RELATIVE ABUNDANCE AND DISTRIBUTIONS OF SCIURIDS IN BURNABY LAKE REIGONAL PARK

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Abstract

We examined the relative abundance, distribution and habitat preference of Douglas squirrels (*Tamiasciurus douglasii*), northern flying squirrels (*Glaucomys sabrinus*) and introduced eastern grey squirrels (*Sciurus carolinensis*) within Burnaby Lake Regional Park, Burnaby, British Columbia. This study was conducted from October 2004 – March 2005, with 2 night trapping sessions occurring once a month. We captured 70 individual squirrels a total of 135 times over 600 trap nights. There were 10 occasions when a squirrel, trapped last year was caught. In total 91 captures occurred in mixed coniferous habitat, compared to 44 captures in mixed deciduous habitats. The mixed coniferous habitat was more productive for Douglas squirrels (55 captures) and northern flying squirrels (20 captures) than mixed deciduous habitat which was more productive for the eastern grey squirrels (23 captures). Native squirrel species were captured on all six lines, whereas the eastern grey squirrel was captured on only four lines. On average we caught 22.5 sciurids per 100 trap nights. The highest number of captures per trap nights, overall, was Douglas squirrels in the mixed coniferous habitat, with 23.8 captures per 100 trap nights. Our study indicated that the eastern grey squirrels are not having a significant impact on the native squirrel's abundance. Instead it indicated differences in relative abundance could be related to habitat preference and food availability rather than species competition. Continuation of this study is recommended to determine trends of the three squirrel species.

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Acknowledgements

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1.0 Introduction

1.1 Background and Objectives

Burnaby Lake supports three squirrel species; the native Douglas squirrel (*Tamiasciurus douglasii*) and northern flying squirrel (*Glaucomys sabrinus*), and the introduced eastern grey squirrel (*Sciurus carolinensis*). There has been an increase in abundance of eastern grey squirrels throughout the Lower Mainland and little information is available on the potential impacts they may have on Douglas squirrels and northern flying squirrels. The eastern grey squirrel has been suspected of displacing the Douglas squirrel and northern flying squirrel from their natural habitat (Klassen and Stooshnoff, 2003).

The eastern grey squirrel is not native to British Columbia, it was introduced into Stanley Park in Vancouver, B.C. in 1914 (Klassen and Stooshnoff, 2004). The distribution of the eastern grey squirrel has continued to expand throughout the Lower Mainland since their introduction. They are the most commonly seen squirrel in urban areas; thus, majority of the public is under the assumption that they are native (Gonzales, 2000). It is unknown whether or not there is competition between native squirrels and eastern grey squirrels for important resources; however, all three species include similar food items in their diet and use similar nesting habitats (Carey, 2004).

Northern flying squirrels and Douglas squirrels are very important components to the natural functioning ecosystems, because they spread mycorrhizal fungi. Without these fungi the ecosystems we are surrounded by would be considerably less productive. The decrease in native squirrel species, or possible extirpation, would have significant impacts on forest health and productivity. For that reason it is important to determine the impacts the introduced eastern grey squirrel may have on native Douglas squirrels and northern flying squirrels.

Artificial cavities have been installed throughout the park, in the form of nest boxes, to provide nesting habitat for species such as wood ducks (*Aix sponsa*). Nest boxes are monitored by volunteers on a yearly basis and checks have found an increase in use by eastern grey squirrels (B.Gunn, per. comm.: cf. Klassen and Stooshnoff, 2003). There is a concern that eastern grey squirrels are preying on native birds and squirrels using the nest boxes.

This is a continuation of a project initiated in 2003 by Klassen and Stooshnoff (2003) through the Fish Wildlife and Recreation Program (FWR) at the British Columbia Institute of Technology (BCIT). It was initiated because little information is known on squirrel populations in Burnaby Lake Regional Park (BLRP). This is the second study on the relative abundance and distribution of the three species in BLRP. The two main objectives for this study were:

1. To study the relative abundance, distribution and habitat preference of Douglas squirrels, northern flying squirrels, and eastern grey squirrels, in Burnaby Lake Regional Park.
2. To record vegetation within the study sites and examine habitat preferences of the 3 sciurid species.

To expand on Klassen and Stooshnoff (2004), this study examined the abundance of each species in different habitat types and examined the relationships between native and introduced species in BLRP. In addition, we examined the impacts of urbanization on these species to determine whether populations of native squirrels were affected by the introduced species. As interurban wildlife species are poorly understood, and little research has been done, we examined the impact that urbanization may have on wildlife.

1.2 Douglas Squirrel

The Douglas squirrel is a small, diurnal, tree-dwelling squirrel that lives almost exclusively in coniferous forests. They inhabit areas from south-western British Columbia through Washington and Oregon to northern California (Steele, 1999). Douglas squirrels are very territorial because of their need to have a sufficient supply of cones to survive through winter (Steele, 1999). Size of their territory is directly proportional to amount of cone bearing trees that it contains (Penner *et al.,* 1999). Douglas squirrels are very noisy and use a large variety of chirps and calls to define their territories (Steele, 1999). The squirrels' main sources of food include cones of Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine *(Pinus contorta)*, Sitka spruce (*Picea sitchensis*), and western hemlock (*Tsuga heterophylla*) (Steele, 1999). They are also known to consume maple (*Acer* spp.), red alder (*Alnus rubra*) and other seeds in deciduous forests (Klassen and Stooshnoff, 2003). Another main food source is fungal fruiting bodies or truffles made by fungal partners of tree species. Spores are then spread throughout the

forest in their feces and the fungi helps significantly with the growth and health of the forest (Carey, 2004). Douglas squirrels have brownish-grey coats with rusty colored bellies (Figure 1). They have a yellowish-white eye ring, a bushy tail, and usually weigh 150-300 grams. They often nest in hollowed-out tree cavities, but also construct nests with leaves and twigs high in conifer trees.

Figure 1. A Douglas squirrel (*Tamiasciurus douglasii*) vocalizes its disproval of invader in its territory in Burnaby Lake Regional Park, Burnaby, February 2005 (photo; G. Rohrmoser).

1.3 Northern Flying Squirrel

The flying squirrel is a small, nocturnal, arboreal squirrel that inhabits coniferous and mixed forests where old or dead trees have numerous woodpecker-type nesting holes (Wells-Gosling and Heaney, 1984). They inhabit areas from the east coast to the west coast and from the tree line in northern Canada south to California in the west, and through the Appalachians in the east (National Wildlife

Federation, 2004). Flying squirrels can be identified by the loose fold of skin that stretches between their front and hind legs. Flying squirrels are brownish-grey in color with a grey/white belly (Figure 2). They have a flattened tail, and large black eyes that help them with night vision (Burke Museum of Natural History and Culture, 2004). The northern flying squirrel feeds primarily on lichens and fungi, both epigeous (above ground fruiting) and hypogeous (underground fruiting) fungi (Thysell *et al.*, 1997). In feeding, it dispenses fungal spores and the nitrogen-fixing bacteria that help trees obtain nutrients and water (National Wildlife Federation, 2004). Northern flying squirrels are not territorial, and sometimes nest in groups over winter, to keep warm (Wells-Gosling and Heaney, 1984). They nest in tree cavities lined with lichen and grass, but in winter they usually construct leaf nests with strips of bark, twigs and some grass and lichen in the center (National Wildlife Federation, 2004).

Figure 2. Northern flying squirrel (*Glaucomys sabrinus*) ascends a tree after it was released from the trap in Burnaby Lake Regional Park, Burnaby, in December 2004 (photo; G. Rohrmoser).

1.4 Eastern Grey Squirrel

The eastern grey squirrel is an introduced species, but is the most commonly seen urban squirrel in the lower mainland (Gonzales, 2000). Six or eight squirrels of mixed morphology, black and grey, were introduced into Stanley Park in Vancouver, B.C. in 1914 (Klassen and Stooshnoff, 2004). The eastern grey squirrel spends most of its time in trees where it can move around with great agility. This squirrel is a very large squirrel ranging from 400-650g and larger. It ranges from grey to black and has a very large bushy tail (Figure 3). They prefer deciduous or mixed forests, but they are well adapted to residential setting and are common in backyards (Gonzales, 2000). They are opportunists when it comes to finding food which is why they can live in a variety of habitats (Koprowski, 1994). They eat the buds of several deciduous trees like maple, and red alder as well as a variety of seeds, nuts and berries. Their diets vary with the seasons and they have also been known to eat eggs or young birds (Woods, 1980). Overlapping of home ranges is extensive; territoriality is not evidenced strongly in this species (Don, 1983: cf. Klassen and Stooshnoff, 2004). Eastern grey squirrels like to nest in people's homes. They are a diurnal species; thus; are only active during the daylight hours. There is a possibility that the eastern grey squirrel are negatively impacting the native sciurids because all three species include similar food items during summer in their diet and use similar nesting habitats (Carey, 2004).

Figure 3. Eastern grey squirrel (*Sciurus carolinensis*) perched on a broken branch as it observed human activity in Burnaby Lake Regional Park, Burnaby, December 2004 (photo; H. Smith)

2.0 Methods

2.1 Study Area

2.1.1 Burnaby Lake Regional Park

Burnaby Lake Regional Park is located between Highway #1 and Lougheed highway, with Sperling Avenue to the west in the Lower Mainland of B.C. The lake is fed by Still, Eagle and Robert Burnaby Creeks and empties into the Brunette River (Humphrey, 1992). Burnaby Lake Regional Park is located in the CWH_{dm} biogeoclimatic sub-zone (Meidinger and Pojar, 1991). Climate is characterized by cool summers and mild winters. Mean annual temperature is 8° C and mean annual precipitation is 2228 mm, with less than 15% occurring as snow fall (Meidinger and Pojar, 1991). The park has trails all around the lake that are used by dog walkers, runners, equestrians, and bird watchers. Since 1979 the park has been managed by the Greater Vancouver Regional District

(G.V.R.D.), who has emphasized recreation and the preservation of nature and heritage within the park (Humphrey, 1992). There is a variety of habitat types for birds and animals within the park, which include peat bogs, grasslands, marshes, old-growth coniferous stands, and mixed deciduous stands. In 1991, B.C.I.T.'s FWR program observed sixty-six bird species and 7 mammal species within the park (Hamilton and Hood, 1992). The park consists of 143 ha of land and 137 ha of lake (Humphrey, 1992). Most of the wildlife habitat has been fragmented by the many trails that surround the lake.

2.1.2 Mixed Deciduous Habitat

Three trap lines were established through a variety of mixed deciduous habitats. Deciduous habitats were primarily comprised of black cottonwood (*Populus balsamifera* ssp*. tricocarpa*), red alder, paper birch (*Betula papyrifera*) and cascara (*Rhamnus purshiani;* figure 4). The shrub layer was dominated by salmonberry (*Rubus spectabilis*), vine maple (*A. circinatum*), lady fern (*Athyrium filix-femina*), spiny wood fern (*Dryopteris expansa*), and red elderberry (*Sambucus racemosa*). Most of the dominant vegetation indicated that these areas were rich and moist sites. The three mixed deciduous lines were named MD line 1, 2, and 3. MD 1 and 2 were established by Klassen and Stooshnoff (2003). MD line 1 was located by the Piper house and ran west, intersecting several trails. MD line 2 was located 15 m north of Avalon trail and ran parallel to the trail. MD line 3 was established this year, near the start of the Freeway trail along the south side of Burnaby Lake.

Figure 4. Mixed deciduous stand where trapping line Mixed Deciduous #2 was located in Burnaby Lake Regional Park, Burnaby (photo; G. Rohrmoser).

2.1.3 Mixed Coniferous Habitat

Three trap lines were established in various mixed-coniferous habitats. This habitat was primarily comprised of western hemlock, western red cedar (*Thuja plicata*), and Sitka spruce (figure 5). Shrubs that dominated these habitats include vine maple, salmon berry, red huckleberry (*Vaccinium parvifolium*), and false azalea (*Menziesii ferruginea*). The three mixed coniferous lines are named MC line 1, 2, and 3. MC 1 and 2 were established by Klassen and Stooshnoff (2003). MC line 1 started at the Spruce Loop Trail and ran west through to the Conifer Loop Trail. MC line 2 was situated at the Avalon Trail and ran south east intersecting several trails. MC line 3 was established this year, along the Freeway Trail. Though the line was in a coniferous stand the surrounding area was primarily composed of deciduous trees. Vegetation plots were located along these lines to describe the specific habitats used by the squirrels.

Figure 5. Mixed Coniferous stand where trapping line Mixed Coniferous #2 was located at Burnaby Lake Regional Park, Burnaby (photo; G. Rohrmoser).

2.2 Vegetation Plots

Vegetation plots were established 75 m along each line and 10 m perpendicular to the left. If placing the plot to the left was not feasible then we placed them to the right. The plots were located to the side of the line to ensure that none of the vegetation had been trampled or disturbed. Each plot consisted of:

- 1.26-m radius plot for herbs and mosses,
- 2.82-m radius plot for shrubs, and
- 5.64-m radius plot for trees and CWD.

For all plots, species composition and percent cover was determined by visual estimates during November, 2004. The percent cover of the three trap lines was averaged to represent that habitat type.

2.3 Live Trapping

Four transects used in Klassen and Stooshnoff (2004) have been re-established, in addition to the two new transects established. Each transect was 300 m long

with stations every 30 m. One Tomahawk live trap (Model 201, Tomahawk Live Trap Co., Tomahawk Wisc.) was placed at each station. Each trap was equipped with a plastic nest box, cotton, sunflower seed and 45 cm by 45 cm poly-sheet. Traps were pre-baited with sunflower seeds approximately ten days before the first trapping session. Trapping was conducted one weekend a month from October 2004 through February 2005. Traps were set Friday evening, checked Saturday morning, reset Saturday evening, and checked again Sunday morning. Traps were locked shut between trapping sessions. Net bags were used to facilitate squirrel handing. Species, ear tag number, weight, and gender of each squirrel were recorded. Our methods were conducted in accordance with the Resource Inventory Committee Standards for sciurids (RISC, 1998). Results were standardized to 100 trap nights. Relative abundance and captures per 100 trap nights were calculated. We did not correct for sprung or missing traps, because these occurrences happened evenly among the two habitat types. We were not concerned about this biasing our study.

Figure 6. Data being collected the data on a Douglas squirrel (*Tamiasciurus douglasii*) on trapping line Mixed Coniferous #1 in Burnaby Lake Regional Park, Burnaby, November, 2004 (photo; G. Rohrmoser).

3.0 Results

3.1 Vegetation Plots

The average herb layer was 18% larger in the mixed coniferous stand (MC) than the mixed deciduous stand (MD) (Table 1). The shrub layer in the mixed coniferous stand was approximately twice as large as in the mixed deciduous stand. Mixed coniferous stands had 29% more vegetation cover than the mixed deciduous stands.

Table 1. Averaged percent cover of each trapping line in the mixed coniferous (MC) and mixed deciduous (MD) stands in Burnaby Regional Park, October 2004. Percent cover was visually estimated for three layers; herbs, shrubs, and trees (conifers and deciduous).

Habitat Type	Vegetation Layer			
	Herb	Shrub	Coniferous Tree	Deciduous Tree
Coniferous Line				
1	120%	53%	50%	8%
2	132%	59%	90%	26%
3	100%	64%	55%	33%
Average	117.3%	58.7%	65.0%	22.3%
Deciduous Line				
1	100%	84%	3%	71%
2	100%	114%	3%	80%
3	97%	130%	0	49%
Average	99%	109.3%	2.0%	66.7%

3.2 Trapping

In total we captured 70 individual squirrels a total of 135 times over 600 trap nights. Four squirrels were dead on arrival (DOA). There were 10 occasions when a squirrel trapped last year was caught. In total, 91 captures occurred in the mixed-coniferous habitat, compared to 44 captures in the mixed-deciduous habitats. The most productive trap line was MC#3 which had 32 captures (Table 2). MD#3 was the most productive line of the deciduous habitats with a total of 21 captures (Table 2). Mixed-coniferous habitat was more productive for

Douglas squirrels (55 captures) and northern flying squirrels (20 captures), but mixed-deciduous habitat was more productive for the eastern grey squirrels (23 captures). No eastern grey squirrels were captured on MC#1 or MD#2 and only one was captured on MC#2 (Table 2). In MC#3 there were more eastern grey squirrels and northern flying squirrels than Douglas squirrels. Northern flying squirrels and Douglas squirrels were captured on every line. The eastern grey squirrels were caught only on 4 of the 6 lines.

Table 2. Total number of individuals for Douglas squirrels (*Tamiasciurus douglasii*), northern flying squirrels (*Glaucomys sabrinus*), and eastern grey squirrels (*Sciurus carolinensis*) trapped from October 2004 to March 2005 in Burnaby Lake Regional Park, Burnaby.

Habitat Type	Species			Total captured per line
	Douglas squirrel	northern flying squirrel	eastern grey squirrel	
MC#1	8	3	0	**11**
MC#2	7	2	1	**10**
MC#3	5	7	10	**22**
MD#1	2	2	9	**13**
MD#2	2	3	0	**5**
MD#3	4	1	7	**12**
Total captured	**28**	**18**	**27**	

The highest number of captures per 100 trap nights (C/100TN) was Douglas squirrels in mixed-coniferous habitat, with 26 C/100TN (Table 3). MC#3 was the most productive trap line for northern flying squirrels (12 C/100TN) and eastern grey squirrels (15 C/100TN). MD#2 was the least productive trap line with an average 1.7 squirrels per 100 trap nights. In the mixed-deciduous habitat eastern grey squirrels were caught more often than Douglas or northern flying squirrels. On average we caught 7.5 individuals per 100 trap nights. The highest number of captures per trap nights (C/100TN) was on MC#1, with an average of 10.7 captures per 100 trap nights

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Table 3. Captures per 100 trap nights for Douglas squirrels (*Tamiasciurus douglasii*), northern flying squirrels (*Glaucomys sabrinus*), and eastern grey squirrels (*Sciurus carolinensis*) around Burnaby Lake Regional Park, Burnaby, from October 2004 to January 2005.

Habitat Type	Species			Average
	Douglas squirrel	northern flying squirrel	eastern grey squirrel	
MC#1	26	6	0	**10.7**
MC#2	20	2	1	**7.7**
MC#3	9	12	15	**12**
MD#1	2	3	13	**6**
MD#2	2	3	0	**1.7**
MD#3	10	1	10	**7**

For all trap lines there is large variability abound the mean except for northern flying squirrels in mixed-deciduous habitats at an average of 2.3 C/100TN (Figure 7). Douglas squirrels had an average of 18.3 C/100TN in mixed-coniferous habitats. Averages of the other lines ranged from 4.6 C/100TN to 7.6C/100TN, a difference of 3 C/100TN. Douglas squirrels and northern flying squirrels were found to be more abundant in mixed-coniferous stands than in mixed-deciduous stands with eastern grey squirrels being highly variable in both habitat types. Eastern grey squirrel abundance was highest in mixed-coniferous stand #3; but on average was higher in mixed-deciduous stands.

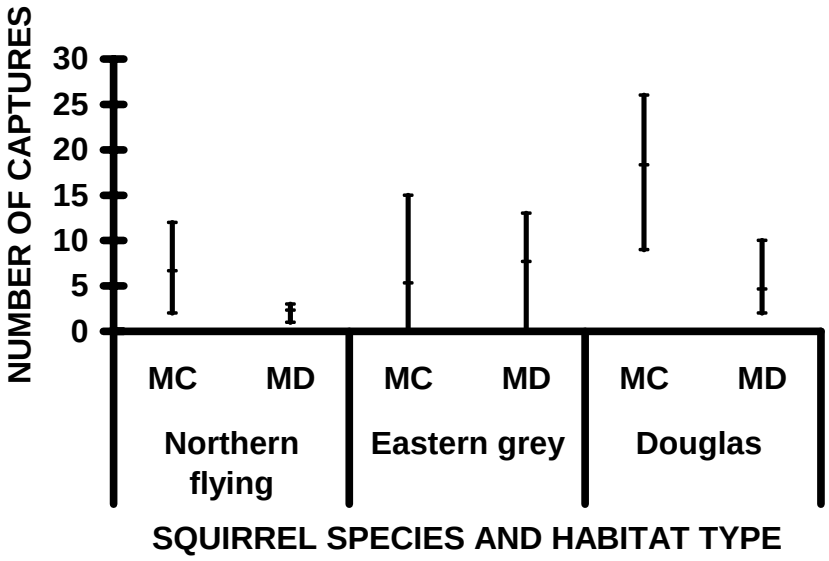

Figure 7. Show the average, minimum, and maximum number of squirrels captured per 100 trap nights on each trap line for each species of sciurid in Burnaby Lake Regional Park. Trapping took place from October 2004 to March 2005 by BCIT's Fish Wildlife and Recreation program.

In 2003/04 Klassen and Stooshnoff captured squirrels on line transects MD#1, MD#2, MC#1, and MC#2. This year we established two additional trap lines; MD#3 and MC#3. Figure 8 shows our data from this year on the four line transects established by Klassen and Stooshnoff. Figure 8 shows the reduction in variability around the means in comparison to Figure 7. Mixed-deciduous #3 and mixed-coniferous #3 made the variability around the mean much larger compared to without. Without MC#3 eastern grey squirrels mean dropped to .5 average individuals on a trap line because MC#3 was the only coniferous line to have high eastern grey squirrel abundance.

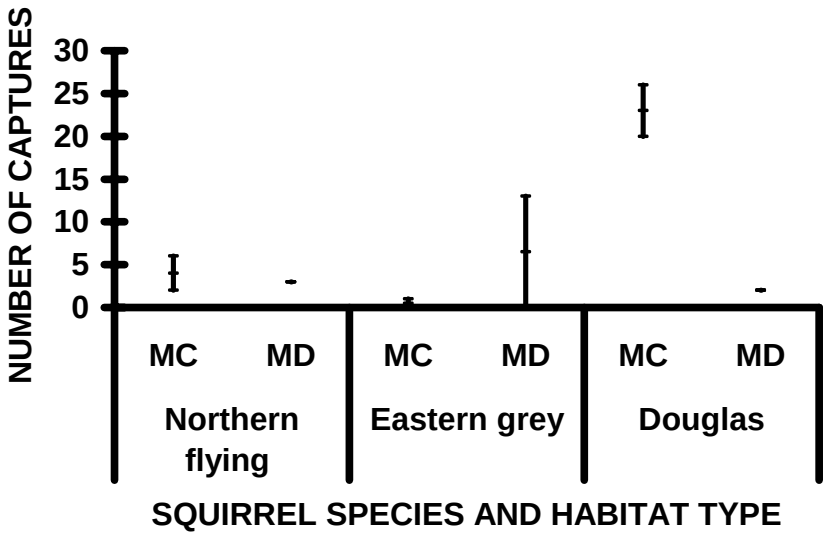

Figure 8. Shows the average, minimum, and maximum number of squirrels captured per hundred trap nights for each species of sciurid in Burnaby Lake Regional Park on the trapping lines that Klassen and Stooshnoff used in their study in 2003/05. This years trapping took place from October 2004 to March 2005 by BCIT's Fish Wildlife and Recreation program.

The highest number of individual squirrels per trap line was 10 eastern grey squirrels on MC#3 (Figure 9). It appears that when eastern grey squirrels are present they occur in relatively high numbers. Douglas squirrels were most abundant in MC#1 and had moderate abundance on the other two mixed-coniferous lines. On mixed-deciduous lines Douglas squirrels were found in relatively low numbers. Eastern grey squirrels were found in high numbers on MD#1 and MD#3 but none were found on MD#2.

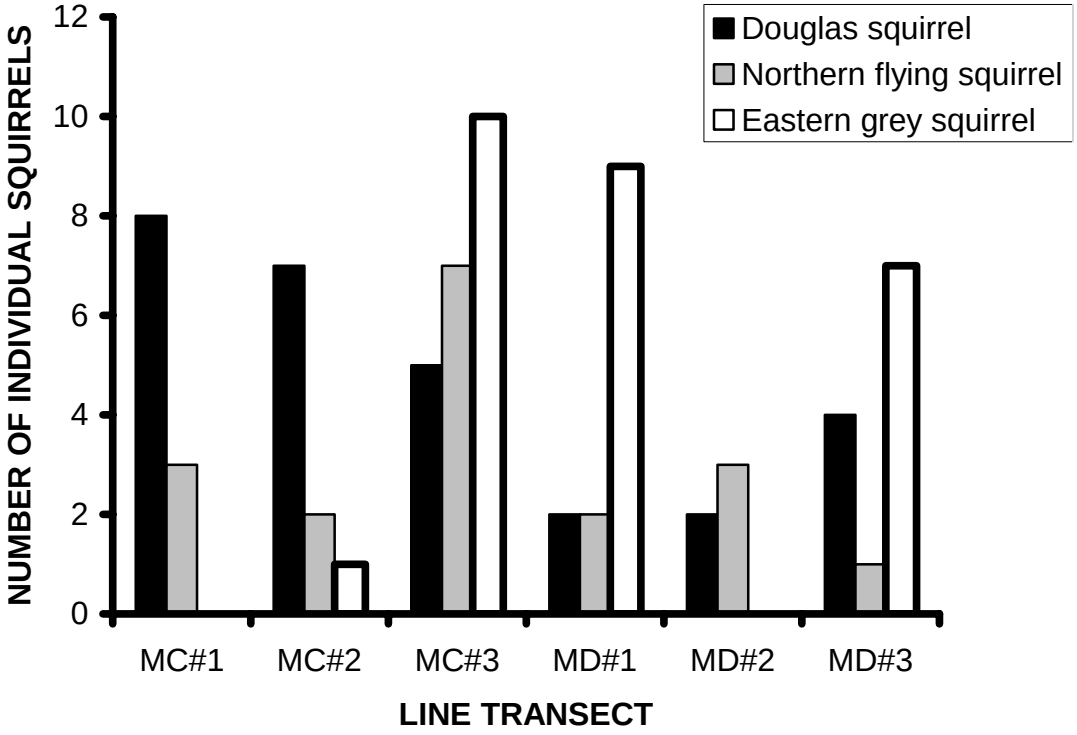

Figure 9. Shows the number of individual squirrels that were caught on each trap line of the two habitat types in Burnaby Lake Regional Park over 600 trap nights. Trapping occurred from October 2004 to March 2005.

Twenty-two individual squirrels were captured on MC#3 (Figure 10). Five squirrels were captured on MD#2. The other four lines ranged from ten to thirteen individuals, a difference of three. The average number of individual squirrels captured per transect was 12.2.

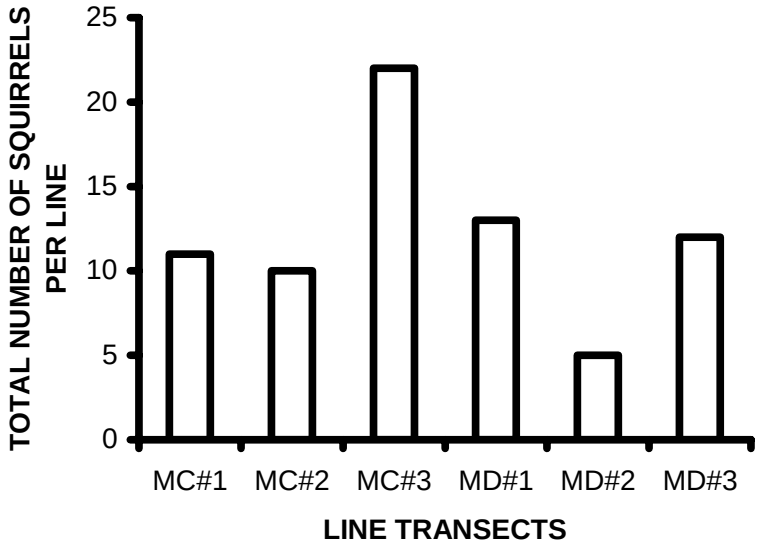

Figure 10. Shows the total number of individual squirrels found on each trap line in Burnaby Lake Regional Park over 600 trap nights. Trapping occurred from October 2004 to March 2005.

4.0 Discussion

It appeared that mixed coniferous habitats around Burnaby Lake Regional Park were preferred by the Douglas squirrels and northern flying squirrels. Douglas squirrels preferred the coniferous habitats because of their reliance on cones. Densities in other habitats, may be high, if food supply is elevated (Sullivan and Sullivan, 1982; Steele, 1999). This is probably why Douglas squirrel captures were elevated in MD#3. That line had a larger component of conifers than the other two deciduous lines.

Eastern grey squirrel's densities were highest in habitats composed of tree species that produce winter-storable foods such as oak (*Quercus*), hickory (*Carya*) and walnut (*Juglans*; Koprowski, 94). In general, studies concluded that eastern grey squirrels were generalists and well adapted to areas of human development (SPES, 2004), our data supported this conclusion. However, the highest number of individual eastern grey squirrels was on a coniferous line far from human residential development.

Habitat requirement for the northern flying squirrel is still in debate. Some studies have indicated it is old-growth dependant (Carey, 1995), while others

claim it is related to food availability (Ransome and Sullivan, 1997). Across North America northern flying squirrels have been found in a diverse variety of habitats (Wells-Gosling and Heaney, 1984). Flying squirrels were caught on all our trap lines; however they were more abundant on the coniferous lines. This may indicate that northern flying squirrels prefer the structure of a coniferous stand. There were no old-growth stands in Burnaby Lake Regional Park, and we captured a healthy population of northern flying squirrels within the park. This leads us to believe in the theory that northern flying squirrels are not old-growth dependant, but limited by food availability.

It is unknown how the three species are interacting and whether the introduction of the eastern grey squirrel is affecting the abundance and distribution of the native Douglas and northern flying squirrels. The few studies completed on the effects of eastern grey squirrels on native squirrel demography suggested no displacement of native squirrels (Hwang, 1997). Our study indicates that the eastern grey squirrels are not having a significant impact on the native squirrel's abundance. Differences in relative abundance could be connected to habitat preference rather than species competition. The content of deciduous trees in mixed coniferous line three was higher than either of the other coniferous lines. In addition, there were large patches of Himalayan blackberry bushes adjacent to MC#3 and MD#3, which may be a food source for eastern grey squirrels. Of the coniferous lines, number three was the only one with an abundance of eastern grey squirrels. The high deciduous content and Himalayan blackberry could be attributed to an increased number of eastern grey squirrels. Mixed deciduous line three had a patch of coniferous trees at the east end; this is the area where all Douglas squirrels were captured on this line. The high coniferous content could be attributed to the high number captures of Douglas squirrels on a deciduous line. Mixed deciduous line two had no eastern grey squirrels, a trend found in Klassen and Stooshnoff, 2004, this could be attributed to the high water table and a high density of thin-stemmed trees.

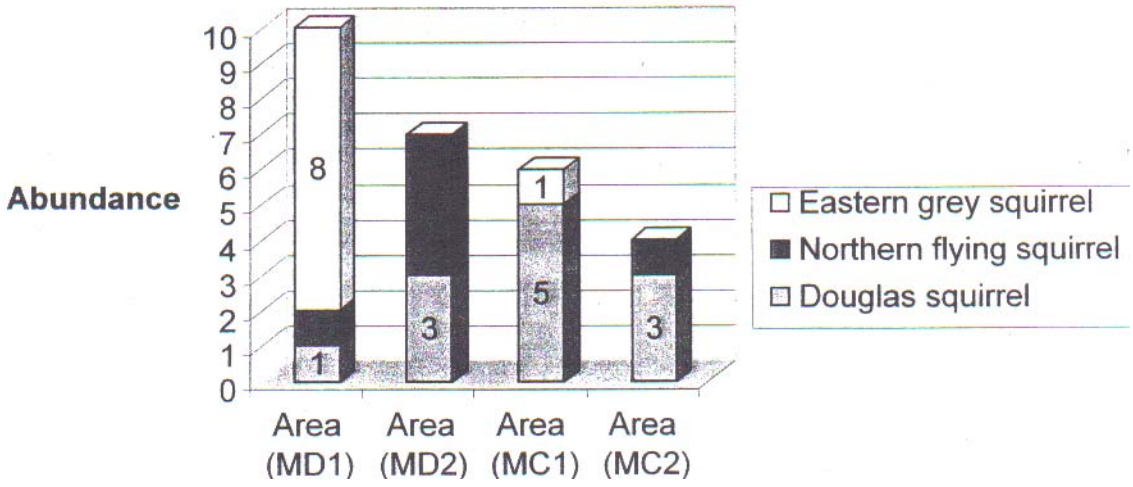

Figure 11. Shows the total number of eastern grey squirrels, northern flying squirrels, and Douglas squirrels captured from Klassen and Stooshnoff's report from March 2004 on squirrels in Burnaby Lake Regional Park.

We trapped a total of 400 trap nights on the trap lines Klassen and Stooshnoff used in 2003/04, compared to Klassen and Stooshnoff's total of 160 trap nights. In comparison our lines indicated similar trends to Klassen and Stooshnoff with MD#1 having high numbers of eastern grey squirrels and low numbers of Douglas squirrels, the coniferous lines having low number of eastern grey squirrels, and MD#2 having no eastern grey squirrels. There were a few minor differences between Klassen and Stooshnoff, 2004 and our study but these can be attributed to the differences in trapping effort. For example, we captured northern flying squirrels on all lines where as Klassen and Stooshnoff caught none on mixed coniferous line one.

Since we conducted our vegetation surveys during November some vegetation layers may be poorly represented. To avoid bias in our study we set the same number of traps in each habitat type and had the same amount of trap nights for each trap line. We did not correct for sprung or missing traps, because these occurrences happened evenly among the two habitat types. We are not concerned about this biasing our study. Each individual caught was tagged with a distinctive number to prevent over estimating the population. Traps were all baited equally to prevent bias, and all animals were handled quickly and gently to mitigate trap shyness.

5.0 Recommendations

We recommend that this project be continued in future years to monitor populations and identify trends of the three squirrel species in Burnaby Lake Regional Park. Individual years of data are only able to give us a snap shot of what is really happening, but with many years of data, trends will be much easier to identify. The vegetation plots should be completed in the spring time to ensure that each layer is properly represented. More vegetation plots should be conducted, preferably one at each trap station, instead of other locations on the trap line. If feasible, the addition of more trap lines in areas currently unrepresented would give a better idea of sciurid populations within the park. It is also recommended that the locations of the trap lines and stations are mapped using a Global Positioning System (GPS).

We also recommend that a separate study be conducted on cavities in Burnaby Lake Regional Park. This study would include locating suitable natural cavities in trees along each established line, and assessing their use by squirrels. It would also include assessing squirrel use of artificial cavities already in the park, as well as installing and monitoring more artificial cavities suitable only for native species.

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Appendix A: Trapping Results

Table 4. Trap Night #1 – October 30, 2004

Area	Trap #	Tag #	Species	Weight	Sex	Notes
Mixed Deciduous # 3	1	796	SCCA****	620g	F	NT*
Mixed Deciduous # 3	3	795	SCCA	670g	F	NT
Mixed Deciduous # 3	9	794	TADO*****	180g	M	NT
Mixed Coniferous #1	1	799	TADO	190g	F	NT
Mixed Coniferous #1	2	231	TADO	190g	M	TLY**
Mixed Coniferous #1	3	800	GLSA******	120g	M	NT
Mixed Coniferous #1	6	231	TADO	190g	M	TLY-RC***
Mixed Coniferous #2	2	798	TADO	170g	M	NT
Mixed Coniferous #2	10	224	TADO	180g	M	TLY
Mixed Coniferous #3	2	793	SCCA	370g	F	NT
Mixed Coniferous #3	3	792	TADO	170g	M	NT
Mixed Coniferous #3	9	791	TADO	170g	M	NT

*NT: New tag
**TLY: Tagged last year
***RC: Recapture
****SCCA: Eastern grey Squirrel
*****TADO: Douglas Squirrel
******GLSA: Northern flying Squirrel

Table 5. Trap Night #2 – October 31, 2004

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	5	788	SCCA	650g	M	NT
Mixed Deciduous # 1	10		TADO	190g	F	DOA*
Mixed Deciduous # 2	4	782	GLSA	90g	M	NT
Mixed Deciduous # 3	10	794	TADO	180g	M	RC
Mixed Coniferous #1	2	799	TADO	190g	F	RC
Mixed Coniferous #1	8	790	TADO	170g	M	NT
Mixed Coniferous #2	1	789	TADO	190g	M	NT
Mixed Coniferous #2	9	784	TADO	190g	F	NT
Mixed Coniferous #3	2	787	SCCA	340g	M	NT
Mixed Coniferous #3	3	786	SCCA	550g	F	NT
Mixed Coniferous #3	5	792	TADO	170g	M	RC
Mixed Coniferous #3	6	781	SCCA	640g	F	NT
Mixed Coniferous #3	7	785	TADO	160g	M	NT

*DOA: Dead on arrival

Table 6. Trap Night #3 – November 20, 2004

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	1	785	SCCA	600g	F	NT
Mixed Deciduous # 1	2	751	SCCA	430g	M	NT
Mixed Deciduous # 1	5		SCCA	630g	M	DOA
Mixed Deciduous # 3	4	752	SCCA	580g	M	NT
Mixed Deciduous # 3	9	753	TADO	170g	F	NT
Mixed Deciduous # 3	10	754	TADO	200g	M	NT
Mixed Coniferous #1	6	231	TADO	190g	M	TLY-RC
Mixed Coniferous #2	4	798	TADO	170g	M	RC
Mixed Coniferous #2	5	782	GLSA	80g	F	RC
Mixed Coniferous # 2	9	224	TADO	190g	M	TLY-RC
Mixed Coniferous # 3	5	755	GLSA	130g	F	NT
Mixed Coniferous # 3	6	756	GLSA	90g	M	NT

Table 7. Trap Night #4 – November 21, 2004

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	1	772	SCCA	410g	F	NT-RE*
Mixed Deciduous # 1	2	771	SCCA	350g	M	NT
Mixed Deciduous # 3	4	770	SCCA	490g	M	NT
Mixed Deciduous # 3	8	769	GLSA	120g	M	NT
Mixed Deciduous # 3	10	754	TADO	200g	M	RC
Mixed Coniferous #1	3	230	TADO			TLY
Mixed Coniferous #1	8	790	TADO	170g	M	RC
Mixed Coniferous #2	8	224	TADO	180g	M	TLY-RC
Mixed Coniferous #2	10	784	TADO	190g	F	RC
Mixed Coniferous #3	3	768	TADO	140g	M	NT
Mixed Coniferous #3	6	767	GLSA	120g	F	NT
Mixed Coniferous #3	7	792	TADO	170g	M	RC

*RE: Right ear

Table 8. Trap Night #5 – December 10, 2004

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	1	771	SCCA	350g	M	RC
Mixed Deciduous # 1	3	772	SCCA	410g	F	RC
Mixed Deciduous # 1	5	765	SCCA	590g	F	NT
Mixed Deciduous # 1	6	788	SCCA	650g	M	RC
Mixed Deciduous # 3	4	795	SCCA	670g	F	RC
Mixed Coniferous # 1	1	230	TADO			TLY
Mixed Coniferous # 1	4	766	TADO	210g	F	NT
Mixed Coniferous # 1	5	231	TADO	200g	M	RC
Mixed Coniferous # 1	9	757	TADO	190g	M	NT
Mixed Coniferous # 1	10	790	TADO	170g	M	RC
Mixed Coniferous # 2	1	789	TADO	190g	M	RC
Mixed Coniferous # 2	4	798	TADO	170g	M	RC
Mixed Coniferous # 2	6	224	TADO	180g	M	DOA
Mixed Coniferous # 2	7	784	TADO	190g	M	RC
Mixed Coniferous # 2	8	758	GLSA	130g	F	NT
Mixed Coniferous # 3	2	787	SCCA	340g	M	RC
Mixed Coniferous # 3	5	769	GLSA	120g	M	RC
Mixed Coniferous # 3	6	759	GLSA	140g	F	NT
Mixed Coniferous # 3	8	792	TADO	170g	M	RC

Table 9. Trap Night #6 – December 11, 2004

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	6	765	SCCA	590g	F	RC
Mixed Deciduous # 3	2	671	SCCA	420g	M	NT
Mixed Deciduous # 3	9	754	TADO	200g	M	RC
Mixed Coniferous # 1	2	230	TADO			TLY
Mixed Coniferous # 1	6	231	TADO	190g	M	RC
Mixed Coniferous # 1	7	800	GLSA	120g	M	RC
Mixed Coniferous # 1	9	515	GLSA	110g	M	NT
Mixed Coniferous # 2	4	798	TADO	170g	M	RC
Mixed Coniferous # 2	5	784	TADO	190	F	RC
Mixed Coniferous # 2	8	514	TADO	130	F	NT
Mixed Coniferous # 3	1	786	SCCA	550	F	RC
Mixed Coniferous # 3	2	769	GLSA	120	M	RC
Mixed Coniferous # 3	3	760	SCCA	370	F	NT
Mixed Coniferous # 3	4		GLSA			DOA
Mixed Coniferous # 3	5	763	GLSA	140	F	NT
Mixed Coniferous # 3	10	755	GLSA	130	F	RC

Table 10. Trap Night #7 – January 30, 2005

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 2	2	516	GLSA	135g	M	NT
Mixed Deciduous # 3	7	754	TADO	200g	M	RC
Mixed Deciduous # 3	8	753	TADO	170g	F	RC
Mixed Coniferous # 1	5	503	TADO	180g	F	NT
Mixed Coniferous # 1	6	231	TADO	190g	M	TLY-RC
Mixed Coniferous # 2	2	789	TADO	190g	M	RC
Mixed Coniferous # 2	3	798	TADO	170g	M	RC
Mixed Coniferous # 2	8	784	TADO	190g	F	RC
Mixed Coniferous # 3	1	755	GLSA	130g	F	RC

Table 11. Trap Night #8 – January 31, 2005

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	4	525	SCCA	700	F	NT
Mixed Deciduous # 1	5	242	GLSA	120	M	TLY
Mixed Deciduous # 1	10	524	GLSA	120	M	NT
Mixed Deciduous # 2	2	513	GLSA	120	M	NT
Mixed Deciduous # 3	10	523	TADO	190	F	NT
Mixed Coniferous # 1	2	766	TADO	210g	F	RC
Mixed Coniferous # 1	3	800	GLSA	120g	M	RC
Mixed Coniferous # 1	8	511	TADO	190	M	NT
Mixed Coniferous # 1	9	757	TADO	190g	M	RC
Mixed Coniferous # 3	2	522	SCCA	580	M	NT
Mixed Coniferous # 3	4	760	SCCA	370	F	RC
Mixed Coniferous # 3	8	518	SCCA	520	M	NT
Mixed Coniferous # 3	10	517	SCCA	480	M	NT

Table 12. Trap Night #9 – March 1, 2005

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	5	242	GLSA	120 g	M	TLY-RC
Mixed Deciduous # 3	1	509	SCCA	550 g	M	NT
Mixed Deciduous # 3	5	508	SCCA	640 g	F	NT
Mixed Deciduous # 3	7	754	TADO			RC
Mixed Coniferous # 1	1	503	TADO			RC
Mixed Coniferous # 1	2	766	TADO			RC
Mixed Coniferous # 1	6	231	TADO			RC
Mixed Coniferous # 1	9	515	GLSA			RC
Mixed Coniferous # 1	10	521	GLSA	150	M	NT
Mixed Coniferous # 3	5	760	SCCA	380	F	RC
Mixed Coniferous # 3	6	505	SCCA	680	M	NT
Mixed Coniferous # 3	7	755	GLSA	110	F	RC

Table 13. Trap Night #10 – March 2, 2005

Area	Trap #	Tag#	Species	Weight	Sex	Notes
Mixed Deciduous # 1	6	501	SCCA	470	M	NT
Mixed Deciduous # 1	10	512	TADO	200	M	NT
Mixed Deciduous # 2	7	506	TADO	190	M	NT
Mixed Deciduous # 2	8	798	TADO			RC
Mixed Deciduous # 3	2	752	SCCA			RC
Mixed Deciduous # 3	8	795	SCCA			RC
Mixed Coniferous # 1	2	503	TADO			RC
Mixed Coniferous # 1	9	230	TADO			RC
Mixed Coniferous # 1	10	511	TADO			RC
Mixed Coniferous # 2	1	507	SCCA	460	M	NT
Mixed Coniferous # 2	3	502	TADO	180	M	NT
Mixed Coniferous # 2	4	219	TADO	170	M	TLY
Mixed Coniferous # 3	4	510	SCCA	580	M	NT
Mixed Coniferous # 3	5	504	TADO	100	M	NT
Mixed Coniferous # 3	6	755	GLSA			RC
Mixed Coniferous # 3	7	791	TADO			RC
Mixed Coniferous # 3	10	517	SCCA			RC

Appendix B: Vegetation Plots

Percent cover of vegetation by species for each of 5 vegetation plots in mixed-deciduous forest in Burnaby Lake Regional Park for herbs, shrubs and trees, were estimated in 1.26-m radius plots for herbs and mosses, 2.82-m radius plots for shrubs, and 5.64-m radius plots for trees and CWD. Percent cover for each species was averaged across all vegetation plots (n=5).

Table 14. Mixed-deciduous Forest - Area 1

	Plot # 1	**Plot # 2**	**Plot # 3**	**Plot # 4**	
Herb Layer					**Average**
Dirt and detritus	0.690	0.890	0.330	0.150	0.515
Mosses	0	0	0	0.800	0.200
False-lily of the valley	0.010	0.010	0	0	0.005
Lady fern	0.100	0.100	0.500	0	0.175
Bracken fern	0	0	0	0.050	0.013
English ivy	0	0	0.150	0	0.038
Sword fern	0.200	0	0.020	0	0.055
Total					*1.001*
Shrub Layer					
Salmonberry	0.300	0.650	0.150	0.150	0.313
Trailing blackberry	0.010	0	0.010	0	0.005
Vine maple	0.750	0.600	0.500	0	0.463
Willow spp.	0	0	0	0.050	0.013
Red huckleberry	0	0	0	0.150	0.038
Cascara	0	0	0	0.010	0.003
Beaked hazelnut	0	0	0	0.010	0.003
Total					0*.838*
Tree Layer					
Red alder	0.700	0.800	0.800	0	0.575
Paper birch	0	0	0	0.500	0.125
Western hemlock	0	0	0	0.100	0.025
Big leaf maple	0	0	0.050	0	0.013
CWD	0	0.050	0.030	0	0.020
Total					*0.758*

Percent cover of vegetation by species for each of 5 vegetation plots in mixed-coniferous forest in Burnaby Lake Regional Park for herbs, shrubs and trees, were estimated in 1.26-m radius plots for herbs and mosses, 2.82-m radius plots for shrubs, and 5.64-m radius plots for trees and CWD. Percent cover for each species was averaged across all vegetation plots (n=5).

Table 15. Mixed-coniferous Forest - Area 2

	Plot # 1	**Plot # 2**	**Plot # 3**	**Plot # 4**	
Herb Layer 1 m2					**Average**
Dirt and detritus	0	0	0.780	0	0.195
Mosses	0.900	0.850	0.050	0.400	0.550
False-lily of the valley	0	0.150	0.020	0.500	0.168
Lady fern	0.500	0.500	0	0	0.250
Bracken fern	0	0	0.050	0	0.013
Spiny wood fern	0	0	0.100	0	0.025
Total					*1.201*
Shrub Layer 9 m2					
Vine maple	0.200	0.150	0.150	0	0.125
Salmonberry	0.200	0.250	0.600	0	0.263
Indian plum	0	0.050	0	0	0.013
Snowberry	0	0	0.010	0	0.003
Cascara	0	0	0.400	0	0.100
Red huckleberry	0	0	0	0.100	0.025
Introduced ash	0	0	0	0.010	0.003
Total					0.*532*
Tree Layer 25 m2					
Western red cedar	0.600	0.200	0.400	0	0.300
Western hemlock	0	0.400	0	0.200	0.150
Sitka spruce	0	0	0	0.200	0.050
Big leaf maple	0	0	0.300	0	0.075
CWD	0.050	0.200	0.350	0.200	0.200
Total					0.775

Percent cover of vegetation by species for each of 5 vegetation plots in mixed-coniferous forest in Burnaby Lake Regional Park for herbs, shrubs and trees, were estimated in 1.26-m radius plots for herbs and mosses, 2.82-m radius plots for shrubs, and 5.64-m radius plots for trees and CWD. Percent cover for each species was averaged across all vegetation plots (n=5).

Table 16. Mixed-coniferous Forest - Area 3

	Plot # 1	**Plot # 2**	**Plot # 3**	**Plot # 4**	
Herb Layer					**Average**
Mosses	0.600	0.900	0.500	0.700	0.675
False-lily of the valley	0.050	0.100	0.100	0.020	0.068
Lady fern	0.300	0.200	0.500	0	0.250
Bracken fern	0.400	0	0	0	0.100
Spiny wood fern	0	0	0	0.900	0.225
Total					*1.318*
Shrub Layer					
Vine maple		0.250	0.150	0.500	0.225
Himalayan blackberry		0	0	0.150	0.038
Salmonberry	0.250	0.250	0.200	0.100	0.200
Indian plum	0.100	0.050	0.100	0	0.063
Introduced holly		0.050	0	0	0.013
False azalea		0.200	0	0	0.050
Total					0.*589*
Tree Layer					
Western red cedar		0.800	0.600	0.500	0.475
Western hemlock	0.200	0.600	0.500	0	0.325
Sitka spruce	0.150	0	0.250	0	0.100
Pacific crab apple		0.200	0	0	0.050
Red alder	0.450	0	0	0.400	0.213
CWD	0.050	0.010	0.100	0.300	0.115
Total					*1.278*

Percent cover of vegetation by species for each of 5 vegetation plots in mixed-deciduous forest in Burnaby Lake Regional Park for herbs, shrubs and trees, were estimated in 1.26-m radius plots for herbs and mosses, 2.82-m radius plots for shrubs, and 5.64-m radius plots for trees and CWD. Percent cover for each species was averaged across all vegetation plots (n=5).

Table 17. Mixed-deciduous Forest - Area 4

	Plot#1	Plot#2	Plot#3	Plot#4	
Herb Layer					**Average**
Moss	.950	.600	.600	.100	0.563
Bunchberry	0	.050	0	0	0.013
Spiny wood fern	0	0	.200	.010	0.053
Licorice fern	0	0	.010	0	0.003
Wall lettuce	0	0	0	.010	0.003
Bracken fern	0	0	0	.450	0.113
Grasses spp.	0	0	0	.900	0.225
Total					*0.973*
Shrub Layer					
Salmonberry	.950	.950	.800	.250	0.738
Himalayan blackberry	.100	0	0	0	0.025
Indian plum	.010	0	0	0	0.003
Cascara	.800	.400	.800	0	0.500
Vine maple	0	.050	0	0	0.013
Willow spp.	0	0	0	.100	0.250
Total					*1.529*
Tree Layer					
Paper birch	.350	0	.400	.400	0.288
Black cottonwood	0	.800	0	0	0.200
CWD	0	0	.010	.020	0.008
Total					*0.496*

Percent cover of vegetation by species for each of 5 vegetation plots in mixed-deciduous forest in Burnaby Lake Regional Park for herbs, shrubs and trees, were estimated in 1.26-m radius plots for herbs and mosses, 2.82-m radius plots for shrubs, and 5.64-m radius plots for trees and CWD. Percent cover for each species was averaged across all vegetation plots (n=5).

Table 18. Mixed-deciduous Forest - Area 5

	Plot#1	Plot#2	Plot#3	Plot#4	
Herb Layer					**Average**
False Lily of the Valley	0	0	.010	.010	0.005
Spiny wood fern	0	0	0	.100	0.250
Bracken fern	0	0	0	.020	0.005
Mosses	.500	.200	.800	.150	0.413
Dirt/detritus	.500	.800	.150	.720	0.543
English ivy	0	0	.020	0	0.005
Licorice fern	0	0	.020	0	0.005
Total					*1.226*
Shrub Layer					
Salmonberry	.900	.700	.750	.200	0.638
Vine maple	0	.450	0	.600	0.263
Himalayan blackberry	.050	0	0	.050	0.025
Elderberry	0	0	.050	.100	0.038
Willow ssp.	.150	.500	0	0	0.163
Introduced holly	.050	0	0	0	0.013
Total					*1.140*
Tree Layer					
Western hemlock	0	0	0	.100	0.025
Big leaf maple	.400	.300	0	.050	0.188
CWD	.050	.050	0	.150	0.063
Pacific crab apple	0	0	.850	0	0.213
Black cottonwood	.700	0	.050	0	0.188
Red alder	.200	.650	0	0	0.213
Water	0	.050	0	0	0.013
Total					*0.903*

Percent cover of vegetation by species for each of 5 vegetation plots in mixed-coniferous forest in Burnaby Lake Regional Park for herbs, shrubs and trees, were estimated in 1.26-m radius plots for herbs and mosses, 2.82-m radius plots for shrubs, and 5.64-m radius plots for trees and CWD. Percent cover for each species was averaged across all vegetation plots (n=5).

Table 19. Mixed-coniferous Forest - Area 6

	Plot # 1	**Plot # 2**	**Plot # 3**	**Plot # 4**	
Herb Layer					**Average**
Mosses	0.300	0	0.350	0.100	0.188
Dirt and detritus	0.650	0.980	0.140	0.600	0.593
Lady fern	0	0	0.50	0	0.125
Wall lettuce	0	0	0.010	0	0.003
Spiny wood fern	0.050	0.020	0	0.300	0.093
Total					*1.002*
Shrub Layer					
Vine maple	0.900	0.300	0	0.800	0.500
Elderberry	0	0.010	0.020	0.100	0.033
Introduced holly	0	0	0.010	0	0.003
Salmonberry	0	0.100	0.300	0	0.100
Total					0*.636*
Tree Layer					
Western red cedar	0.400	0.450	0.450	0.900	0.550
Black cottonwood	0.050	0	0	0.300	0.088
Pacific crab apple	0	0	0.200	0	0.050
Paper birch	0	0	0.200	0	0.050
Big leaf maple	0	0.350	0	0	0.088
Red alder	0	0.200	0	0	0.050
CWD	0.010	0.050	0.250	0.050	0.090
Total					*0.966*