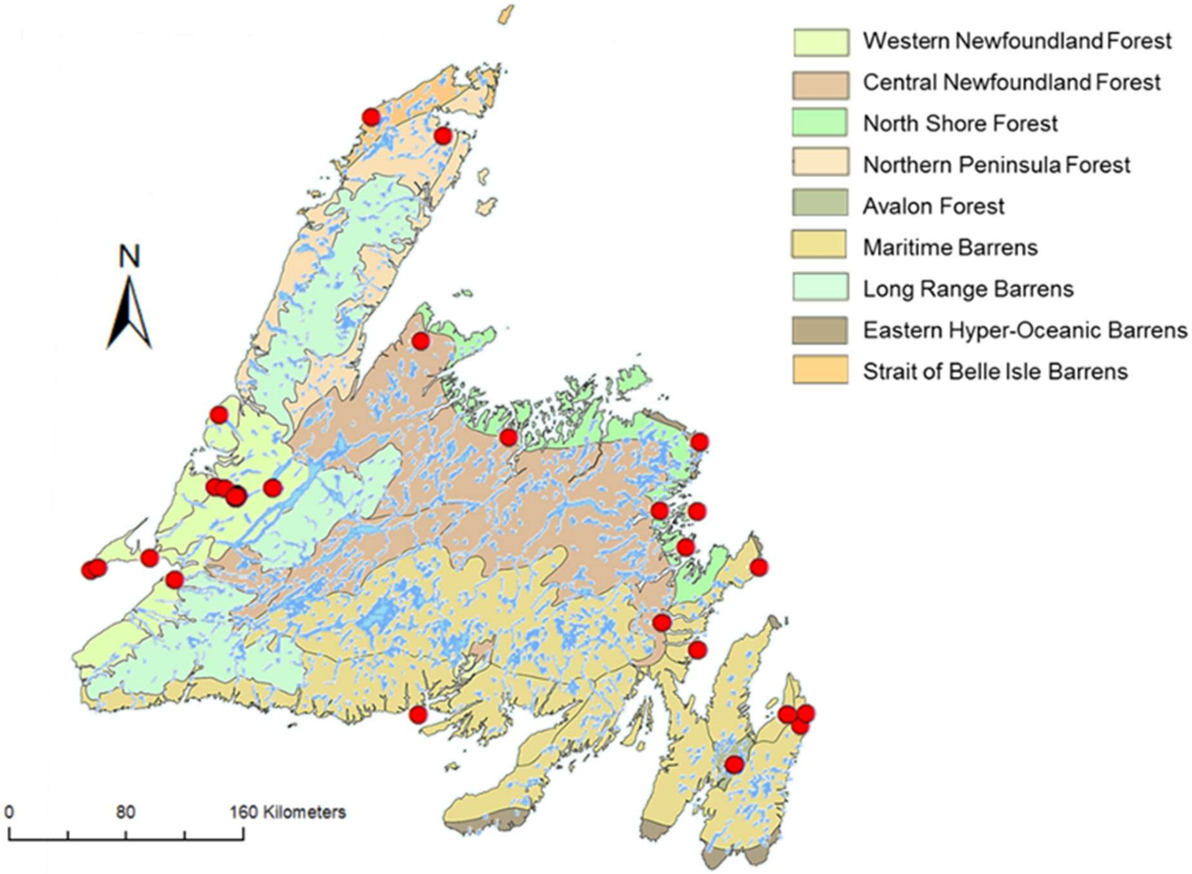


**Figure 1.1 Locations of class point count/call broadcast surveys.** There were 43 call broadcast surveys with some surveys including multiple point counts, for a total of 85 point counts in seven ecoregions in Newfoundland: Western Newfoundland Forest (n=43), Central Newfoundland Forest (n=10), North Shore Forest (n=9), Northern Peninsula Forest (n=3), Avalon Forest (n=3), Maritime Barrens (n=14), and Strait of Belle Isle Barrens (n=3).

There was no difference in the mean number of *T. hudsonicus* that were seen or heard per point count among four Newfoundland ecoregions (Figure 1.2; Kruskal-Wallis test: $H$=3.95, df=3, $p$=0.27). The highest mean number of *T. hudsonicus* per point count was in CNF (1.90 ± 0.31, n=10) and the lowest number was in MB (1.07 ± 0.44, n=14). Because *T. striatus* were only reported in CNF and the WNF ecoregions, and in very low numbers (0.1 ± 0.1, n=10, and 0.12 ± 0.06, n=14, *Tamias striatus* per point count, respectively), no statistical analyses were conducted on these data. A total of nine point counts from the AF, IB, and NPF ecoregions were not included in the statistical analyses due to insufficient sample sizes (n<5).

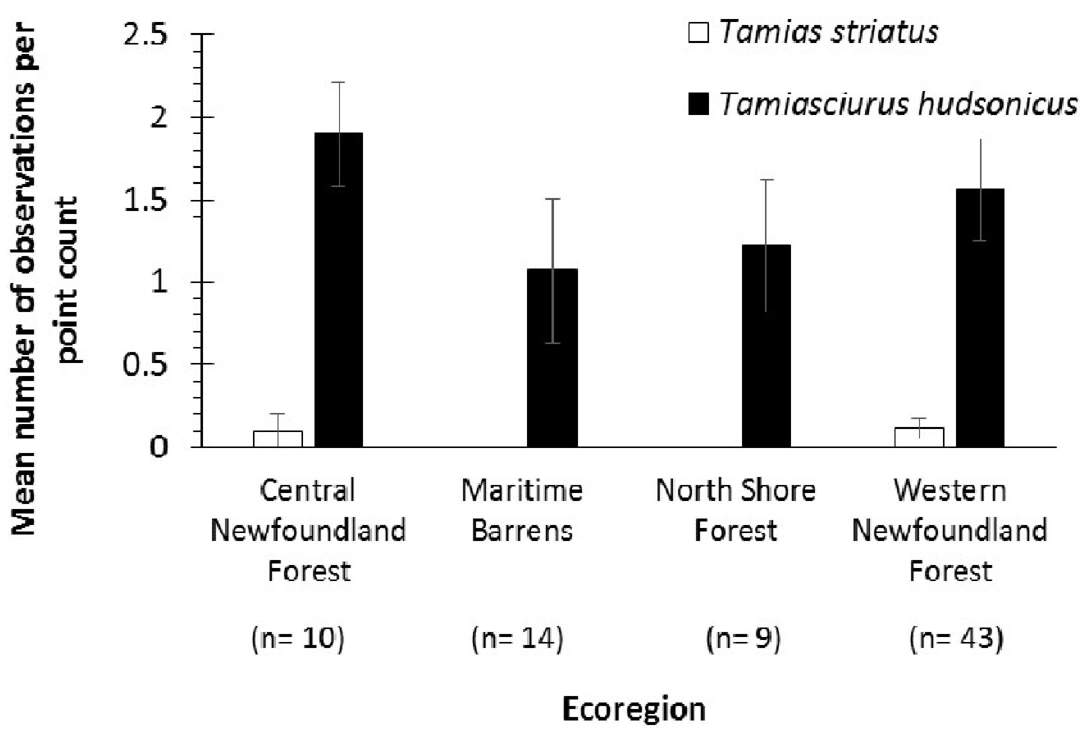


**Figure 1.2 Class point count/call broadcast - mean number of observations per point count.** There was no difference in the mean number (± standard error) of *Tamiasciurus hudsonicus* (filled bars) observed per point count among the ecoregions surveyed. There was insufficient data to make the same comparison for *Tamias striatus* observations (open bars). Nine point counts from the Avalon Forest, Strait of Belle Isle Barrens, and Northern Peninsula Forest were not included due to insufficient sample sizes (n<5) in each of these ecoregions.

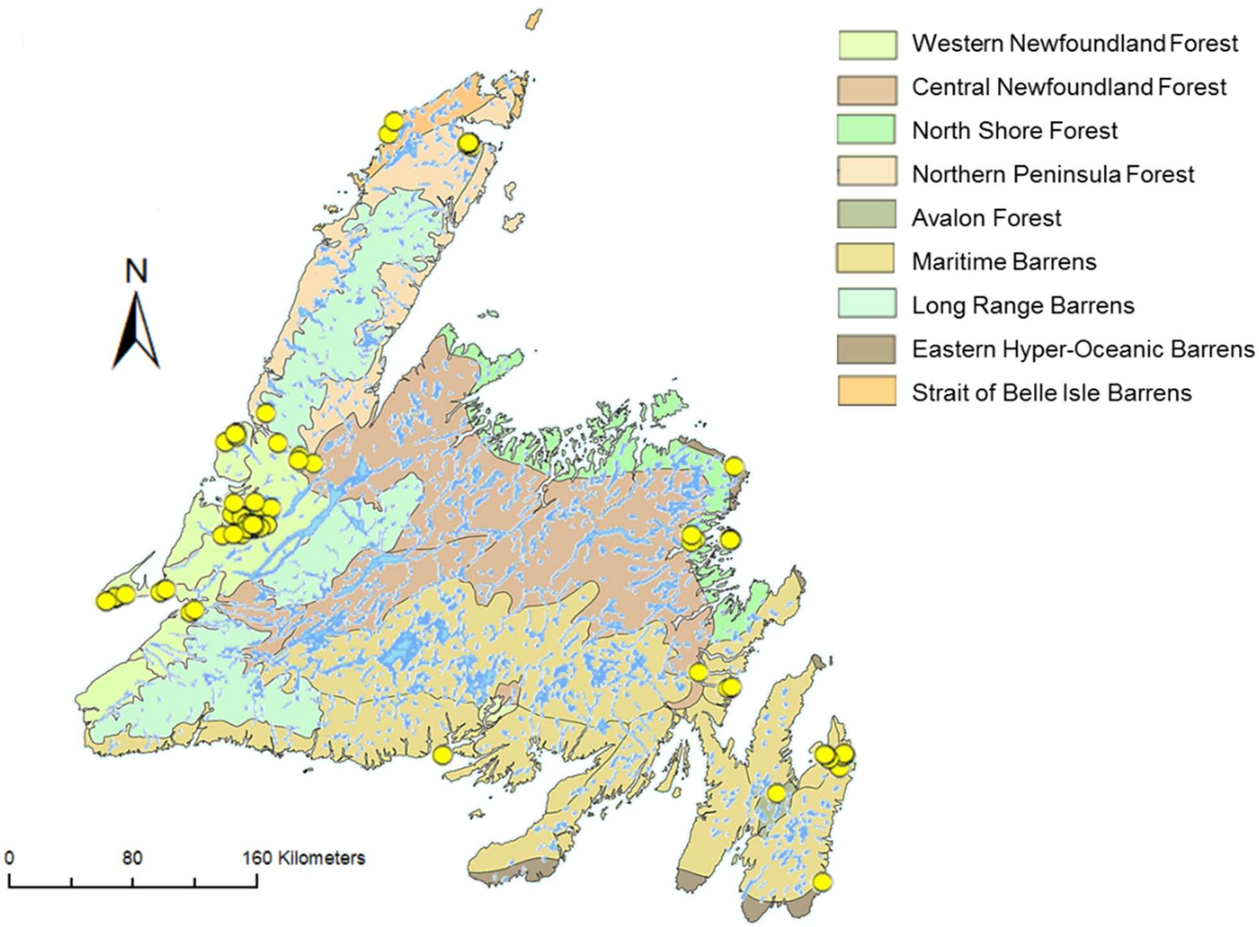


**Figure 1.3 Locations of individual walk in the woods.** Walks were conducted at 159 locations in six ecoregions: Western Newfoundland Forest (n=113), Central Newfoundland Forest (n=1), North Shore Forest (n=9), Northern Peninsula Forest (n=11), Maritime Barrens (n=23), and Strait of Belle Isle Barrens (n=2).

Data sheets from 159 individual walks in the woods were received (Figure 1.3). The proportion of sites with *T. hudsonicus* and *T. striatus* present did not vary significantly among ecoregions (Figure 1.4; *Tamiasciurus hudsonicus* chi-square test: $\chi^2$=1.24, df=3, $p$>0.05; *Tamias striatus* chi-square test*:* $\chi^2$=3.67, df=3, $p$>0.05). The ecoregions with the highest proportion of sites with *T. hudsonicus* present were NSF (n=9, *T. hudsonicus* present at 100% of sites) and WNF (n=113, *T. hudsonicus* present at 78% of sites.). The proportion of sites with *T. striatus* present was always lower than the proportion with *T. hudsonicus* present across all ecoregion studied. The ecoregion with the highest proportion of sites with *T. striatus* present was WNF (n=113, *T. striatus* present at 31% of sites). Three walks from the CNF and IB were not included due to insufficient sample sizes (n<5) in these two ecoregions.

Citizen scientists submitted 142 data sheets from interviews with family and friends, including information about cabin sites in six Newfoundland ecoregions (Figure 1.5). The proportion of sites with *T. hudsonicus* present did not vary significantly among ecoregions (Figure 1.6; *Tamiasciurus hudsonicus* chi-square test: $\chi^2$=0.725, df=5, $p$>0.05). The proportion of sites with *T. striatus* present did vary significantly among ecoregions (Figure 1.6; *T. striatus* chi-square test: $\chi^2$=12.61, df=5, $p$<0.05). Results from a Marascuilo Procedure indicated that except for the pairs CNF-NSF and MB-NPF, all the comparisons involving the proportions of the six ecoregions were significantly different from each other (Table 1.1). Of four cabin sites on nearshore islands, *T. hudsonicus* were reported only at two cabins in Bonavista Bay, and there were no reports of *T. striatus* on nearshore islands (Table 1.2).

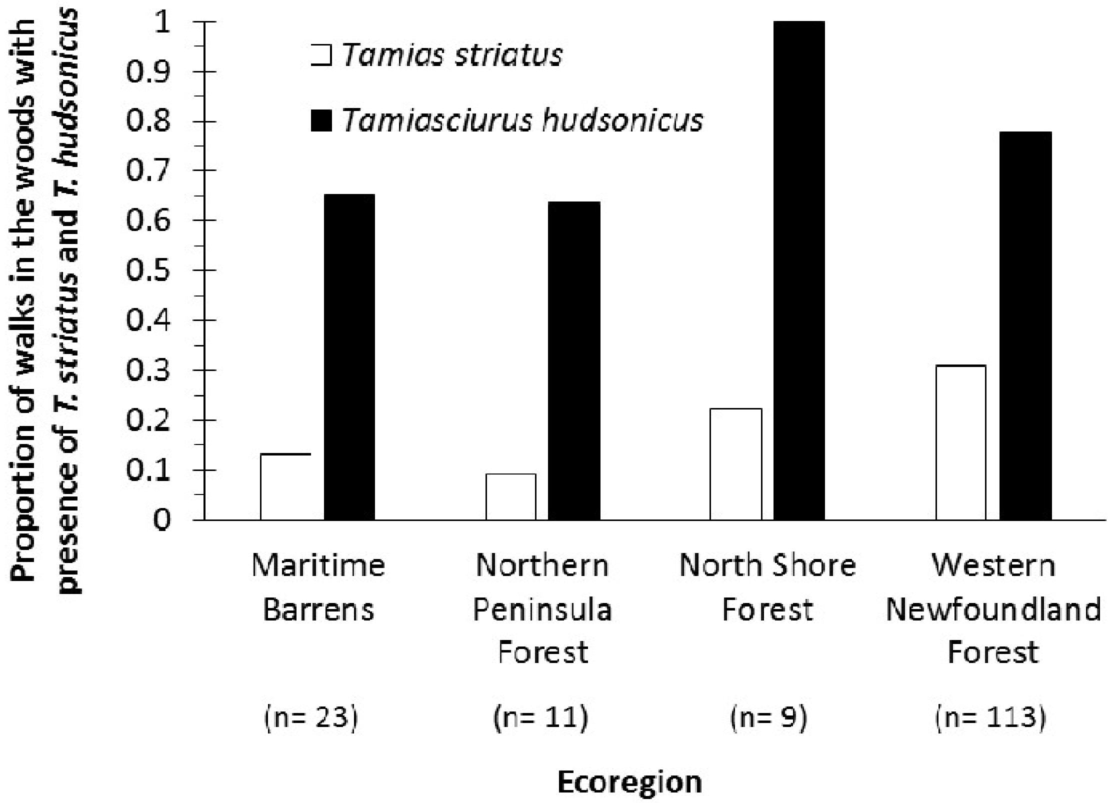


**Figure 1.4 Individual walk in the woods – proportion of sites with *Tamiasciurus hudsonicus* and *Tamias striatus* present.** In all ecoregions, there was a higher proportion of sites with *T. hudsonicus* (filled bars) present, than with *T. striatus* present (open bars). There were no significant differences in the proportion of sites with either species present among four ecoregions in Newfoundland: Maritime Barrens, Northern Peninsula Forest, North Shore Forest, and Western Newfoundland Forest. Other ecoregions were excluded from analysis due to non-existent or insufficient sample sizes.

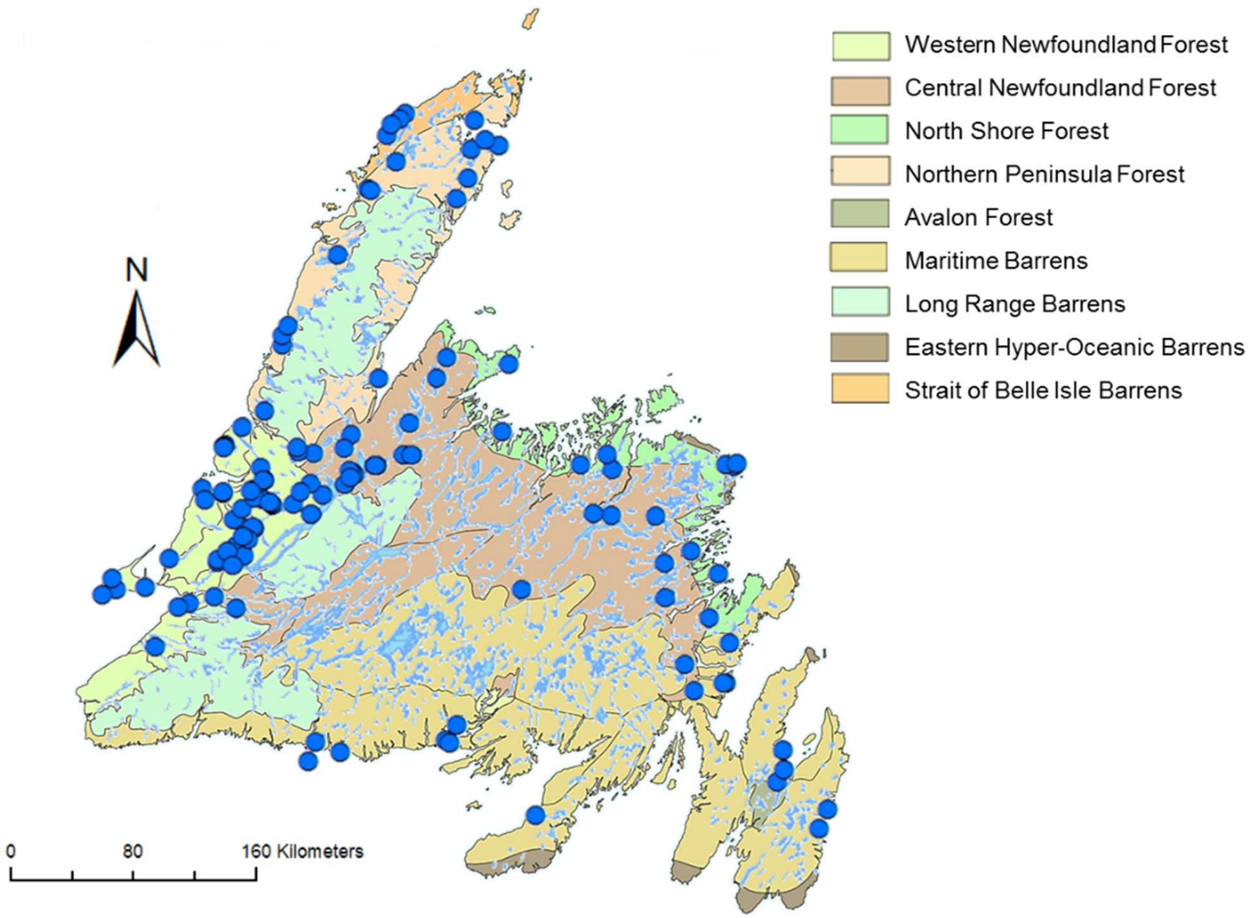


**Figure 1.5 Locations of cabins from interviews with family and friends.** 142 interviews were conducted about cabins located in six ecoregions: Western Newfoundland Forest (n=59), Central Newfoundland Forest (n=34), North Shore Forest (n=9), Northern Peninsula Forest (n=14), Maritime Barrens (n=13), and Strait of Belle Isle Barrens (n=5).

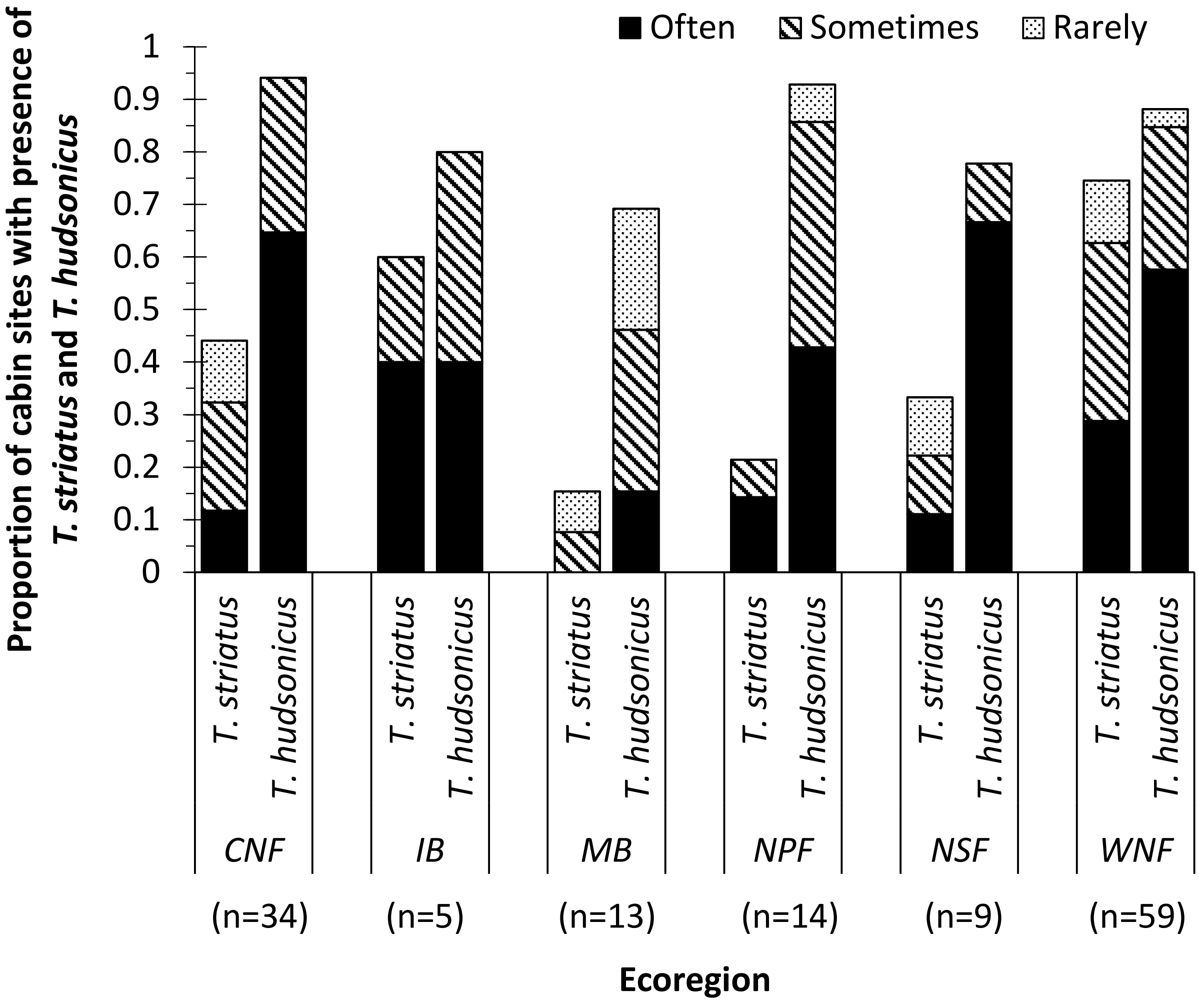


**Figure 1.6 Interviews with family and friends - presence of *Tamiasciurus hudsonicus* and *Tamias striatus* at cabins across Newfoundland.** The proportion of sites where *T. hudsonicus* and *T. striatus* were reported as present at cabins in six different ecoregions in Newfoundland: Central Newfoundland Forest (CNF), Strait of Belle Isle Barrens (IB), Maritime Barrens (MB), Northern Peninsula Forest (NPF), North Shore Forest (NSF), and Western Newfoundland Forest (WNF). The proportion of sites with *T. striatus* varied significantly among ecoregions while there was no significant variation in the proportion of sites with *T. hudsonicus* present.

**Table 1.1 Variation in the proportion of sites sampled with *Tamias striatus* present.** Paired-comparisons of the proportion of cabin sites with *T. striatus* present among six ecoregions in Newfoundland: Central Newfoundland Forest (CNF), Strait of Belle Isle Barrens (IB), Maritime Barrens (MB), Northern Peninsula Forest (NPF), North Shore Forest (NSF), and Western Newfoundland Forest (WNF).

| | Ecoregion Comparison | Difference | Absolute Value | Critical Value |
|---|---|---|---|---|
| 1 | CNF - IB | 0.4413 - 0.6000 | 0.159 | 0.124* |
| 2 | CNF - MB | 0.4413 - 0.1538 | 0.288 | 0.109* |
| 3 | CNF - NPF | 0.4413 - 0.2143 | 0.227 | 0.115* |
| 4 | CNF - NSF | 0.4413 - 0.3333 | 0.108 | 0.122 |
| 5 | CNF - WNF | 0.4413 - 0.7456 | 0.304 | 0.117* |
| 6 | IB - MB | 0.6000 - 0.1538 | 0.446 | 0.108* |
| 7 | IB - NPF | 0.6000 - 0.2143 | 0.386 | 0.114* |
| 8 | IB - NSF | 0.6000 - 0.3333 | 0.267 | 0.121* |
| 9 | IB - WNF | 0.6000 - 0.7456 | 0.146 | 0.117* |
| 10 | MB - NPF | 0.1538 - 0.2143 | 0.060 | 0.097 |
| 11 | MB - NSF | 0.1538 - 0.3333 | 0.180 | 0.106* |
| 12 | MB - WNF | 0.1538 - 0.7456 | 0.592 | 0.101* |
| 13 | NPF - NSF | 0.2143 - 0.3333 | 0.119 | 0.111* |
| 14 | NPF - WNF | 0.2143 - 0.7456 | 0.531 | 0.106* |
| 15 | NSF - WNF | 0.3333 - 0.7456 | 0.412 | 0.114* |

Note: Indicates significance--*

**Table 1.2 Presence of *Tamiasciurus hudsonicus* and *Tamias striatus* at cabins on nearshore islands.** Of four cabin sites described in interviews that were located on nearshore islands, *T. hudsonicus* were reported only at two cabins in Bonavista Bay, and there were no reports of *T. striatus*.

| Location | *Tamiasciurus hudsonicus* | *Tamias striatus* |
|---|---|---|
| Ramea, Southwest coast | Not reported | Not reported |
| Woods Island, Bay of Islands | Not reported | Not reported |
| Cat Bay Island, Bonavista Bay | Present | Not reported |
| Saint Brendan’s, Bonavista Bay | Present | Not reported |

## Discussion

*Tamiasciurus hudsonicus* and *Tamias striatus* were reported as present by citizen scientists across ecoregions of Newfoundland for which sufficient data were collected. The mean number of *T. hudsonicus* seen or heard per class point count/call broadcast did not vary significantly among ecoregions, nor did the proportion of walks in the woods and cabin sites (reported in interviews) with *T. hudsonicus* present. The proportion of cabin sites with *T. striatus* present did vary significantly among ecoregions, with the highest incidence of this species in the Western Newfoundland Forest ecoregion and the lowest in the Maritime Barrens ecoregion.

*Tamiasciurus hudsonicus* is well-documented as an opportunistic species, able to make use of a variety of habitats throughout North America (Steele 1998). This ability likely explains the widespread distribution of this species in Newfoundland. *Tamias striatus* are frequently found in in deciduous and mixed deciduous-coniferous forests, and this tendency may explain why they appear to be restricted to ecoregions that contain hardwood vegetation. The Western Newfoundland Forest and Central Newfoundland Forest ecoregions, where *T. striatus* were most frequently detected, have the highest proportions of hardwood tree species (e.g. red maple *(Acer rubrum),* white birch *(Betula papyrifera)* and aspen *(Populus tremuloides)* (Ecoregions of Newfoundland 2017), and likely most closely match the ideal condition for *T. striatus* presence. Forest habitat is patchily distributed across the Northern Peninsula Forest and North Shore Forest ecoregions, and suitable forest cover is almost non-existent in the Strait of Belle Isle Barrens and the Maritime Barrens (Ecoregions of Newfoundland 2017), where fewer *T. striatus* were observed. There was a surprisingly high proportion of sites with *T.*

*striatus* reported as present in Strait of Belle Isle Barrens, however, the relatively low sample size of sites from this ecoregion could account for this discrepancy.

Movement of *T. hudsonicus* around the island has largely been aided by humans through deliberate translocation efforts (Whitaker 2015). It is likely that these efforts may have led to the presence of *T. hudsonicus* on nearshore islands in Bonavista Bay. Other mechanisms for *T. hudsonicus* migrating to these islands could include them running across ice in the winter, or perhaps even swimming in open water as there is evidence to suggest that *T. hudsonicus* possess adequate swimming abilities (Pauli 2005). The lack of reports of *T. striatus* on any of the nearshore islands included in the study suggests that this species may have had less success surviving on small islands, or may have never been introduced to these areas in the first place.

Citizen science data collection is a cost effective and efficient means of collecting standardized information across a large geographical range, however it has limitations. These include the potential for variability in reporting observations; variable observer search effort or skill to detect a species; and non-random choices of survey locations (Snäll et al. 2011). Prior knowledge and experience of the volunteers can also affect the quality of the data because of varying levels of interest and motivation to learn more about the subject matter (Lewandowski and Specht 2015). In the present study, the students collecting the data did not have any formal scientific training or field experience (Elbroch et al. 2011; Lewandowski and Specht 2015). It is important to consider this when interpreting the data, and to view surprising reports (such as audible-only reports of *T. striatus*) with caution.

## Conclusion

With the exception of Whitaker's (2015) overview, there have been no studies investigating the distribution of non-native *T. hudsonicus* and *T. striatus* throughout insular Newfoundland and the nearshore islands. Given the potential for both species to have substantive impacts on native species, it is crucial to gain a better understanding of their distribution and abundance. In this citizen science investigation, *Tamiasciurus hudsonicus* were reported in all Newfoundland ecoregions that were surveyed, as well as on two nearshore islands in the Bonavista Bay region, and their presence did not vary significantly among ecoregions from which data were received. The proportion of sites with *T. striatus* present did vary among ecoregions, with the highest frequency of records coming from the Western Newfoundland Forest and Central Newfoundland Forest ecoregions where, correspondingly, there is the highest proportion of deciduous and mixed deciduous-coniferous forests. The citizen science approach was a successful means of increasing knowledge about the distribution of *T. hudsonicus* and *T. striatus* across Newfoundland. These findings can be used in the future to inform study design when investigating the impacts of non-native species *T. hudsonicus* and *T. striatus* on native Newfoundland species.

# **Chapter 2:** Factors contributing to the probability of detection of red squirrels *(Tamiasciurus hudsonicus)* during call broadcast surveys in western Newfoundland

## Introduction

*Tamiasciurus hudsonicus* use vocalizations to establish territories, alert other conspecifics to their presence, and to expel intruders (Lair 1990). Vocal and behavioural responses associated with territory defense can also be elicited in response to broadcasts of recorded *T. hudsonicus* calls (Digweed and Rendall 2010; Shonfield et al. 2012). These responses involve a combination of calling back to the recording and approaching the broadcast point.

Point count surveys are commonly used to detect the presence of various wildlife species and have previously been used to assess *T. hudsonicus* populations (Digweed and Rendall 2010; Shonfield et al. 2012). The method involves at least one observer visiting a series of points at which the number of individuals detected either by sight or sound are recorded over a pre-determined period (Ralph et al. 1995). A problem with point count surveys is that they often result in an underestimate of animal abundance due to the limited likelihood that every individual present will be detected (Mitchell and Donovan 2008). Detection of an individual does translate to 'presence', but non-detection does not necessarily mean there is an 'absence' (MacKenzie et al. 2002). Analyzing patterns of detection and non-detection over multiple visits to each point count enables estimates of site occupancy *($\psi$)*, the probability that a species is present at a site, and estimates of detection probability *($p$)*, the probability that an individual will be detected during the survey period given that it is present (MacKenzie et al. 2002). Point counts that are modified to include both silent and playback treatments can be effective for quantifying the importance of call broadcasts in promoting higher detection probabilities (Rae et al. 2015).

Variation in detection probability of *T. hudsonicus* during point counts is likely affected in large part by the likelihood that local squirrels will respond to call broadcasts (an aspect of territoriality.) Two factors may impact territoriality over the annual cycle: dispersal of juveniles from their natal territory and their subsequent establishment of their own territories; and increased territoriality of growing food caches as the season progresses. In the spring and early summer, *T. hudsonicus* young are dependent on their mothers (Kemp and Keith 1970; Steele 1998) and produce territorial vocalizations infrequently. Later in the summer, corresponding with their dispersal from their natal territories, the number of territorial vocalizations emitted by juvenile squirrels is said to increase (Larsen and Boutin 1994; Sun 1997). Throughout the summer season, *T. hudsonicus* cache food to consume during winter. Some authors have suggested that they may call more frequently as the season progresses and their cache becomes larger (Kemp and Keith 1970).  This peak in territoriality at times of high dispersal and at a time when individuals are spending time caching food for the winter, may explain why probability of detection of *T. hudsonicus* is thought to increase at this time.

The objectives of this study were to quantify the probability of detection of *T. hudsonicus* in western Newfoundland and to investigate whether that probability changes over time. Two approaches were used: (1) Oral and visual detections of individual animals were counted using a point count/call broadcast approach to quantify probability of direct detection of animals; and (2) piles of cone scales were observed and counted around point count centres in order to develop a proxy of squirrel activity over time. Considering that *T. hudsonicus* are vocal and responsive to conspecific territorial calls, this should make them easily detectable at all times of the year, however I predicted that detection probabilities would peak in late summer/early fall, corresponding to an increase in territoriality. I also predicted that the number of cone scale piles would remain constant over time during the summer and fall season, but would decrease once the arrival of snow made them no longer visible (Soper 1942; Pruitt and Lucier 1958).

## Methods

### *Study sites*

Surveys of *T. hudsonicus* activity were conducted at two sites in Corner Brook and Pasadena, on the west coast of Newfoundland, Canada in mainly coniferous forest stands of the Western Newfoundland Forest ecoregion. While both sites were forested, the Pasadena site was less fragmented and perhaps more densely forested than the Corner Brook site which was in the middle of the city landscape. At each site, eight point counts were sampled along an already established footpath. Each point was at least 300 m from the nearest neighbouring point to avoid surveying the same individual *T. hudsonicus* (Larsen and Boutin 1994; Rae et al. 2015). In Corner Brook, the survey transect was broken into two segments: the first segment included two points along a 0.8 km loop behind the Corner Brook Long Term Care Home (48° 56’ 18.17” N. -57° 55’ 51.51” E) and the second segment included the remaining six points along a 2.2 km section of the Ginger Route trail that began at the upper parking lot of Margaret Bowater Park (48° 56’ 38.31” N. -57° 55’ 55.87” E), and ended at the Crocker’s Road trail head (48° 56’ 13.65” N. -57° 54’ 54.12” E). In Pasadena, the survey transect encompassed three different trails (Lone Pine, Twisted Pine, and Looper Run) at the Pasadena Ski and Nature Park (48° 59’ 43.44” N. -57° 35’ 22.26” E), to make up a 3.0 km loop with all eight points.

*Survey method*

From August 2016 to February 2017, I conducted point count surveys of *T. hudsonicus* activity at each site in the third week of every month. Surveys began two hours after sunrise and continued until all point counts were complete. Point count order was reversed in alternating months and surveys were not conducted during periods of heavy precipitation or high winds (Beaufort Wind Scale Force 5; >29 km/h). Each individual point count consisted of two treatments (silent/playback), where there were four 2-minute quiet observation intervals followed by four 2-minute intervals of call broadcasts of recorded *T. hudsonicus* territorial calls (following the procedure of Rae et al. 2015). Broadcasts were made using a JBL Flip 3 portable Bluetooth speaker attached to a smartphone with the same recorded sound file that was used during the citizen science data collection. These recordings were obtained from Cornell sound library Macaulay Library at the Cornell Lab of Ornithology and edited by D. Whitaker (ML Catalogue #numbers:100916, 136185). The volume settings on the smartphone and speaker were maximized during each survey to produce an average volume of 80 dB at 1 m from the speaker. During each 2-minute interval, detections of *T. hudsonicus* were recorded, as well as the type of observation (i.e., whether the observer saw, heard, or both saw and heard an individual *T. hudsonicus*), and at what approximate distance (<25 m, or between 25 m and 50 m) the animal was from the point count center. The number of cone scale piles within a 10-meter radius of each point count center was also recorded to document evidence of *T. hudsonicus* activity.

*Statistical analyses*

A set of occupancy models were built to calculate differences in detection probabilities (MacKenzie et al. 2002) of *T. hudsonicus* between sites, over time, and with/without call broadcasts. The analyses were conducted using the software package PRESENCE (version 11.8). Simple, multi-season occupancy models were run in order to model the probability of site occupancy ($\psi$) and the probability of species detection at a site ($p$; MacKenzie et al. 2002). The multi-season model allowed us to manipulate the number of seasons included in the study period and the colonization rate ($\gamma$) that may modify site occupancy among seasons. Survey data were split into two seasons, based on known attributes of *T. hudsonicus* life history (Rusch and Reeder 1978; Larsen and Boutin 1994; Sun 1997). Data collected during August was considered to come from one season, when young of the year may still be dependent on their parents, or are dispersing to new territories (Sun 1997) and September to February as a second season, when squirrels are established in their territories.

Six models were run to represent different hypotheses to describe the influence of month (August through February), point count treatment (silent vs. playback), and location (Corner Brook vs. Pasadena) on probability of detection (Table 2.1) (MacKenize et al. 2002; Mitchell and Donovan 2008; Rae et al. 2015). In all models, $\psi$ was assumed to vary between seasons and locations, and the colonization rate ($\gamma$) was fixed. Models were ranked based on Akaike's Information Criterion (AIC), a measure of model likelihood with the lowest AIC value indicating the most parsimonious model. Support for each model was given by the Akaike weight and the numerical difference between the AIC value of a given model and the most parsimonious model ($\Delta$AIC).

Simple linear regressions were used to assess changes in the frequency of different types of detection (auditory vs. visual) over the seven-month survey period. All data were reported as mean ± standard error, and an α of 0.05 was used for all statistical tests.

**Table 2.1 Set of multi-season occupancy models.** $\psi$ is the probability of site occupancy and $p$ is the probability of species detection. Models and number of parameters used to test hypotheses about the influence of month, point count treatment, and location on detection probability of *Tamiasciurus hudsonicus* during point count surveys over seven months in Corner Brook and Pasadena, NL.

| Model | Hypothesis | Full Model | Parameters |
|---|---|---|---|
| 1 | $p$ is fixed | $\psi$(season,location), $p$(fixed) | 5 |
| 2 | $p$ is affected by month | $\psi$(season,location), $p$(month) | 11 |
| 3 | $p$ is affected by month and treatment | $\psi$(season,location), $p$(month,treatment) | 13 |
| 4 | $p$ is affected by month and treatment and $p$ is modified by location during silent treatment | $\psi$(season,location), $p$(month,treatment,location:silent) | 14 |
| 5 | $p$ is affected by month and treatment and $p$ is modified by location during playback treatment | $\psi$(season,location), $p$(month,treatment,location:playback) | 14 |
| 6 | $p$ is affected by month and treatment and $p$ is modified by location during all treatments | $\psi$(season,location), $p$(month,treatment,location:all) | 14 |

## Results

The model indicating that detectability was influenced by month, treatment (silent vs. playback), and further modified by location during playback was the most parsimonious, as indicated by its AIC weight and the large (>2) ΔAIC values of all of the other models (model 5 in Table 2.2; AIC= 535.71, Weight 0.9907). As a result, this model was used to estimate detection probability and no model averaging was required.

Detection probability estimates steadily declined at both sites over the seven-month survey period, with a slight rebound in February (Figure 2.1). Probability of detection was always higher during playback treatments than during silent treatments, and probability of detection during playback treatment was higher in Corner Brook than in Pasadena for the first three months and then estimates overlapped, coinciding with the first surveys that were conducted after the arrival of snow.

**Table 2.2 Model selection results**. Top model best described the influence of month, point count treatment, and location on detection probability (*p*) of *Tamiasciurus hudsonicus* during point count surveys over seven months in Corner Brook and Pasadena, NL.

| Model | Description | AIC | ΔAIC | Weight | Model Likelihood |
|---|---|---|---|---|---|
| 5 | *p*(month,treatment,location:playback) | 535.71 | 0.00 | 0.9907 | 1.0000 |
| 3 | *p*(month,treatment) | 545.81 | 10.10 | 0.0063 | 0.0064 |
| 4 | *p*(month,treatment,location:silent) | 547.37 | 11.66 | 0.0029 | 0.0029 |
| 2 | *p*(month) | 581.05 | 45.34 | 0.0000 | 0.0000 |
| 1 | *p*(fixed) | 602.92 | 67.21 | 0.0000 | 0.0000 |
| 6 | *p*(month,treatment,location:all) | 620.52 | 84.81 | 0.0000 | 0.0000 |

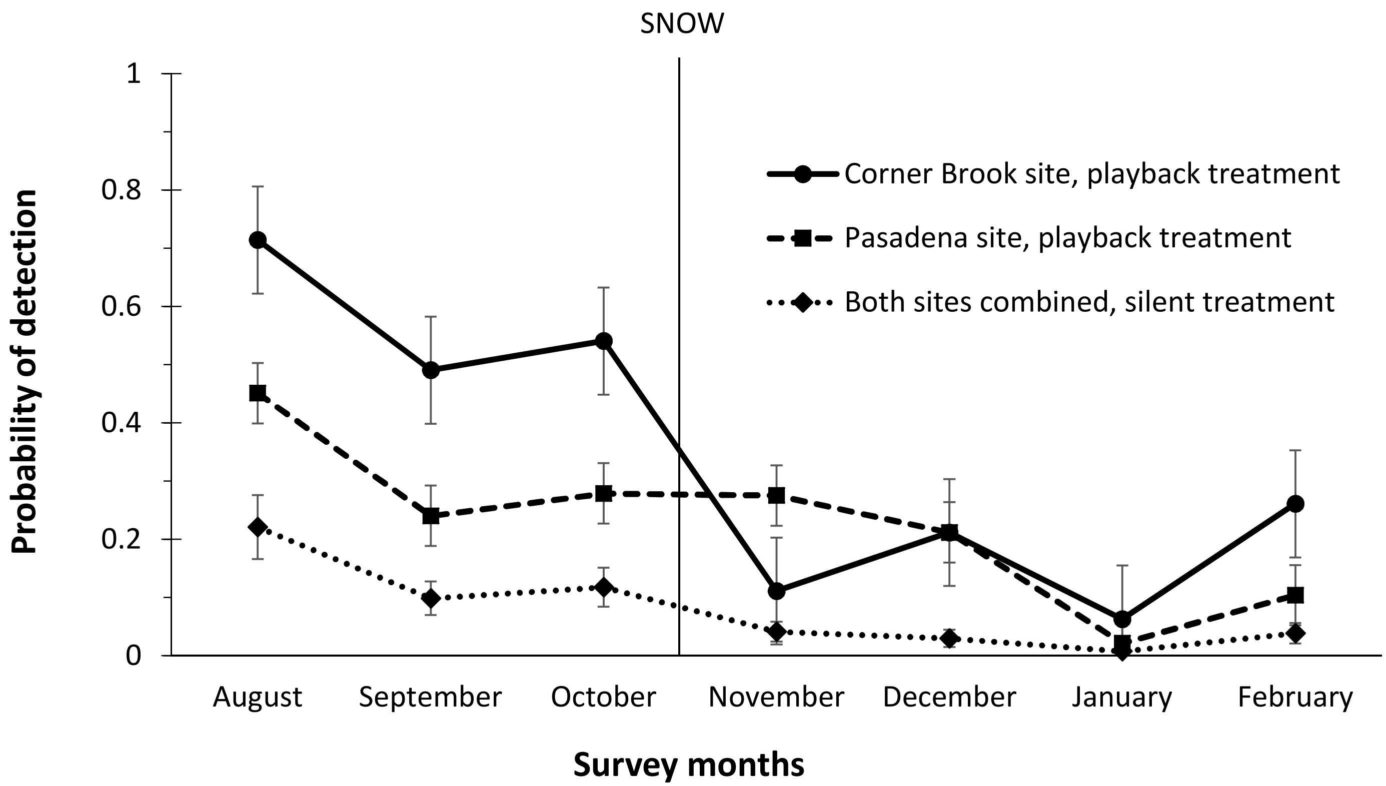


**Figure 2.1 Probability of detection of *Tamiasciurus hudsonicus*.** Over the study period, probability of detection declined and the playback treatment (solid and dashed lines) always exceeded the silent treatment (dotted line.) Probability of detection in Corner Brook (solid line) was higher than Pasadena (dashed line) in the first three months and then overlapped once snow arrived as indicated by the vertical line. The most parsimonious model indicated that location only modified probability of detection during the playback treatment, so data from silent treatment observations are pooled for both locations.

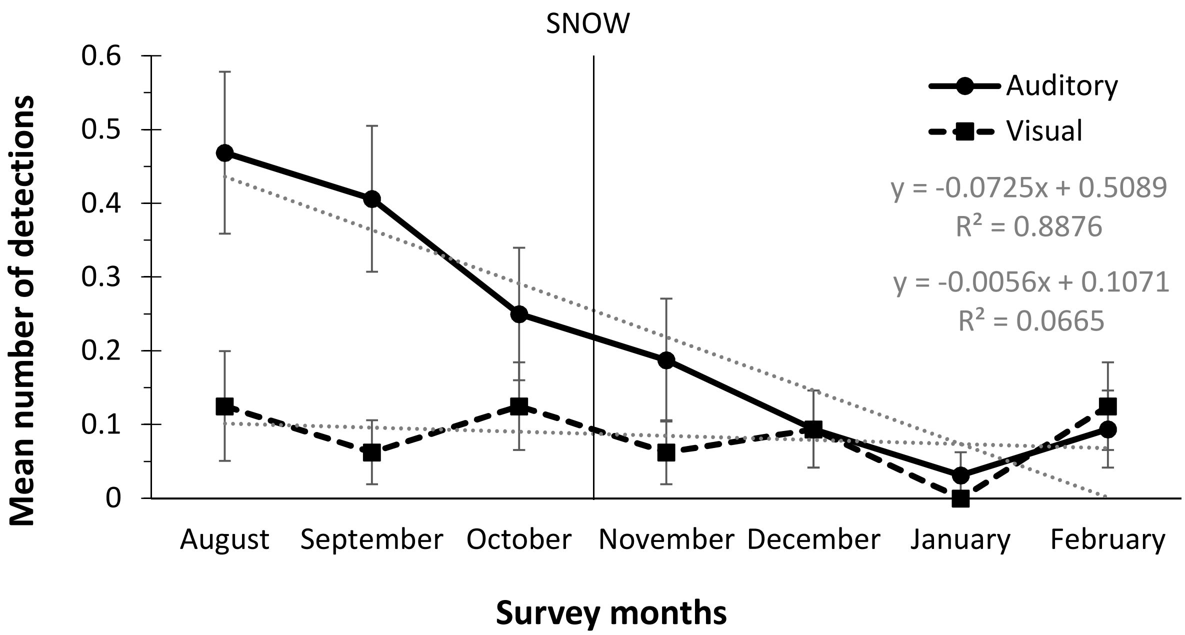


**Figure 2.2 Auditory and visual detection of *Tamiasciurus hudsonicus*.** There was a significant decline in the mean number (± standard error) of auditory detections, but no difference in the mean number of visual detections per point count as pooled from two locations, Corner Brook and Pasadena, NL over seven months. The arrival of snow is indicated by the vertical line.

There was a significant decline in auditory detections of *T. hudsonicus* over time (Simple Linear Regression- $R^2$=0.8876, $F$=39.486, $p$=0.0015, df=6), but no significant change in visual detections (Simple Linear Regression- $R^2$=0.0665, $F$=0.356, $p$=0.58, df=6) (Figure 2.2).

The mean number of cone scale piles per point count in Corner Brook and Pasadena remained relatively consistent during the first 4 months of the survey period (Figure 2.3). After the first substantial arrival of snow in December (snow present in November was sparse and underlying features were still evident at that time), many of the previously visible cone scale piles were covered and no longer visible.

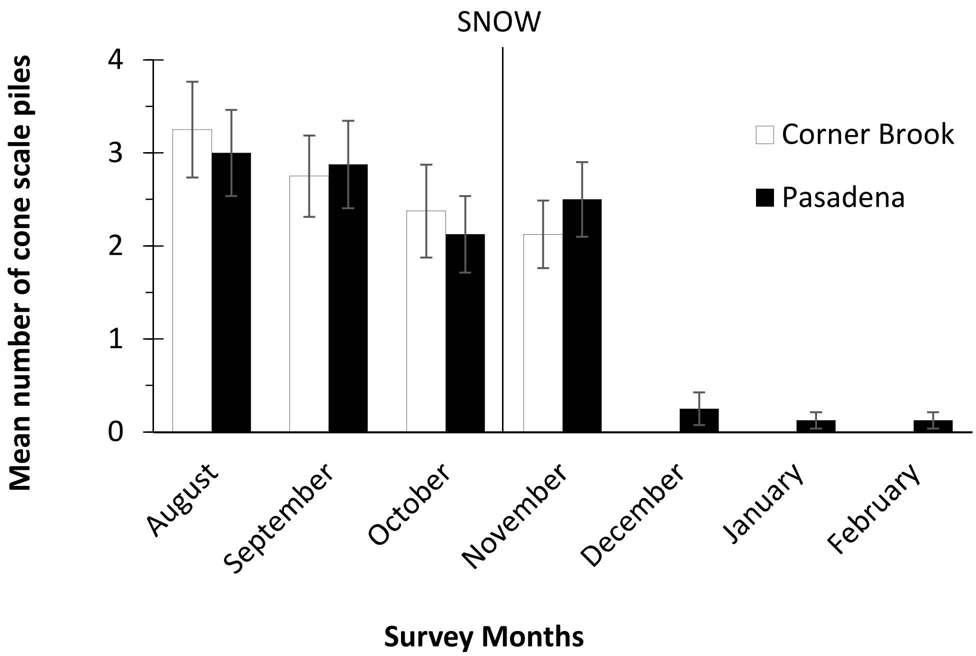


**Figure 2.3 Detection of cone scale piles at point count sites.** The mean number (± standard error) of cone scale piles found within a 10-meter radius of eight point counts at two locations, Corner Brook and Pasadena, NL, remained relatively consistent over the first four months of the survey, but were no longer visible following the first major snow falls.

## Discussion

This study identified systematic variation in the probability of detection of *T. hudsonicus* at two sites in western Newfoundland. *Tamiasciurus hudsonicus* detection probability estimates declined over the seven-month study period, detection was always higher during playback treatment than the silent treatment, and detection during the playback treatment was higher in Corner Brook than in Pasadena for the first three months and then estimates overlapped as the winter season approached. The way that *T. hudsonicus* were detected also changed over time, as shown by the significant decline in auditory detections, but no change in the mean number of visual detections.

These findings confirm that the use of call broadcasts during point count surveys is an effective method for surveying *T. hudsonicus* (Digweed and Rendall 2010; Shonfield et al. 2012), but that it is most effective in the summer and early fall. The low probability of detection of *T. hudsonicus* during both silent and playback treatments in winter suggests that point counts may not be an appropriate method for surveying this species during winter months. This drop in probability of detection could be for two reasons: (1) *T. hudsonicus* are less likely to respond to call broadcasts using vocalizations in the winter, but just approach quietly, and therefore are more difficult to detect; or (2) *T. hudsonicus* are known to spend more time underground than in tree nests during the winter (Soper 1942) where they live in extensive burrows under their middens (Pruitt and Lucier 1958), so they might not hear or respond as quickly to the call broadcasts.

Surprisingly, detectability of *T. hudsonicus* did not peak as predicted in late summer/early fall. This prediction was made based on the assumption that *T. hudsonicus* would be most territorial at this time because of the pressure to retain possession of caches of food for survival over the winter (Kemp and Keith 1970). Perhaps a peak in detectability is not as related to resource-holding potential, but is more a function of intruder pressure during times of high dispersal (Shonfield et al. 2012). Juvenile *T. hudsonicus* emerge from their natal territory and make forays in search of a vacant territory during the summer (Larsen and Boutin 1994; Sun 1997). This influx of juveniles searching for territories may be met with increased territoriality (and an increase in the number of rattle responses) by local adults in already established territories (Shonfield et al. 2012). Once juveniles have established territories, then adult territoriality may decrease. A peak in *T. hudsonicus* detectability may be earlier in the summer, but it was not captured during the scope of this project.

The observed differences in detectability during playback between the Corner Brook and Pasadena survey sites could be a result of differences in habitat structure (e.g. tree density), which may have had an effect on how individual squirrels heard the call broadcasts even though the recording was projected at the same sound level (Shonfield et al. 2012). Vegetation surveys were not conducted at each point count location, however, the overall impression of tree density in the Corner Brook site seemed to be less than the Pasadena site. This could allow individual squirrels to hear the call broadcasts better at the Corner Brook site, which would correspond to higher estimates of probability of detection for *T. hudsonicus* at that site. Probability of detection may also differ between sites because of the reduced ability for the observer to detect squirrels along transects with more dense habitat, however, the probability of detection was the same at both sites during the silent treatments suggesting that the observer was equally effective at both sites.

The detection of cone scale piles at point count sites helped to develop a proxy of squirrel activity regardless of time, however, similarly to the call broadcasts, this is not a good method for surveying *T. hudsonicus* in the winter. Before the arrival of snow, *T. hudsonicus* were likely utilizing the same areas to feed (Hurly and Lourie 1997), so the same cone scale piles were likely observed month after month. These did not appear to be reliably replaced once the presence of snow made them no longer visible.

## Conclusion

There have been no studies investigating the detectability of *T. hudsonicus* in Newfoundland, however, occupancy modelling has frequently been used to quantify the probability of detection of *T. hudsonicus* and other squirrel relatives in a number of studies (Trudeau et al. 2011; Amori et al. 2012; Chavel et al. 2017). We have demonstrated that the probability of detection of *T. hudsonicus* changes throughout the year both with and without the use of call broadcasts, highlighting the importance of knowing when survey methods (e.g. point count/call broadcasts, detection of cone scale piles) are most effective and planning accordingly. Given that *T. hudsonicus* are likely substantively impacting native species in Newfoundland, it is important to have a way to detect their presence across the island. I recommend that further study of *T. hudsonicus* detectability in Newfoundland is continued in the spring and summer to see how the probability of detection changes across all four seasons

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Appendix A- Teacher's Guide and Scientific Research Permit

# Red squirrels and eastern chipmunks in Newfoundland: Citizen science project

Photos: G. Gonthier

Prepared by Heather Spicer and Erin Fraser
Environmental Science (Biology)
Grenfell Campus, Memorial University of Newfoundland
in partnership with Let's Talk Science

let's talk science outreach

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# Welcome Letter

Dear Educator,

Thank you for agreeing to work with your class to participate in our red squirrel and eastern chipmunk survey project! We are interested to learn more about where these animals live in Newfoundland and the nearshore islands, and we are excited to have your help in completing this project. The participation of schools from all areas of the province means that we will be able to collect much more data and paint a more complete picture than if we were working alone. We will be reporting our findings back to all of the classes that contribute to our project. While we are thrilled to have you on our citizen scientist team, of course participation is optional, and you can stop at any time if you start but do not want to continue.

Both red squirrels and eastern chipmunks are introduced species to Newfoundland, and there is evidence that red squirrels have had major impacts on other local animals and plants. Please see the included teacher's guide to learn the full story about these species in our province, as well as a description of the overall project. Also included in this booklet are instructions and sample data sheets for all parts of data collection; an information letter for you to send home to your students' families; a list of the associated educational activities that we can provide for you; and a copy of the provincial permit that we obtained to conduct this research. Separately in your package are paper-clipped versions of all sheets that you may want to photocopy (data sheets, letter to parents, educational activities, etc.).

Your involvement with this project can have three parts. We hope that you will consider completing all three parts, but of course it is up to you to decide which parts are most appropriate for you and your class to do. Full descriptions of each part are included in the following pages.

1) **Data Collection, Part 1 – Class group activity, for the class to report back to us**

   Class members and their teacher will go as a group to a forested area where they will play recordings of squirrel calls and watch to see how many squirrels respond! See the "class group activity" section for instructions on this component. We hope that ALL classes will complete group data collection, but understand that for some urban schools, it may be difficult for classes to get to forested areas. Don't worry if you are unable to complete this part of the project; we are still really excited to learn about your individual data collection findings (part 2)!

2) **Data Collection, Part 2 – Individual/Small Groups, for individual students to complete and report back to us**

   For this part of the project, students who wish to do so will complete individual or small group out-of-school activities. Students may complete one or both of the following two tasks, and we would like you to return the results of the efforts to us in the enclosed pre-paid return envelope.

*(a) Walk in the Woods:*

Students completing this option will go with a responsible adult to do a short walk in a forest near their home. During this walk, they will note and record squirrel and chipmunk sightings and other evidence of squirrel activity (don't worry, we will provide information about how to do this!). Students completing this option should receive the "Walk in the Woods" hand-outs and will provide us with a completed data sheet.

*(b) Interview with Family or Friends:*

Students completing the interview will speak with a responsible adult (perhaps a parent, grandparent, or friend in their community) who has a cabin in a forested area. During the interview, they will record information about whether or not red squirrels and/or eastern chipmunks are present at the cabin. They should use the "individual interview" hand-outs and should provide us with a completed interview sheet.

**3) Educational Activities – no need to report back to us**

These are designed for YOUR enjoyment and use! We have made activities that align with components of the Grades 4 to 8 science curricula. These activities will help your students to learn key biological concepts and will connect the red squirrel project to the provincial science curricula. You can choose to do them or not; there is no need for you to report back to us about them.

**Please return all data sheets and interview forms to us in the included pre-addressed envelopes. We have already paid the postage fees, so all you have to do is drop them in the mail!**

**In order to be consistent, we need all data to be collected in October and the first half of November 2016. We ask that you put all completed datasheets and interview forms in the mail by <u>November 15, 2016.</u>**

Thank you in advance for your contributions to this valuable project. We are excited to hear about what you find! If you have any questions throughout the data collection process, please e-mail Heather Spicer (hespicer@grenfell.mun.ca)

Sincerely,

Heather Spicer

Heather Spicer
(Student, Environmental Biology, Grenfell Campus, Memorial University of Newfoundland)

Erin Fraser

Erin Fraser
(Assistant Professor, Environmental Biology, Grenfell Campus, Memorial University of Newfoundland)

# Teacher's Guide

## Red squirrels and eastern chipmunks in Newfoundland – Why are we interested?

*Below are short descriptions of the life histories of red squirrels and eastern chipmunks, as well as why we are interested in learning more about them in Newfoundland. We recommend sharing this information with your class so that they better understand why they are contributing to the project.* ***We particularly request that you are clear with students that red squirrels have a known negative impact on some other species in Newfoundland. We definitely do not recommend deliberately moving either red squirrels or eastern chipmunks from one part of the province to another.***

*Red squirrels*
American red squirrels (sometimes called pine squirrels in the US) are small and red with a white stomach. They are tree squirrels and are usually found in forested areas, particularly forests containing a lot of coniferous trees, such as pines, spruce, and fir. They usually live in tree cavities or in nests that they build using twigs and leaves. They primarily feed on the seeds of conifer cones but also eat a range of other foods, such as fungi and occasionally other animals, such as bird nestlings and eggs. Red squirrels store food in caches called middens and are highly territorial. They will respond to the presence of other squirrels (and sometimes humans and other animals!) by making chirping/rattling sounds and coming out to investigate. It is often easy to see where red squirrels are present because they often have a favourite perch for extracting seeds from cones, resulting in piles of cone scales.

Red squirrels can be found across Canada and the US but are not native to the island of Newfoundland, which means that they were not originally found on the island. They were successfully introduced by humans to various spots in Newfoundland starting in 1963 and can now be found across the island. We now know that red squirrels have had a major impact on other Newfoundland plants and animals. Because they can harvest and store a lot of cones each year, they can prevent some conifers, such as balsam fir, from reproducing at the previously normal rate[1]. They can also compete with other animals that eat cones, such as a bird called the red crossbill[2]. Further, researchers now think that they may be negatively impacting a local bird called the grey-cheeked thrush by eating eggs and nestlings[3,4]. Both red crossbills and gray-cheeked thrush are listed as species at risk in Newfoundland and Labrador, so it is important to understand their threats.

*Eastern chipmunks*
Eastern chipmunks are small ground squirrels with distinctive black stripes on their backs. They are solitary, use burrows, and spend much of the winter underground. They are found across eastern North America, usually in deciduous or mixed deciduous/coniferous forests, and eat a diet composed of seeds, nuts, insects, fungi, and occasionally other small animals. They store food for the winter in their underground burrows. They respond to threats by vocalizing loudly, usually producing a series of loud "chucks", either alone or in groups. Like red squirrels, they are not native to Newfoundland and were first introduced to the island in 1963. There is not a great deal known about the impacts of eastern chipmunks on other species in Newfoundland.

*References*
[1]Gosse et al. 2011. Natural Areas Journal. 34(4): 331-339; [2]Benkman et al. 2008. Molecular Ecology. 17: 395-404; [3]Whitaker et al. 2015. Avian Conservation and Ecology. 10(2): 4;[4]Whitaker 2015. The Osprey. 46(4): 23-29.

## Scientific Context of the Project

*Components of the scientific research process are part of the science curriculum objectives throughout the NLESD elementary/intermediate grades (e.g., Grade 4: students "propose questions to investigate" and "state a prediction and a hypothesis"; Grade 5: they "carry out procedures to explore a given problem" and "record observations using a single word"; Grade 6: they "describe examples of scientific questions…" and "identify examples of scientific knowledge that have developed as a result of the accumulation of evidence" etc.). Participation in this project will provide your students the opportunity to learn about scientific research in an experiential way as they work as active agents in the scientific process. To help you present the project to them in this context, please see the description below.*

*Research Questions*

We are interested in learning more about where red squirrels and eastern chipmunks live in Newfoundland and the nearshore islands. They are likely present across most of the island of Newfoundland, but we would like to better understand where they are more and less abundant (their density). Further there is little known about their presence/absence on some of the nearshore islands. We have three research questions:

1) Where are red squirrels and eastern chipmunks present in Newfoundland and the nearshore islands?
2) What patterns of dispersal exist for both species since their introductions (i.e., when were they found where?)
3) How does red squirrel and eastern chipmunk density vary across Newfoundland and the nearshore islands?

Citizen science is the perfect approach for investigating these questions! It would take a really long time for one group for researchers to survey the entire island of Newfoundland for red squirrels and eastern chipmunks. We will really benefit from having lots of citizen scientists contributing to the project from locations across Newfoundland!

*Methods*

NLESD student citizen scientists will collect data on red squirrel and eastern chipmunk activity. Fifty teachers from more than 40 schools from all across the island of Newfoundland will be participating with their classes in three different methods of data collection:

1) Classes will conduct surveys and call broadcasts as a group and record observations.
2) Individual students will go for a "walk in the woods" with their family and record observations.
3) Individual students will conduct an "interview with family and friends" to learn more about where eastern chipmunks and red squirrels have been spotted across the province and when.

All three methods will help us answer research question #1. Data from the "interview with family and friends" will help us answer research question #2. Group call broadcasts and the "walks in the woods" will help us answer research question #3. All participating classes will send their results to researchers at Grenfell Campus, who will combine all of the data and conduct analyses.

*Results*

Researchers at the Grenfell Campus will report the findings of the project back to all participating classes as those results become available. So stay tuned!!

## Additional Resources

If you would like to read further on the topics related to this project, we recommend that you have a look at some of the following resources:

***On mammal species in general, including red squirrels and eastern chipmunks:***

1) International Union for Conservation of Nature (IUCN) Red List of Threatened Species

    http://www.iucnredlist.org/search - To read about red squirrels, search for "*Tamiasciurus hudsonicus*" and to read about eastern chipmunks, search for "*Tamias striatus*".

2) Review papers on mammal species

    http://www.science.smith.edu/msi/ - Red squirrels (*Tamiasciurus hudsonicus*) are PDF #586 and eastern chipmunks (*Tamias striatus*) are PDF #16.

    i) Steele, M.A. 1998. *Tamiasciurus hudsonicus. Mammalian Species.* 586: 1-9.
    ii) Snyder, D.P. 1982. *Tamias striatus. Mammalian Species.* 168: 1-8.

***On some Newfoundland species that are threatened, possibly partially as a result of red squirrel presence:***

1) Species at risk in Newfoundland and Labrador – Department of Environment and Conservation website

    http://www.env.gov.nl.ca/env/wildlife/endangeredspecies/birds.html - Look up Red Crossbill and Gray-cheeked Thrush

2) Research paper on Gray-cheeked Thrush in Newfoundland:

    http://www.ace-eco.org/vol10/iss2/art4/

    Whitaker, D.M., Taylor, P.D., and Warkentin, I.G. 2015. Gray-cheeked Thrush (*Catharus minimus minimus*) distribution and habitat use in a montane forest landscape of western Newfoundland, Canada. *Avian Conservation and Ecology*. 10(2):4

***On citizen science:***

1) Citizen Science Central – a website summarizing citizen science projects and resources.

    http://www.birds.cornell.edu/citscitoolkit

2) Scientific American – A list of ongoing Citizen Science initiatives.

    http://www.scientificamerican.com/citizen-science/?page=1

## Using Your Wireless Speaker (Audiopod)

*All participating schools will be provided with at least one Audiopod wireless speaker for conducting the group call broadcasts. If multiple educators from your school are participating in this project, you may need to coordinate your efforts and share a speaker. Here are a few tips on using the speakers:*

1. The Audiopod speakers should work using Bluetooth with most handheld devices (phones, tablets, laptops, etc.) and do not require that you be in an area with wireless internet access to use them.

2. To use the speakers, simply turn them on and connect them via Bluetooth to the device of your choice. When you play the provided audio file of squirrel calls on your device it should be broadcast through the speaker.

3. You can download the squirrel audio files from our Google Docs Drive. The link to this will be e-mailed to you. If you cannot access the Drive, please let us know and we will set up an alternate arrangement.

4. **IMPORTANT:** You should conduct your call broadcasts with the speaker at maximum volume. It is important that call broadcasts be standardized among sites. We have measured the energy of broadcasts at maximum volume and have judged them to be ideal for attracting red squirrels.

5. If you have trouble operating your speaker, please feel free to contact us for troubleshooting.

# Information Letter for Parents/Guardians

Dear Parent or Guardian,

Your child's class is participating in a Newfoundland-wide citizen science project to investigate red squirrels and eastern chipmunks in the province. The project is being led by researchers at the Grenfell Campus of Memorial University in Corner Brook. There are currently more than 40 schools from across the province participating in this exciting research initiative.

Red squirrels and eastern chipmunks are both introduced species to Newfoundland and have had profound impacts on other local animals and plants. We are interested to learn more about where these animals live in Newfoundland and the nearshore islands.

As part of the project, we are asking you to help your child collect data on red squirrels and eastern chipmunks in your area. Completion of these activities is optional and you can stop at any time if you start but don't want to continue. We would appreciate your help in doing one or both of the following:

*(a)* *A Walk in the Woods:* Together, you or another adult will go with your child for a short walk on a nearby forested trail and look for red squirrels/eastern chipmunks and evidence of red squirrels/eastern chipmunks. If you choose this option, please fill out the attached data sheet.

AND/OR

*(b)* *Interview with Family or Friends:* Your child will interview one or more family members or friends who have cabins in forested areas. The point of the interview will be to learn whether red squirrels and eastern chipmunks have been seen around the cabin. **We are particularly interested in hearing from people who have cabins on nearshore islands (e.g., Fogo/Change Islands group, Ramea group, any other islands off of Newfoundland)**

Once your child has completed one or both of these two options, **they should return their completed data sheet or interview form to school to be sent to the researchers at the Grenfell Campus of Memorial University of Newfoundland (Corner Brook).** Once available, the results of this survey will be reported to your child's class.

Thank you in advance for your contribution to this exciting initiative!
Sincerely,

Heather Spicer

Heather Spicer
(Student, Environmental Biology, Grenfell Campus, Memorial University of Newfoundland)

Erin Fraser

Erin Fraser
(Assistant Professor, Environmental Biology, Grenfell Campus, Memorial University of Newfoundland)

# Data Collection Part 1: Class Group Activity

## Introduction

*Overview:*
The goal of this part of the citizen science project is to gain a better understanding of red squirrel and eastern chipmunk abundance across Newfoundland and the nearshore islands, as well as reasons why squirrel abundance may vary. Red squirrels are a territorial species and will respond to the calls of other squirrels by calling back or coming closer to investigate. Classes participating in this part of the project will visit and walk through forested areas to look for red squirrels and eastern chipmunks, as well as evidence of squirrel activity. They will also broadcast recordings of red squirrel calls and record any responses that they get from wild squirrels.

*Picking a location:*
Both red squirrels and eastern chipmunks are forest species, so you should visit a forested location near your school to collect data for this part of the project. An area with an easily walked trail that goes through the forest is ideal because you will need to travel several hundred metres. You will be stopping every 300 m to conduct observations called point counts. During a point count, the group stops, broadcasts a recording of squirrel calls, and records the number of squirrels and chipmunks that you observe in response to the broadcast. We recommend that you do one or two point counts, but you are welcome to do more if you want - the more point counts that you want to conduct, the farther you will walk.

*Broadcasting squirrel calls:*
Red squirrels have distinctive territorial calls. Red squirrels typically make a series of chirps and rattles in response to intruders. You can download the squirrel audio files from our Google Docs drive. The link to this will be e-mailed to you. If you cannot access the Drive, please let us know and we will set up an alternate arrangement. Be sure to listen to these with your class before going into the field so that you are all familiar with the calls.

You will need to download the file of the red squirrel calls to a device such as a smartphone, tablet, or laptop before going into the field. You will be broadcasting the calls using the wireless Audiopod speaker that we have included in your kit.

*Detecting squirrels:*
Both red squirrels and eastern chipmunks are highly visible during the day. Both can frequently be seen moving up and down trees and calling. It is also possible to see evidence of red squirrel activity, as these squirrels eat the seeds of conifers such as black spruce, balsam fir, and white pine. Red squirrels often pull apart cones in one or two specific areas, leading to the formation of large piles of cone scales. Before you head out on your walk, you should carefully study the photos on the next page so that you know what to look for.

## Red squirrel

## Eastern chipmunk

Photos: G. Gonthier

A typical pile of cone scales at a red squirrel feeding station is shown here with a pen included for scale. Cone scale piles may also be smaller or much, much larger than the one shown.

## Instructions

Once you arrive at the trail where you will conduct your survey, instruct students that they are about to go look for red squirrels and eastern chipmunks and that they should be quiet and attentive while both looking and listening. Consider appointing two or three students as scribes to keep track of the number of observations being made. You will complete at least two data sheets for this part of the project: one transect data sheet and one point count data sheet for each point count that you complete.

**Please instruct students that they should never harass red squirrels or eastern chipmunks by attempting to feed, chase, or touch them during this exercise.**

1. Begin to walk slowly down the trail, all the while looking and listening for red squirrels and eastern chipmunks. Also look for piles of cone scales that suggest that red squirrels have been feeding in the area. Scribes should keep track of all instances where squirrels/chipmunks are sighted or heard, as well as the number of cone scale piles observed on the “transect data sheet”.

2. After walking for 100 metres, the group should stop and conduct the first point count. Gather the group close and ask them to be quiet while you play the red squirrel call file. The file begins with four minutes of silence and then contains four minutes of squirrel calls. During this eight-minute period, students should stay silent and listen/look around. Scribes should keep track of the number of responding calls and visible squirrels and chipmunks on the “point count data sheet”.

**Note: Individual call broadcasts have minimal impact on the day-to-day activities of red squirrels and eastern chipmunks, but they can be a distraction for these animals if they are done repetitively. Think how you feel about your phone: one call a day is fine, but you get annoyed if it rings off the hook! To minimize your impact on local wildlife, please ONLY play the squirrel call broadcasts once per point count and not at other times during the walk.**

3. We only need results from one point count per class, but we would be happy to accept more if you would like to keep going! If so, continue walking and stopping to conduct point counts for as long as you would like; point counts should be at least 300m apart. Not sure how far you’ve walked? Here are a few ideas for estimating your distance travelled:

   i) Use a public interpretive trail: these often have mile markers or a map at the beginning that indicates distances.

   ii) Use Google maps: zoom in on the area where you did your walk and then use the “distance measured” function to determine the distance travelled (to do this, right click on the map and trace the route travelled).

   iii) Download a pedometer app to your phone: there are many free pedometer apps that will allow you to estimate you distance travelled while carrying your phone. We recommend the Pacer app as a good option.

## Transect Data Sheet

1. Teacher's name, school: ________________________________________

2. Where did you conduct your walk? (Please provide enough detail so that we can place your walk on a map of Newfoundland.)

3. What is the date? ______________________

4. What time did you start? _______________________

5. What time did you finish? _______________________

6. How far did you walk (in metres)? _______________________

7. How many stops (point counts) did you make to broadcast squirrel calls? ___________

**Next, we're curious to learn about what you observed during your <u>walk</u> (NOT including your point counts)**

8. How many eastern chipmunks did you **See?** _____ **Hear only?** _____

9. How many red squirrels did you **See?** _____ **Hear only?** _____

10. How many separate **piles of cone scales** did you see within one metre on either side of the trail? ________

**Finally, we'd like to know about the area where you conducted your walk.**
How would you describe the landscape (habitat) surrounding your trail? (check all that apply)

☐ Forest (mainly conifer – trees with needles and cones e.g. spruce, pine)

☐ Forest (mainly deciduous – trees with broad leaves e.g. birch)

☐ Meadow

☐ Bog

☐ Urban/suburban

☐ Other (please describe) ____________________________________________

## Point Count Data Sheet

Please fill out a point count data sheet for every call broadcast/point count that you do.

Teacher's name, school: ______________________________________________

**First, we'd like to know about your point count.**

1. What time did you start your call broadcast? _______________

2. When you look around you, what does the surrounding landscape look like?

   ☐ Forest (mainly conifer – trees with needles and cones e.g. spruce, pine)

   ☐ Forest (mainly deciduous – trees with broad leaves e.g. birch)

   ☐ Meadow

   ☐ Bog

   ☐ Urban/suburban

   ☐ *Other (please describe)* ______________________________________________

**Next, we'd like to know about the kind of response that you observed.**

3. During the silent four minutes at the beginning of the broadcast:

| How many red squirrels did you: | | How many eastern chipmunks did you: | |
|---|---|---|---|
| SEE | | SEE | |
| HEAR only | | HEAR only | |

4. During the four minutes of squirrel calls during the broadcast:

| How many red squirrels did you: | | How many eastern chipmunks did you: | |
|---|---|---|---|
| SEE | | SEE | |
| HEAR only | | HEAR only | |

5. In **TOTAL**, during your entire eight minutes of observation:

   A) How many red squirrels did you detect (number you saw AND/OR heard)? ☐

   B) How many eastern chipmunks did you detect (number you saw AND/OR heard)? ☐

# Data Collection Part 2(a): Individual/Small Group Portion, A Walk in the Woods

## Instructions

*This activity should be done out of class time by individual students and their families. Please conduct surveys in the morning and on a day when it is not raining. For safety, and to ensure correct completion of the data sheet, children should be accompanied by an adult while they do the survey.*

1. *Selecting a survey area:* Choose an easy path through a forested area near you that is at least a few hundred metres long (should take 10-20 minutes to walk at a normal pace). You will conduct your red squirrel/eastern chipmunk survey as you walk along this path.

2. *Beginning your survey:* Make note of the time on your data sheet and begin to walk slowly along the path. As you walk, you should be looking and listening carefully for red squirrels and eastern chipmunks. You should also look for piles of cone scales like the ones shown in the picture below. If you see these scales you will know that a red squirrel has been having a meal! Before you head out on your walk, you should carefully study the photos below so that you know what to look for.

Red squirrel

Eastern chipmunk

Photos: G. Gonthier

A typical pile of cone scales at a red squirrel feeding station is shown here with a pen included for scale. Cone scale piles may also be smaller or much, much larger than the one shown.

3. *Observing squirrels and chipmunks:* As you are walking, you may see squirrels and/or chipmunks and you may hear them calling. Squirrel calls sound like a series of chirps and rattles and eastern chipmunk calls are usually a regular series of high-pitched barks. Keep careful track of the number of squirrels and chipmunks that you see and the number that you hear.

4. *Observing feeding stations:* Also keep track of the number of cone scale piles that you see within one metre on either side of the trail.

5. *How far?* We recommend that you conduct your survey over 500 metres (which is half a kilometer or about one third of a mile) of the trail. If this is too far, it is also fine for you to walk a shorter distance. However, for our analysis, we need to know how far you went. For tips on tracking your distance, see below*. Remember, you are only counting squirrels and cone piles on your <u>way out</u> along the trail, <u>not</u> on your way back.

6. *The data sheet:* When you reach the end of your walk, take a few minutes to fill out the data sheet. Make sure that you don't miss any sections! Return your data sheet to your teacher and they will send it to the researchers who are interested in learning about red squirrels and eastern chipmunks in Newfoundland.

7. *The results:* The researchers leading this project will report the findings of all of the citizen scientists once those results are available.

***Tips for tracking your distance - Not sure how far you've walked? Here are a few ideas for estimating your distance travelled:**

1. Use a public interpretive trail: these often have mile markers or a map at the beginning that indicates distances.

2. Use Google maps: zoom in on the area where you did your walk and then use the "distance measured" function to determine the distance travelled (to do this, right click on the map and trace the route travelled).

3. Download a pedometer app to your phone: there are many free pedometer apps that will allow you to estimate you distance travelled while carrying your phone. We recommend the Pacer app as a good option.

## A Walk in the Woods Data Sheet

**First, we'd like to know about some of the details of your survey:**

1. Where did you conduct your walk? (Please provide enough detail so that we can place your walk on a map of Newfoundland.)

2. What is the date today? ________________________

3. What time did you start? ________________________

4. What time did you finish? ________________________

5. How far did you go (how many metres did you travel?) __________________

**Next, we're curious to learn about what you observed during you walk:**

1. How many eastern chipmunks did you **See? _____ Hear only? ____**

2. How many red squirrels did you **See? _____ Hear only? ____**

3. How many separate **piles of cone scales** did you see within one metre on either side of the trail? ________

**Finally, we'd like to know about the area where you conducted your walk.**

4. How would you describe the landscape (habitat) surrounding your trail? (check all that apply)

   ☐ Forest (mainly conifer/evergreen; trees with needles and cones e.g. spruce, pine)

   ☐ Forest (mainly deciduous; trees with broad leaves e.g. birch)

   ☐ Meadow

   ☐ Bog

   ☐ Urban/suburban

   ☐ Other (please describe) ____________________________________________

# Data Collection Part 2(b): Individual/Small Group Portion, Individual Interview

## Instructions

*This interview should be conducted by individual students outside of class time. We are interested in hearing about experiences that Newfoundlanders have had sighting red squirrels and eastern chipmunks at their cabins.*

1. Find an adult that you trust (a family member of close family friend) who has a cabin in Newfoundland or on a nearshore island. Ask them if they would be willing to complete a short interview discussing red squirrels and eastern chipmunks around their cabin. We are particularly interested in learning about squirrels and chipmunks on nearshore islands, so if you know someone who has a cabin on an island, that is a bonus!

2. Sit down with the person you are interviewing and work through the interview sheet (attached) with them. Write down their answers as you are speaking with them.

3. Return your interview sheet to your teacher, and they will send it to the researchers who are interested in learning about red squirrels and eastern chipmunks in Newfoundland.

4. The researchers leading this project will report the findings of all of the citizen scientists once those results are available.

## Interview Data Sheet

**First, we would like to learn about your cabin and how you use it:**

1. Where is your cabin?

2. Newfoundland is a big place! To help us better understand the location of your cabin, imagine that are providing directions to it. What would you say?

3. For how many years have you been visiting your cabin?

4. During which seasons do you visit your cabin? (Circle all that apply)

   Spring

   Summer

   Autumn

   Winter

5. On average, how often do you visit your cabin?

6. On average, how many days per year do you spend at your cabin?

**Now, we are curious to learn about the red squirrels & eastern chipmunks that you see near your cabin.**
*Please take a moment to look at the following pictures of a red squirrel and an eastern chipmunk:*

Red squirrel

Eastern chipmunk

Photos: G. Gonthier

7. Do you see red squirrels in the area around your cabin (within 5 km of your cabin)? (circle one of the following options)

   I have never seen a red squirrel near my cabin

   I have rarely seen a red squirrel near my cabin

   I sometimes see red squirrels near my cabin

   I often see red squirrels near my cabin

8. Do you see eastern chipmunks in the area around your cabin (within 5 km of your cabin)? (circle one of the following options)

   I have never seen an eastern chipmunk near my cabin

   I have rarely seen an eastern chipmunk near my cabin

   I sometimes see eastern chipmunks near my cabin

   I often see eastern chipmunks near my cabin

*You ONLY need to respond to Question 9 if you reported that you DO see red squirrels around your cabin.*

9. As accurately as you can, please tell us WHEN (what year) you first noticed red squirrels in the area near your cabin (circle the appropriate answer and fill in the blank if necessary.)

    There have been red squirrels in the area near my cabin for as long as I can remember.

    Red squirrels first appeared in the area near my cabin in approximately (fill in year) _______________________.

*You ONLY need to respond to Question 10 if you reported that you DO see eastern chipmunks around your cabin.*

10. As accurately as you can, please tell us WHEN (what year) you first noticed eastern chipmunks in the area near your cabin (circle the appropriate answer and fill in the blank if necessary.)

    There have been eastern chipmunks in the area near my cabin for as long as I can remember

    Eastern chipmunks first appeared in the area near my cabin in approximately (fill in year) _______________________.

11. Do you have an interesting story or account about red squirrels and/or eastern chipmunks at your cabin that you would like to share? If so, please include it here.

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Thank you for your participation in this survey. We appreciate hearing about your experiences at your cabin and will report the findings of our project to all participating classes.

# Educational Activities

The following activities have been designed to meet curriculum objectives from the NLESD elementary and intermediate science curricula and are available to support your offering of the red squirrel and eastern chipmunk citizen science project to your students. We have included hard copies of the activities that are relevant to your students' grade levels in your package. If you would like copies of any of the other activities, you can access them through the project's Google Docs Drive or contact us.

| Grade level | Activity topic | Activity name | Activity type |
|---|---|---|---|
| 4 | Food chains and habitats | Build a Newfoundland forest habitat food chain | Hands-on activity |
| 4 | Food chains and habitats | Habitats of Newfoundland | Worksheet |
| 5 | Animal body systems | Insulation experiment | Hands-on activity |
| 5 | Animal body systems | Squirrel anatomy | Worksheet |
| 6 | Animal adaptations | Invent your own animal | Hands-on activity |
| 6 | Animal adaptations | Classification of vertebrates | Worksheet |
| 7/8 | Interactions within ecosystems | Draw the biological hierarchy of life | Hands-on activity |
| 7/8 | Interactions within ecosystems | Citizen science word search (Grade 7) / Citizen science crossword (Grade8) | Worksheet |

# Provincial Wildlife Permit

Please bring this document with you when you complete your class group activity data collection (call broadcasts).

Newfoundland Labrador

Government of Newfoundland and Labrador
**Department of Environment and Conservation**

**Scientific Research Permit**
Wildlife Division
(as under section 86 of the Wildlife Regulations, Consolidated Newfoundland and Labrador Regulation 1156/96)

| | |
|---|---|
| **Permit request #:** | WLR2016-18 |
| **Issued to:** | **Dr. Erin Fraser,** Environmental Science (Biology), Grenfell Campus, Memorial University of Newfoundland, Corner Brook, NL, A2H 6P9 |
| **Study Title:** | Citizen science investigation of red squirrel (*Tamiasciurus hudsonicus*) and eastern chipmunk (*Tamias striatus*) distribution and abundance across Newfoundland and the nearshore islands |
| **Permit to:** | Broadcast recordings of red squirrel vocalizations along survey transects (via a citizen science project) for the purpose of determining red squirrel distribution and habitat use. |
| **Location of the Project:** | Across the Island of Newfoundland and offshore islands |

**Conditions:**

- The permit holder may designate other individuals to conduct field activities on his/her behalf.
- The permit holder is responsible for the training of any designated individuals and must ensure designated individuals follow all conditions related to this permit.
- Any unusual wildlife observations or any adverse effects observed during the research project are to be reported immediately to the Wildlife Division.
- This permit does not absolve or relieve the permit holder from any other laws, permits, regulations or orders.
- This permit is only valid for the period indicated below.
- An interim report on the project and field activities is due by **December 31, 2016**.
- A final report on the project is due by **August 31, 2017**. Field data (such as locational/distributional data for Red squirrels and Eastern chipmunk) is to be included in this report for the purpose of helping to inform provincial management efforts.
- **Under the discretion of the Director of Wildlife this permit can be revoked without notice.**

**Date of Commencement:** July 15, 2016

**Date of Expiration:** July 31, 2017

7-16-16
**Date**

**Director of Wildlife**

117 Riverside Drive, Brakes Cove, P.O. Box 2007, Corner Brook, Newfoundland and Labrador, A2H 7S1
Telephone (709) 637-2026 Facsimile (709) 637-2004

GRENFELL CAMPUS | MEMORIAL UNIVERSITY

Erin Fraser, PhD
Assistant Professor, Environmental Science (Biology)
Grenfell Campus, Memorial University of Newfoundland
Corner Brook, NL

September 26, 2016

Dear Principal,

This letter is a consent form requesting your permission for members of your school to participate in a citizen science initiative. One or more educators at your school is/are interested in participating in the Grenfell Campus red squirrel and eastern chipmunk citizen science project, and your consent is required for them to join the project. The project is being offered in partnership with Let's Talk Science (a national science outreach program) and has already been approved by the Newfoundland and Labrador English School District (NLESD). It has an overall budget of more than $6000 and will be offered at no cost to your school.

The goal of the project is to provide an enriching and hands-on opportunity for elementary and intermediate school students in Newfoundland and Labrador to participate in the scientific process and to learn about the natural history of the province while concurrently completing components of the provincial science curriculum. For this project, participating classes will collect information about red squirrel and eastern chipmunk presence and abundance in their area, and these data will be provided to researchers at Grenfell Campus, who will report back to all participating classes on project results. All necessary materials will be provided to participating groups, including age-specific educational activities that align with the NLESD science curriculum and that link the curriculum to the citizen science project. A summary of the research objectives of the study, the methods that we will ask students and educators to complete, and a list of the educational materials that will be provided to all participants is on the second page of this letter. If you would like a full copy of the project proposal or to ask further questions, please feel free to contact us. Participation in all components of the project is voluntary, and educators and students may stop at any time.

If you consent to allowing classes in your school to participate in this project, please fill in the necessary information below and forward a scan of the letter to Heather Spicer at hespicer@grenfell.mun.ca.

With thanks,

Erin Fraser

Dr. Erin Fraser

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**CONSENT:**

As principal, I consent to allow educators at my school to participate with their classes in the red squirrel and eastern chipmunk citizen science project.

Name: ____________________________________ Date: ______________________________

School: ____________________________________ Signature: ______________________________

Name(s) of involved educators: ________________________________________________________________________

**Red squirrel and eastern chipmunk citizen science project – overview**

Red squirrels and eastern chipmunks are introduced species to Newfoundland. There is evidence that red squirrels have had negative impacts on several native Newfoundland species, and there is little known about the impact of eastern chipmunks locally. We do not have complete knowledge of the distribution of both species across Newfoundland and the nearshore islands, nor do we know a lot about their local habitat associations. Through this project, we hope to address the following research questions:

1) Where are red squirrels and eastern chipmunks found in insular Newfoundland and the nearshore islands?
2) What patterns of dispersal exist for both species since their introductions (i.e. when were they found where?)
3) How does red squirrel and eastern chipmunk density vary across Newfoundland and the nearshore islands?

**Methods**

Participating classes will gather information about red squirrels and eastern chipmunks in their area. We understand that participating classes and students will come from a range of circumstances, and so we have designed a flexible data collection protocol. we expect that at least some part will be accessible to all participants. The protocol has two main components: 1) whole class observations and 2) individual data collection. We will encourage participants to complete both components, but of course the extent to which they wish to participate in the project is at their discretion.

1) *Whole class observations:* We will ask teachers to take their students for a walk in a local forested area to look for signs of squirrels and chipmunks (e.g. cone piles), as well as for the animals themselves. Red squirrels are highly territorial, and a common technique for surveying their populations involves broadcasting their calls (called "rattles"). Nearby squirrels will usually come closer to investigate these rattles and may call back. We will provide teachers with the materials to conduct broadcasts of red squirrel calls. We anticipate that participating students will really enjoy this aspect of the survey process (our third year university students find it very exciting!) We will provide teachers with the digital files of squirrel calls and each participating school will receive a free wireless speaker for conducting call broadcasts.

2) *Individual data collection:* Individual students can contribute to the project outside of class time in one of two ways:
(a) Go with a member of their family on a forest walk to look for signs of red squirrels and chipmunks, as well as for the animals, themselves. We will not ask students and their families to conduct call broadcasts.
(b) Conduct an interview with a family member or trusted friend who owns a cabin. We will provide an interview form with a few simple questions about the location of the cabin, whether the cabin occupants have ever seen red squirrels or eastern chipmunks around the cabin, and if so, when they first recall seeing these species.

**Data submission**

Participating classes will submit their data to our research team at the Grenfell Campus. All data will be compiled and analyzed by Heather Spicer, an undergraduate student in Environmental Science (Biology) who will be using the data from the red squirrel/eastern chipmunk project as the basis of her honours thesis. Heather will periodically report back to participating classes to let them know about the status of the project, as well as her findings.

**Educational activities**

All participating classes will be provided with supplementary materials that support teachers in offering educational activities that directly link the red squirrel/eastern chipmunk project with the relevant parts of the science curriculum, including:

Grade 4 – Food chains
Grade 5 – Comparison of body systems of humans to other animals
Grade 6 – Classification of animals and animal adaptations
Grade 7 – Ecosystems, food chains and food webs, producers/consumers/decomposers
Grade 8 – Abiotic and biotic factors in an ecosystem

Teachers will also receive a teacher's guide that includes background information on the life history of red squirrels and eastern chipmunks, as well as some history about these species in Newfoundland. Further, we will provide teachers with a description of the overall citizen science project, including research questions, methods, etc. The purpose of this final document will be to support them in helping their students to understand their own role in the scientific process.

**Newfoundland & Labrador English School District**

*Office of the Senior Education Officer (Human Resources)* | *Chairperson: Milton Peach* |
*Deborah Toope (709) 758-2391* | *CEO/Director of Education: Darrin Pike*

## Research Approval Conditions

**Research Title & Investigator(s):** Red Spuirrels and Easter Chipmunks

Your request to conduct this research is NOT approved: ______

Your request to conduct research in our district is approved subject to the conditions/requirements checked below:

1. A list of selected schools must be forwarded to my office before the research can begin. ✔
   1a. The list of targeted schools has been received
2. Final approval to conduct this study will rest with the principal of each targeted school and the targeted group of teachers/students/parents where applicable. ✔
3. Conducting the research will in **no way negatively impact instructional time for students and teachers.** ✔
4. Conducting this research must not put any burden of responsibility on our school administrators or other staff unless they specifically agree to it. **Such agreement must not negatively impact instructional time.** ✔
5. **Participation in the study will be voluntary** and participants will be able to opt out at any time without prejudice. This must be clearly communicated to the participants at the outset. ✔
6. For students under 19 years of age, **the researcher(s) must secure parental consent and confirm such consent with the principal before the research proceeds.** Students 19 years of age and older must provide their own consent. Regardless of age, youth must be clearly informed from the outset that they may refuse to participate, even if their parents consented to their participation. ✔
7. Anonymity of participants must be ensured. ✔
8. Before the research project can begin, **it must receive final approval from your university's Research Ethics Committee** and a copy of this approval must be sent to the Senior Education Officer (HR) as per the contact information listed below. 8a. Ethics Committee approval letter has been received ☐ 8b. Not applicable ✔
9. Given the inherent potential risk in this research project that some participants may relive a traumatic experience which can cause emotional or psychological stress, counseling services and other appropriate supports must be available during and subsequent to the data collection process. **Researchers are responsible for providing such supports. This service will not be provided by the NLESD.** NA
10. A copy of the research findings and resulting papers/reports must be directed to the Senior Education Officer (HR) and to the regional Assistant Directors of Education (Programs) where applicable. ✔
11. Research results must be made available to the schools involved and the individual participants who request them. ✔
12. The Newfoundland and Labrador English School District takes no responsibility in conducting this research, and will not be held liable for any negative impacts relating to this research effort. **The full responsibility to organize & conduct this research rests with the researcher(s).** ✔

Recommended by: ______ Date: September 21, 2016
Deborah Toope, Senior Education Officer

Signature of Approval: ______ Date: September 22, 2016
Anthony Stack, Associate Director of Education

Signature of Compliance: ______ Date: ______
Researcher

**A signed copy of this form MUST be returned to the address below and to the target schools before research can begin:**
**Attention: Senior Education Officer (HR)**
**Newfoundland and Labrador English School district, suite 601, Atlantic Place**
**215 Water Street, St. John's, NL, A1C 6C9**

# Your Animal Use Protocol has been approved

nfairbridge@mun.ca

Thu 7/14/2016 2:40 PM

To:Dr. Erin Fraser (Principal Investigator) <erinf@mun.ca>;

Cc:ors@mun.ca <ors@mun.ca>; nfairbridge@mun.ca <nfairbridge@mun.ca>;

Institutional Animal Care Committee (IACC)
St. John's, NL, Canada A1C 5S7
Tel: 709 777-6620 acs@mun.ca
www.mun.ca/research/about/acs/

Dear: Dr. Erin Fraser, Assistant Professor/Division of Science\Environmental Science

**RE: Protocol Number and Project Title: "(16-05-EF) Citizen science investigation of red squirrel (Tamaisciurus hudsonicus) and eastern chipmunk (Tamias striatus) distribution and abundance across Newfoundland and the nearshore islands"**

**Approval Date: [July 5, 2016] End Date: [July 5, 2019]**

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Your Animal Use Protocol application to engage in procedures involving animals was considered by the IACC and has been approved on a three-year term.

Other approved personnel include: Heather Spicer and citizen scientist participants.
Approved funding sources include: Quick-Start funds from the MUN Office of Public Engagement; research award from Grenfell Environmental Science Program (awarded to Heather Spicer), an external sources Let's Talk Science and a funded Canada Summer Jobs position.
Internal peer review for scientific merit was conducted and received.

The committee commends you for a well-written application.

The protocol procedures were deemed to be Category of Invasiveness B.

Please inform the committee of any changes to the protocol procedures or content made in response to the scientific peer review process.

An Event - Annual Report will be required following each year of protocol activity.

Should you encounter an unexpected incident that negatively affects animal welfare or the research project relating to animal use, please submit an Event - Incident Report.

Any alterations to the protocol requires prior submission and approval of an Event - Amendment.

All event forms can be found in the Memorial Researcher Portal.

Sincerely,

Nicholas Fairbridge, PhD
ACC Coordinator
Animal Care Services
Memorial University of Newfoundland
Tel: (709) 777-6620
Fax: (709) 777-8468

Email: nfairbridge@mun.ca
Email: acs@mun.ca