Habitat Use and Dietary Habits of Yellownose Voles (*Microtus chrotorrhinus*), Meadow Voles, (*Microtus pennsylvanicus*), and Red-backed Voles (*Clethrionomys gapperi*) in Logged and Mature Black Spruce Stands in the Claybelt of Northeastern Ontario

by

Sylvia Donato

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biology

School of Graduate Studies and Research

Laurentian University

Sudbury, Ontario

August, 1998

0-612-31426-X

Abstract

Small mammal trapping was undertaken in 1995 and 1996, a continuation of a previous study initiated in 1994. Four logging treatments were sampled, with 2 parallel transects in each - one for vegetation sampling and one for trapping. Using vegetation data collected in a separate study, trap stations were grouped into habitat types via a hierarchical cluster analysis, and habitat use was determined for three vole species - red-backed vole (*Clethrionomys gapperi*), meadow vole (*Microtus pennsylvanicus*), and yellownose vole (*Microtus chrotorrhinus*). Stomach contents of the three vole species were also analyzed in order to determine dietary habits. Responses to logging treatments were also determined.

The results of the study indicate that in black spruce - labrador-tea lowlands in Northeastern Ontario, the yellownose vole is not as specialized in habitat requirements as the other two vole species, and availability of cover and food appear to be the primary habitat determinants. Yellownose vole dietary habits were as specialized as meadow voles, which ate mostly grasses and mosses, and red-backed voles, which ate primarily fungus and lichens. Yellownose voles, on the other hand, ate primarily forbs and leaves from ericaceous plant species. Finally, the three vole species responded differently to logging treatments. The meadow voles responded favourably to cutting, with larger numbers occurring in the logged sites, whereas red-backed voles were most abundant in the undisturbed forest. Yellownose voles, however, showed no consistent response to logging treatment. It is recommended that logging in black spruce lowlands should occur in the form of careful cutting, and an adequate residual should

be left to provide cover and forage. Logging debris also provides cover in disturbed habitats, and should be left to enhance habitat for yellownose voles.

Dedication

This thesis is dedicated to my family.

To my mother, Terttu, who always knew I could do it.

To my father, Paul, who nurtured and encouraged my interest in science.

To my sister, Gloria, who is such an inspiration to me.

To my husband and best friend Randy, whose pride and faith in me never faltered.

Acknowledgments

First I would like to thank Dr. G. M. Courtin, my supervisor, who provided valuable input throughout the course of this investigation. His assistance in the field is gratefully acknowledged, as is the moral and academic support he provided. I would also like to thank Dr. P. J. Beckett, a member of my Advisory Committee for his statistical and botanical advice. Thanks also is extended to Dr. F. F. Mallory, also of my Advisory Committee, who provided me with insight into animal behaviour and ecology. Thanks also to Mr. W. R. Watt for serving as my External Examiner, and providing helpful criticisms.

I would like to extend my thanks to Eric Turk of the Lake Abitibi Model Forest, who provided funding for this study.

I would like to thank Jean Beckerton and April Poitras who assisted me both in the field and with data compilation. Both Jean and April were responsible for 1994 data collection, in connection with a study by Steve Lawrence.

My gratitude is extended to all of the field workers who braved the black flies and other perils to help with this study. The Environmental Youth Corps provided me with funding to hire proficient field crews, whom I also thank. Special thanks is extended to Diane Carlsson, Rhonda Contant, and Rose-Marie Van der Ham, for their invaluable field and laboratory assistance.

Thanks to Dr. R. Pitblado for assisting me with my statistics, and Tracey L. Hillis, Monika A. Jost, and Glenn S. Brown, for their help with statistics and ecological theory.

I also would like to express my gratitude to Aleta Karstad, who provided the artwork for the frontispiece, which she painted while seated in a truck parked on Pierre Lake Road.

Finally, thanks to all of my friends for their confidence in me. A special thanks goes to Jocelyne Heneberry for everything from help with statistics to moral support.

Table of Contents

Frontispiece iii

Abstract iv

Dedication vi

Acknowledgments vii

Table of Contents ix

List of Figures xii

List of Tables xvi

Introduction 1

Interspecific Competition 3

Species Description 4

Yellownose Voles 4

Meadow Voles 6

Red-backed Voles 7

Dietary Habits 8

Yellownose Voles 8

Meadow Voles 8

Red-backed Voles 9

Logging Practices : A Summary of Implications for Small Mammals 9

Hypotheses 12

Materials and Methods 13
Study Site 13
Clear Cut Description 17
Light Residual Description 17
Heavy Residual Description 18
Uncut Site Description 19
Trapping Methodology 19
Habitat Analysis 20
Stomach Content Analysis 21
Statistical Analysis 23
Logging Treatment Comparison 24
Habitats 24
Habitat Use 25
Stomach Content Analysis 26
Results 27
Vole Response to Logging 27
Red-backed Voles 27
Meadow Voles 31
Yellownose Voles 34
Habitat Use by Three Vole Species 37
Determination of Habitat Types 37
Red-backed Voles 40
Meadow Voles 42
Yellownose Voles 44

Stomach Content Analysis 44
Stomach Contents 44
Red-backed Voles 44
Meadow Voles 44
Yellownose Voles 47
Differences in Contents between the Voles 47
Discussion 53
Habitat Use 53
Yellownose Voles 53
Red-backed Voles 58
Meadow Voles 60
Logging Treatment Responses 61
Yellownose Voles 61
Red-backed Voles 62
Meadow Voles 64
Implications, Limitations, and Recommendations for
Further Research 65
Summary 67
Literature Cited 69
Appendix 1 73
Appendix 2 101
Appendix 3 121

List of Figures

Figure 1.	Map of study site	14
Figure 2.	Total number of red-backed, meadow, and yellownose voles caught per 100 trap-nights in 1994, 1995, and 1996	28
Figure 3.	(a) Total number of red-backed voles caught in 1994 in four logging treatments (b) Total number of red-backed voles caught in 1995 and 1996 in four logging treatments	29
Figure 4.	(a) Mean captures of red-backed voles per 100 trap-nights for each logging treatment in 1994. Bars indicate standard error of the mean, and letters above each bar indicate significant differences (b) Mean captures of red-backed voles per 100 trap-nights for each logging treatment in 1995 and 1996. Bars indicate standard error of the mean, and letters above each bar indicate significant differences	30
Figure 5.	(a) Number of meadow voles caught in 1994 in each logging treatment (b) Number of meadow voles caught in 1995 and 1996 in each logging treatment	32

Figure 6. (a) Mean captures of meadow voles per 100 trap-nights for each logging treatment in 1994. Bars indicate standard error of the mean, and letters above each bar indicate significant differences
(b) Mean captures of meadow voles per 100 trap-nights for each logging treatment in 1995 and 1996. Bars indicate standard error of the mean, and letters above each bar indicate significant differences 33

Figure 7. (a) Number of yellownose voles caught in 1994 in each logging treatment.
(b) Number of yellownose voles caught in 1995 and 1996 in each logging treatment 35

Figure 8. (a) Mean captures of yellownose voles per 100 trap-nights for each logging treatment in 1994. Bars indicate standard error of the mean, and letters above each bar indicate significant differences.
(b) Mean captures of yellownose voles per 100 trap-nights for each logging treatment in 1995 and 1996. Bars indicate standard error of the mean 36

Figure 9. (a) Mean percent occurrence of blueberry leaves (*Vaccinium* spp.) in the stomachs of the three vole species. Bars indicate standard error of the mean, and letters above bars indicate significant differences 48

(b) Mean percent occurrence of cranberry leaves (*Vaccinium oxycoccus*) in the stomachs of the three vole species. Bars indicate standard error of the mean, and letters above bars indicate significant differences 48

Figure 10. (a) Mean percent occurrence of leaves from the raspberry family (*Rubus* spp.) in the stomachs of the three vole species. Bars indicate standard error of the mean, and letters above bars indicate significant differences 50

(b) Mean percent occurrence of grass leaves in the (Graminoids) stomachs of the three vole species. Bars indicate standard error of the mean, and letters above bars indicate significant differences 50

Figure 11. (a) Mean percent occurrence of horsetail (*Equisetum* spp.) in the stomachs of the three vole species. Bars indicate standard error of the mean, and letters above bars indicate significant differences 51

(b) Mean percent occurrence of lichen in the stomachs of the three vole species. Bars indicate standard error of the mean, and letters above bars indicate significant differences 51

Figure 12. Mean percent occurrence of seeds in the stomachs of the three vole species. Bars indicate standard error of the mean, and letters above the bars indicate significant differences 52

List of Tables

Table 1. Vegetative characteristics of Site Type 11 15

Table 2. Vegetation types found within Site Type 11 16

Table 3. Habitats derived from cluster analysis 38

Table 4. Habitat use by red-backed voles in 1994 41

Table 5. Habitat use by red-backed voles in 1995 and 1996 41

Table 6. Habitat use by meadow voles in 1994 43

Table 7. Habitat use by meadow voles in 1995 and 1996 43

Table 8. Habitat use by yellownose voles in 1994 45

Table 9. Habitat use by yellownose voles in 1995 and 1996 45

Table 10. Average percent occurrence of vegetation in stomachs of three vole species 46

Introduction

In the first half of this century, timber harvesting was undertaken manually, using hand felling and horse skidding operations (MacDonell and Groot, 1997). When logging was mechanized in the 1950's and 1960's, survival of advanced growth of conifers was compromised, especially through the use of wheeled skidders (MacDonell and Groot, 1997). Mechanized logging caused a great deal of disturbance in both the vegetation and underlying soil (MacDonell and Groot, 1997). To remedy this, careful or strip cutting has been used with increased success. Careful logging ideally involves removal of only merchantable timber, with minimal disturbance to the remaining trees, vegetation, and soil. This technique benefits the timber companies because it may decrease turnover time in the black spruce forests, allowing subsequent harvest much sooner than an area that has been completely cleared.

Timber harvest greatly alters the soil and vegetation of a forest, which in turn affects small mammals (Swan *et al.*, 1982). Small mammals have been considered to be of little economic importance, yet they play an integral part in any ecosystem. Burrowing activities of some voles can loosen and aerate the soil, and mix topsoil and litter (Swan *et al.*, 1984). They are at a key location in the food chain, being both primary herbivores, and prey for many predators. Some predators are so reliant on small rodents that their populations are influenced by the fluctuations seen in vole populations. The most vivid example of such a close predator / prey relationship is seen in the Arctic fox whose primary food source is the collared lemming. The collared lemming populations follow a 3 to 4 year crash / peak cycle - this cyclic pattern is seen also in Arctic fox populations (Krebs, 1996). Arctic foxes die of starvation resulting from fewer lemmings during a population low which, in turn, allows lemming numbers to increase (Krebs, 1996). Avian predators are also affected by the cyclic nature of *Microtus* populations (Chapman and Feldhamer, 1982). In years of population peaks, habitats are invaded by various birds of prey, including the barn owl (Chapman and Feldhamer, 1982). Northern hawk-owls (*Surnia ulula caparoch*) show a preference to voles of the genus *Microtus* spp., and will avoid *Clethrionomys* spp. (Rohner *et al.*, 1995). In North America, voles are a source of food for many mammals, including skunks (*Mephitis* spp.), red fox (*Vulpes vulpes*), coyotes (*Canis latrans*), marten (*Martes martes*), weasels (*Mustela* spp.), bobcats (*Felis rufus*) and short-tailed shrews (*Blarina brevicauda*) (Chapman and Feldhamer, 1982). A diversity of vole species is important in communities with numerous predators, which is the case in the boreal forest.

Voles are more than just an important source of food for predators. Their diversity can influence community ecology, as well. Small mammal communities with *Microtus* are very different from those without. For example, desert rodent or forest mammal communities lacking microtines tend to have more nocturnal species, and population levels are not on a 3 to 4 year cycle, but rather, fluctuate in a seasonal pattern, with little annual variability (Rose and Birney, 1985). Winter activity in general may be reduced, because there are a higher proportion of hibernators (Rose and Birney, 1985). In general, these types of communities have less population variability than those with *Microtus* (Rose and Birney, 1985). On the other hand, communities with *Microtus* fluctuate greatly both with seasonal and yearly population changes. The community also has proportionally more crepuscualar activity ; that is, periodic as opposed to diurnal or nocturnal (Rose and Birney, 1985). Finally, vegetation is harvested more regularly because microtines do not store food in caches.

Each species in a habitat occupies a niche and thus decreases interspecific competition. The niche occupied by an animal is the ecological role it plays in a system (Krohne, 1998). When considering the concepts of niche and competition, one must consider limiting resources. Intense competition can select for more specialized individuals, decreasing the niche breadth, or variance in resource use (Krohne, 1988). In order to decrease interspecific competition, resource use must differ between species. For example, three sympatric voles that occur in northeastern Ontario are the meadow vole, red-backed vole, and the yellownose vole. The meadow vole is one of the most well known species in North America, and certainly one of the most widely distributed. It is associated with meadow habitat, as the name suggests. The red-backed vole is also a common species, associated with wet forested habitats. In contrast, the yellownose vole, or rock vole, is not widely distributed and little is known of the habits of this animal, especially in Northeastern Ontario. This animal is the focus of this investigation.

<u>Interspecific Competition</u>

Habitat use in voles varies between species. For example, the meadow vole (*Microtus pennsylvanicus*) inhabits areas dominated by graminoid plant species, which provide cover and food (Getz, 1985). Red-backed voles, on the other hand, are primarily forest species, and consume forest plants such as lichens and fungi. Competition between vole species and other small mammals can influence habitat utilization by microtines (Getz, 1985) and has been found to be an important factor influencing local distributions (Getz, 1961). Competition studies reveal that on islands that are devoid of red-backed voles, meadow voles occupy forest habitats (Getz, 1985).

It has been determined that red-backed voles exclude meadow voles from forested areas, and experimental removal studies indicate that competitive interactions occur between the two species. During population peaks, animals that tend to dominate in competitive situations may force other species into marginal habitats with less cover and forage (Batzli and Lesieutre, 1995). However, Batzli and Lesieutre (1995) noted that in Alaska, where singing voles (*Microtus miurus*) and tundra voles (*M. oeconomus*) occupy different habitats, a removal of the tundra voles resulted in a decrease in the numbers of singing voles. However, the reverse was not true (ie. the removal of singing voles did not result in a decrease in the tundra vole population). They suspected that this relationship occurred as a result of the indirect effect of predation, where singing voles were preyed upon more when the tundra voles were removed. In order to reduce competition, sympatric voles may have different foraging habits, and should tend to occupy different habitats (Krebs and Wingate, 1976). Despite the differences in habitat use, meadow voles, red-backed voles, and yellownose vole have been captured in the same habitats in a number of studies. For instance, Kirkland and Schmidt (1982), captured the three species amoung rocks in mixed forests, adjacent to a stream. They concluded that this is "typical" habitat for yellownose voles.

Species Description

Yellownose Voles (*Microtus chrotorrhinus*)

The yellownose vole, also known as the rock vole, closely resembles the more common meadow vole also of family Muridae, subfamily Microtinae, but is distinguished by the yellow to rust coloration on the snout and dorsal pelage (Kirkland and Jannett, 1982). The Latin name, *Microtus chrotorrhinus*, can be traced to the Greek chrotorrhinus, meaning "coloured nose". Adults measure about 140 to 185 mm long, and weigh about 30 to 48 g. In general, the males are slightly larger, but the sexual dimorphism is slight (Kirkland and Jannett, 1982). The gestation period of the yellownose vole ranges from 19 to 21 days, and litters consist of 1 to 8 offspring. Reproduction in females, determined by embryos, placental scars, and lactation, occurs in voles weighing 30 g or more, and with a body length of 140 mm. Males are sexually mature when they are 150 mm long and weigh approximately 30 g or more (Kirkland and Jannett, 1982).

The common name, rock vole, aptly describes some previous findings of habitat use by *M. chrotorrhinus*. Rocks, boulder strewn fields, and talus slopes have been associated with the presence of rock voles in the literature (Snyder, 1942; Timm *et al.*, 1977; Whitaker and Martin, 1977; Kirkland and Knipe, 1979; Kirkland and Jannett, 1982; Christian and Daniels, 1985; Getz, 1985). Whereas, boulder fields, talus slopes, and moss covered rocks and logs were found in yellownose vole habitat, not all research has found that rocks are the most important habitat feature. Both Nagorsen and Peterson (1981) and Christian and Daniels (1985) suggested that wind-downed trees were key habitat components for yellownose voles. Beuch *et al.* (1977) suggested that young vegetation communities were more important than the rocks themselves. This type of early successional habitat is often associated with proximity to rocky areas and logging activity. Water is also an important habitat feature, and according to Kirkland and Jannett (1982) and Kirkland and Knipe (1979), both surface and subsurface streams are important. Moist litter has also been associated with these animals (Beuch *et al.*, 1977), and Snyder (1942), Kirkland and Knipe (1979), and Christian and Daniels (1985) trapped yellownose voles in areas associated with moist sphagnum. According to D'Eon and Watt (1994), the sites which support rock voles have soils which are all classified, based on the Forest Ecosystem Classification (FEC) guide for northeastern Ontario, as fresh to moist. However, in some investigations, the largest proportion of yellownose voles have been trapped in extremely dry portions of habitats (Kirkland, 1977). Thick ground cover in the form of moss has also been considered an important component of yellownose vole habitat (Snyder, 1942 ; Kirkland and Knipe, 1979; Christian and Daniels, 1985; Kirkland and Jannett, 1982). Christian and Daniels (1985) also establish that increased moss cover resulted in a poor herb layer. On the other hand, Goodwin (1929), Kirkland and Jannett (1982), Kirkland and Knipe (1979), and Getz (1985) state that an abundance of herbs was noted in sites where yellownose voles were captured.

Meadow Voles (*Microtus pennsylvanicus*)

The meadow vole, also known commonly as the field mouse, is the most widely distributed vole in North America. The fur is dull grey or brownish in colour, and size varies greatly depending on geographic location. It is typically a grassland species, and runways are often seen in overgrown meadows (Ambrose, 1973). Their home range is about 320 - 930 m^2, and territories of about 2 m across are defended (Banfield, 1974). Kirkland (1977) found that *M. pennsylvanicus* was absent in forests that had not been cut for 25 years. The habitat of the meadow vole includes wet meadows, as well as forest edges and openings or clearings (Banfield, 1974; Kirkland and Schmidt, 1982; Etnier, 1989; Pasitschniak-Arts and Gibson, 1989). Getz (1961) noted that wooded areas were avoided by meadow voles, as were areas that contained only forbs. The only time that meadow voles were caught in association with forbs was when the forbs were interspersed with grasses. According to the habitat suitability matrix for northeastern Ontario constructed by D'Eon and Watt (1994), meadow voles also use the forest initiation stages of lowland black spruce which often regenerate to sedge and grass.

Red-backed Voles (*Clethrionomys gapperi*)

Red-backed voles are distributed throughout the southern portions of Canada and the low Arctic, and extend into the states. These voles inhabit moist deciduous, mixed and coniferous forests (Banfield, 1974; Martell, 1981; Kirkland and Schmidt, 1982; Etnier, 1989; Pasitschniak-Arts and Gibson, 1989). They have been found to prefer coniferous forests with debris that provides cover, such as brush, and rotting or moss covered logs, stumps, and rocks (Kirkland and Schmidt, 1982). They also are associated with standing or running water, including bogs and swamps (Miller and Getz, 1977; Pasitschniak-Arts and Gibson, 1989). Red-backed voles are diurnal in the winter, and nocturnal or crepuscular in the summer (Herman, 1977) and occupy home ranges as extensive as 14 400 m^2 (1.44 ha) (120m x 120m) in the summer, or as small as 0.13 hectares (1350 m^2).

Red-backed voles are solitary, except in the winter when they form aggregations. It has been suggested that red-backed voles will displace meadow voles in times of high population densities (Getz, 1985). Breeding occurs between March and October, and often more than two litters result throughout the season (Burt and Grossenheider, 1980). After a gestation period of 17 - 19 days, anywhere from 3 - 8 offspring are born (Burt and Grossenheider, 1980).

Dietary Habits

Yellownose Voles

Most studies addressing the foraging habits of yellownose voles are comprised of anecdotal accounts. Goodwin (1929), found clippings of forbs such as mitrewort, violet, bunchberry, and Canada mayflower in a burrow adjacent to a known yellownose vole trap site. The field notes of Osgood from Mount Washington, NH., state that yellownose voles ate goldenrod, because clippings were found near a trapped vole (Whitaker and Martin, 1977). Preble's field notes mentioned that woodfern clippings were found in a burrow of a trapped vole (Whitaker and Martin, 1977). Whitaker and Martin (1977); however, examined stomach contents of 47 yellownose voles, 44 of which were caught in mountainous regions in the US, including Mount Washington, New Hampshire, and Essex county in New York. Only three of the voles were caught in Canada (2 from Labrador, and one from Quebec). They found that they ate a great deal of bunchberry (47% of volume), followed by unidentified green vegetation, *Lepidoptera* larvae, moss, grass stems and leaves, and various seeds. Captive rock voles consumed entire bunchberry plants readily, as well as ripe cranberries, bilberries, and bunchberries. In general, the literature states that yellownose voles use forbs primarily for food, with small amounts of grass and arthropods.

Meadow Voles

These herbivores primarily eat grasses, and if available, will eat sedges to a lesser extent. This diet is supplemented with seeds, fruits, flowers, snails, insects, and other voles. Meadow voles are notorious as agricultural pests, and girdle both jack pine and orchard fruit trees (Zimmerman, 1965; Banfield, 1974; M'Closkey and Fieldwick, 1975).

Red-backed Voles

Red-backed voles primarily consume lichens (*Cladina* spp and *Cladonia* spp.) and green plant material, which are important diets throughout the summer. Seeds are consumed in the early summer, with berries gaining importance as the summer continues (Miller and Getz, 1977; Pasitschniak-Arts and Gibson, 1989). Mushrooms are eaten in early fall as they become available (Martell, 1981), and *Endogone* is also consumed (Williams and Finney, 1964). Arthropods and other voles are also consumed, and they have been known to strip bark from maple, cherry, and white ash trees (Banfield, 1974).

<u>Logging Practices : A Summary of Implications for Small Mammals</u>

Kirkland (1977) found that small mammal diversity and evenness increased after clear cutting in both deciduous and coniferous forest types in the Appalachian Mountains of West Virginia. It was expected that clearcutting would have a detrimental effect on yellownose vole populations, because they occupy a narrow spectrum of habitats in the Appalachians (cool, moist forests with boulder strewn areas). However, yellownose voles responded variably to clear-cutting, with abundance increasing in coniferous stands and decreasing in deciduous stands. Red-backed vole numbers also increased in response to clear-cutting, a result that was unexpected considering the potential adverse interactions with meadow voles and the undisturbed forest habitat that these voles occupy. Meadow vole numbers also increased in recent deciduous and coniferous clear-cuts in the Appalachians (Kirkland, 1977). Martell and Radvanyi (1977) investigated small mammal communities after logging in black spruce in Ontario, and they noted varied responses between different species. Meadow voles were common after clear-cutting, despite their relative rarity in uncut forests. The reverse was seen for red-backed voles. In contrast, yellownose voles were abundant in selectively cut stands and uncut forests, but rare in the clear-cut forest. They also noted that abundance of this species in uncut black spruce forest was unexpected, because it conflicts with the findings of previous literature which emphasized the importance of rocky areas in yellownose vole habitats. Lawrence (1996) investigated the impact of logging treatments on small mammal populations in black spruce in Northeastern Ontario. Red-backed voles were most abundant in uncut forests and almost absent in the clear cut habitat. Meadow voles, on the other hand, were more abundant at two carefully cut sites, followed by the clear-cut site. Yellownose voles were most commonly found in uncut sites, and then the two carefully cut sites, supporting data of Martell and Radvanyi (1977). Martell (1983a) found similar results, and noted that the actual response of small mammals to cuttings depends on the exact composition of the stand before cutting, the invasiveness of the logging operation, and the succession of the site. Thus, sites that were scarified (soil upturned) were more disturbed and took longer to recover, whereas those that were not scarified contained red-backed voles after 2 years, even if the site was clear-cut. However, red-backed voles showed reduced survival on clear-cuts compared to uncut forests (Martell, 1983b). Red-backed vole numbers decrease after other disturbances such as fires (Martell, 1984), whereas deer mice (*Peromyscus maniculatus*) numbers actually increase after such events.

Thus, the three vole species respond differently to logging. Red-backed voles consistently thrive in uncut mature forests and abundance and reproduction decline after cutting, with almost no animals occurring in clear-cut habitats. Meadow voles, on the other hand, tend to be more abundant in clear-cuts and carefully cut stands. Presumably carefully cut stands provide sufficient grassy habitat with the added cover of islands and leave strips. Finally, yellownose voles respond differently in different forest types. In red spruce in the Appalachians, they increase in abundance after clear cutting, yet in black spruce in Northeastern Ontario, they have been found primarily in uncut forests, followed by carefully cut habitats.

Based on the literature, it is clear which habitats are utilized preferentially by meadow voles and red-backed voles, and their responses to logging are predictable, and have been documented. However, it is unclear what characteristics of the habitat are important to yellownose voles and as a result, their responses to logging are unknown and unpredictable. The primary objective of this study was to determine habitat use by yellownose voles and identify features that comprise suitable habitat in black spruce - labrador tea lowlands in Northeastern Ontario (classified as Site Type 11) (McCarthy *et al.*, 1994). Dietary habits, responses to selective cutting and clear cutting, and the utilized habitats were examined.

Hypotheses

Logging Treatment

H_{0a}: Yellownose voles use Site Type 11 clear cut, careful cut with light residual, careful cut with heavy residual, and uncut forest equally.

H_{0b}: Meadow voles use Site Type 11 clear cut, careful cut with light residual, careful cut with heavy residual, and uncut forest equally.

H_{0c}: Red-backed voles use Site Type 11 clear cut, careful cut with light residual, careful cut with heavy residual, and uncut forest equally.

Habitat Utilization

H_{0d}: Yellownose voles use habitats in proportion to the availability of those habitats.

H_{0e}: Meadow voles use habitats in proportion to the availability of those habitats.

H_{0f}: Red-backed voles use habitats in proportion to the availability of those habitats.

Feeding Habits

H_{0g}: There are no significant differences between the stomach contents of yellownose, meadow, and red-backed voles

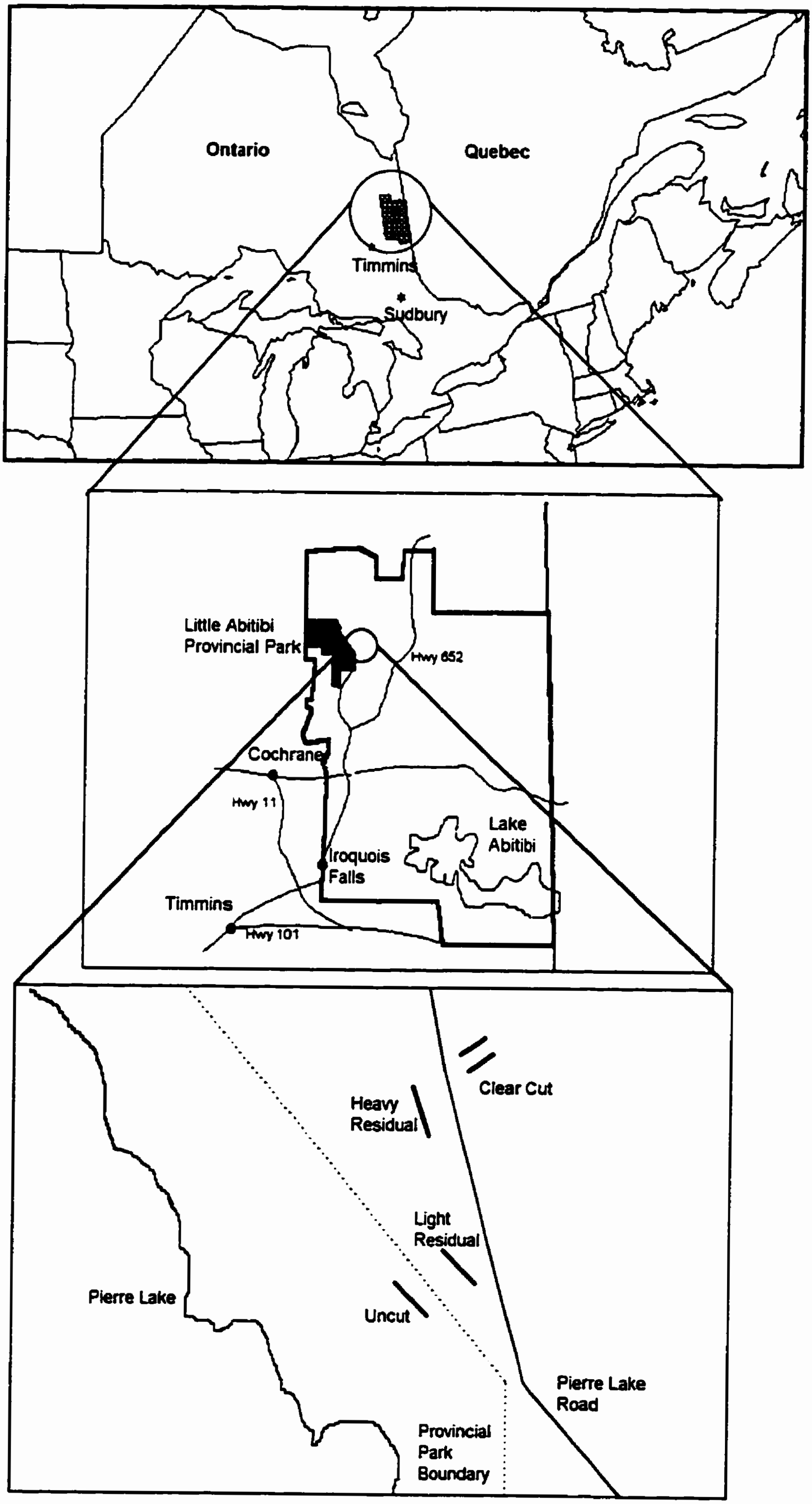
Materials and Methods

Study Site

The research area was in the Abitibi Model forest in northeastern Ontario, near the provincial border between Ontario and Quebec (Figure 1). The study site was east of Pierre Lake, with access via Pierre Lake Road. The portion of the forest sampled has been classified by the Ministry of Natural Resources as Site Type 11 according to the Forest Ecosystem Classification system for Northeastern Ontario. This system is based on vegetation, moisture, and soil type (McCarthy *et al.*, 1994). Site Type 11 is characterized as a black spruce - labrador-tea lowland. The black spruce stands occur on moderately decomposed organic soils, with abundant peat moss (*Sphagnum* spp.) and feather moss (*Pleurozium schreberi*) hummocks occasionally accompanied by small water filled depressions. Forbs are not abundant; however, the sites have a moderate amount of ericaceous shrubs (Table 1) (McCarthy *et al.*, 1994). Soil of Site Type 11 is classified as fibric organic (S17), which implies very wet (7 to 8), very poorly drained organic soils, with a fibric upper 40 cm, and a thick (average of 51 cm) surface horizon (McCarthy *et al.*, 1994). There are 4 vegetative types within Site Type 11, all dominated by black spruce, with varying moss species and understorey species (Table 2).

The study site was logged in the winter of 1992 - 1993. One of the sites is intact and found within Abitibi Provincial Park. Adjacent to the uncut site, an area was harvested, but trees with a DBH (diameter at breast height) of 12 cm or less were left. Since the area had mostly large trees, those that remain after cutting are in the form of

Figure 1. Diagrams showing location of sites. **Top**: Shaded area represents the Lake Abitibi Model Forest. **Centre**: Shaded area indicates Little Abitibi Provincial Park found in the Lake Abitibi Model Forest. **Bottom**: Location of study sites within the Lake Abitibi Model Forest.



Ontario
Quebec
Timmins
Sudbury
Little Abitibi
Provincial Park
Hwy 652
Cochrane
Hwy 11
Lake
Abitibi
Iroquois
Falls
Timmins
Hwy 101
Clear Cut
Heavy
Residual
Light
Residual
Pierre Lake
Uncut
Pierre Lake
Road
Provincial
Park
Boundary

Table 1. Vegetative characteristics of Site Type 11, based on the northeastern Forest Ecosystem Classification guide (NE-FEC) (McCarthy *et al.*, 1994).

Canopy Level	**Common Name**	***Scientific Name***
Overstorey	Black spruce	*Picea mariana*
Shrub Layer	Black spruce	*Picea mariana*
	Balsam fir	*Abies balsamea*
	Labrador-tea	*Ledum groenlanicum*
	Creeping snowberry	*Gaultheria hispidula*
	Velvetleaf blueberry	*Vaccinium myrtilloides*
	Early low blueberry	*Vaccinium angustifolium*
	Small cranberry	*Vaccinium oxycoccus*
	Leatherleaf	*Chamaedaphne calyculata*
	Pale laurel	*Kalmia polifolia*
	Sheep laurel	*Kalmia angustifolia*
	Twinflower	*Linnaea borealis*
Herb Layer	Sedge	*Carex sp.*
	Three-leaved smilacina	*Smilacina canadensis*
	Bunchberry	*Cornus canadensis*
	Goldthread	*Coptis trifolia*
	Northern commandra	*Geocaulon lividum*
	Woodland horsetail	*Equisetum sylvaticum*
Moss and Lichen Layer	Schreber's moss	*Pleurozium schreberi*
	Common red sphagnum	*Sphagnum nemoreum*
	Common green sphagnum	*Sphagnum girgensohnii,*
	Common brown sphagnum	*Sphagnum fuscum,*
	Midway peat moss	*Sphagnum magellanicum*
	Poor-fen sphagnum	*Sphagnum angustifolium*
	Stair-step moss	*Hylocomium splendens*
	Plume moss	*Ptilium crista-castrensis*
	Reindeer lichen	*Cladina rangiferina*
	Liverworts	*Hepaticae*

Table 2. Description of vegetation types found within Site Type 11, based on the northeastern Forest Ecosystem Classification guide (NE-FEC) (McCarthy *et al.*, 1994). Frequency refers to frequency of occurrence of vegetative type, as found by McCarthy *et al.* (1994).

Vegetation Type	Frequency (%)	Description
V25	40	Black Spruce - Labrador-tea - Sphagnum: • medium ericaceous shrubs (Labrador-tea) • abundant *Pleurozium schreberi* and *Sphagnum fuscum* • wet organic or very moist mineral soils
V24	30	Black Spruce - Speckled Alder (*Alnus rugosa*) - Sphagnum - *Pleurozium schreberi* • abundant speckled alder • abundant *Pleurozium schreberi* and *Sphagnum* spp. • goldthread and plume moss present • wet organic or very moist mineral soils
V22	20	Black Spruce - Feathermoss (*Pleurozium* spp.) • abundant feathermoss and *Sphagnum nemoreum* • medium herbs and shrubs • sweet coltsfoot (*Petasites frigidus*) present • wet organic or very moist mineral soils
V21	10	Black Spruce - Speckled Alder - Sphagnum - Stair-step moss • abundant speckled alder, *Pleurozium shreberi, Sphagnum* spp., stair-step moss (*Hylocomium splendens*) • medium shrubs and herbs • naked mitrewort present • wet organic or very moist mineral soils

residual "islands", and the site was considered a "light residual" site. The "heavy residual" site, one kilometre north of the uncut site, was also subjected to careful cutting but the resulting black spruce stand was more dense, containing forested leave strips and corridors that were harvested. The fourth sampling site was a clear cut, which had been completely stripped of black spruce and scarified. Despite the different treatments in each site, they are still considered Site Type 11. These four sites were selected for study because they were used for previous research (Lawrence, 1996; Poitras, 1996), and the resulting three years of data yielded animal numbers that were large enough for statistical analyses.

Clear-cut Description

The clear-cut site was the location of trap stations numbered 51 - 75. Densiometer readings taken in 1994 (Poitras, 1996) indicated that the clear-cut had 0% canopy cover. Black spruce seedlings were found and shrubs included willow (*Salix* spp.), paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), and balsam poplar (*Populus balsamifera*). Other shrubs found in the clear-cut included; labrador-tea, leatherleaf, pale laurel, and blueberry (Appendix 1). The dominant herbs in the clear-cut included grasses, sedges (*Carex* spp.), and field horsetail (*Equisetum arvense*). Standing water was evident and aquatic plants such as cattails (*Typha* spp.) were present. The clear-cut was also characterized by bare soil, wood, and debris, with the hummocks vegetated by *Dicranum* mosses (Appendix 2).

Light Residual Description

Trap stations numbered 1 - 25 were located in the light residual site. This site had a mean tree canopy density of 8%, an average tree height of 4.7 m, and a mean stand age of 5.1 years (Poitras, 1996). Leave strips formed patchy islands of residual plants. Labrador-tea, blueberry, and black spruce made up the majority of the shrub layer. A small stream bisected the light residual site at trap station 23, which had high percent cover of speckled alder (Appendix 1). This shrub was present wherever there was standing water.

Shrubs were more abundant in this site than in the clear-cut site, as was the percent cover of both wood (slash piles) and debris. The dominant moss cover on this site was *Sphagnum* spp., formed into hummocks and often associated with creeping snowberry. The corridors in the light residual site tended to be drier than the residual islands and were dominated by bare ground, grasses, dried sphagnum hummocks, creeping snowberry, and horsetail. The residual islands of black spruce contained moist hummocks vegetated by *Sphagnum* spp. in the black spruce dominated islands, and *Dicranum* spp., *Ribes* spp., and grasses in the alder dominated areas.

Heavy Residual Description

The heavy residual site had a higher canopy cover, with a densiometer reading of 28 % (Poitras, 1996). The tree sizes of the stand at the time of cutting dictated the amount of residual left. The minimum size limit of harvested trees was 12 cm diameter at breast height (DBH), and the structure of residual strips depended on the number of trees smaller than this minimum DBH. Thus, the light residual site was characterized by residual islands, whereas, the heavy residual site had residual strips. Common species found in the shrub layer included; black spruce, Labrador-tea, some leather leaf, and some blueberry (Appendix 1). Items that provided appreciable cover for animals included; downed wood, miscellaneous plant debris, and species such as bunchberry, snowberry, low cranberry, and liverworts. Moist to wet hummocks were common, and were vegetated by a combination of *Sphagnum* spp. and *Pleurozium* spp. (Appendix 2).

Uncut Site Description

The uncut site contained trap stations numbered 26 - 50, and was situated in Little Abitibi Provincial Park. Average true canopy cover was of 85 % and much of the forest had an almost complete canopy cover; however, canopy gaps and areas of recent blowdown provide openings. There was little shrub or forb cover in the heavily shaded areas, and the forest floor was dominated by mats of *Pleurozium* spp. and creeping snowberry. In contrast, gaps in the canopy were dominated by shrubs such as Labrador tea, sheep laurel, and seedlings and saplings of black spruce (Appendix 1). Herb layer components included bunchberry, snowberry, liverworts, and *Sphagnum* spp. and *Pleurozium* spp. (Appendix 2). Because the uncut is parallel to the light residual site, the stream that bisects the latter was also found in the uncut. The stream had speckled alder, *Mnium* spp., balsam fir, and *Ribes* spp. associated with it (Appendices 1 and 2).

The uncut, light residual, and heavy residual sites each had two parallel, adjacent 500 m long transect lines. The clear-cut site contained a wet marshy area, and to avoid sampling in this habitat, the transects were shortened to two 250 m lines. In each site, one line was for sampling animals and the other for plants.

Trapping Methodology

Each transect contained 25 trapping stations spaced 20 metres apart. Each station consisted of 2 Victor mouse traps, 1 Victor rat trap, and one pitfall trap, providing a total of 400 traps. Sites were large enough that the 500 m transect line was sampling voles only from the site in question. Trapping was carried out during a period of three consecutive days per month following two days of pre-baiting, where the traps were baited but not set. Bait consisted of peanut butter combined with almond extract for the mouse traps and Kolbassa sausage for the rat traps. The pitfall traps were half-filled with water to target small insectivores that might not be attracted to baited traps. Traps were set in the morning and remained set for 24 hours. Upon collecting the animals, species and sex were determined. Total body length and tail length were measured to the nearest millimetre with a 30 cm plastic ruler, and the voles were weighed with a 50g Pesola scale. Animals were frozen for later dissection. Animals were dissected in order to positively identify sex, and sexual maturity identified by lactation, placental scars, embryos, and in males, seminal vesicle size. Sampling occurred during the summers of 1994, 1995 and 1996 for a total of 12 000 trap-nights.

Habitat Analysis

A detailed vegetational analysis was performed along an adjacent vegetation line examining shrubs in 1 m by 1 m quadrats, and herbs in 0.5 m by 0.5 m quadrats (Poitras, 1996). Both herb and shrub layer species and percent cover were quantitatively examined. The location of the vegetation quadrats with respect to the leave strips and corridors was also considered for the two carefully cut sites.

Stomach Content Analysis

Stomach content analysis with microhistological assessment of the contents was carried out on meadow voles, red-backed voles, and yellownose voles as this was the most accurate and viable method for voles. Methods of determining foraging habits were considered; however, none were suited to this study (Holechek *et al.*, 1982a). Some examples of other techniques included fistula techniques, utlilization techniques, direct observation of animals, and faecal analysis (Holechek *et al.*, 1982b). Esophageal and rumen fistulation were both invasive techniques, where partially digested food is removed from a portion of the digestive tract. Fistula techniques are difficult for wild animals and small animals such as voles. Utilization is one of the oldest techniques used for estimating dietary habits, and involved an examination of plants that show evidence of grazing or browsing. The benefits of this technique include increased efficiency of data collection, and the lack of need for animal samples. However, when a plant species was used, and how often it was used, cannot be determined with this technique. Regrowth after defoliation, loss of foliage from weathering, trampling of vegetation, and use by other animals all decrease the accuracy of the utilization technique.

Direct observation of animals is another method used for determining dietary habits. However, it is very difficult to observe wild animals closely enough to determine exactly what plant species are being consumed and it is impossible to determined the quantities being consumed. Laboratory kept animals can be used, but the investigation tends to be biased as the researcher must present various plant species for the animal to consume. Faecal analysis has numerous advantages and is now being used extensively. This technique does not interfere with the behaviour, habits, or movements of the animal, and is useful for studying dietary habits of endangered species. Sampling is practically unlimited, and requires no expensive equipment. However, faeces of different species can be difficult to differentiate, especially when considering microtines. Another problem faced by researchers involves the differential rate of digestion of various plant species, resulting in the underestimation of plant species which digest quickly. The age of the faecal sample may also affect the ease of plant identification.

Stomach content analysis has some of the same disadvantages as the faecal analysis technique, including the need for extensive reference plant collections, the tediousness and difficulty of identifying plant species microscopically, and the training required for the researcher to identify plant fragments. Stomach content analysis is only suitable for animals with high enough population numbers that removal of some individuals does not decimate the population. Differential destruction of plant materials during digestion also reduces accuracy of estimation, but to a lesser extent than the fecal analysis technique. For the majority of wild microtines, however, the most accurate method for determining dietary habits is through stomach content analysis. Fistulation of voles would be highly inefficient, because they would have to be kept in captivity, and the surgery would likely kill them. Animal observation would require too much time to observe adequate numbers of each microtine species. Utilization techniques would be virtually impossible considering the scale of consumption. Not only would it be very difficult to determine if a blade of grass or a forb leaf had been grazed, but it would be impossible to determine which vole species had consumed it. Fecal analysis also presents the problem of vole species differentiation.

Dietary habits of yellownose voles, meadow voles, and red-backed voles were determined by analysis of stomach contents. Before analysis could begin, a reference collection of plant material was compiled, so that microhistological characteristics could be established. Reference plant material was collected from all four transects, and all plant families were represented. The material was oven dried, ground using a mortar and pestle and reconstituted in water for 2 hours. The resulting paste was then cleared in 0.05M NaOH for 30 minutes for ease of identification following the protocol of Holechek *et al.* (1982a). A suspension of plant material and molten glycerine jelly, which was heated and kept warm on a hot plate, was placed on microscope slides to create a reference collection. Actual stomach contents were treated similarly, by clearing in 0.05M NaOH, then filtering using Eaton-Dikeman qualitative filter papers (grade 613, size 9 cm) and a Büchner funnel suction apparatus. To keep the density of the plant material on the slide consistent, a ratio of volume of glycerine jelly to mass of stomach contents (which would allow ease of viewing and identification by preventing particle overlap) was determined. For every ml of glycerine jelly, 0.0237 g of stomach contents were used. The cleared and filtered stomach contents were mixed into the appropriate volume of molten glycerine jelly and 0.8 ml of the suspension was pipetted onto each slide and covered with a 25 mm x 50 mm coverslip. In order to determine percentage frequency of a given item in the animal's diet, 5 slides were made from the stomach contents of each vole, and twenty random observations were made per slide. The frequency of occurrence per 100 fields of view at 100X magnification was determined, resulting in percent frequency of occurrence.

Statistical Analysis

Multiple, one sample, Komogorov - Smirnov tests for normality indicated that no small mammal populations had a normal distribution. Kruskal Wallis non-parametric oneway analysis of variance tests were used to determine significant differences in small mammal populations between the three study years, to determine which years could be pooled. Small mammal populations differed significantly between 1994 and 1995, and 1994 and 1996. No differences occurred between the samples from 1995 and 1996, so those data were pooled.

Logging Treatment Comparisons

Kruskal-Wallis non-parametric analysis of variance was used to determine significant differences between the three logging treatments and the uncut forest for yellownose voles, meadow voles, and red-backed voles for 1994, and separately for 1995 and 1996 combined. The Nemenyi method, which is a multiple comparison test modified for non-parametric methods, was subsequently used to determine where differences existed (Zar, 1984).

Habitats

To obtain representative plant species composition and percent cover for each trap station, average percent cover was determined by taking the mean of the percent covers for the three preceding and the three following shrub and herb quadrats at each trap station. Thus, each trap station had an average percent cover of both shrubs and herbs. To reduce variability, pooling was done so that species within a genus, or in some cases, family, were grouped together. Thus, the categories *Carex* (sedges), *Dicranum* (moss), *Sphagnum* (peat mosses), liverworts, grasses, and mosses (all species except for *Sphagnum* and *Dicranum*) were created. Statistics were done using the statistical package SPSS for Windows and Microsoft Excel (7.0). Trap stations were grouped, based on the vegetation data into sub-habitats using Ward's method of hierarchical cluster analysis, following Amiro and Courtin (1981). These sub-habitats were used for habitat use analysis.

Habitat Use

There are various statistical methods for determining habitat utilization, and the method described by Neu *et al.* (1974), which utilizes a Chi-square goodness of fit test and a Bonferroni confidence interval post hoc was most suited to the data and study design. Other methods for testing resource selection include the Johnson, Friedman, and Quade methods (Alldredge and Ratti, 1986). The Johnson method compares ranks of habitat selection with the ranks of the habitat availability for each animal (Alldredge and Ratti, 1986). Alldredge and Ratti (1986) found that after ranking the selected versus available habitats, differences in percent of habitat utilized tended to be masked, and were not detected if the ranks were the same. The Friedman test is a commonly used non-parametric test, but like the Johnson method, is most effective when the number of habitats is large. Neither test was considered for this investigation because only a total of 6 habitats were analyzed. Quade's test, in essence, is a 2-way analysis of variance for ranked data. Both the Quade test and the Friedman test assume that variation in the differences between use and availability are equal for all habitats, whereas, the Neu method incorporates variation estimates for each habitat separately. Each observation (in this case, animal trapped) is given equal weight when using the Neu method. Due to the small number of habitats identified, habitat use by three vole species was done using Chi-square goodness-of-fit with a modified Bonferroni confidence interval analysis. The Bonferroni confidence interval analysis assigns acceptance intervals based on 95% confidence intervals and observed frequencies. If the proportion of habitat that was available to the vole fell below the acceptance interval, the animals used the habitat to a greater degree than that dictated by habitat availability. If the proportion of the habitat available fell within the acceptance interval, the animals used the habitat based on the availability of the habitat. Finally, if the proportion of available habitat fell above the acceptance interval, the animals used the habitat to a lesser degree than what was available.

Stomach Content Analysis

Ten randomly chosen stomachs of each of the three species of voles were prepared for analysis. Significant differences in dietary habits between vole species was determined using Kruskal-Wallis one-way analysis of variance test. The Nemenyi multiple comparison method was subsequently used to determine where differences existed between species (Zar, 1984).

Results

By the third year of trapping, it was apparent that the small mammal populations were declining. The most drastic change was seen in the red-backed vole population, which dropped significantly from a total of 8.25 animals per 100 trapnights in 1994 to 1.44 animals per 100 trapnights in 1995 ($X^2 = 107.0$, df = 2, $p < 0.05$). Between 1995 and 1996, the population decline continued, though it was not statistically significant, to 0.17 animals per 100 trapnights (Figure 2). The next most dramatic change was seen in the meadow vole population. Captures decreased significantly from 4.71 animals per 100 trapnights in 1994 to 0.28 animals in 1995 ($X^2 = 160.8$, df = 2, $p<0.05$). The difference between numbers in 1995 and 1996 were not significant, but the numbers still decreased (Figure 2). Yellownose vole captures also declined over the three years of trapping, from 1.23 animals per 100 trapnights to 0.67 animals per 100 trapnights in 1995, and 0.14 animals per 100 trapnights in 1996 (Figure 2). The only significant drop in the yellownose vole captures was seen between 1994 and 1996 ($X^2 = 16.8$, df = 2, $p<0.05$). More yellownose voles were caught in 1995 and 1996 than meadow voles.

Vole Response to Logging

Red-backed voles

In 1994, 2 red-backed voles were caught in the clear cut site (0.04/100 trap-nights [TN]), which was significantly lower than the other 2 logging treatments and the uncut forest (Figures 3a, 4a). Figures 3a and b show the total numbers of red-backed

Figure 2. Total number of red-backed voles (*C. gapperi*), meadow voles (*M. pennsylvanicus*) and yellownose voles (*M. chrotorrhinus*) caught per 100 trapnights in 1994, 1995, and 1996. Numbers above bars indicate number caught per 100 trapnights. Total number of animals caught; n_{1994}=670, n_{1995}=76, n_{1996}=13.

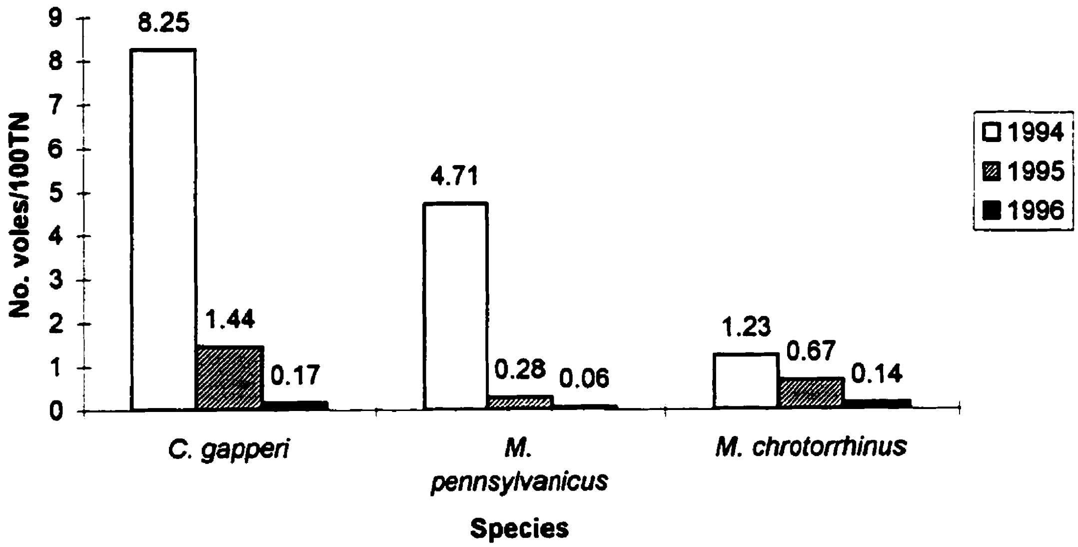

No. voles/100TN
9
8
7
6
5
4
3
2
1
0
8.25
1.44
0.17
4.71
0.28
0.06
1.23
0.67
0.14
C. gapperi
M. pennsylvanicus
M. chrotorrhinus
Species
1994
1995
1996

Figure 3. (a) Number of red-backed voles caught in 1994 in each logging treatment (n_{CC}=2, n_{LR}=56, n_{HR}=153, n_{UC}=185).

(b) Number per of red-backed voles caught in 1995 and 1996 in each logging treatment (n_{CC}=0, n_{LR}=0, n_{HR}=14, n_{UC}=44). CC - clear-cut, LR - light residual, HR - heavy residual, UC - uncut.

Red-backed voles

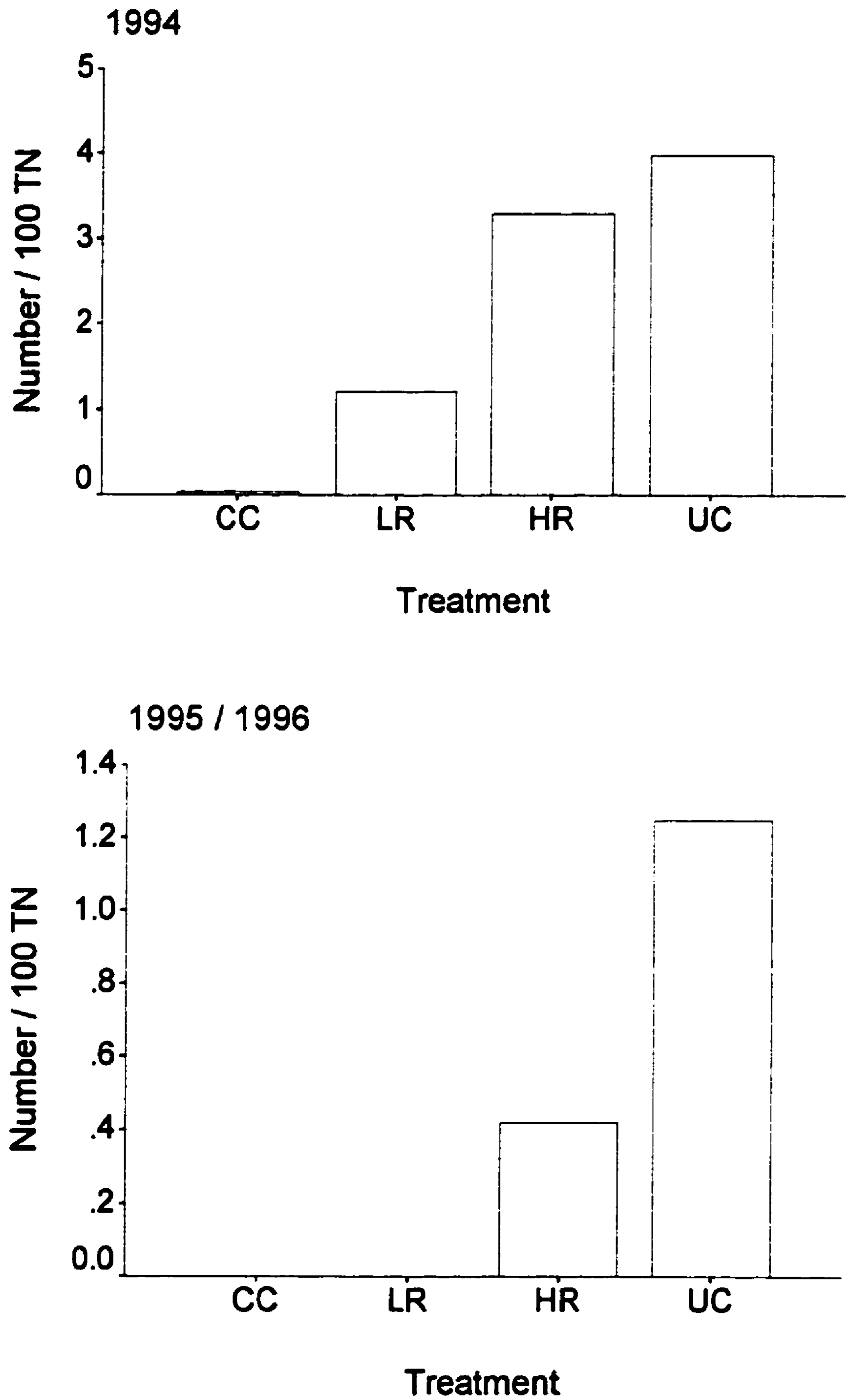
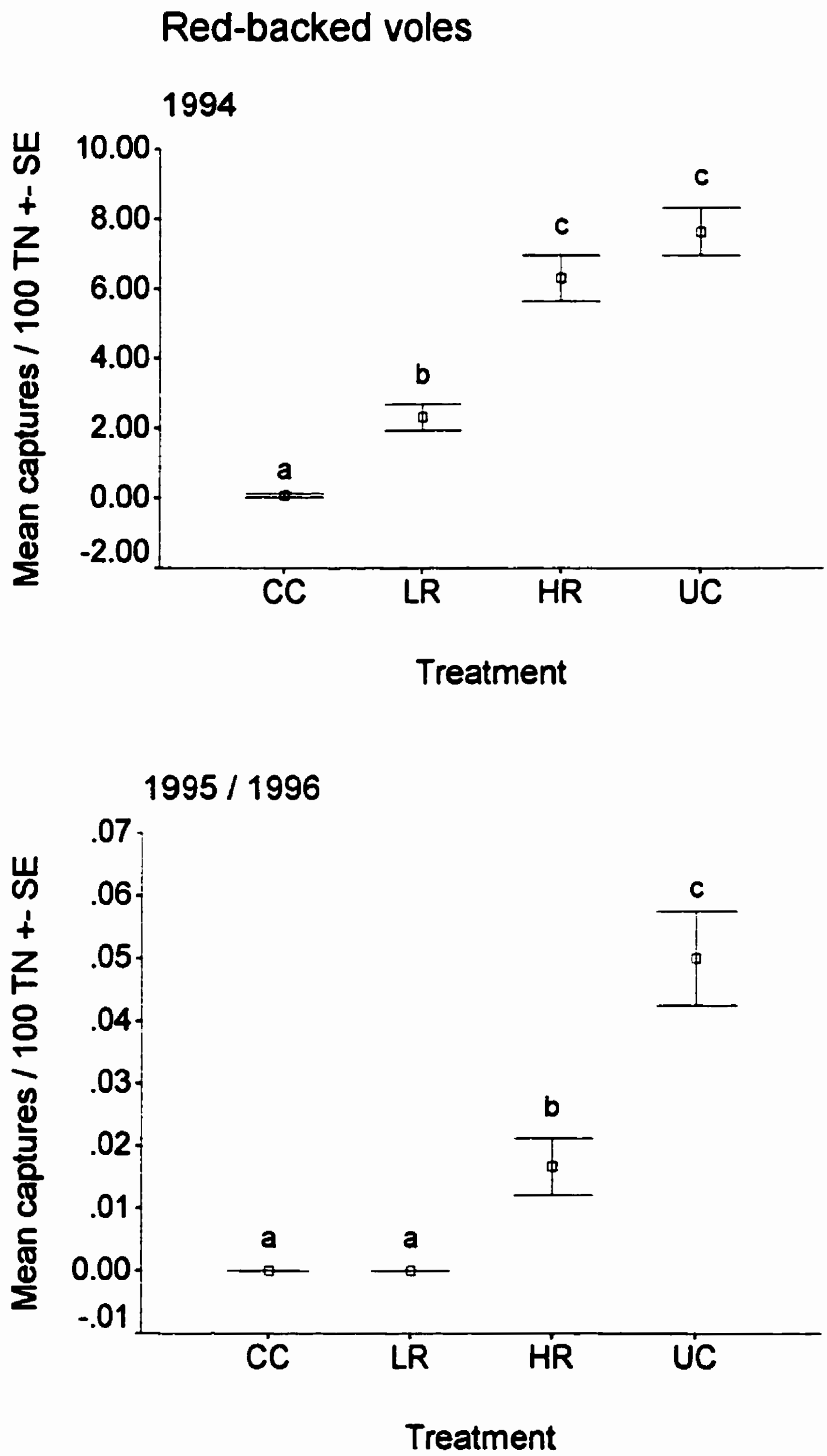


Figure 4. (a) Mean captures of red-backed voles per 100 trapnights for each logging treatment in 1994. Bars indicate standard error of the mean and letters above each bar indicate significant differences (X^2=66.5, df=3, p<0.01) (n_{CC}=2, n_{LR}=56, n_{HR}=153, n_{UC}=185).

(b) Mean pooled captures of red-backed voles per 100 trapnights for each logging treatment in 1995 and 1996. Bars indicate standard error of the mean and letters above each bar indicate significant differences differences (X^2=55.97, df=3, p<0.001) (n_{CC}=0, n_{LR}=0, n_{HR}=14, n_{UC}=44). CC - clear-cut, LR - light residual, HR - heavy residual, UC - uncut.


Red-backed voles
1994
Mean captures / 100 TN +- SE
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
a
b
c
c
CC
LR
HR
UC
Treatment
1995 / 1996
Mean captures / 100 TN +- SE
.07
.06
.05
.04
.03
.02
.01
0.00
-.01
a
a
b
c
CC
LR
HR
UC
Treatment

voles captured per 100 trap-nights (TN), and figures 4a and b show the mean number of animals captured plus or minus one standard error about the mean. The graphs that show the mean number of captures also show significant differences as determined by the Kruskal Wallis test (Figures 3a, 3b). The number of red-backed voles caught in the light residual (1.21/100 TN) was significantly greater than the clear-cut site, and significantly smaller than the number caught in the heavy residual or uncut site (Figures 3a, 4a). There was no significant difference between the number of red-backed voles caught in the heavy residual site (3.85/100 TN) and the uncut site (3.98/100 TN) ($X^2 =$ 66.5, df = 3, $p<0.001$) (Figure 3a).

In the pooled years of 1995 and 1996, there were no red-backed voles caught on either the clear-cut or the light residual sites (Figure 3b). The number of voles that were caught in the heavy residual site was 0.42 / 100 TN and 1.25 voles / 100 TN were caught in the uncut site (Figure 3b). The numbers of red-backed voles that were caught in the heavy residual and uncut sites were both significantly different from those caught in the clear-cut and the light residual sites, and from each other ($X^2 = 56.0$, df = 3, $p<0.001$) (Figure 4b).

Meadow voles

In 1994, significantly more meadow voles were caught in the clear-cut site (1.50 / 100 TN) and heavy residual site (1.50 / 100 TN) than in the uncut site (0.44 / 100 TN) (Figures 5a, 6a). The number of meadow voles caught in the light residual site was not significantly different from those in any other site (Figure 6a) ($X^2 = 19.5$, df = 3, $p<0.001$).

In 1995 and 1996, there was no significant difference between the number of meadow voles in the light residual site (1.17 / 100 TN) and the numbers in any of the

Figure 5. (a) Number of meadow voles caught in 1994 in each logging treatment (n_{CC}=68, n_{LR}=65, n_{HR}=73, n_{UC}=20).

(b) Number of meadow voles caught in 1995 and 1996 in each logging treatment (n_{CC}=6, n_{LR}=6, n_{HR}=0, n_{UC}=0). CC - clear-cut, LR - light residual, HR - heavy residual, UC - uncut.

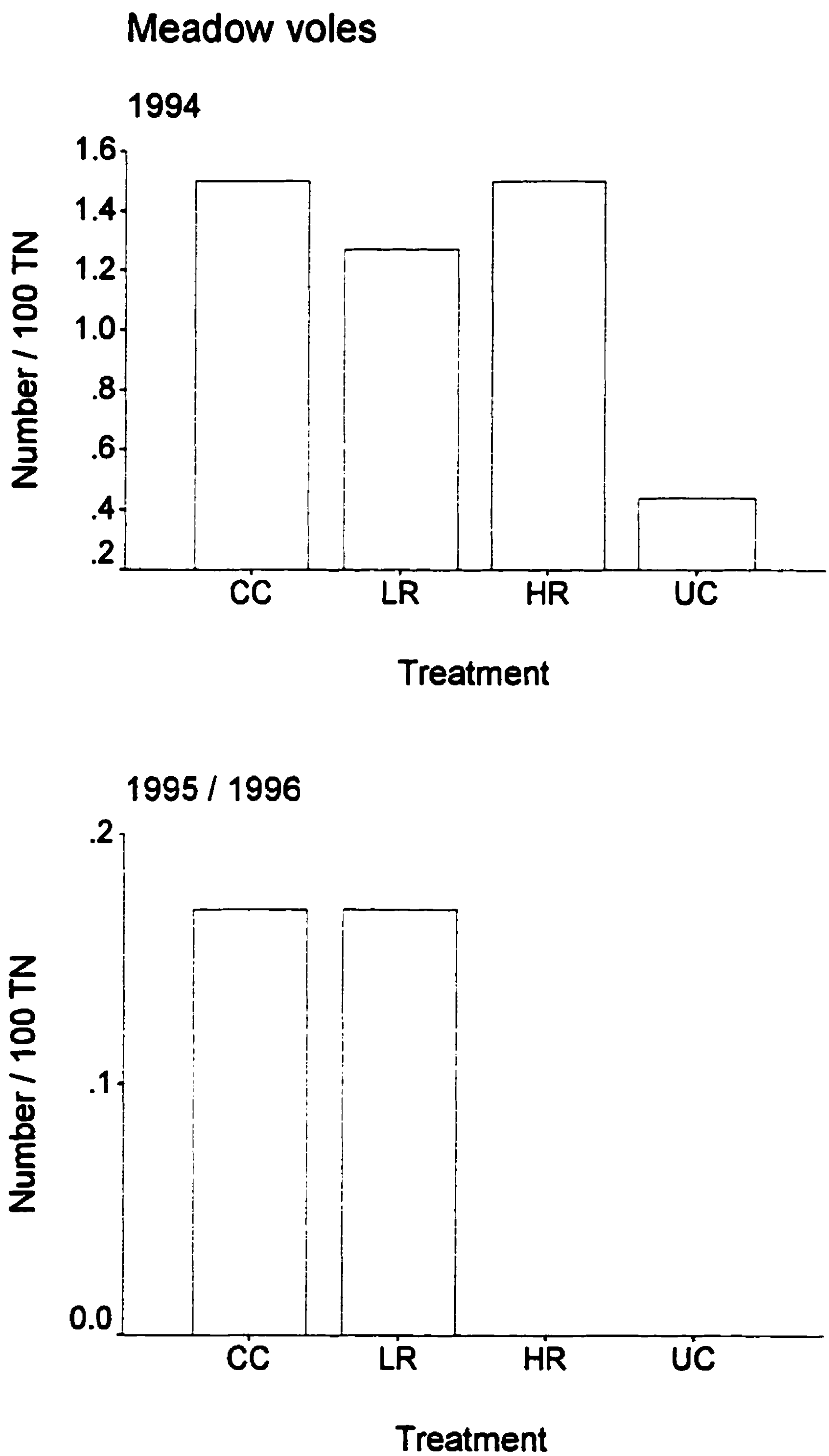
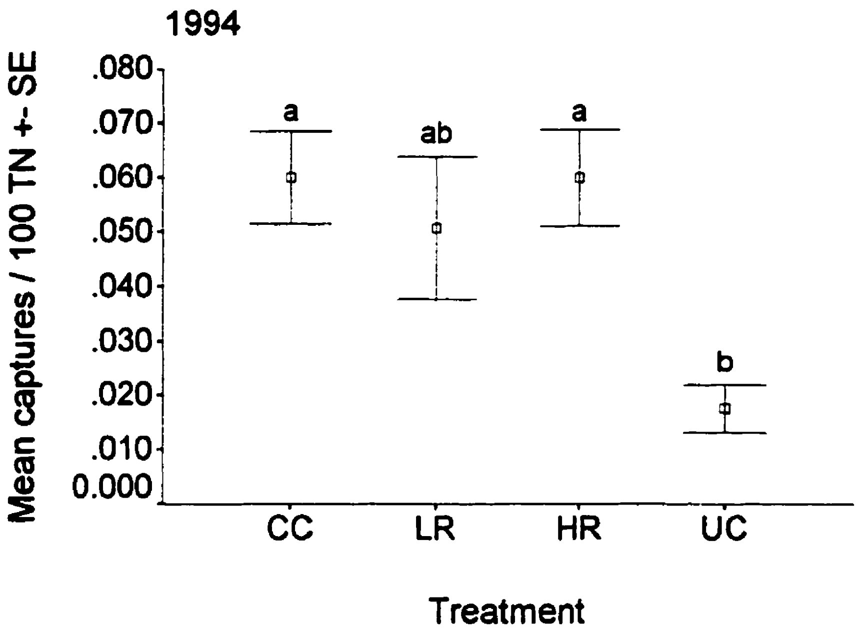
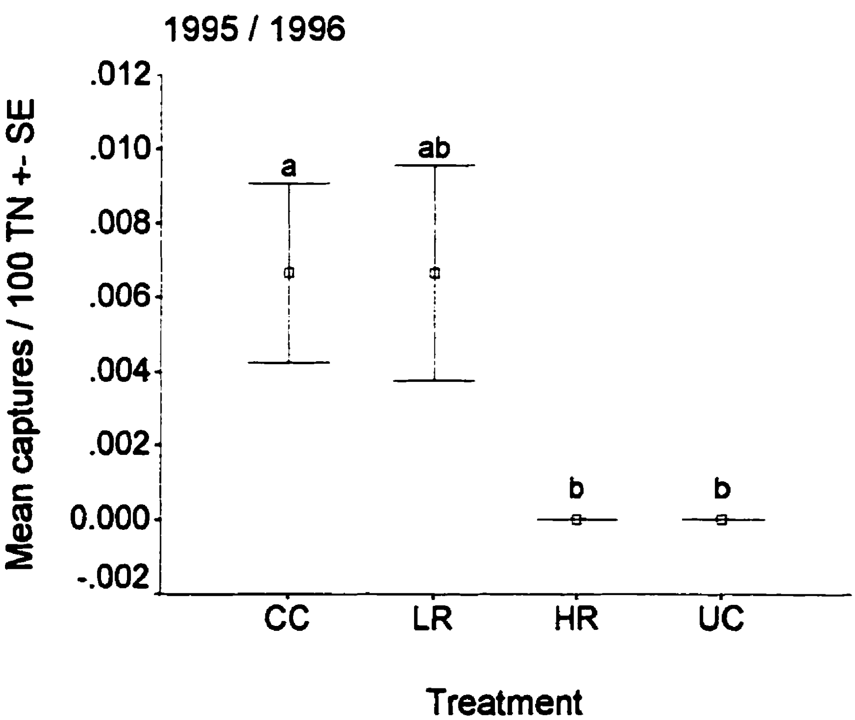

Meadow voles
1994
1.6
1.4
1.2
1.0
.8
.6
.4
.2
Number / 100 TN
CC
LR
HR
UC
Treatment
1995 / 1996
.2
.1
0.0
Number / 100 TN
CC
LR
HR
UC
Treatment

Figure 6. (a) Mean captures of meadow voles per 100 trapnights for each logging treatment in 1994. Bars indicate standard error of the mean and letters above each bar indicate significant differences (X^2=19.5, df=3, $p<0.001$) (n_{CC}=68, n_{LR}=65, n_{HR}=73, n_{UC}=20).

(b) Mean captures of meadow voles per 100 trapnights for each logging treatment in 1995 and 1996. Bars indicate standard error of the mean and letters above each bar indicate significant differences (X^2=12.38, df=3, $p<0.01$) (n_{CC}=6, n_{LR}=6, n_{HR}=0, n_{UC}=0). CC - clear-cut, LR - light residual, HR - heavy residual, UC - uncut.

Meadow voles





other three sites (Figures 5b, 6b). There were significantly more meadow voles caught in the clear cut site (1.17 / 100 TN) than in the heavy residual or uncut sites, where none were caught (Figure 6b) ($X^2 = 12.4$, df = 3, $p<0.01$).

Yellownose voles

In 1994, a total of 47 yellownose voles were caught. The highest number of yellownose voles were caught in the uncut site (0.5 / 100 TN), and the lowest number were caught in the clear-cut (0.02 / 100 TN) (Figure 7a). Significantly more yellownose voles were caught in the light residual than in the clear-cut (Figure 8a). However, there was no significant difference seen between numbers caught in the uncut site and the clear-cut site, even though the light residual site had fewer voles per 100 trapnights than the uncut (0.35 versus 0.50) (Figure 7a). There were no significant differences between numbers of voles caught in the heavy residual site and any other site ($X^2 = 12.8$, df = 3, $p<0.01$).

In 1995 and 1996, a total of 22 yellownose voles were caught, the majority occurring in the light residual site (0.25 / 100 TN) (Figure7b). Numbers in the heavy residual and clear-cut per hundred trapnights were 0.17, and 0.11, respectively. Finally, only 0.08 / 100 TN were caught in the uncut site (Figure 7b). There were no significant differences between any of the four sites (Figure 8b).

Figure 7. (a) Number of yellownose voles caught in 1994 in each logging treatment (n_{CC}=1, n_{LR}=17, n_{HR}=4, n_{UC}=26).

(b) Number of yellownose voles caught in 1995 and 1996 in each logging treatment (n_{CC}=3, n_{LR}=9, n_{HR}=4, n_{UC}=3). CC - clear-cut, LR - light residual, HR - heavy residual, UC - uncut.

Yellow-nose voles

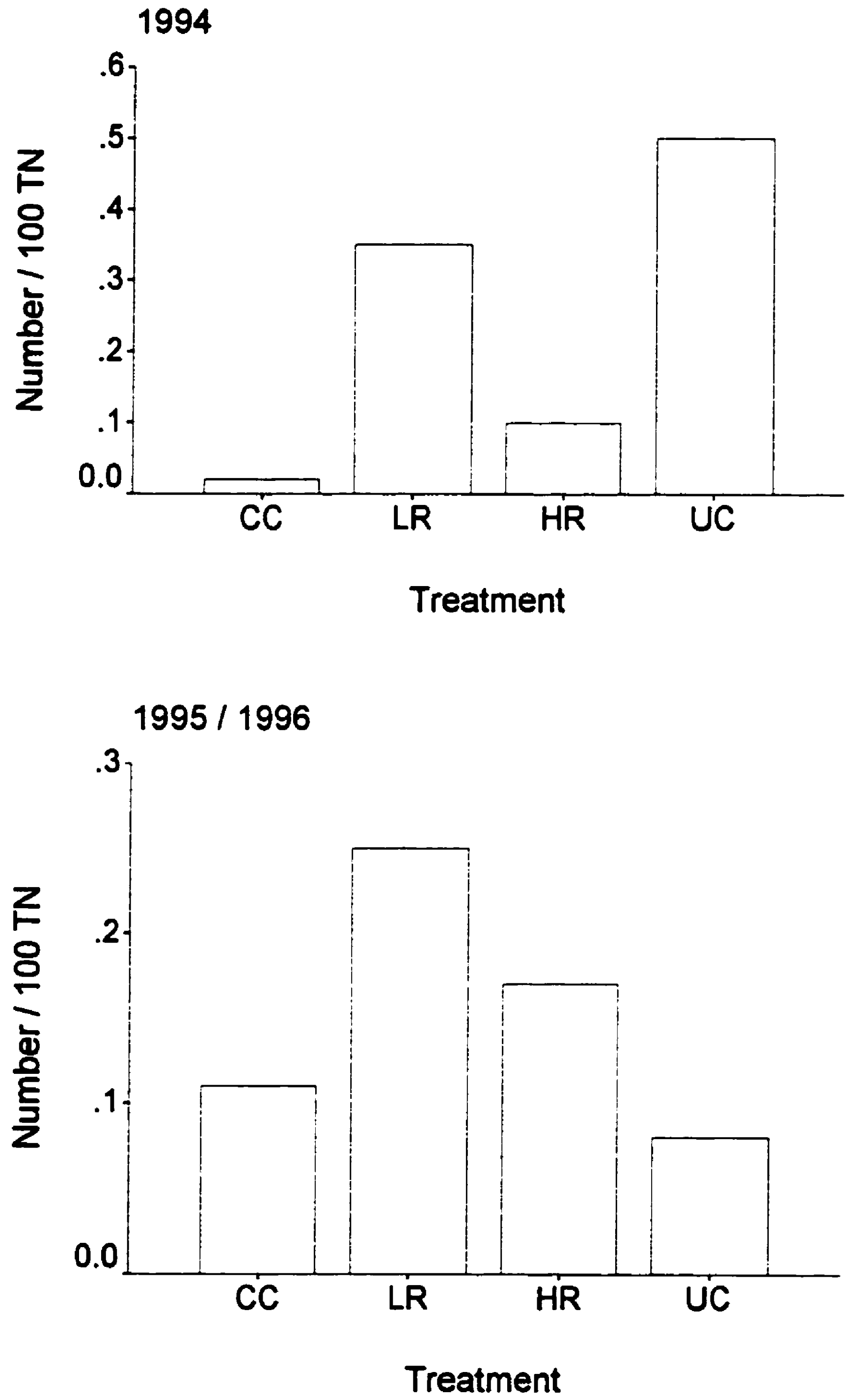
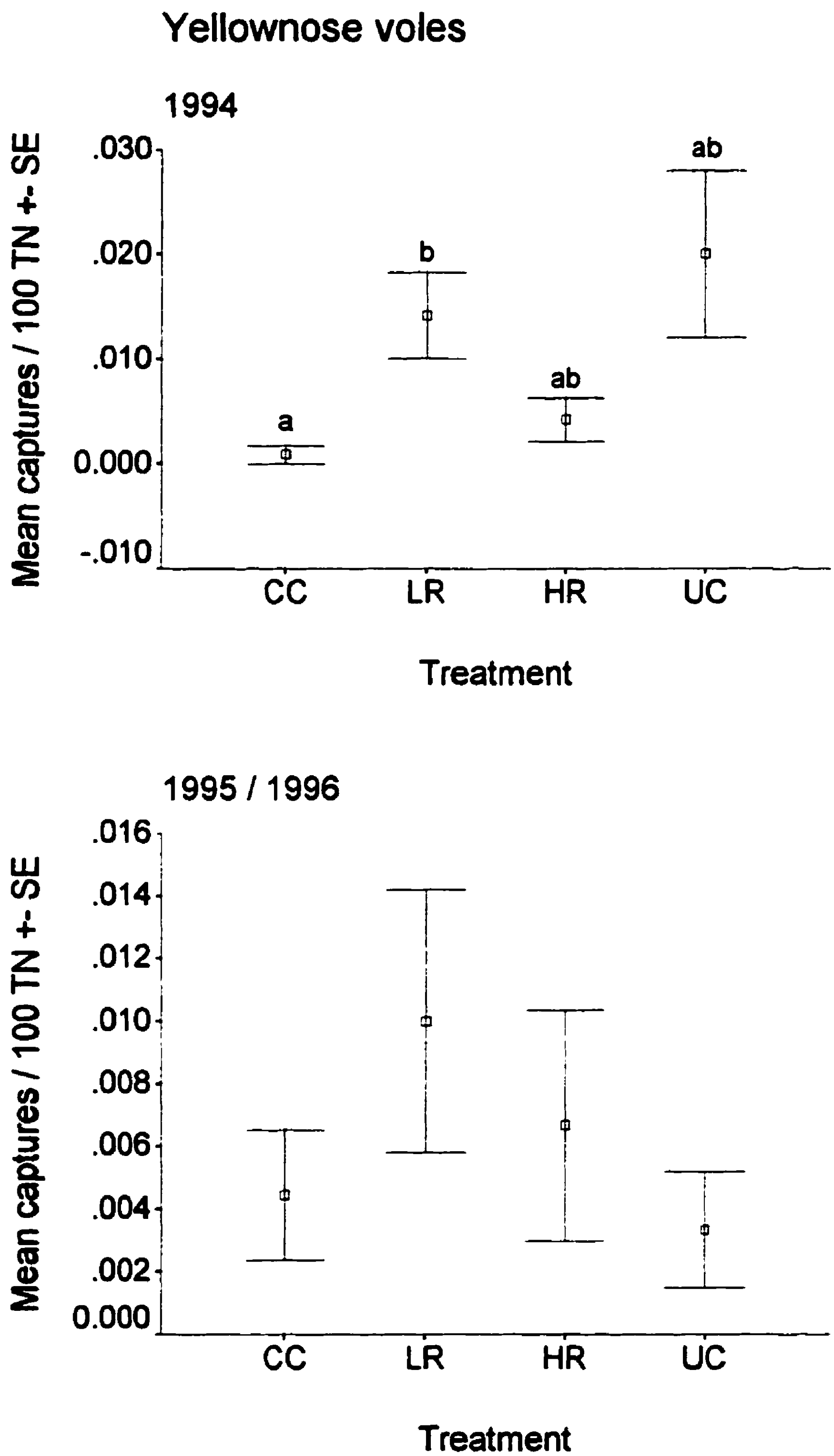


Figure 8. (a) Mean captures of yellownose voles per 100 trapnights for each logging treatment in 1994. Bars indicate standard error of the mean and letters above each bar indicate significant differences (X^2=12.81, df=3, p<0.01) (n_{CC}=1, n_{LR}=17, n_{HR}=4, n_{UC}=26).

(b) Mean captures of yellownose voles per 100 trapnights for each logging treatment in 1995 and 1996. Bars indicate standard error of the mean. Note that there are no significant differences between the treatments (n_{CC}=3, n_{LR}=9, n_{HR}=4, n_{UC}=3). CC - clear-cut, LR - light residual, HR - heavy residual, UC - uncut.



Yellownose voles
1994
Mean captures / 100 TN +- SE
.030
.020
.010
0.000
-.010
a
b
ab
ab
CC
LR
HR
UC
Treatment
1995 / 1996
Mean captures / 100 TN +- SE
.016
.014
.012
.010
.008
.006
.004
.002
0.000
CC
LR
HR
UC
Treatment

Habitat use by three vole species

1. Determination of habitat types

Hierarchical cluster analysis using Ward's method was performed using all average percent covers for both the herb and shrub strata (Appendices 1 and 2). The 100 trap stations were grouped into clusters based on these data. The analysis resulted in 7 primary clusters, which were named based on vegetative composition. They are listed in Table 3.

Disturbed with slash

Cluster 1 was a relatively disturbed habitat dominated by slash, or logging debris. It had a residual of 33 %, meaning 33 % of the habitat occurs as residual islands. It was dominated by feathermoss (*Pleurozium schreberi*) and abundant miscellaneous plant debris and wood, or slash piles.

Dense black spruce / *Pleurozium schreberi*

Cluster 2 was classified as a dense black spruce habitat. This habitat was almost completely undisturbed, with 97 % being "residual" or uncut. Unlike the disturbed habitat of cluster 1, this habitat had no slash and little other debris. The dominant herb layer was composed of feathermoss and creeping snowberry.

Disturbed speckled alder associated

Cluster 3 was another disturbed site, classified as a cleared speckled alder habitat with shrubs. There was only 10 % residual, indicating a large degree of

Table 3. Habitats derived from hierarchical cluster analysis (Ward's method) using trap station vegetation percent cover values for shrubs and herbs.

Cluster	Habitat	% Residual	Description
1	Disturbed with woody debris	33 %	• dominated by feathermoss (*Pleurozium schreberi*) • abundant debris and wood
2	Dense black spruce - *Pleurozium schreberi*	97 %	• dominated by feathermoss and snowberry • very little debris
3	Disturbed alder with shrubs	10 %	• black spruce shrubs • *Ribes* spp., grasses, and *Sphagnum* spp.- associated with speckled alder
4	Dense black spruce - *Sphagnum* - cranberry	97 %	• dominated by *Sphagnum* spp. and cranberry • some feathermoss, very little debris
5	Black spruce / Alder transition	95 %	• moist transition with balsam fir, black spruce, and speckled alder • much debris, *Sphagnum* spp., and *Ribes* spp.
6	Clearings with debris and cranberry	51 %	• black spruce partially cleared • abundant debris, *Sphagnum* spp., cranberry, Labrador-tea
7	Cleared	0 %	• dominated by bare soil, and *Dicranum* spp. • abundant juniper hair-cap moss (*Polytrichum junipericum*), field horsetail, cranberry, and sedges

disturbance. Plants dominating the shrub layer included; black spruce, raspberry, and cloudberry (*Rubus chamaemorus*). The herb layer consisted primarily of grasses and *Sphagnum* spp.

Dense black spruce with *Sphagnum*

Cluster 4 was dense black spruce with *Sphagnum* spp. and a high percentage of undisturbed habitat. The dominant moss, peat moss, was covered with small cranberry (*Vaccinium oxycoccus*). There was scattered feathermoss associated with the *Sphagnum* spp., but very little else in the way of a herb layer was found.

Dense black spruce / speckled alder transition

Cluster 5 was another dense habitat with 95 % of it undisturbed. It contained balsam fir, black spruce, alder, and cloudberry and raspberry. The dominant moss was *Sphagnum* spp., and there was abundant plant debris. This habitat was found in areas surrounding small streams or areas of standing water, with alder occurring closest to the water and balsam fir in the transition between the alder and the black spruce. In general, this habitat type had saturated soil or standing water.

Disturbed with cranberry

Only 51 % of the habitat defined by cluster 6 was undisturbed. Unlike the disturbed with debris habitat (cluster 1), this habitat was dominated by *Sphagnum* spp. and small cranberry. There was an abundance of miscellaneous plant debris and not as much slash as in the aforementioned habitat. Labrador-tea was found in abundance in this habitat.

Cleared

This habitat had no residual, and was defined by barren areas of the clear-cut site. The habitat contained moss (*Dicranum* spp., *Polytrichum* spp.), sedges, field horsetail, but was mostly characterized by dried hummocks and exposed soil. There was virtually no shrub cover.

2. Habitat Utilization

Habitat use versus habitat availability by each vole species was determined using the Bonferroni statistic, which is a modified Chi-square with confidence intervals. The availability of a particular habitat was the number of trap stations that occurred in that habitat type according to the cluster analysis. For instance, the greater number of traps that are grouped together into a cluster, the greater the availability of that habitat. Proportion of habitat available (Table 4) was the number of trap stations that occurred in that habitat type divided by the total number of trap stations (100). The proportion of habitat used by the animals was calculated as the number of voles of a particular species that were caught in that habitat type divided by the total number of that vole species caught in all habitats. The lower and upper limits of the confidence interval were calculated using the proportion of habitat used. If the proportion of habitat available fell within the confidence interval, the habitat was used in equal proportion to availability.

Red-backed voles

In 1994, red-backed voles used both the *Sphagnum* spp. dominated and *Pleurozium schreberi* dominated dense black spruce habitats more than available. This

Table 4. Multiple Chi-square analysis with Bonferroni confidence intervals for habitat use by red-backed voles (*C. gapperi*) in 1994.

Habitat	Proportion Available	Proportion Used	Expected Use	Actual Use	Bonferroni lower limit	Bonferroni upper limit	Use
Disturbed with debris	0.13	0.14	53.17	57	0.093	0.185	=
Dense black spruce - Pleurozium	0.14	0.23	57.26	93	0.172	0.283	more
Cleared alder with shrubs	0.09	0.04	36.81	15	0.012	0.062	less
Dense black spruce - Sphagnum - cranberry	0.19	0.32	77.71	131	0.258	0.382	more
Black spruce / Alder transition	0.13	0.13	53.17	55	0.089	0.180	=
Clearings with debris and cranberry	0.10	0.14	40.90	56	0.091	0.183	=
Cleared	0.22	0.005	89.98	2	-0.004	0.014	less

χ^2= 163.71; df=6, $p<0.05$

Table 5. Multiple Chi-square analysis with Bonferroni confidence intervals for habitat use by red-backed voles (*C. gapperi*) in 1995 and 1996 pooled.

Habitat	Proportion Available	Proportion Used	Expected Use	Actual Use	Bonferroni lower limit	Bonferroni upper limit	Use
Disturbed with debris	0.13	0.02	7.80	1	-0.028	0.061	less
Dense black spruce - Pleurozium	0.14	0.23	8.40	14	0.086	0.380	=
Cleared alder with shrubs	0.09	0.03	5.40	2	-0.029	0.096	=
Dense black spruce - Sphagnum - cranberry	0.19	0.43	11.40	26	0.261	0.605	more
Black spruce / Alder transition	0.13	0.20	7.80	12	0.061	0.339	=
Clearings with debris and cranberry	0.10	0.08	6.00	5	-0.013	0.179	=
Cleared	0.22	0	13.20	0	0	0	less

χ^2= 46.13; df=6, $p<0.05$

species used disturbed areas with debris, black spruce / alder transition, and clearings with cranberry in proportion to availability of each habitat. The two habitats with the lowest residual component, the cleared alder with shrubs, and the clear-cut site were used less than expected based on availability ($X^2 = 163.7$, df = 6, $p<0.05$) (Table 4).

The only results that were reproduced from 1994 to 1995 and 1996 were that the red-backed voles used the dense black spruce and *Sphagnum* spp. sites more and the cleared habitat less, than would have been expected based on the availability of these habitats. Unlike the 1994 results, voles in 1995 and 1996 used both the dense black spruce and feathermoss, and the cleared alder with shrubs habitats in proportion to availability. The black spruce / alder transition and the clearings with cranberry were also used in proportion to availability. Finally the disturbed with debris, and cleared habitats were used less than expected based on availability. No confidence interval was calculated for the cleared habitat, because no red-backed voles were caught there. Despite the lack of confidence intervals, the fact that no voles were caught in the cleared habitat indicated there was no utilization ($X^2 = 46.1$, df = 6, $p<0.05$) (Table 5).

Meadow voles

In 1994, meadow voles used almost all habitats in equal proportion to availability. The only difference was seen in the dense black spruce and feathermoss habitat, which was used less than available ($X^2 = 30.8$, df = 6, $p<0.05$) (Table 6).

In 1995 and 1996, no intervals were calculated for the two dense black spruce habitats and the clearings with debris and cranberry, as no meadow voles were caught there. All other habitats were used in proportion to availability ($X^2 = 15.1$, df = 6, $p<0.05$) (Table 7).

Table 6. Multiple Chi-square analysis with Bonferroni confidence intervals for habitat use by meadow voles (*M. pennsylvanicus*) in 1994.

Habitat	Proportion Available	Proportion Used	Expected Use	Actual Use	Bonferroni lower limit	Bonferroni upper limit	Use
Disturbed with debris	0.13	0.13	29.38	30	0.072	0.193	=
Dense black spruce - Pleurozium	0.14	0.04	31.64	9	0.005	0.075	less
Cleared alder with shrubs	0.09	0.13	20.34	29	0.068	0.188	=
Dense black spruce - Sphagnum - cranberry	0.19	0.14	42.94	31	0.076	0.199	=
Black spruce / Alder transition	0.13	0.16	29.38	36	0.094	0.225	=
Clearings with debris and cranberry	0.10	0.11	22.60	24	0.051	0.161	=
Cleared	0.22	0.30	49.72	67	0.215	0.378	=

$\chi^2 = 30.80$; df=6, $p<0.05$

Table 7. Multiple Chi-square analysis with Bonferroni confidence intervals for habitat use by meadow voles (*M. pennsylvanicus*) in 1995 and 1996 pooled.

Habitat	Proportion Available	Proportion Used	Expected Use	Actual Use	Bonferroni lower limit	Bonferroni upper limit	Use
Disturbed with debris	0.13	0.33	1.56	4	-0.033	0.669	=
Dense black spruce - Pleurozium	0.14	0.00	1.68	0	0	0	less
Cleared alder with shrubs	0.09	0.08	1.08	1	-0.131	0.298	=
Dense black spruce - Sphagnum - cranberry	0.19	0.00	2.28	0	0	0	less
Black spruce / Alder transition	0.13	0.08	1.56	1	-0.131	0.298	=
Clearings with debris and cranberry	0.10	0.00	1.20	0	0	0	less
Cleared	0.22	0.50	2.64	6	0.112	0.888	=

$\chi^2 = 15.05$; df=6, $p<0.05$

Yellownose voles

In 1994, yellownose voles used all habitats in proportion to availability, with the exception of the cleared habitat, which was used less than expected ($X^2 = 20.3$, df = 6, $p<0.05$) (Table 8).

In 1995 and 1996, no differences were observed between habitat use and availability for any of the habitats, as all were used in proportion to availability ($X^2 = 3.3$, df = 6, $p<0.05$) (Table 9).

Stomach content analysis

1. Items found in stomachs

Red-backed voles

The most commonly found item in the stomachs of red-backed voles was lichen (47.92 %), followed by unidentified material (16.91 %), and spores (14.94 %). Fungus, moss, and algae were also items in the diet of red-backed voles, but none occurred more than 7 % of the time (Table 10). No evidence of berry consumption was seen and herb species all occurred at a frequency of less than 1 %, with the exception of bunchberry leaves and leather leaf leaves. Arthropods were not commonly observed, occurring 0.6 % of the time.

Meadow voles

Aside from unidentifiable material, which occurred 21.78 % of the time, grasses were the most frequently encountered item in the diets of meadow voles, occurring 17.30 % of the time (Table 10). Moss, spores, *Equisetum* spp., and fungus were also

Table 8. Multiple Chi-square analysis with Bonferroni confidence intervals for habitat use by yellow-nose voles (*M. chrotorrhinus*) in 1994.

Habitat	Proportion Available	Proportion Used	Expected Use	Actual Use	Bonferroni lower limit	Bonferroni upper limit	Use
Disturbed with debris	0.13	0.23	6.11	11	0.068	0.400	=
Dense black spruce - Pleurozium	0.14	0.23	6.58	11	0.068	0.400	=
Cleared alder with shrubs	0.09	0.06	4.23	3	-0.032	0.160	=
Dense black spruce - Sphagnum - cranberry	0.19	0.30	8.93	14	0.118	0.477	=
Black spruce / Alder transition	0.13	0.11	6.11	5	-0.015	0.227	=
Clearings with debris and cranberry	0.10	0.04	4.70	2	-0.037	0.122	=
Cleared	0.22	0.02	10.34	1	-0.035	0.078	less

$\chi^2 = 20.31$; df=6, $p<0.05$

Table 9. Multiple Chi-square analysis with Bonferroni confidence intervals for habitat use by yellow-nose voles (*M. chrotorrhinus*) in 1995 and 1996 pooled.

Habitat	Proportion Available	Proportion Used	Expected Use	Actual Use	Bonferroni lower limit	Bonferroni upper limit	Use
Disturbed with debris	0.13	0.23	2.86	5	-0.013	0.468	=
Dense black spruce - Pleurozium	0.14	0.14	3.08	3	-0.060	0.333	=
Cleared alder with shrubs	0.09	0.09	1.98	2	-0.074	0.256	=
Dense black spruce - Sphagnum - cranberry	0.19	0.18	4.18	4	-0.039	0.403	=
Black spruce / Alder transition	0.13	0.14	2.86	3	-0.060	0.333	=
Clearings with debris and cranberry	0.10	0.09	2.2	2	-0.074	0.256	=
Cleared	0.22	0.14	4.84	3	-0.060	0.333	=

$\chi^2 = 3.34$; df=6, $p<0.05$

Table 10. Average percent occurence of vegetation in stomachs of three vole species. Values in parentheses indicate standard error of the mean.

Plant	*M. chrotorrhinus*	*M. pennsylvanicus*	*C. gapperi*
	n = 10	n = 10	n = 10
Leaves			
Blueberry leaf	14.01 (5.76)	7.17 (2.61)	0.11 (0.11)
Bunchberry leaf	8.50 (3.31)	7.51 (4.97)	1.36 (1.11)
Snowberry leaf	8.16 (5.16)	0.64 (0.54)	0.53 (0.32)
Rubus spp. leaf	7.89 (6.54)	0.16 (0.11)	0.05 (0.05)
Cranberry leaf	3.36 (1.28)	0 (0)	0.44 (0.36)
Canada Mayflower	0.61 (0.61)	0 (0)	0.36 (0.28)
Bog laurel	0.18 (0.18)	0 (0)	0 (0)
Goldthread	0.09 (.09)	0 (0)	0 (0)
Leather leaf	0 (0)	0 (0)	1.21 (1.21)
Grass leaf	2.31 (1.09)	17.30 (5.31)	0.39 (0.26)
Fruit			
Blueberry	2.67 (2.25)	2.09 (1.72)	0 (0)
Rubus spp. fruit	0 (0)	0.84 (0.84)	0 (0)
Unidentified berry	0.3 (0.21)	0 (0)	0 (0)
Ferns and Allies			
Equisetum spp.	7.29 (3.47)	9.59 (4.28)	0.14 (0.10)
Moss	16.74 (5.70)	14.06 (2.75)	5.52 (1.89)
Lichen	0 (0)	0.05 (0.05)	47.92 (9.72)
Fungus	0.77 (0.57)	6.68 (4.46)	6.11(5.05)
Algae	2.17 (1.52)	0 (0)	2.98 (2.68)
Other			
Seed	0 (0)	0 (0)	0.43 (0.31)
Spores	6.09 (3.41)	11.92 (5.37)	14.94 (6.13)
Arthropod	0.07 (0.07)	0.21 (0.21)	0.6 (0.57)
Unidentifiable material	18.8 (3.88)	21.78 (4.54)	16.91 (4.47)

observed at relatively high frequencies (14.06 %, 11.92 %, 9.59 %, and 6.68 %, respectively). Unlike red-backed voles, meadow voles ate blueberries (2.09 %) and raspberries (0.84 %), and also the leaves of blueberry (7.17 %) and bunchberry (7.51 %). No other herbs were found in frequencies greater than 1 %.

Yellownose voles

Aside from unidentified plant material (18.8 %), yellownose voles consumed a relatively high percentage of leaves (Table 10). Moss accounted for an average of 16.74 % of the contents, spores accounted for 6.09 %, *Equisetum* spp. occurred 7.29 % of the time, and algae, 2.17 % of the time. Leaves, with the exception of grass, occurred more frequently in the yellownose vole stomachs than the other voles. Blueberry leaves occurred 14.01 % of the time, followed by bunchberry, creeping snowberry, *Rubus* spp., and small cranberry (Table 10). Grass only occurred 2.31 % of the time.

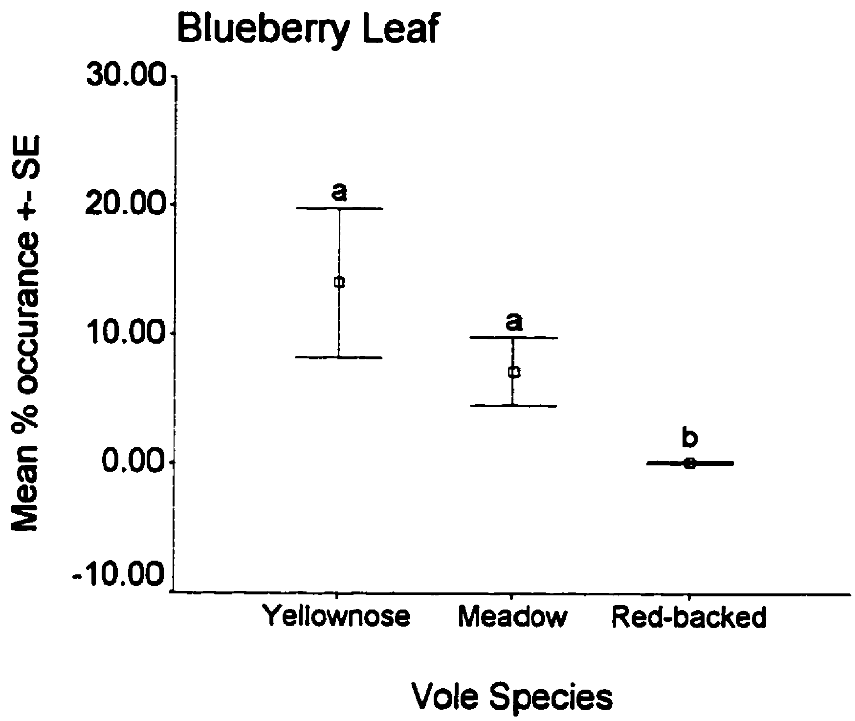
2. Differences in stomach contents between the three vole species

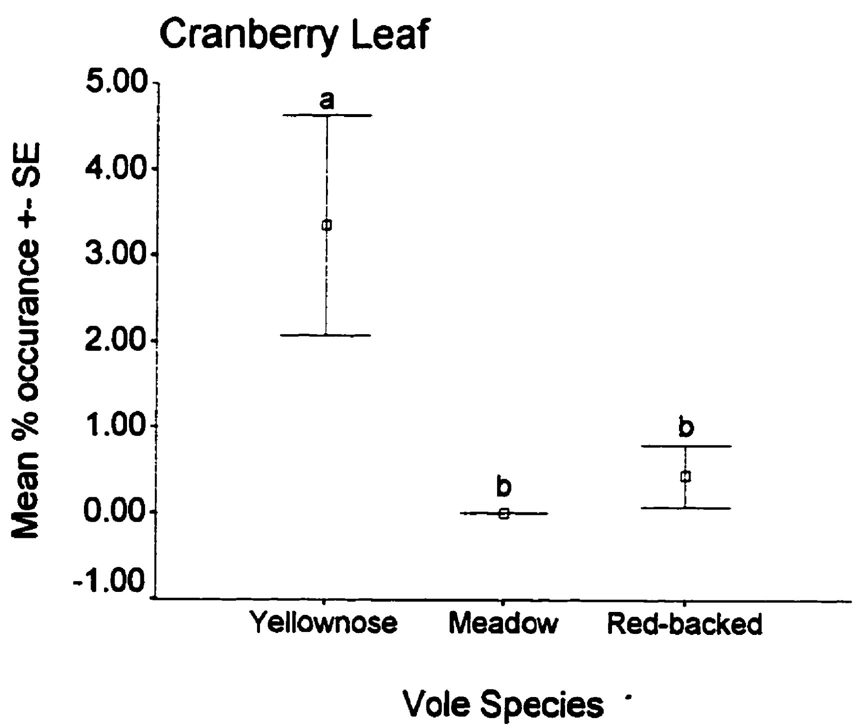
A Kruskal-Wallis non-parametric one-way analysis of variance showed significant differences between the three vole species for blueberry leaves, small cranberry leaves, *Rubus* spp. leaves, grasses, *Equisetum* spp., lichen, and seeds.

No significant differences were seen between yellownose voles and meadow voles for percentage of occurrence of blueberry leaves; however, red-backed voles had significantly smaller amounts of this plant in their stomachs, than the other two vole species ($X^2 = 11.6$, df = 2, $p<0.01$) (Figure 9a).

Figure 9. (a) Mean percent occurrence of blueberry leaves (*Vaccinium* spp.) in the stomachs of the three vole species. Bars indicate standard error of the mean and letters above bars indicate significant differences (X^2=11.67, df=2, p<0.01) (for each vole species n=10).

(b) Mean percent occurrence of cranberry leaves (*Vaccinium oxycoccus.*) in the stomachs of the three vole species. Bars indicate standard error of the mean and letters above bars indicate significant differences (X^2=13.5, df=2, p<0.01) (for each vole species n=10).


Blueberry Leaf
30.00
20.00
10.00
0.00
-10.00
Mean % occurance +- SE
a
a
b
Yellownose
Meadow
Red-backed
Vole Species


Cranberry Leaf
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
Mean % occurance +- SE
a
b
b
Yellownose
Meadow
Red-backed
Vole Species

Meadow voles and red-backed voles did not eat significantly different amounts of cranberry leaves. Yellownose voles, on the other hand, ate significantly more cranberry leaves than either of the other two species ($X^2 = 13.5$, df = 2, $p<0.01$) (Figure 9b).

Yellownose voles ate significantly more leaves from the cloudberry and raspberry family than red-backed voles, but not significantly more than meadow voles. Meadow voles and red-backed voles did not differ significantly in the consumption of *Rubus* spp. leaves ($X^2 = 7.2$, df = 2, $p<0.05$) (Figure 10a).

Meadow voles ate significantly more grasses than either yellownose voles or red-backed voles, which did not differ from each other in their own grass consumption ($X^2 = 14.6$, df = 2, $p<0.01$) (Figure 10b).

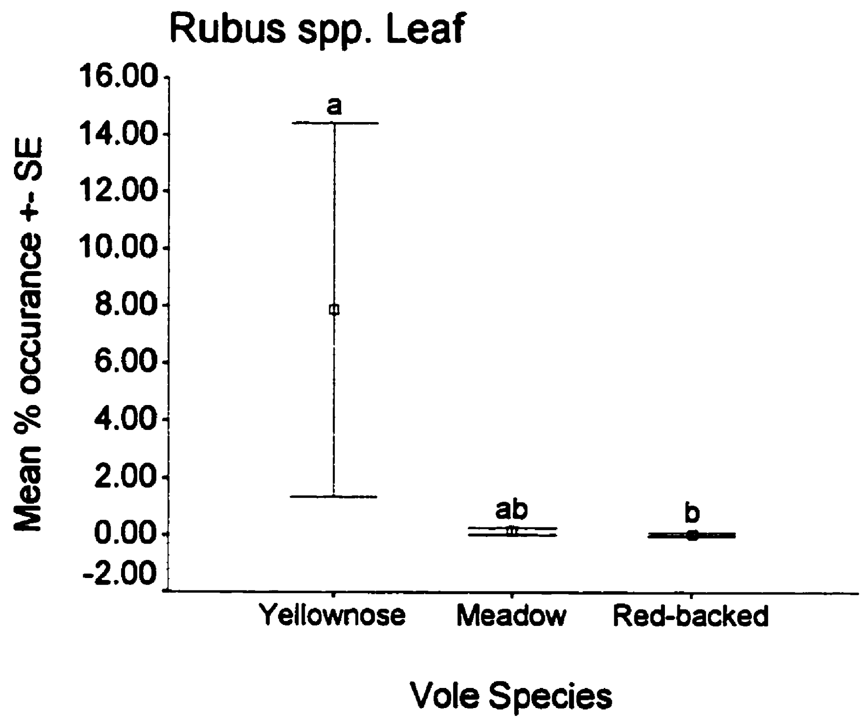
Both yellownose vole and meadow vole stomachs contained greater than 6% *Equisetum* spp., and these two species did not differ significantly in percent frequency of occurrence. Red-backed voles, on the other hand, consumed significantly less horsetail than either of the other vole species ($X^2 = 10.2$, df = 2, $p<0.01$) (Figure 11a).

The most abundant plant found in the stomachs of red-backed voles was lichen, which accounted for an average 47.92% of all contents (Table 10). This value was significantly higher than the average percent occurrence of lichen in either yellownose voles or meadow voles, neither of which differed from the other ($X^2 = 27.0$, df=2, $p<0.001$) (Figure 11b).

Finally, neither yellownose voles nor meadow voles consumed any seeds. Red-backed voles on the other hand, consumed significantly more seeds than either of the other two vole species ($X^2 = 6.7$, df = 2, $p<0.05$) (Figure 12).

Figure 10. (a) Mean percent occurrence of leaves from the raspberry family (*Rubus* spp.) in the stomachs of the three vole species. Bars indicate standard error of the mean and letters above bars indicate significant differences (X^2=7.2, df=2, $p<0.05$) (for each vole species n=10).

(b) Mean percent occurrence of grass leaves (Graminoids) in the stomachs of the three vole species. Bars indicate standard error of the mean and letters above bars indicate significant differences (X^2=14.65, df=2, $p<0.01$) (for each vole species n=10).


Rubus spp. Leaf
Mean % occurance +- SE
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
a
ab
b
Yellownose
Meadow
Red-backed
Vole Species

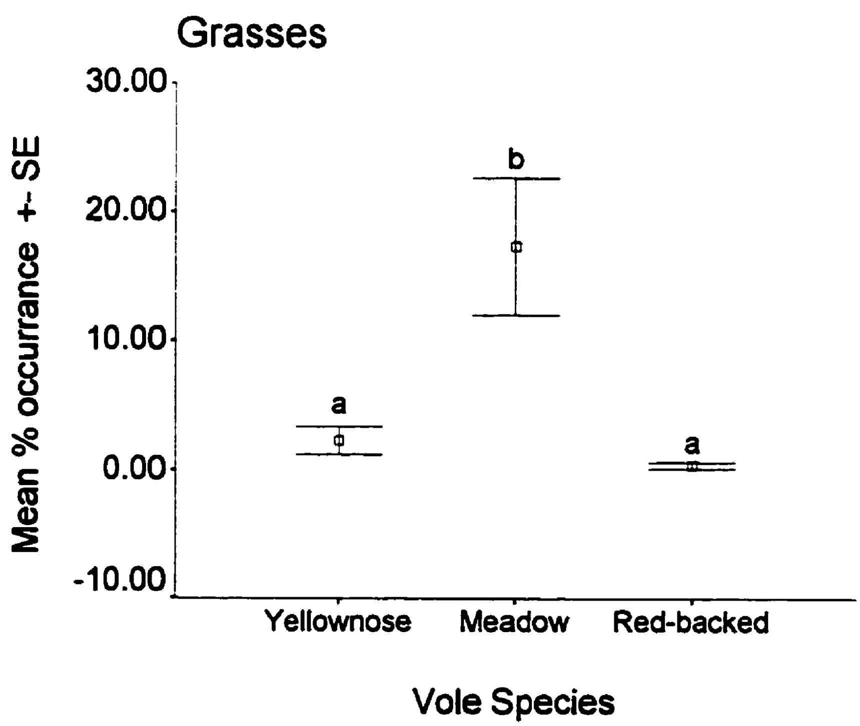
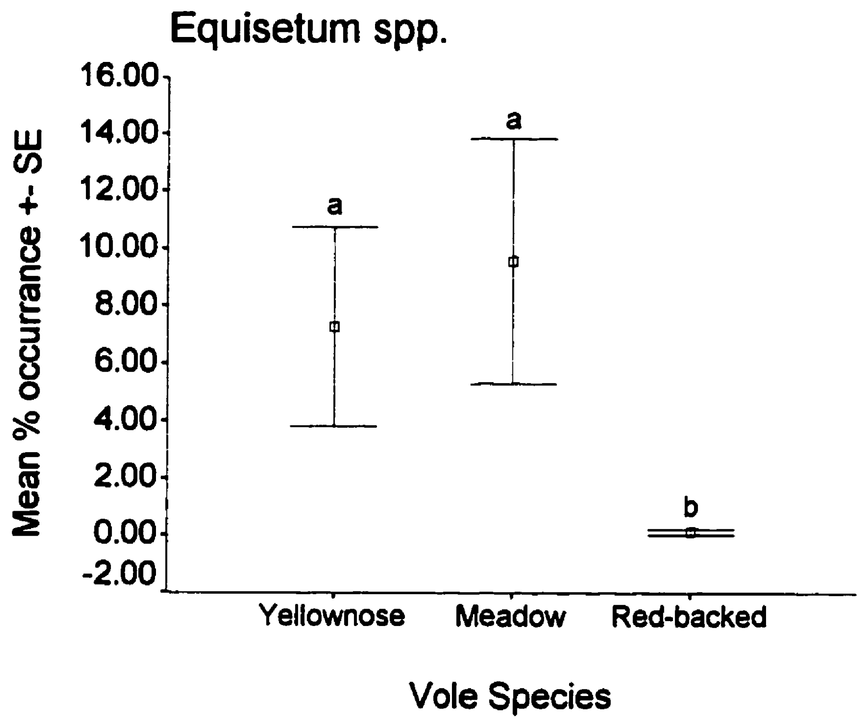
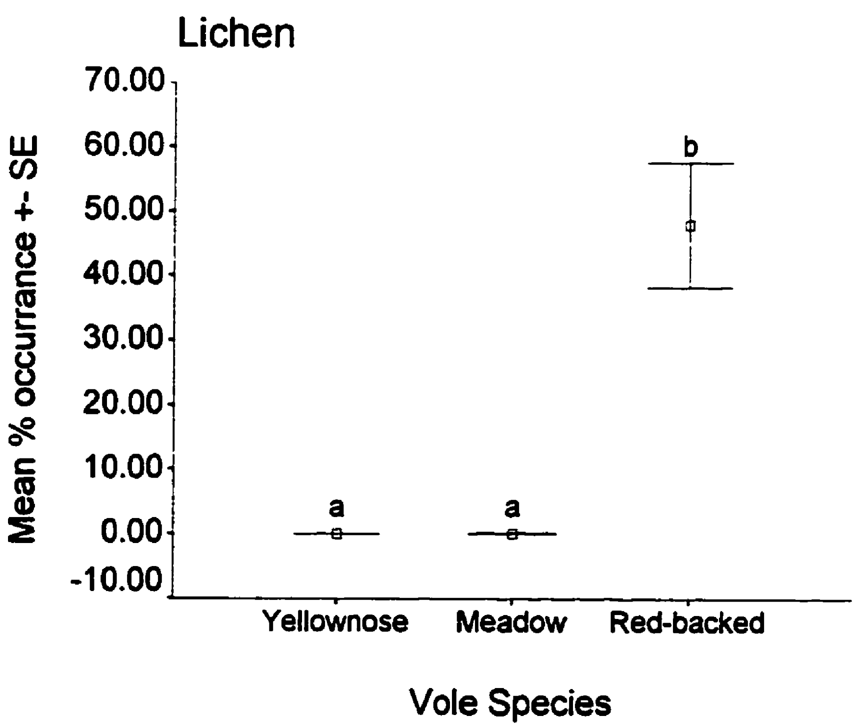

Grasses
Mean % occurrance +- SE
30.00
20.00
10.00
0.00
-10.00
b
a
a
Yellownose
Meadow
Red-backed
Vole Species

Figure 11. (a) Mean percent occurrence of horsetail (*Equisetum* spp.) in the stomachs of the three vole species. Bars indicate standard error of the mean and letters above bars indicate significant differences (X^2=10.18, df=2, $p<0.01$) (for each vole species n=10).

(b) Mean percent occurrence of lichen in the stomachs of the three vole species. Bars indicate standard error of the mean and letters above bars indicate significant differences (X^2=27.0, df=2, $p<0.001$) (for each vole species n=10).

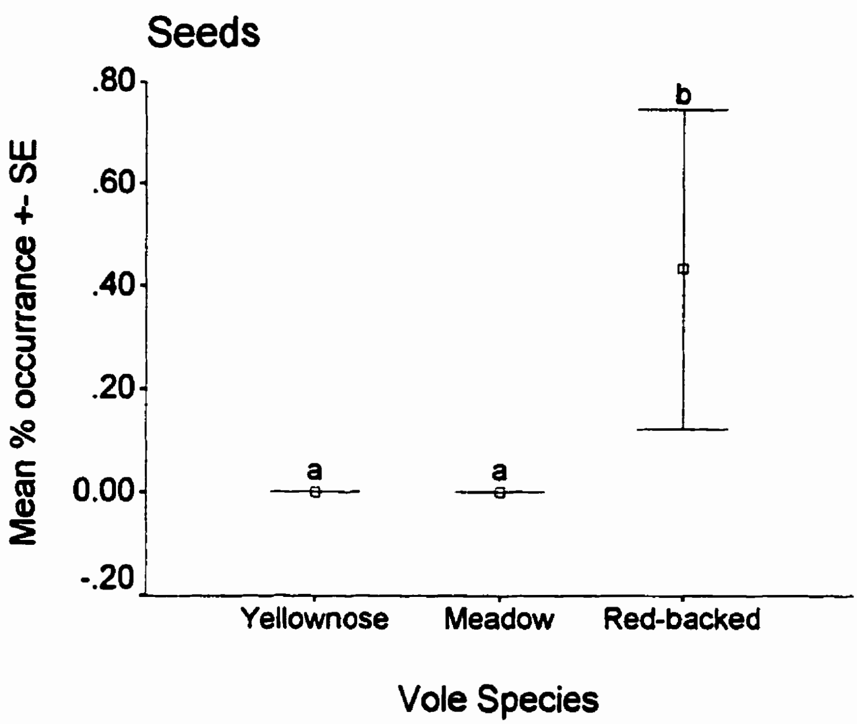


Equisetum spp.
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
Mean % occurrance +- SE
a
a
b
Yellownose
Meadow
Red-backed
Vole Species



Lichen
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
Mean % occurrance +- SE
b
a
a
Yellownose
Meadow
Red-backed
Vole Species

Figure 12. Mean percent occurrence of seeds in the stomachs of the three vole species. Bars indicate standard error of the mean and letters above the bars indicate significant differences (X^2=6.73, df=2, $p<0.05$) (for each vole species n=10).



Seeds
.80
.60
.40
.20
0.00
-.20
Mean % occurrance +- SE
a
a
b
Yellownose
Meadow
Red-backed
Vole Species

Discussion

Unlike meadow voles and red-backed voles, yellownose voles did not show any statistically consistent response either to logging treatment, or the habitats that resulted from the logging treatments. The smallest number of yellownose voles occurred in the clear-cut (Figure 7a), yet the mean number of animals caught in this site was not significantly different from the mean number of voles caught in the uncut forest, where numbers were highest (Figure 8a). In the pooled years of 1995 and 1996, there were no statistical differences in either habitat use or logging treatment response by yellownose voles (Figures 7b, 8b). Furthermore, yellownose voles ate primarily forb species, unlike meadow voles, that specialized on grasses, and red-backed voles, that specialized on fungus and lichen. It is important to note that the following suggestions are drawn only from data collected in black spruce - labrador-tea lowlands in Northeastern Ontario.

Habitat Use

Yellownose Voles

In Site Type 11 in Northeastern Ontario, yellownose voles did not use any habitats to a greater degree than the availability (Tables 8, 9). One possible explanation for this is that the dietary habits of yellownose voles might be influenced by the habitat in which they are found and they are adapted to eat a wide variety of forage items. Perhaps there is some factor other than food that is influencing choice of habitat. According to Getz (1961), the majority of small mammal studies on habitat usage consider only physical factors, such as temperature and moisture. He identified three biotic factors as having a potential impact on habitat use including food availability, plant cover, and competition.

Both cover and food supply have been considered through the analysis of the vegetation data. In 1994, yellownose voles used all habitats in proportion to availability, with the exception of the cleared habitat, which was used less than available (Table 8). The cleared habitat had absolutely no tree or shrub cover. Ground cover was dominated by moss (*Dicranum* spp.) and horsetail (*Equisetum* spp.), and bare ground was extensive (Table 3).

No differences in yellownose vole habitat use were seen in 1995 and 1996. This result implies that the importance of specific plant cover in these sites may be reduced in yellownose voles. The only site which completely lacked any form of cover was the completely cleared site. All other habitats had cover either from forbs, grasses and shrubs, or from slash or downed trees. Kirkland and Knipe (1979) noted that the majority of yellownose voles were found in similarly unexposed sites including; under logs, rocks, roots, or overhangs. Previous studies of yellownose vole populations indicated a strong association with rocks and talus slopes. Beuch *et al.* (1977) suggest that this association was related more to the plants that were found in rocky areas than because of the cover associated with the rocky terrain. Results from the present study suggest that yellownose voles require only limited cover, and that piles of logs and slash seem adequate.

Are yellownose voles specialized in their habitat use? The small range of habitats assessed make it difficult to say. D'Eon and Watt (1994) and Boos and Watt (1997) suggest that Site Type 11 is marginal habitat for these animals. Selection, then, may not be expressed in such marginal habitat. However, within Site Type 11, yellownose voles appeared to be less specialized in their habitat use than either red-backed voles or meadow voles. This conflicts with the theory suggested by Christian and Daniels (1985), who state that "it is clear that rock voles are much more specialized in their habitat selection than, for example, red-backed voles". Their habitat identification scale was similar to that of this investigation and based primarily on herb and shrub layer composition. It is possible that in marginal habitats, low numbers caused by yearly fluctuations were kept low by trapping. If this was the case, it may explain why yellownose vole numbers did not decline as sharply as the other vole species. Observations from field trapping indicated that yellownose voles may not have been as attracted to baited traps as the other vole species. Thus, yellownose vole numbers may have been less affected by the trapping. The less dramatic decrease of yellownose vole numbers compared to the other species may also suggest that yellownose voles were exploiting a variety of habitats that were previously occupied by red-backed voles or meadow voles (Figure 2). This suggestion is supported by the habitat use data, which indicated that yellownose voles utilize virtually all habitats in equal proportion to availability. This theory is supported also by a suggestion made by Kirkland (1977) that "if, as is suggested by their generally boreal distribution, [this] species [is a] Pleistocene relict, [it] may be adapted to surviving in variable, if not frequently disturbed, environments".

Is it the food supply that is influencing habitat use in yellownose voles? Stomach content analysis indicated that yellownose voles consumed more forbs and shrubs including blueberry, bunchberry, creeping snowberry, and raspberry than the other vole species. Moss was also consumed by these animals (Table 10). Red-backed voles ate mostly lichen (47.92 %) and very small amounts of the different herb species. Meadow voles ate large amounts of grass (17.30 %) followed by moss, fungus, and horsetail. Based on dietary habits, one would expect to find red-backed voles primarily in uncut forest areas and undisturbed habitats, where most lichen and fungus species would be found (Martell, 1981). Red-backed voles need more water and are thus restricted to moister habitats (Miller and Getz, 1977). Meadow voles eat the most commonly found plant in their major habitat, the sedge-grass clearing (Zimmerman, 1965). The question is: Either, do yellownose voles prefer a specific habitat based on food preferences, and in this investigation it happened that all habitats contained yellownose vole foods? Or, do yellownose voles select habitat based on another unstudied factor and they are not as specialized as red-backed voles or meadow voles in their dietary habits?

Standing or flowing water has been identified as an important habitat feature for yellownose voles (Kirkland and Knipe, 1979; Kirkland and Jannett, 1982). Standing pools of water were present in all habitat types, but were most abundant in the cleared habitat, which was used less than expected by yellownose voles. In this case, the confounding factor may have been the lack of plant cover, and the high level of disturbance in this site. Moist substrate has also been identified as an important feature in habitats where yellownose voles have been caught (Kirkland and Knipe, 1979; Christian and Daniels, 1985). Of all the habitats identified using the cluster analysis, the cleared habitat had the most disturbance, no tree cover, and the most exposure. This combined with scarified soil resulted in dried bare ground, and drying of any moss hummocks that survived disturbance. The only source of moisture is from small waterlogged ruts.

If yellownose voles do select habitats specifically, then it is important to determine what the key factors are. However, data collected in this study did not lead to any specific conclusions with respect to these factors. One difficulty in this study could have been the scale of habitat classification. If, based on cluster analysis, the habitat types were too small, perhaps the broader scale of site type used by Boos and Watt (1997) would be more appropriate and would identify significant differences. These workers found that Site Type 11 was an extremely poor habitat for yellownose voles, but found them to be most abundant in site types characterized by mixed- and hard-wood. They also found that yellownose voles showed a preference for forb-rich habitats, which supports the finding that yellownose vole diets are dominated by forbs. However, preferences would probably not have been expressed in a habitat that is marginal. If in this investigation, the habitat scale was too large, then microclimate factors may be the prime concern, although if yellownose voles occupy home ranges as large as red-backed voles (1.4 ha) (Banfield, 1974), it is unlikely that the habitat scale of this investigation was too large.

Yellownose vole associations with other microtines were not considered in depth for this study, and further research needs to address interactions and competition between *M. chrotorrhinus* and other species. It is possible to make inferences about behaviour in yellownose voles in this study, but laboratory studies are required. Red-backed voles have been found to dominate meadow voles, and exclude them from preferred forest habitats (Getz, 1985). Island meadow vole populations inhabit forested areas when red-backed voles are absent. In this case a preferred habitat is one with an abundance of cover, burrows, and food sources. It is also possible, that yellownose voles tend to be subordinate to red-backed voles. This would explain some of the population dynamics observed over the three years of the study. For example, if red-backed voles were dominant, then once their populations decreased, the yellownose voles could disperse into habitats previously occupied by this species. This may be why more yellownose voles were trapped in the heavy residual site in 1996, when in previous years the site was dominated by red-backed voles. By being less specific in their habitat requirements than red-backed voles, yellownose voles can adapt to less optimal habitats and avoid confrontation with red-backed voles. However, such a small sample, and possible affects of differential trapping of vole species, may be both contributing to variability. Timm *et al.* (1977) noted that one subadult male yellownose vole appeared to be dominant in interactions with three adult red-backed voles in the laboratory, but the sample size was four and his observations were not part of a study that was specifically investigating agonistic behaviours. Laboratory studies on aggression are useful for the researcher by making it easier to observe the interactions, but field studies should supplement this type of research. Animals respond differently in captivity, and this could alter their perception of, and reaction to, other animals. Further research needs to be undertaken to determine the nature of interactions between these species.

Thus, yellownose voles in Site Type 11 are less specialized in their habitat utilization than red-backed voles and meadow voles. In this study, they did not use any habitat type or logging treatment predictably, and were found wherever physical cover either as live plants or logging debris were present. Competition between yellownose voles and sympatric species may also affect habitat use by this animal.

Red-backed Voles

In 1994, habitat use in red-backed voles varied greatly between habitats. As expected, the voles utilized the dense black spruce habitats with both *Sphagnum* spp. and feathermoss more than expected based on the availability of the habitat (Tables 4, 5). Red-backed voles utilize habitats with moist soil where food items such as seeds, plant material, and fungi have relatively high moisture levels (Miller and Getz, 1977). This work supports the finding of the present study that red-backed voles used the cleared site less than its availability, in all probability, because this site is extremely dry, due to exposure and soil scarification. The only source of moisture in the cleared site is from flooded ruts surrounded by dry soil and hummocks. However, previous research that associates red-backed voles with wet forested sites was not entirely supported by these findings. In 1994, red-backed voles used very wet alder habitat less than available. Perhaps the sheer saturation of the cleared alder soils reduced the suitability of this habitat type. This habitat type was also recently disturbed, or cleared, which would decrease the availability of important foods such as lichen and fungus (Martell, 1981). The reason is that the reduction in cover produced by timber harvest results in great temperature fluctuations and hence a very inhospitable habitat for the establishment of these food plants (Martell, 1981). In 1995 and 1996, red-backed voles used the two driest and most open sites less than their availability (Table 5). These were disturbed with logging debris, and clear-cut. Again, the data support the findings of Miller and Getz (1977). This vole species used dense black spruce with *Sphagnum* spp. and cranberry more than available. as did the animals caught in 1994.

Red-backed voles used a narrow range of habitats in Site Type 11 compared to yellownose voles. The undisturbed black spruce habitats were used more than available. Further, very wet and very dry habitats that were disturbed were used less than available. These animals require habitats where food items such as fungus and lichen can be found.

Meadow Voles

Meadow voles utilized disturbed habitats in proportion to availability. This is because the early successional stages following a disturbance are characterized by an abundance of graminoid species, and a greater species richness than that seen in later successional stages (Kirkland, 1977; Poitras, 1996). This richness of herb layer vegetation such as grasses provides a great deal of dietary options for herbivorous small mammals such as meadow voles. Meadow voles used the dense black spruce habitats less than available presumably to both avoid competition with red-backed voles and because there are few graminoids in that habitat. Meadow voles in 1995 and 1996 avoided clearings with debris and cranberry, that were characteristic of heavy residual and some light residual corridors (Table 7). The reason for this remains unclear; however, it may be a result of low numbers of meadow voles in 1995 and 1996. The absence of meadow voles in these sites may have been due also to a low availability of grasses, the presence of red-backed voles, and numerous potential perches for avian predators.

Meadow voles utilized habitats with an abundance of graminoid vegetation, primarily because this the main forage plant for these animals.

It is important to note that the results of the habitat use data may underestimate actual responses to various habitats. This is especially true of the results from 1995 and 1996, when fewer animals were caught. A sample size of at least 20 is suggested for the Bonferroni test (Alldredge and Ratti, 1986), but in 1995 and 1996, only 12 meadow voles were caught. Thus, the population decline may have had an impact on the accuracy of the Bonferroni test. The availabilities of habitat types were estimated using the transect method which can lead to problems with the Chi-square analysis.

When the availability is not known but estimated, the probability of determining that selection for a habitat did occur (Type 1 error) is greater than considered desirable based on the level of significance (Thomas and Taylor, 1990). This would only be a problem with red-backed voles, because no other animals utilized any habitats greater than available. Also, no confidence intervals were calculated for meadow voles caught during 1995 and 1996 for three habitats, because none were found. This problem is not addressed in the literature, but I assumed that if none were caught there, the habitat was used significantly less than available.

Logging Treatment Responses

Yellownose Voles

In 1994, yellownose voles were significantly more abundant in the light residual than the clear-cut, but no differences were observed between numbers in the light residual site, heavy residual site, and uncut (Figure 8a). In 1995 / 1996, yellownose voles were most numerous in the light residual, but there were no statistically significant differences (Figures 7b, 8b). As with individual habitat use, yellownose vole responses to logging treatment most likely are a result of a combination of many factors, including food availability, cover, and competition. While the meadow voles responded positively to clear cutting, using the clear-cut significantly more than any other site, the red-backed voles did not, and instead used the uncut and heavy residual sites equally, but significantly more than the light residual or the clear cut. This left the light residual site with the least utilization by the small mammals. Perhaps the yellownose vole used this site to avoid competition with the other species. This site was adjacent to the uncut forest, and both the light residual and uncut were bisected by a small stream. The areas around the stream were dominated by alder, grasses, and members of the raspberry family. There also were numerous forb species in this site, which would have provided food for yellownose voles. The soil in these locations was wetter than in the more open areas, which supported frequent, dried sphagnum hummocks. The vegetative community around the stream was quite different from that of the surrounding areas, which prompted the aforementioned grouping of trap stations using the hierarchical cluster analysis. However, when considering the logging treatment alone, the light residual had a great deal of cover available in the form of logging debris and downed trees. Trap sites that had little vegetative cover had dried hummocks, with dried *Sphagnum* spp. and desiccated creeping snowberry plants. Yellownose voles were caught the most at these trap stations (stations 1 - 8), including juveniles, adult males, and pregnant females (Appendix 3). The difference between this barren site in the light residual and the clear cut site was the presence of logging debris whereas, the clear-cut had very little debris or other sources of cover. Yellownose voles in cutover black spruce can occupy areas with dried soil, and little vegetative cover, provided that they have cover in some form, either as shrubs or logging debris.

Red-backed Voles

In 1994, the heavy residual site was used by red-backed voles as much as the uncut site (Figure 4a). This was expected because red-backed voles are deep forest specialists, and their feeding habits reflect this. They consume lichen in the spring, herbaceous matter in the summer, and fungus and berries in the early fall (Martell, 1981). Kirkland (1977) found that red-backed vole abundance increased in response to clear-cutting in red spruce stands in the Appalachian forest of West Virginia. Kirkland asserts that the red-backed vole is responding positively to the increased herb layer cover that occurs as a result of clear-cutting. Kirkland also noted that this finding was not what was expected, because the normal habitat preference for red-backed voles was undisturbed forest. It is suggested that the presence of red-backed voles in a recent clear-cut would increase competitive interaction with meadow voles (Kirkland, 1977). However, Martell and Radvanyi (1977) found that red-backed voles responded poorly to clear-cutting in black spruce, and their numbers were greatest in uncut forests. In 1994, meadow voles were found significantly more in the clear-cut, light residual, and heavy residual sites than in the uncut forest (Figure 6a). In this investigation, red-backed voles were caught in significantly fewer numbers in the light residual site than the heavy residual or the uncut site. The smallest number of red-backed voles were caught in the clear-cut, with the difference being significant.

In 1995 and 1996, slight differences were noted in the responses of red-backed voles to cutting. They responded equally to the clear-cut and light residual, both having significantly fewer voles than the heavy residual, which had significantly fewer than the uncut (Figure 4b). This difference may be explained by the time frame of the investigation during which disturbed sites were undergoing changes owing to the reestablishment of vegetation. The cutoff for age related differences in habitats was 5 years for Kirkland's investigation (1977). That is, red-backed voles responded more positively after 5 years had elapsed since cutting. These changes are likely occurring in this study as well, because the sites were logged in 1992. With time, therefore, negative responses to clear cut and light residual sites may be reduced.

Red-backed voles were most numerous in the undisturbed site, and least numerous in the clear cut. These results were similar between the 1995 / 1996 and the 1994 data sets.

Meadow Voles

The number of meadow voles caught in the light residual in both 1994 and 1995 / 1996 was not significantly different from any other site (Figures 6a, b). One would expect that meadow voles would be most abundant in the clear-cut and the light residual sites, because these two sites were the most disturbed, with the largest amount of grasses and sedges. This result was found by Swan *et al.* (1984), where meadow voles were more abundant on clear cuts and strip cuts. Both sites had wet patches with *Sphagnum* spp., and sites with sedges and grasses were created as a result of the logging activity. Kirkland (1977) also found that meadow voles occurred only in coniferous sites that had been cut less than 5 years prior to the study. Both sample periods (1994 and 1995 / 1996) were similar in that significantly more meadow voles were trapped in the clear-cut than in the uncut forest. However in 1994, there was no significant difference between meadow vole numbers in the heavy residual and clear-cut site, where in 1995 and 1996, there were no differences between the heavy residual and uncut sites. It is possible that for 1995 / 1996 sampling period, the heavy residual site was recovering enough to reduce optimal habitat for meadow voles. That, combined with the avoidance of competition with red-backed voles may explain the changes in meadow vole responses to logging.

Meadow voles tended to be most numerous in the disturbed sites, and numbers were significantly reduced in the uncut forest sites for both 1995 / 1996 and 1994 data sets. This supports previous research stating that meadow voles inhabit sites with an abundance of grasses and sedges.

Implications, Limitations, and Recommendations for Further Research

Responses of small mammals to logging varies between forest types and animals respond differentially to cutting in deciduous and coniferous stands. For example, Kirkland (1977) found that yellownose voles responded differently to clear-cutting in deciduous and coniferous forests. Their numbers increased in coniferous clear-cuts and decreased in deciduous clear-cuts. Because forest types were not compared in the present study, any conclusions drawn about small mammal responses to cutting practices can only be made with respect to Northern Ontario lowland black spruce forests.

Clear-cutting results in a reduction of available habitat for red backed voles, and yellownose voles. Meadow voles respond favourably to the resulting lack of competition and increase in food in the clear-cut site. However, to maintain optimal habitat for all animals, a combination of different degrees of cutting is recommended. The light residual site is tolerable but not ideal for red-backed voles, which respond poorly to any form of cutting in Northern Ontario black spruce lowlands. Overall, yellownose voles responded favourably to careful cutting and were able to utilize light residual sites when populations were high, and exploited heavy residual sites when the numbers of other vole species had declined.

Trapping should continue for another 5 years to ensure that the decline is indeed a true cycle. To show this, 8 years of trapping in total would be sufficient. More stomachs should also be analyzed, and formal training should be required for all individuals doing microhistological observations (Holechek and Gross, 1982; Holechek *et al.*, 1982a). A larger sample size would allow the use of a Bonferroni test comparing actual vegetation use and availability. Such an approach may support the assertion that yellownose voles are specializing on forb species. Mirror studies should be undertaken in other Site Types to determine the effects of logging treatments on small mammal populations. It is important especially to investigate responses of yellownose voles to these treatments, because knowledge of the species should be as extensive as it is for meadow and red-backed voles. Furthermore, behavioural studies of yellownose voles are needed. For instance radio tracking in summer and winter would shed light on habitat use, seasonal variability, and home range sizes. Most importantly, studies considering competitive interactions between yellownose voles and red-backed voles, and meadow voles should be undertaken. All of these animals have been found in sites containing yellownose voles, and the impact and importance of competitive behaviours could explain some of the findings in this study.

Summary

In lowland black spruce stands in Northeastern Ontario, yellownose voles appear less specialized in their habitat requirements than either red-backed voles or meadow voles, but all three vole species appear to be specialized in their dietary habits. Red-backed voles utilized dense black spruce forests, and meadow voles use cleared habitats with graminoids. Yellownose voles did not use any sites more or less than their availability, with the exception of the completely cleared habitat, which they used less than available. Yellownose voles ate primarily forb species, red-backed voles ate primarily lichen and fungus, and meadow voles ate mostly grasses. Finally, meadow voles and red-backed voles are relatively predictable in their responses to logging. Meadow voles respond positively and red-backed voles responded negatively, preferring the uncut forest. Yellownose voles showed varying responses to logging, and showed no real pattern in their use of various logging treatments. In 1995 and 1996, yellownose voles used all sites equally.

Yellownose voles are able to exploit disturbed sites and it is possible that the presence of other vole species, combined with a lack of physical cover may be limiting factors in their distribution. Another common name used for the yellownose vole is the rock vole, because previous research has indicated that rocks, boulders, and talus slopes are important habitat features of this species. In this study, it is possible that piles of logging debris took the place of rocks, providing cover in habitats that seemed otherwise inhospitable.

Data from 1994 showed that the clear-cut site in this study had significantly fewer yellownose voles than the light residual site. There should be some residual left after cutting to protect the soil from desiccation and allow forbs to establish themselves. The minimal amount of residual forest should be no less than that represented by the light residual site. It is also recommended that piles of logging debris be left to provide cover for these voles.

Yellownose voles may not be as rare or specialized in habitat requirements as once thought and reproductive populations do exist in Site Type 11 (black spruce lowlands) in Northeastern Ontario. A species that is as integral to the small mammal community as the yellownose vole should most certainly be better understood. More research is required to shed knowledge upon this enigma of the slash pile.

Literature Cited

Alldredge, J. R., and J. T. Ratti. 1986. Comparison of some statistical techniques for analysis of resource selection. Journal of Wildlife Management 50(1): 157-165.

Ambrose III, H. W. 1973. An experimental study of some factors affecting the spatial and temporal activity of *Microtus pennsylvanicus*. Journal of Mammalogy 54(1): 79-110.

Amiro, B. D., and G. M. Courtin. 1981. Patterns of vegetation in the vicinity of an industrially disturbed ecosystem, Sudbury, Ontario. Canadian Journal of Botany 59(9): 1623-1639.

Banfield, A. W. S. 1974. The mammals of Canada. University of Toronto Press, Toronto. 439 pp.

Batzli, G. O. and C. Lesieutre. 1995. Community organization of arvicoline rodents in northern Alaska. Oikos 72: 88-98.

Boos, J. D., and W. R. Watt, 1997. Small mammal habitat associations in the Lake Abitibi Model Forest of northeastern Ontario. OMNR, Northeast Science and Technology. TR-030. 48 pp.

Buech, R. R., R. M. Timm, and K. Siderits. 1977. A second population of rock voles, *Microtus chrotorrhinus*, in Minnesota with comments on habitat. Canadian Field-Naturalist 91(4): 413-414.

Burt, W. H., and R. P. Grossenheider. 1980. A Field Guide to the Mammals. Houghton Mifflin Company. U.S.A. 289 pp.

Chapman, J. A. and G. A. Feldhamer, 1982. Wild Mammals of North America. The Johns Hopkins University Press. 1147 pp.

Christian, D. P., and J. M. Daniels. 1985. Distributional records of Rrock voles, *Microtus chrotorrhinus*, in northeastern Minnesota. Canadian Field-Naturalist 99(3): 356-359.

D'Eon, R.G. and Watt, W.R. 1994. A forest habitat suitability matrix for northeastern Ontario. OMNR, Northeast Science and Technology. TM004. 83 pp.

Etnier, D. A. 1989. Small mammals of the Boundary Waters Canoe Area, with a second Minnesota record for the heather vole, *Phenacomys intermedius*. Canadian Field-Naturalist 103(3): 353-357.

Getz, L. L. 1961. Factors influencing the local distribution of *Microtus* and *Synaptomys* in southern Michigan. Ecology 42(1): 110-119.

Getz, L. L. 1985. Habitats. Pg. 286-309. *In* Biology of New World *Microtus*. Robert H. Tamarin (ed.). The American Society of Mammalogists, Special Publication No. 8.

Goodwin, G. G. 1929. Mammals of the Cascapedia Valley, Quebec. Journal of Mammalogy 10: 239-246.

Herman, T. B. 1977. Activity patterns and movements of subarctic voles. Oikos 29: 434-444.

Holechek, J. L., and B. Gross. 1982. Training needed for quantifying simulated diets from fragmented range plants. Journal of Range Management. 35(5): 644-648.

Holechek, J. L., B. Gross, S. M. Dabo, and T. Stephenson. 1982a. Effects of sample preparation, growth stage, and observer on microhistological analysis of herbivore diets. Journal of Wildlife Management 46(2): 502-505.

Holechek, J. L., M. Vavra, and R. D. Pieper. 1982b. Botanical compostition determination of range herbivore diets - a review. Journal of Range Management 35(3): 309-315.

Kirkland, G. L., Jr. 1977. Responses of small mammals to the clearcutting of northern Appalachian forest. Journal of Mammalogy 58(4): 600-609.

Kirkland, G. L. Jr., and Frederick J. Jannett Jr. 1982. Mammalian Species: *Microtus chrotorrhinus*. Mammalian Species 180: 1-5.

Kirkland, G. L. Jr., and C. M. Knipe. 1979. The rock *vole (Microtus chrotorrhinus*) as a transition zone species. Canadian Field - Naturalist 93(3): 319 - 321.

Kirkland, G. L. Jr. , and D. F. Schmidt. 1982. Abundance, hatibat, reproduction, and morphology of forest-dwelling small mammals of Nova Scotia and Southeastern New Brunswick. Canadian Field - Naturalist 96(2): 156-162.

Krebs, C. J., and I. Wingate. 1976. Small mammals communities in the Kluane region, Yukon Territory. Canadian Field - Naturalist 90(4): 379-389.

Krebs, C. J. 1996. Population cycles revisited. Journal of Mammalogy 77(1): 8-24.

Krohne, D. T. 1998. General Ecology. Wadsworth Publishing Company, Toronto. 722 pp.

Lawrence, S. W. 1996. Demographic changes in small mammal populations on black spruce peatlands impacted by clearcut and careful-cut forest management practices. M.Sc. thesis, Laurentian University. Sudbury. 157pp.

MacDonell, M. R., and A. Groot. 1997. Harvesting peatland black spruce: Impacts on advance growth and site disturbance. The Forestry Chronicle 73(2): 249-255.

Martell, A. M. 1981. Food habits of southern red-backed voles (*Clethrionomys gapperi*) in northern Ontario. Canadian Field - Naturalist 95(3): 325-328.

Martell, A. M. 1983a. Demography of southern red-backed vo'es (*Clethrionomys gapperi*) and deer mice (*Peromyscus maniculatus*) after logging in north-central Ontario. Canadian Journal of Zoology 61: 958-969.

Martell, A. M. 1983b. Changes in small mammal communities after logging in north-central Ontario. Canadian Journal of Zoology 61: 970-980.

Martell, A. M. 1984. Changes in small mammal communities after fire in northcentral Ontario. Canadian Field - Naturalist 98(2): 223-226.

Martell, A. M., and A. Radvanyi. 1977. Changes in small mammal populations after clearcutting of northern Ontario black spruce forest. Canadian Field - Naturalist 91:41-46.

McCarthy, T. G., R. W. Arnup, J. Nieppola, B. G. Merchant, K. C. Taylor, and W. J. Parton. 1994. Field Guide to Forest Ecosystems of Northeastern Ontario. OMNR, Northeast Science and Technology. FG-001. 219 pp.

M'Closkey, R. T., and B. Fieldwick. 1975. Ecological separation of sympatric rodents (*Peromyscus* and *Microtus*). Journal of Mammalogy 56: 119-129.

Miller, D. H., and L. L. Getz. 1977. Factors influencing local distribution and species diversity of forest small mammals in New England. Canadian Journal of Zoology 55: 806-814.

Nagorsen, D. W., and R. L. Peterson. 1981. Distribution, abundance, and species diversity of small mammals in Quetico Provincial Park, Ontario. Le Naturaliste Canadien - Revue d'écologie et de systématique 108(3): 209-218

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization - availability data. Journal of Wildlife Management 38(3): 541-545.

Pasitschniak-Arts, M. and J. Gibson. 1989. Distribution and abundance of small mammals in Lake Superior Provincial Park, Ontario. Canadian Field - Naturalist 103(1): 70-74.

Poitras, A. A. 1996. The impact of careful logging on the floristic composition of black spruce, *Picea mariana* (Mill.) B.S.P., stands of the Lake Abitibi Model Forest. B.Sc. (Hons.) thesis. Laurentian University, Sudbury. 36 pp.

Rohner, C., J. N. M. Smith, J. Stroman, M. Joyce, F. I. Doyle, R. Boonstra. 1995. Northern hawk-owls in the nearctic Boreal Forest : prey selection and population consequences of multiple prey cycles. The Condor 97: 208-220

Rose, R. K., and E. C. Birney. 1985. Community Ecology. Pg. 310-335. *in* Biology of New World *Microtus*. Robert H. Tamarin (ed.). The American Society of Mammalogists, Special Publication No. 8.

Snyder, L. L. 1942. Mammals of the Sault Ste. Marie Region. Transactions of the Royal Canadian Institute 51: 105-120.

Swan, D., B. Freedman, and T. Dilworth. 1984. Effects of various hardwood forest management practices on small mammals in Central Nova Scotia. Canadian Field-Naturalist 98(3): 362-364.

Thomas, D. L., and E. J. Taylor. 1990. Study designs and tests for comparing resource use and availability. Journal of Wildlife Management 54(2): 322-330.

Timm, R. M., L. R. Heaney, and D. Day Baird. 1977. Natural history of Rock Voles (*Microtus chrotorrhinus*) in Minnesota. Canadian Field-Naturalist 91: 177-181.

Whitaker Jr., J. O., Jr. and R. L. Martin. 1977. Food habits of *Microtus chrotorrhinus* from New Hampshire, New York, Labrador, and Quebec. Journal of Mammalogy 58: 99-100.

Williams, O., and B. A. Finney. 1964. *Endogone* - food for mice. Journal of Mammalogy 45(2): 265-271

Zar, J. H. 1984. Biostatistical Analysis - second edition. Prentice Hall, Inc., New Jersey. 718 pp.

Zimmerman, Earl G. 1965. A comparison of habitat and food of two species of *Microtus*. Journal of Mammalogy 46(4): 605-612.

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Balsam Fir *Abies balsamea*	Black Spruce *Picea mariana*	Bunchberry *Cornus canadensis*	Cloudberry *Rubus chamaemorus*	Confetti Moss *Mnium spp.*	Snowberry *Gaultheria hispidula*	Wood	Debris	Dominant Peat Moss *Dominant Sphagnum*
1	.0	.0	.3	.0	.0	1.0	31.7	.0	.0
2	.0	.0	.2	.0	.0	2.5	30.0	.0	.0
3	.0	.5	.0	.0	.0	.7	42.5	.0	.0
4	.0	.0	.0	.0	.0	.3	30.0	.0	.0
5	.0	.0	.0	1.0	.0	1.2	14.2	.0	9.2
6	.0	.0	.0	.5	.0	.5	45.0	31.7	10.2
7	.0	.2	.0	.0	.0	.8	3.3	20.8	29.3
8	.2	.3	.0	1.2	.0	3.5	12.5	10.8	50.0
9	.2	.2	.5	.2	.0	.7	48.3	32.5	23.7
10	.3	.3	.7	.0	.0	2.0	25.0	3.3	53.3
11	.0	.3	1.2	.5	.0	1.5	30.8	18.3	31.8
12	.0	.3	1.0	1.0	.0	.7	16.7	16.7	36.7
13	.0	.2	.2	.5	.0	.2	31.7	15.8	23.3
14	.0	.2	.0	.0	.0	.0	35.0	25.0	.0
15	.0	.0	.5	3.0	.0	1.5	25.0	45.8	16.0
16	.2	.0	.0	.0	.0	2.0	35.5	35.0	10.8
17	.0	.0	6.7	.7	.0	1.0	25.8	30.0	5.0
18	.0	.5	1.2	.0	.0	.7	11.7	21.7	22.3
19	.0	.0	.0	.0	.0	.0	43.3	32.5	2.0
20	.0	.0	.0	.0	.0	.0	16.7	71.7	.0
21	.0	.2	1.2	.0	.0	3.0	17.5	57.5	11.8
22	.0	.3	.8	.2	.0	.8	26.7	30.8	24.2
23	.2	.0	.0	.0	.0	.0	20.5	43.3	33.8
24	.0	.2	2.3	.0	.0	1.2	13.3	21.7	52.5
25	.0	.0	.0	.0	.0	.2	28.3	45.0	.5
26	.0	.3	.7	.0	.0	1.0	.0	.0	.0
27	.0	.0	.0	.0	.0	.8	1.7	.0	.0
28	.0	.0	.0	.5	.0	.7	.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Total Peat Moss *Total Sphagnum*	Soil	Fireweed *Epilobium angustifolium*	Goldthread *Coptis trifolia*	Juniper Hair-Cap Moss *Polytrichum juniperinum*	Naked Mitrewort *Mitella nuda*	Water	Fragrant Bedstraw *Galium triflorum*	Northern Commandra *Geocaulon lividum*
1	.0	.0	.0	.0	.0	.0	.0	.0	.3
2	.0	.0	.0	.0	.0	.0	.0	.0	.0
3	.0	.0	.0	.0	.0	.0	.0	.0	.0
4	.0	.0	.0	.0	.0	.0	.0	.0	.0
5	.0	.0	.0	.0	.0	.0	.0	.0	.0
6	.0	.0	.0	.0	.0	.0	.0	.0	.0
7	.0	.0	.0	.0	.0	.0	.0	.0	.0
8	66.7	.3	.0	.0	.0	.0	.0	.0	.0
9	23.7	.0	.0	.0	.0	.0	.0	.0	.0
10	60.0	.0	.0	2.0	.0	.0	.8	.0	.0
11	40.2	.8	.0	.2	.2	.0	9.5	.0	.0
12	42.5	18.0	.0	.0	.2	.0	.0	.0	.0
13	25.0	.2	.0	.0	.2	.0	.0	.0	.0
14	.0	7.5	.0	.0	.0	.0	.0	.0	.0
15	17.7	10.8	.0	.0	.0	.0	.0	.0	.0
16	11.7	.8	.0	.2	.0	.0	.0	.0	.0
17	6.7	16.7	.0	.0	.2	2.8	.0	.0	.0
18	25.3	17.5	.0	.0	.0	.0	.0	.0	.0
19	2.5	7.5	.0	.0	.0	.0	.0	.0	.0
20	.0	12.5	.0	.0	.0	.0	.0	.0	.0
21	11.8	10.0	.0	.0	.2	.0	.0	.0	.0
22	31.7	9.2	1.7	.7	.5	.0	4.2	.0	.0
23	33.8	1.7	.0	.0	.0	.8	5.8	2.7	.0
24	58.3	.0	.0	.5	.0	.3	1.0	.0	.0
25	.5	5.0	.0	.0	.0	.0	.0	.0	.0
26	86.7	.0	.0	.0	.0	.0	.0	.0	.0
27	84.2	.0	.0	.0	.2	.0	.0	.0	.0
28	17.3	.0	.0	.0	.0	.0	.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Interrupted Club Moss *Lycopodium annotinum*	Oak Fern *Gymnocarpium dryopteris*	Ostrich Plume Moss *Ptilium crista-castrensis*	Red Stem Moss *Pleurozium schreberi*	Shinleaf *Pyrola elliptica*	Small Cranberry *Vaccinium oxycoccus*	Field Horsetail *Equisetum arvense*
1	.0	.0	.7	53.3	.0	.0	.0
2	.0	.0	.5	30.5	.0	.0	.0
3	.0	.0	.3	25.0	.0	.0	.0
4	.0	.0	.3	20.3	.0	.0	.0
5	.0	.0	.0	37.5	.0	.3	.0
6	.0	.0	.8	7.8	.0	.3	.0
7	.0	.0	.0	26.8	.0	.7	.0
8	.0	.0	.2	12.0	.0	.5	.0
9	.0	.0	.5	5.2	.0	.5	.0
10	.0	.0	.0	8.0	.0	.8	.0
11	1.2	.8	.3	4.2	.0	.2	.0
12	.2	.0	.0	7.2	.0	.7	.0
13	.5	.0	.2	21.3	.0	.0	.0
14	.0	.0	1.2	32.5	.0	.0	.0
15	.0	.0	.2	3.7	.0	.7	.0
16	1.0	.0	.0	8.3	.0	.0	.0
17	.0	.0	1.2	8.3	.0	.2	.0
18	.0	.0	.0	17.2	.0	.3	.0
19	.0	.0	.2	8.3	.0	.0	.0
20	.0	.0	.0	2.2	.0	.0	.0
21	.0	.0	.0	3.0	.0	.0	.0
22	.0	.0	.0	1.8	.0	.0	.0
23	.0	.2	.2	.0	.0	.0	.0
24	.0	.3	.2	5.0	.0	.0	.0
25	.0	.0	.0	30.2	.0	.0	.0
26	.0	.0	.0	3.7	.0	.7	.0
27	.0	.0	.2	8.0	.0	.7	.0
28	.2	.0	.0	68.0	.0	.5	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Starflower *Trientalis borealis*	Speckled Alder (<15cm) *Alnus rugosa*	Step moss *Holocomium splendens*	Roundleaved Sundew *Drosera rotundifolia*	Strawberry *Fragaria virginiana*	Sweet Coltsfoot *Petasites frigidus*	Three-Leaved Smilacina *Smilacina canadensis*
1	.0	.0	.0	.0	.0	.0	.7
2	.0	.0	.0	.0	.0	.0	.0
3	.0	.0	.0	.0	.0	.0	.0
4	.0	.0	.0	.0	.0	.0	.0
5	.0	.0	.0	.0	.0	.0	1.0
6	.0	.0	.0	.0	.0	.0	.2
7	.0	.0	.0	.0	.0	.0	.3
8	.0	.0	.0	.0	.0	.0	.2
9	.0	.0	.0	.0	.0	.0	.0
10	.0	.3	1.7	.0	.0	.0	.0
11	.0	.0	.2	.0	.0	.0	.5
12	.0	.0	.0	.0	.0	.0	.2
13	.0	.0	.0	.0	.0	.0	.0
14	.0	.0	.0	.0	.0	.0	.0
15	.0	.0	.0	.0	.0	.0	.0
16	.0	.0	5.0	.0	.0	.0	.0
17	.2	.0	.3	.0	.0	.0	2.8
18	.0	.0	.0	.0	.0	.0	.0
19	.0	.0	.0	.0	.0	.0	.0
20	.0	.0	.0	.0	.0	.0	.0
21	.0	.0	.0	.0	.0	.0	.0
22	.0	.0	.0	.0	.0	.0	.2
23	.0	.0	.0	.0	.0	.0	.0
24	.2	.0	1.7	.0	.0	.0	.5
25	.0	.0	.0	.0	.0	.0	.0
26	.0	.0	.0	.0	.3	.0	.0
27	.0	.0	.0	.0	.0	.0	.0
28	.0	.0	.0	.0	.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Twinflower *Linnea borealis*	Heart-Leaved Twayblade *Listera cordata*	Violet *Viola sp.*	Wood anenome *Anemone quinquefolia*	Woodland Horsetail *Equisetum sylvaticum*	Blue Bead Lily *Clintonia borealis*	Smaller Enchanter's Nightshade *Circaea alpina*	Cattail *Typha sp.*
1	.0	.0	.0	.0	.0	.0	.0	.0
2	.3	.0	.0	.0	.0	.0	.0	.0
3	.0	.0	.0	.0	.2	.0	.0	.0
4	.0	.0	.0	.0	.3	.0	.0	.0
5	.0	.0	.0	.0	.2	.0	.0	.0
6	.0	.0	.0	.0	.2	.0	.0	.0
7	.0	.0	.0	.0	.2	.0	.0	.0
8	.0	.0	.0	.0	1.0	.0	.0	.0
9	.0	.0	.0	.0	.2	.0	.0	.0
10	1.0	.0	2.0	.0	1.7	.0	.0	.0
11	.2	.0	.2	.0	.3	.0	.0	.0
12	.0	.0	.0	.0	.8	.0	.0	.0
13	.0	.0	.0	.0	1.8	.0	.0	.0
14	.0	.0	.0	.0	.0	.0	.0	.0
15	.0	.0	.0	.0	.5	.0	.0	.0
16	.0	.0	.7	.0	.7	1.3	.0	.0
17	.8	.0	.0	.0	2.3	.0	.0	.0
18	.2	.0	.0	.0	3.2	.0	.0	.0
19	.0	.0	.0	.0	.3	.0	.0	.0
20	.0	.0	.0	.0	.2	.0	.0	.0
21	.0	.0	.0	.0	.7	.0	.0	.0
22	.2	.0	.0	.0	.0	.3	.0	.0
23	.0	.0	11.2	.0	.0	.0	.0	.0
24	1.0	.0	.0	.0	2.5	.2	.0	.0
25	.0	.0	.0	.0	.0	.0	.0	.0
26	.0	.0	.0	.0	.3	.0	.0	.0
27	.0	.0	.0	.0	.3	.0	.0	.0
28	.0	.0	.0	.0	.0	.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Rush *Luzula parviflora*	Fowl Manna Grass *Glyceria striata*	Wool-grass *Scirpus cyperinus*	Quack Grass *Agropyron repens*	Cow Wheat *Melampyrum lineare*	Cottongrass *Eriophorum spissum*	Dandelion *Taraxacum officinale*	Leave Strip	Corridor
1	.0	.0	.0	.0	.0	.0	.0	.0	100.0
2	.0	.0	.0	.0	.0	.0	.0	.0	100.0
3	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
4	.0	.0	.0	.0	.0	.0	.0	100.0	.0
5	.0	.0	.0	.0	.0	.0	.0	83.3	16.7
6	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
7	.0	.0	.0	.0	.0	.0	.0	83.3	16.7
8	.0	.0	.0	.0	.0	.0	.0	16.7	83.3
9	.0	.0	.0	.0	.0	.0	.0	33.3	66.7
10	.0	.0	.0	.0	.0	.0	.0	100.0	.0
11	.0	.0	.0	.0	.0	.0	.0	.0	100.0
12	.0	.0	.0	.0	.0	.0	.0	.0	100.0
13	.0	.0	.0	.0	.0	.0	.0	100.0	.0
14	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
15	.0	.0	.0	.0	.0	.0	.0	100.0	.0
16	.0	.0	.0	.0	.0	.0	.0	100.0	.0
17	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
18	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
19	.0	.0	.0	.0	.0	.0	.0	16.7	83.3
20	.0	.0	.0	.0	.0	.0	.0	66.7	33.3
21	.0	.0	.0	.0	.0	.0	.0	83.3	16.7
22	.0	.0	.0	.0	.0	.0	.0	100.0	.0
23	.0	.0	.0	.0	.0	.0	.0	100.0	.0
24	.0	.0	.0	.0	.0	.0	.0	100.0	.0
25	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
26	.0	.0	.0	.0	.0	.0	.0	100.0	.0
27	.0	.0	.0	.0	.0	.0	.0	100.0	.0
28	.0	.0	.0	.0	.0	.0	.0	100.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Sedges *Carex sp.*	Dicranum moss *Dicranum*	Grasses	Liverworts	Unidentified Herbs
1	.00	3.00	.00	.00	.0
2	.00	.50	.00	.17	.0
3	.00	1.00	.00	.50	.0
4	.17	.33	.00	.17	.0
5	.17	.17	.17	.00	.0
6	.00	.33	.00	1.17	.0
7	.00	.00	.00	3.33	.0
8	.00	.17	.00	.50	.0
9	.00	.17	.00	.33	.0
10	.33	1.50	1.17	.00	2.2
11	.00	.33	3.17	.00	4.3
12	.00	.33	2.00	.00	.0
13	.00	.00	.00	7.17	.8
14	.00	.33	.00	4.33	.0
15	.00	.00	.00	.83	.0
16	.17	.33	.33	.00	.0
17	.00	8.33	.00	.00	.8
18	.00	.00	.00	8.33	.0
19	.00	.17	.00	1.67	.3
20	.00	.33	.00	1.17	.2
21	.00	.17	.00	.17	1.0
22	.00	.00	.00	.00	.5
23	.00	.00	.17	.00	8.7
24	.33	.00	4.33	.00	.8
25	.00	.17	.00	1.67	.0
26	.00	.00	.00	.00	.0
27	.00	.00	.00	.00	.0
28	.00	.17	.00	1.17	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Balsam Fir *Abies balsamea*	Black Spruce *Picea mariana*	Bunchberry *Cornus canadensis*	Cloudberry *Rubus chamaemorus*	Confetti Moss *Mnium spp.*	Snowberry *Gaultheria hispidula*	Wood	Debris	Dominant Peat Moss *Dominant Sphagnum*
29	.0	.0	.2	.2	.0	.8	.0	.0	.0
30	.0	.2	.5	.5	.0	1.0	.0	.8	24.2
31	.0	.0	.7	.0	.0	8.5	13.7	1.7	.0
32	.2	.7	.5	.0	.0	1.3	5.8	9.2	42.5
33	.0	.0	.0	.0	.0	.0	16.7	50.0	1.8
34	.0	.0	1.3	.0	.0	.5	15.7	37.2	22.5
35	.0	.0	.7	.3	.0	2.8	1.2	11.7	20.3
36	.0	.3	.8	.5	.0	.8	12.3	9.7	28.3
37	.0	.0	1.7	3.0	.0	1.0	7.5	26.3	11.8
38	.0	.0	.0	.0	.0	.0	13.0	23.0	.0
39	.5	.5	.7	.0	.0	1.0	10.0	17.5	.0
40	.0	.0	.2	.0	.0	1.7	4.0	13.3	.0
41	.2	.0	.2	.0	.3	.5	5.8	6.2	75.8
42	.2	.2	1.2	.2	.2	1.0	9.2	12.5	25.0
43	.2	.3	.2	.0	.8	.5	7.5	47.5	23.0
44	.0	.3	.0	.0	.0	.3	18.3	31.7	16.3
45	.0	.0	.0	.0	.0	.7	15.0	12.0	15.3
46	.0	.0	.3	.0	.0	.8	3.2	8.3	27.2
47	.0	.0	.8	.0	.0	.8	3.7	9.5	.0
48	.0	.0	.5	.2	.0	5.5	20.0	16.7	10.0
49	.2	.0	1.5	.0	.0	1.0	12.8	9.5	40.8
50	.0	.0	7.0	.0	.0	6.3	12.5	6.8	.0
51	.0	.0	.0	.0	.0	1.0	3.3	.0	10.0
52	.0	.0	.0	.0	.0	.0	4.5	.0	57.5
53	.0	.5	.0	.2	.0	.5	12.8	.0	26.7
54	.0	.0	.0	.2	.0	.7	12.5	.0	60.8
55	.0	.0	.0	.3	.0	.5	2.7	.0	5.0
56	.0	.0	.0	.0	.0	.3	5.0	.0	4.5

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Total Peat Moss *Total Sphagnum*	Soil	Fireweed *Epilobium angustifolium*	Goldthread *Coptis trifolia*	Juniper Hair-Cap Moss *Polytrichum juniperinum*	Naked Mitrewort *Mitella nuda*	Water	Fragrant Bedstraw *Galium triflorum*	Northern Commandra *Geocaulon lividum*
29	76.3	.0	.0	.0	.0	.0	.0	.0	.0
30	63.5	.0	.0	.0	.0	.0	.0	.0	.0
31	.0	1.7	.0	.0	.0	.0	.0	.0	.0
32	43.3	.8	.0	.0	.0	.0	.3	.0	.0
33	1.0	13.3	.0	.0	.0	.0	17.7	.3	.0
34	22.5	.0	.0	.7	.0	.0	.0	.0	.0
35	20.3	1.0	.0	.2	.0	.2	.0	.0	.0
36	30.0	3.3	.0	.0	.0	.0	.0	.0	.0
37	11.8	.5	.0	.0	.0	.0	.0	.0	.0
38	.0	10.0	.0	.0	.0	.0	.0	.0	.0
39	.0	10.0	.0	.0	.0	.0	.0	.0	.0
40	.0	.0	.0	.0	.0	.0	.0	.0	.0
41	81.7	1.7	.0	.3	.0	.3	4.2	.0	.0
42	35.8	1.2	.0	.8	.0	.3	.0	.0	.0
43	26.3	1.7	.0	.2	.0	.5	5.0	.2	.0
44	16.3	1.7	.0	.0	.0	.0	.0	.0	.0
45	15.3	1.7	.0	.0	.0	.0	.0	.0	.0
46	56.0	.0	.0	.0	.0	.0	.0	.0	.0
47	.0	.5	.0	.0	.0	.0	.0	.0	.0
48	10.0	.0	.0	.0	.0	.0	.0	.0	.0
49	43.3	.0	.0	.0	.0	.0	.0	.0	.7
50	.0	1.7	.0	.0	.0	.0	.0	.0	.7
51	10.0	30.0	.0	.0	1.0	.0	.0	.0	.0
52	57.5	.0	.0	.0	.0	.0	.0	.0	.0
53	26.7	12.5	.0	.0	1.2	.0	.0	.0	.0
54	52.5	6.7	.0	.0	.5	.0	.0	.0	.0
55	5.0	55.0	.0	.0	1.0	.0	.0	.0	.0
56	4.5	25.0	.0	.2	.2	.0	5.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Interrupted Club Moss *Lycopodium annotinum*	Oak Fern *Gymnocarpium dryopteris*	Ostrich Plume Moss *Ptilium crista-castrensis*	Red Stem Moss *Pleurozium schreberi*	Shinleaf *Pyrola elliptica*	Small Cranberry *Vaccinium oxycoccus*	Field Horsetail *Equisetum arvense*
29	.0	.0	3.3	7.7	.0	.2	.0
30	.0	.0	2.5	29.2	.0	.0	.0
31	.0	.0	1.2	85.0	.0	.0	.0
32	.0	.0	12.3	10.3	.0	.2	.0
33	.0	1.0	.0	.0	.0	.0	.0
34	.0	.0	1.0	5.5	.0	.0	.0
35	.0	.0	11.5	40.0	.0	.0	.0
36	.0	.0	1.2	36.7	.0	.0	.0
37	.0	.0	.8	53.0	.2	.5	.0
38	.0	.0	1.8	47.7	.0	.0	.0
39	.0	.0	.0	41.7	.0	.0	.0
40	.0	.0	1.7	89.2	.0	.0	.0
41	.0	.2	.0	.0	.0	.0	.0
42	.0	.0	.2	36.8	.0	.3	.0
43	.7	.3	.0	5.8	.0	.0	.0
44	.0	.0	1.8	21.7	.0	.0	.0
45	.0	.0	.3	42.2	.0	.2	.0
46	.0	.0	.3	58.0	.0	.0	.0
47	.0	.0	10.8	67.5	.0	.0	.0
48	.3	.0	1.8	48.3	.0	.3	.0
49	.0	.0	1.2	32.2	.0	.0	.0
50	.0	.0	13.5	65.8	.0	.0	.0
51	.0	.0	40.0	3.3	.0	.0	.0
52	.0	.0	.0	.0	.0	.2	.0
53	.0	.0	.0	.0	.0	.8	.0
54	.0	.0	.0	2.3	.0	.2	.0
55	.0	.0	.0	.5	.0	1.0	.3
56	.0	.0	.0	4.2	.0	.7	1.2

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Starflower *Trientalis borealis*	Speckled Alder (<15cm) *Alnus rugosa*	Step moss *Holocomium splendens*	Roundleaved Sundew *Drosera rotundifolia*	Strawberry *Fragana virginiana*	Sweet Coltsfoot *Petasites frigidus*	Three-Leaved Smilacina *Smilacina canadensis*
29	.0	.0	.0	.0	.0	.0	.0
30	.0	.0	.0	.0	.0	.0	.3
31	.0	.0	.2	.0	.0	.0	.0
32	.0	.0	15.2	.0	.0	.0	.0
33	.0	.0	.0	.0	.0	.0	.2
34	.0	.0	2.0	.0	.0	.0	.2
35	.0	.0	5.8	.0	.0	.0	.2
36	.0	.0	1.0	.0	.0	.0	.0
37	.0	.0	.0	.0	.0	.0	.0
38	.0	.0	.0	.0	.0	.0	.0
39	.0	.0	.0	.0	.0	.0	.0
40	.0	.0	.0	.0	.0	.0	.0
41	.0	.0	.5	.0	.0	.0	.5
42	.0	.0	4.7	.0	.0	.2	.3
43	.5	.0	5.0	.0	.0	.0	.0
44	.0	.0	1.8	.0	.0	.0	.0
45	.0	.0	.3	.0	.0	.0	.5
46	.0	.0	.0	.0	.0	.0	.0
47	.0	.0	1.7	.0	.0	.0	.0
48	.0	.0	.0	.0	.0	.0	1.0
49	.0	.0	.0	.0	.0	.0	.0
50	.0	.0	.8	.0	.0	.0	.0
51	.0	.0	.0	.0	.0	.0	.0
52	.0	.0	.0	.0	.0	.0	.3
53	.0	.0	.0	.0	.0	.0	.2
54	.0	.0	.0	.0	.0	.2	.7
55	.0	.0	.0	.0	.3	.0	3.2
56	.0	.0	.0	.7	.0	.2	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Twinflower *Linnea borealis*	Heart-Leaved Twayblade *Listera cordata*	Violet *Viola sp.*	Wood anenome *Anemone quinquefolia*	Woodland Horsetail *Equisetum sylvaticum*	Blue Bead Lily *Clintonia borealis*	Smaller Enchanter's Nightshade *Circaea alpina*	Cattail *Typha sp.*
29	.0	.0	.0	.0	.2	.0	.0	.0
30	.0	.3	.0	.0	.2	.0	.0	.0
31	.0	.0	.0	.0	.0	.0	.0	.0
32	.0	.0	.0	.0	.0	.0	.0	.0
33	.0	.0	1.7	.0	.0	.0	.3	.0
34	.0	.0	.0	.0	.2	.0	.0	.0
35	.2	.0	.0	.0	.5	.0	.0	.0
36	.0	.0	.0	.0	.3	.0	.0	.0
37	.0	.0	.0	.0	1.2	.0	.0	.0
38	.0	.0	.0	.0	.0	.0	.0	.0
39	.0	.0	.0	.0	.2	.0	.0	.0
40	.0	.0	.0	.0	.0	.0	.0	.0
41	.0	.0	1.0	.0	.5	.3	.0	.0
42	.3	.0	.2	.0	.8	.0	.0	.0
43	.2	.0	1.0	.0	.3	.5	.0	.0
44	.2	.0	.0	.0	.0	.0	.0	.0
45	.0	.0	.0	.0	.0	.0	.0	.0
46	.0	.0	.0	.0	.0	.0	.0	.0
47	.0	.0	.0	.0	.0	.0	.0	.0
48	.0	.0	.0	.0	.3	.0	.0	.0
49	.0	.0	.0	.0	.0	.0	.0	.0
50	.0	.0	.0	.0	.0	.0	.0	.0
51	.0	.0	.0	.0	.3	.0	.0	.0
52	.0	.0	.0	.0	.0	.0	.0	.0
53	.0	.0	.0	.0	.5	.0	.0	.0
54	.0	.0	.0	.0	1.3	.0	.0	.0
55	.0	.0	.0	.0	1.2	.0	.0	.0
56	.0	.0	.0	.0	.5	.0	.0	.5

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Rush *Luzula parviflora*	Fowl Manna Grass *Glyceria striata*	Wool-grass *Scirpus cyperinus*	Quack Grass *Agropyron repens*	Cow Wheat *Melampyrum lineare*	Cottongrass *Eriophorum spissum*	Dandelion *Taraxacum officinale*	Leave Strip	Corridor
29	.0	.0	.0	.0	.0	.0	.0	100.0	.0
30	.0	.0	.0	.0	.0	.0	.0	100.0	.0
31	.0	.0	.0	.0	.0	.0	.0	100.0	.0
32	.0	.0	.0	.0	.0	.0	.0	100.0	.0
33	.0	.0	.0	.0	.0	.0	.0	100.0	.0
34	.0	.0	.0	.0	.0	.0	.0	100.0	.0
35	.0	.0	.0	.0	.0	.0	.0	100.0	.0
36	.0	.0	.0	.0	.0	.0	.0	100.0	.0
37	.0	.0	.0	.0	.0	.0	.0	100.0	.0
38	.0	.0	.0	.0	.0	.0	.0	100.0	.0
39	.0	.0	.0	.0	.0	.0	.0	100.0	.0
40	.0	.0	.0	.0	.0	.0	.0	100.0	.0
41	.0	.0	.0	.0	.0	.0	.0	100.0	.0
42	.0	.0	.0	.0	.0	.0	.0	100.0	.0
43	.0	.0	.0	.0	.0	.0	.0	100.0	.0
44	.0	.0	.0	.0	.0	.0	.0	100.0	.0
45	.0	.0	.0	.0	.0	.0	.0	100.0	.0
46	.0	.0	.0	.0	.0	.0	.0	100.0	.0
47	.0	.0	.0	.0	.0	.0	.0	100.0	.0
48	.0	.0	.0	.0	.0	.0	.0	100.0	.0
49	.0	.0	.0	.0	.0	.0	.0	100.0	.0
50	.0	.0	.0	.0	.0	.0	.0	100.0	.0
51	.0	.0	.0	.0	.0	.0	.0	.0	100.0
52	.0	.0	.0	.0	.0	.2	.0	.0	100.0
53	.0	.0	.0	.0	.0	.2	.0	.0	100.0
54	.0	.0	.0	.0	.0	.0	.0	.0	100.0
55	.0	.0	.0	.0	.0	.0	.0	.0	100.0
56	.0	.0	.0	.0	.0	.0	.0	.0	100.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Sedges *Carex sp.*	Dicranum moss *Dicranum*	Grasses	Liverworts	Unidentified Herbs
29	.00	.00	.00	1.17	.0
30	.00	.17	.00	.33	.0
31	.00	.83	.00	.17	.2
32	.00	.00	.00	.00	1.2
33	.00	.00	.17	.00	9.7
34	.00	.00	.33	.00	3.3
35	.00	.33	.00	5.50	.2
36	.00	.50	.00	.50	.0
37	.00	.33	.00	.50	.0
38	.00	2.00	.00	3.83	.2
39	.00	.17	.00	22.00	.5
40	.00	.67	.00	.67	.0
41	.00	.00	1.00	.00	1.5
42	.00	.00	.00	.33	1.2
43	.00	.17	.17	3.33	2.0
44	.00	.67	.00	6.33	.0
45	.00	.33	.00	13.50	.2
46	.00	.33	.00	1.50	.0
47	.00	.83	.00	3.33	.3
48	.00	.50	.00	4.17	.0
49	.00	.00	.00	1.00	.8
50	.00	.00	.00	.17	.0
51	2.67	.67	.00	.00	20.0
52	2.67	.83	5.00	.00	.2
53	4.00	11.33	10.83	.00	3.7
54	1.67	1.00	.00	.00	.8
55	5.17	11.33	.00	.00	3.3
56	15.67	33.50	.00	.00	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Balsam Fir *Abies balsamea*	Black Spruce *Picea mariana*	Bunchberry *Cornus canadensis*	Cloudberry *Rubus chamaemorus*	Confetti Moss *Mnium spp.*	Snowberry *Gaultheria hispidula*	Wood	Debris	Dominant Peat Moss *Dominant Sphagnum*
57	.0	.3	.0	.7	.0	1.3	13.8	6.7	47.2
58	.0	.0	.3	.2	.0	1.0	5.3	6.0	7.5
59	.0	.0	.7	.2	.0	.5	1.7	11.7	1.5
60	.0	.2	.2	.0	.0	.7	13.3	3.8	3.5
61	.0	.2	.2	.2	.0	.2	6.0	.7	1.2
62	.0	.0	.0	.0	.0	.2	.0	.2	.2
63	.0	.3	.3	.3	.0	.7	4.2	2.0	18.8
64	.0	.3	.7	.0	.0	1.2	5.8	1.3	21.7
65	.0	.0	.0	.0	.0	.2	1.3	1.7	.0
66	.0	.2	.0	.0	.0	.2	13.0	1.7	.2
67	.0	.3	.0	.0	.0	.5	10.0	5.0	1.0
68	.0	.0	.0	.0	.0	.2	1.2	2.0	.0
69	.0	.0	.0	.0	.0	.7	5.0	2.5	2.7
70	.0	.0	.0	.0	.0	.3	30.0	12.5	1.3
71	.0	.2	.0	.5	.0	1.2	12.2	7.5	21.5
72	.0	.0	.0	.7	.0	.5	4.2	1.2	21.7
73	.0	.3	.0	.3	.0	.2	12.5	2.0	8.3
74	.0	.0	.0	.0	.0	.5	4.7	.3	1.0
75	.0	.5	.0	.0	.0	1.7	10.5	7.5	14.0
76	.0	.0	.0	2.7	.0	.3	28.3	46.7	11.7
77	.0	.2	.7	1.0	.8	.3	2.5	8.7	51.7
78	.0	.2	.7	1.3	.0	.7	.8	8.5	45.8
79	.0	.2	1.2	.8	.0	.8	4.8	22.0	52.5
80	.0	.2	.3	.2	.3	.5	20.8	18.8	49.2
81	.0	.0	1.2	.7	.0	.5	18.7	26.3	30.0
82	.0	.0	1.0	1.3	.0	.8	9.5	16.5	19.7
83	.0	.2	1.0	.7	.0	1.0	8.3	10.3	58.3
84	.0	.0	.3	.3	.0	.2	43.3	38.7	9.3

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Total Peat Moss *Total Sphagnum*	Soil	Fireweed *Epilobium angustifolium*	Goldthread *Coptis trifolia*	Juniper Hair-Cap Moss *Polytrichum juniperinum*	Naked Mitrewort *Mitella nuda*	Water	Fragrant Bedstraw *Galium triflorum*	Northern Commandra *Geocaulon lividum*
57	47.2	1.7	.0	.0	.3	.0	.0	.0	.0
58	7.5	30.0	.0	.0	.8	.0	.0	.0	.0
59	1.5	44.2	.2	.0	2.2	.0	.0	.0	.0
60	3.5	67.5	.0	.0	1.3	.0	.0	.0	.0
61	1.2	86.7	.0	.0	1.7	.0	.0	.0	.0
62	.2	47.5	.2	.0	.0	.0	4.5	.0	.0
63	18.8	50.8	.0	.0	.7	.2	8.5	.0	.0
64	21.7	31.7	.0	.0	7.2	.0	5.0	.0	.0
65	.0	12.5	.2	.0	.7	.5	38.3	.0	.0
66	.2	80.0	.5	.0	.8	.5	.0	.0	.0
67	1.0	81.7	.0	.0	.8	.0	.0	.0	.0
68	.0	39.2	.0	.0	.5	.0	24.2	.0	.0
69	2.7	85.8	.0	.0	1.0	.0	.0	.0	.0
70	1.3	38.3	.0	.0	.2	.0	.0	.0	.0
71	21.5	27.5	.0	.0	3.3	.0	.0	.0	.0
72	21.7	29.2	.0	.0	1.2	.0	.3	.0	.0
73	8.7	48.3	.0	.0	.8	.0	.0	.0	.0
74	1.0	23.7	.0	.2	.2	.0	57.0	.0	.0
75	17.8	27.5	.0	.0	1.8	.0	.0	.0	.0
76	11.7	.0	.0	.0	.3	.0	.0	.0	.0
77	65.0	1.2	.0	.3	.2	.5	.0	.0	.0
78	62.5	.0	.0	.5	.0	.5	.0	.0	.0
79	61.7	.0	.0	.2	.0	.2	.0	.0	.0
80	59.2	.0	.0	.0	.0	.3	.0	.0	.0
81	42.0	.0	.0	.0	.0	.7	2.5	.0	.0
82	24.7	.8	.0	.3	.0	.2	2.0	.0	.0
83	70.8	.0	.0	.3	.0	.0	.3	.0	.0
84	10.2	.0	.2	.0	.0	.0	5.8	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Interrupted Club Moss *Lycopodium annotinum*	Oak Fern *Gymnocarpium dryopteris*	Ostrich Plume Moss *Ptilium crista-castrensis*	Red Stem Moss *Pleurozium schreberi*	Shinleaf *Pyrola elliptica*	Small Cranberry *Vaccinium oxycoccus*	Field Horsetail *Equisetum arvense*
57	.0	.0	.0	10.3	.0	.5	.2
58	.0	.0	.0	2.0	.0	1.0	3.7
59	.0	.0	.2	.2	.0	1.0	5.7
60	.0	.0	.0	4.5	.0	.3	.7
61	.0	.0	.0	.7	.0	.3	1.0
62	.0	.0	.0	.0	.0	.0	.7
63	.0	.0	.0	1.8	.0	1.2	1.3
64	.0	.0	.0	1.3	.0	1.0	.7
65	.0	.2	.0	.0	.0	.0	.8
66	.0	.0	.0	.5	.0	.3	1.7
67	.0	.0	.0	.8	.0	.3	.0
68	.0	.0	.0	.3	.0	.7	2.3
69	.0	.0	.2	.2	.0	1.0	.5
70	.0	.0	.0	12.2	.0	.2	.0
71	.0	.0	.0	5.0	.0	.8	.0
72	.0	.0	.0	8.7	.0	.7	.0
73	.0	.0	.0	16.7	.0	.3	.0
74	.0	.0	.0	.2	.0	.2	.0
75	.0	.0	.0	1.2	.0	.8	.0
76	.0	.0	.0	5.3	.0	.7	.3
77	.0	.0	.2	18.3	.2	.7	.2
78	.0	.0	.0	13.2	.2	.8	.2
79	.0	.0	.0	10.3	.0	.8	.0
80	.0	.0	.0	2.0	.3	.7	.0
81	.0	.0	.3	9.2	.8	.8	.0
82	.0	.0	.0	47.5	.0	.5	.0
83	.0	.0	.5	12.5	.2	.8	.0
84	.0	.0	.8	3.3	.0	.2	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Starflower *Trientalis borealis*	Speckled Alder (<15cm) *Alnus rugosa*	Step moss *Holocomium splendens*	Roundleaved Sundew *Drosera rotundifolia*	Strawberry *Fragaria virginiana*	Sweet Coltsfoot *Petasites frigidus*	Three-Leaved Smilacina *Smilacina canadensis*
57	.0	.0	.0	.0	.0	.0	.3
58	.0	.0	.0	.0	.0	.0	.0
59	.0	.0	.0	.0	.0	.0	.0
60	.0	.0	.0	.0	.0	.0	.0
61	.0	.0	.0	.0	.0	.0	.0
62	.0	.0	.0	.0	.0	.0	.0
63	.0	.0	.0	.0	.0	.0	3.5
64	.0	.0	.0	.0	.0	.0	1.0
65	.0	.0	.0	.0	.0	.0	.0
66	.0	.0	.0	.0	.0	.0	.0
67	.0	.0	.0	.0	.0	.0	.0
68	.0	.0	.0	.0	.0	.0	.0
69	.0	.0	.0	.0	.0	.0	.0
70	.0	.0	.0	.0	.0	.0	.0
71	.0	.0	.0	.0	.0	.0	1.5
72	.0	.0	.0	.0	.0	.0	.8
73	.0	.0	.0	.0	.0	.0	.3
74	.0	.0	.0	.0	.0	.0	.0
75	.0	.0	.0	.0	.0	.0	1.3
76	.0	.0	.0	.0	.0	.0	1.0
77	.0	.0	.3	.0	.0	.0	.8
78	.0	.0	.0	.0	.0	.0	.8
79	.0	.0	.0	.0	.0	.2	.8
80	.0	.0	.5	.0	.0	.0	3.2
81	.0	.0	.0	.0	.0	.2	.8
82	.0	.0	.2	.0	.0	.2	.3
83	.0	.0	.0	.0	.0	.0	1.5
84	.0	.0	.0	.0	.0	.0	.7

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Twinflower *Linnea borealis*	Heart-Leaved Twayblade *Listera cordata*	Violet *Viola sp.*	Wood anenome *Anemone quinquefolia*	Woodland Horsetail *Equisetum sylvaticum*	Blue Bead Lily *Clintonia borealis*	Smaller Enchanter's Nightshade *Circaea alpina*	Cattail *Typha sp.*
57	.0	.0	.0	.0	2.2	.0	.0	.0
58	.0	.0	.0	.7	.7	.0	.0	.0
59	.0	.0	.0	.0	1.5	.0	.0	.0
60	.0	.0	.0	.0	.8	.0	.0	.0
61	.0	.0	.0	.0	.5	.0	.0	.0
62	.0	.0	.0	.0	.0	.0	.0	2.5
63	.0	.0	.0	.0	1.5	.0	.0	.2
64	.0	.0	.0	.0	2.5	.0	.0	.8
65	.2	.0	.0	.0	.0	.0	.0	6.3
66	.0	.0	.0	.0	.5	.0	.0	.0
67	.0	.0	.0	.0	1.8	.0	.0	.0
68	.2	.0	.0	.0	.7	.0	.0	.3
69	.0	.0	.0	.0	1.8	.0	.0	.0
70	.0	.0	.0	.0	.0	.0	.0	.0
71	.0	.0	.0	.0	.5	.0	.0	.0
72	.0	.0	.0	.0	1.2	.0	.0	.0
73	.0	.0	.0	.0	2.8	.0	.0	.0
74	.0	.0	.0	.0	.0	.0	.0	1.7
75	.0	.0	.0	.0	1.3	.0	.0	.0
76	.0	.0	.0	.0	.3	.0	.0	.0
77	.7	.0	.0	.0	.0	.0	.0	.0
78	.2	.0	.0	.0	.0	.0	.0	.0
79	.2	.0	.0	.0	.0	.0	.0	.0
80	.0	.0	.0	.0	.0	.0	.0	.0
81	.2	.0	.0	.0	.2	.0	.0	.0
82	.3	.0	.0	.0	.0	.0	.0	.0
83	.0	.0	.0	.0	1.2	.0	.0	.0
84	.0	.0	.0	.0	.0	.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Rush *Luzula parviflora*	Fowl Manna Grass *Glyceria striata*	Wool-grass *Scirpus cyperinus*	Quack Grass *Agropyron repens*	Cow Wheat *Melampyrum lineare*	Cottongrass *Eriophorum spissum*	Dandelion *Taraxacum officinale*	Leave Strip	Corridor
57	.0	.0	.0	.0	.0	.0	.0	.0	100.0
58	.0	.0	.0	.0	.0	.0	.0	.0	100.0
59	.0	.0	.0	.0	.0	.0	.0	.0	100.0
60	.0	.2	.0	.0	.0	.0	.0	.0	100.0
61	2.2	.0	.0	.0	.0	.0	.2	.0	100.0
62	.3	24.2	.5	.0	.2	.0	.0	.0	100.0
63	.3	.2	.0	.2	.0	.0	.0	.0	100.0
64	.7	.5	.0	.0	.0	.0	.0	.0	100.0
65	.0	.0	.0	.2	.0	.0	.0	.0	100.0
66	.0	.5	.0	.0	.0	.0	.0	.0	100.0
67	.0	.0	.0	.0	.0	.0	.0	.0	100.0
68	.0	.0	.2	.0	.2	.0	.0	.0	100.0
69	.2	.0	.0	.0	.0	.0	.0	.0	100.0
70	.0	.0	.0	.0	.0	.0	.0	.0	100.0
71	.0	.0	.0	.0	.0	.0	.0	.0	100.0
72	.0	.0	.0	.0	.0	.0	.0	.0	100.0
73	.0	.0	.0	.0	.0	.0	.0	.0	100.0
74	.0	.0	.0	.0	.0	.0	.0	.0	100.0
75	.0	.0	.0	.0	.0	.0	.0	.0	100.0
76	.0	.0	.0	.0	.0	.0	.0	.0	100.0
77	.0	.0	.0	.0	.0	.0	.0	100.0	.0
78	.0	.0	.0	.0	.0	.0	.0	100.0	.0
79	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
80	.0	.0	.0	.0	.0	.0	.0	16.7	83.3
81	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
82	.0	.0	.0	.0	.0	.0	.0	66.7	33.3
83	.0	.0	.0	.0	.0	.0	.0	83.3	16.7
84	.0	.0	.0	.0	.0	.0	.0	33.3	66.7

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Sedges *Carex sp.*	Dicranum moss *Dicranum*	Grasses	Liverworts	Unidentified Herbs
57	.17	.33	.00	.00	.0
58	10.50	7.67	.00	.00	1.3
59	13.33	3.50	.00	.00	.5
60	.67	1.17	.00	.33	.0
61	.83	1.17	.00	.00	.5
62	2.00	2.00	.00	.00	25.0
63	1.83	3.17	.00	.00	.2
64	2.67	10.17	.00	.00	.0
65	20.67	2.83	.00	.00	10.5
66	1.00	3.33	.00	.17	.0
67	.00	.33	.00	.00	.0
68	9.17	11.67	.00	.00	3.3
69	2.33	1.00	.00	.00	.5
70	.00	1.17	.00	2.17	.0
71	.50	1.83	.00	1.00	.0
72	7.50	20.33	.00	.17	.2
73	4.67	.17	.00	.17	.0
74	4.83	4.00	.00	.00	2.8
75	2.83	4.00	1.17	.00	7.8
76	.00	.00	.00	.00	.0
77	.33	2.67	.50	.83	.7
78	.83	.50	.83	10.83	1.0
79	.17	.33	1.00	.00	.3
80	.50	.50	.83	.00	.5
81	.33	2.83	.67	.83	3.0
82	.00	.00	.50	1.33	.0
83	.33	1.00	.67	.17	1.0
84	.00	.17	.33	.17	.2

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Balsam Fir *Abies balsamea*	Black Spruce *Picea mariana*	Bunchberry *Cornus canadensis*	Cloudberry *Rubus chamaemorus*	Confetti Moss *Mnium spp.*	Snowberry *Gaultheria hispidula*	Wood	Debris	Dominant Peat Moss *Dominant Sphagnum*
85	.0	.2	2.2	.7	.0	.5	46.7	28.3	13.8
86	.0	.0	.2	1.3	.0	.5	15.8	36.7	28.2
87	.2	.0	.5	.8	.0	.8	9.3	18.0	59.2
88	.2	.0	.2	.0	.0	1.2	15.8	29.2	40.8
89	.0	.2	.0	.0	.0	2.2	19.0	10.8	62.5
90	.0	.2	.0	.0	.0	.2	23.3	35.0	18.8
91	.0	.0	.2	.0	.0	.5	17.2	19.5	24.2
92	.0	.0	.0	.0	.0	.5	23.3	35.0	35.0
93	.0	.0	.7	.0	.0	.0	20.0	34.2	9.8
94	.0	.2	.5	1.0	.0	.7	12.8	16.7	49.2
95	.0	.2	1.0	1.3	.0	.8	12.2	10.3	51.7
96	.0	.2	1.0	1.3	.0	.0	22.2	18.7	36.7
97	.0	.5	.5	1.5	.0	.7	13.8	23.7	46.7
98	.0	.2	.2	1.3	.0	.3	16.7	39.2	35.0
99	.0	.3	.3	3.3	.0	.2	12.5	7.8	62.5
100	.0	.0	.0	3.7	.0	1.0	1.7	16.7	41.7

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Total Peat Moss *Total Sphagnum*	Soil	Fireweed *Epilobium angustifolium*	Goldthread *Coptis trifolia*	Juniper Hair-Cap Moss *Polytrichum juniperinum*	Naked Mitrewort *Mitella nuda*	Water	Fragrant Bedstraw *Galium triflorum*	Northern Commandra *Geocaulon lividum*
85	18.0	.0	.0	.2	.0	.2	.2	.0	.0
86	34.8	.0	.0	.2	.0	.0	.0	.0	.0
87	61.7	.0	.0	.0	.0	.0	.0	.0	.2
88	49.2	.0	.0	.0	.0	.0	.0	.0	.0
89	64.2	.0	.0	.0	.0	.0	.0	.0	.0
90	22.2	.0	.0	.0	.0	.0	.0	.0	.0
91	27.5	.0	.0	.0	.0	.0	.0	.0	.2
92	36.7	.0	.0	.0	.0	.0	.0	.0	.0
93	13.2	1.7	.0	.2	.0	.0	.0	.0	.0
94	54.2	.0	.0	.0	.2	.2	.0	.0	.0
95	67.5	.8	.7	.0	.2	1.0	.0	.0	.2
96	45.0	.0	.3	.0	.0	1.0	.0	.0	.2
97	51.7	.0	.0	.2	.2	.3	.0	.0	.0
98	37.5	.8	.0	.0	.0	.0	.0	.0	.3
99	68.3	.0	.0	.2	.0	.0	.0	.0	.2
100	46.7	.0	.0	.0	.0	.0	.0	.0	.2

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Interrupted Club Moss *Lycopodium annotinum*	Oak Fern *Gymnocarpium dryopteris*	Ostrich Plume Moss *Ptilium crista-castrensis*	Red Stem Moss *Pleurozium schreberi*	Shinleaf *Pyrola elliptica*	Small Cranberry *Vaccinium oxycoccus*	Field Horsetail *Equisetum arvense*
85	.0	.0	.0	1.5	.3	.2	.0
86	.0	.0	.3	5.2	.0	.3	.0
87	.0	.0	.0	6.7	.3	.3	.0
88	.0	.0	.2	4.5	.0	1.0	.0
89	.0	.0	.0	6.7	.0	.8	.0
90	.0	.0	.0	17.0	.0	.5	.0
91	.0	.0	.0	37.0	.0	.7	.0
92	.0	.0	.0	5.0	.0	.7	.0
93	.0	.0	.0	25.2	.0	.2	.0
94	.0	.0	.0	14.2	.0	1.0	.3
95	.0	.0	.0	7.0	.0	1.0	1.3
96	.0	.0	.0	6.0	.5	.7	.3
97	.0	.0	.0	10.8	.0	.8	.0
98	.0	.0	.0	5.5	.0	1.0	.0
99	.0	.0	.0	10.3	.0	1.0	.0
100	.0	.0	.0	35.8	.0	1.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Starflower *Trientalis borealis*	Speckled Alder (<15cm) *Alnus rugosa*	Step moss *Holocomium splendens*	Roundleaved Sundew *Drosera rotundifolia*	Strawberry *Fragaria virginiana*	Sweet Coltsfoot *Petasites frigidus*	Three-Leaved Smilacina *Smilacina canadensis*
85	.0	.0	.0	.0	.0	2.0	.5
86	.0	.0	.0	.0	.0	.0	.3
87	.0	.0	.0	.0	.0	.0	.5
88	.0	.0	.5	.0	.0	.0	.5
89	.0	.0	.0	.0	.0	.0	.2
90	.0	.0	.0	.0	.0	.0	.0
91	.0	.0	.2	.0	.0	.0	.0
92	.0	.0	.0	.0	.0	.0	.0
93	.0	.0	.0	.0	.0	.0	.3
94	.0	.0	.0	.0	.0	.0	.8
95	.0	.0	.0	.0	.0	.7	.5
96	.0	.0	.0	.0	.0	.7	.8
97	.0	.0	.0	.0	.0	.5	1.0
98	.0	.0	.0	.0	.0	.0	.3
99	.0	.0	.0	.0	.0	.0	.3
100	.0	.0	.0	.3	.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Twinflower *Linnea borealis*	Heart-Leaved Twayblade *Listera cordata*	Violet *Viola sp.*	Wood anenome *Anemone quinquefolia*	Woodland Horsetail *Equisetum sylvaticum*	Blue Bead Lily *Clintonia borealis*	Smaller Enchanter's Nightshade *Circaea alpina*	Cattail *Typha sp.*
85	.0	.0	.0	.0	.0	.0	.0	.0
86	.0	.0	.0	.0	.5	.0	.0	.0
87	.0	.0	.0	.0	1.5	.0	.0	.0
88	.0	.0	.0	.0	1.0	.0	.0	.0
89	.0	.0	.0	.0	.8	.0	.0	.0
90	.0	.0	.0	.0	.0	.0	.0	.0
91	.0	.0	.0	.0	.5	.0	.0	.0
92	.0	.0	.0	.0	.2	.0	.0	.0
93	.0	.0	.0	.0	.0	.0	.0	.0
94	.2	.0	.0	.0	1.2	.0	.0	.0
95	1.0	.0	.0	.0	.0	.0	.0	.0
96	.3	.0	.0	.0	.0	.0	.0	.0
97	.3	.0	.0	.0	.0	.0	.0	.0
98	.0	.0	.0	.0	.0	.0	.0	.0
99	.0	.0	.0	.0	.0	.0	.0	.0
100	.0	.0	.0	.0	.0	.0	.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Rush *Luzula parviflora*	Fowl Manna Grass *Glyceria striata*	Wool-grass *Scirpus cyperinus*	Quack Grass *Agropyron repens*	Cow Wheat *Melampyrum lineare*	Cottongrass *Eriophorum spissum*	Dandelion *Taraxacum officinale*	Leave Strip	Corridor
85	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
86	.0	.0	.0	.0	.0	.0	.0	83.3	16.7
87	.0	.0	.0	.0	.0	.0	.0	33.3	66.7
88	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
89	.0	.0	.0	.0	.0	.0	.0	100.0	.0
90	.0	.0	.0	.0	.0	.0	.0	100.0	.0
91	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
92	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
93	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
94	.0	.0	.0	.0	.0	.0	.0	100.0	.0
95	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
96	.0	.0	.0	.0	.0	.0	.0	16.7	83.3
97	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
98	.0	.0	.0	.0	.0	.0	.0	50.0	50.0
99	.0	.0	.0	.0	.0	.0	.0	66.7	33.3
100	.0	.0	.0	.0	.0	.0	.0	100.0	.0

Appendix 1. Raw data - average percent cover for herb layer for each trap station.

Trap	Sedges *Carex sp.*	Dicranum moss *Dicranum*	Grasses	Liverworts	Unidentified Herbs
85	.50	.33	.83	2.50	.2
86	.00	.50	.50	6.67	.8
87	.33	.50	.00	3.33	.3
88	.00	.00	.00	.50	.0
89	.00	.00	.00	.00	.0
90	.00	.00	.00	5.00	.0
91	.00	.00	.00	.50	.0
92	.00	.00	.00	.50	.0
93	.00	1.00	.00	5.33	.3
94	.33	.50	.00	.83	.5
95	.67	.83	.67	.00	1.3
96	.83	.67	1.50	.83	.7
97	.00	.67	.67	.50	.3
98	.00	.17	.33	.00	.0
99	.17	.67	.00	.00	.3
100	.00	.00	.00	.00	.0

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Black Spruce *Picea mariana*	Balsam Fir *Abies balsamea*	Dwarf Raspberry *Rubus pubescens*	Labrador Tea *Ledum groenlandicum*	Leather Leaf *Chamaedaphne calyculata*	Pale Laurel *Kalmia polifolia*	Sheep Laurel *Kalmia angustifolia*
1	.00	.00	.00	2.67	.33	.67	.00
2	1.67	.00	.00	15.00	.00	.00	.00
3	7.33	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.50	.00	.00	.00
5	2.33	.00	.00	1.17	1.17	.33	.00
6	1.33	.00	.00	4.83	.67	.00	1.00
7	8.67	.00	.00	6.00	.33	.17	1.17
8	2.00	.00	.00	6.17	3.33	.00	.00
9	.50	.00	.00	7.83	.00	.17	.00
10	.50	2.00	.67	1.17	.00	.00	.00
11	.67	.17	.17	.83	00	.00	.00
12	.50	.17	.00	.67	1.00	.00	.00
13	.83	.00	.00	10.00	1.00	.00	.00
14	2.33	.00	.00	6.50	.00	.00	.33
15	.67	.17	.00	5.50	.00	.00	.00
16	4.50	1.50	.83	4.67	.17	.00	.00
17	1.00	.17	3.00	.33	.33	.00	.00
18	.33	.00	.00	3.50	4.50	.00	.00
19	1.17	.00	.00	4.33	.00	.00	.00
20	.00	.00	.00	.67	.00	.00	.00
21	.00	.00	.00	1.33	1.33	.00	.00
22	.67	.50	.17	1.17	1.17	.00	.00
23	5.33	1.17	.00	.00	.00	.00	.00
24	3.17	.67	2.17	1.50	1.50	.00	.00
25	.67	.00	.00	1.17	1.17	.00	.00
26	5.00	.00	.00	15.33	.00	.00	6.67
27	.33	.00	.00	11.67	.00	.00	6.83
28	.80	.00	.00	5.70	.00	.00	6.20

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Velvet leaf Blueberry *Vaccinium myrtilloides*	Early Low Blueberry *Vaccinium angustifolium*	Willow herb *Epilobium glandulosum*	Wild Raspberry *Rubus idaeus*	Skunk Currant *Ribes glandulosum*	Bristly Black Currant *Ribes lacustre*	Speckled Alder *Alnus rugosa*
1	.00	.33	.00	.00	.00	.33	.00
2	1.33	.50	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00
4	.83	.00	.00	.00	.00	.00	.00
5	.83	.33	.00	.00	.00	.00	.00
6	.50	.17	.00	.00	.00	.00	.00
7	2.00	.17	.00	.00	.00	.00	.00
8	1.83	1.33	.00	.00	.00	.00	.00
9	.67	.33	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	5.50	.00	5.50
11	.00	.00	.00	.50	11.17	.00	11.17
12	1.00	.17	.00	.17	2.50	.00	2.50
13	1.50	.33	.00	.00	.00	.00	.00
14	.50	.00	.00	.00	.00	.00	.00
15	.83	.00	.00	.00	.00	.00	.00
16	.67	.00	.00	.00	.00	.00	13.83
17	1.00	.00	.00	.17	.00	.00	4.67
18	1.33	.67	.00	.00	.00	.00	.00
19	1.00	1.67	.00	.00	.00	.00	.00
20	.67	1.33	.00	.33	.00	.00	.00
21	1.33	.17	.00	.17	.00	.00	.00
22	.00	.00	.00	1.83	.50	.00	14.50
23	.00	.00	.00	11.00	3.50	.17	17.00
24	1.00	.00	.00	.00	.00	.00	.83
25	.17	.00	.00	.00	.33	.00	.00
26	.67	.00	.00	.00	.00	.00	.00
27	.83	.50	.00	.00	.00	.00	.00
28	1.20	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Red Osier Dogwood *Cornus stolonifera*	Northern Commandra *Geocaulon lividum*	Wild Red Currant *Ribes triste*	American Mountain Ash *Sorbus americana*	Mountain Avens *Geum canadense*	High Bush Cranberry *Viburnum trilobum*	Paper Birch *Betula papyrifera*
1	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00
8	.00	.33	.00	.00	.00	.00	.00
9	.00	.17	.00	.00	.00	.00	.00
10	.00	.00	.17	.00	.00	.00	.00
11	.00	.00	.00	.33	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00
13	.00	.17	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00
17	.00	.00	.00	.00	.00	.00	.00
18	.00	.00	2.00	.00	.00	.00	.00
19	.00	.00	.00	.00	.00	.00	.00
20	.00	.00	.00	.00	.00	.00	.00
21	.00	.00	.00	.00	.00	.00	.00
22	.00	.00	.00	.00	.00	.00	.00
23	1.67	.00	5.00	.83	.00	.00	.00
24	.00	.00	.00	3.00	.00	.00	.17
25	.00	.00	.00	.00	.00	.00	.00
26	.00	.00	.00	.00	.00	.00	.00
27	.00	.00	.00	.00	.00	.00	.00
28	.00	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Bush Honeysuckle *Diervilla lonicera*	Black Currant *Ribes cynobati*	Serviceberry *Amelanchier sp.*	Wild Sarsaparilla *Aralia nudicaulis*	Trembling Aspen *Populus tremuloides*	Balsam poplar *Populus balsamerifera*	Common Strawberry *Fragaria virginiana*	Gooseberry *Ribes hirtellum*
1	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00
10	.50	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00
13	.00	.00	.00	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00
17	.00	.00	.00	.00	.00	.00	.00	.00
18	.00	.00	.00	.00	.00	.00	.00	.00
19	.00	.00	.00	.00	.00	.00	.00	.00
20	.00	.00	.00	.00	.00	.00	.00	.00
21	.00	.00	.00	.00	.00	.00	.00	.00
22	.00	.00	.00	.00	.00	.00	.00	.00
23	.00	.00	.00	.00	.00	.00	.00	.00
24	.17	.00	.00	.00	.00	.00	.00	.00
25	.00	.00	.00	.00	.00	.00	.00	.00
26	.00	.00	.00	.00	.00	.00	.00	.00
27	.00	.00	.00	.00	.00	.00	.00	.00
28	.00	.00	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Unidentified Shrubs
1	.00
2	.00
3	.33
4	.00
5	.00
6	.00
7	.00
8	.00
9	.00
10	.00
11	.00
12	.00
13	.00
14	.00
15	.00
16	.00
17	1.00
18	.67
19	.00
20	.00
21	.00
22	1.17
23	.00
24	.00
25	.00
26	.00
27	.00
28	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Black Spruce *Picea mariana*	Balsam Fir *Abies balsamea*	Dwarf Raspberry *Rubus pubescens*	Labrador Tea *Ledum groenlandicum*	Leather Leaf *Chamaedaphne calyculata*	Pale Laurel *Kalmia polifolia*	Sheep Laurel *Kalmia angustifolia*
29	.30	.30	.00	3.30	.00	.00	2.00
30	.50	.00	.00	7.17	.00	.00	1.50
31	.00	.00	.00	1.30	.00	.00	.00
32	5.83	.20	.00	5.83	.00	.00	1.50
33	.00	.17	.17	.00	.00	.00	.00
34	.00	10.33	.17	1.33	.00	.00	.00
35	.80	.70	.00	7.00	.00	.00	.00
36	.00	.00	.00	3.17	.00	.00	.00
37	5.00	.30	.00	3.80	.00	.00	.20
38	.00	.00	.00	.30	.00	.00	.00
39	2.00	.80	.00	4.70	.00	.00	1.30
40	.00	.00	.00	3.20	.00	.00	.00
41	.50	5.70	.30	1.50	.00	.00	.00
42	.50	.17	.67	1.50	.00	.00	.17
43	2.00	5.50	.00	.30	.00	.00	.00
44	7.33	1.50	.00	2.67	.00	.00	.50
45	.50	1.20	.00	2.20	.00	.00	.00
46	.30	.00	.00	.50	.00	.00	1.20
47	.50	.00	.00	2.70	.00	.00	.00
48	.20	.00	.00	4.00	.00	.00	.00
49	.20	1.80	.00	6.20	.00	.00	.00
50	.00	.00	.00	.67	.00	.00	.00
51	.00	.33	.00	.33	.00	.00	1.33
52	.17	.00	.00	.50	.83	.00	.50
53	.17	.00	.00	1.67	.33	.00	1.00
54	.17	.00	.00	3.17	2.67	.50	.00
55	.00	.00	.00	1.17	1.50	.33	.17
56	.00	.00	.00	2.00	6.33	.50	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Velvet leaf Blueberry *Vaccinium myrtilloides*	Early Low Blueberry *Vaccinium angustifolium*	Willow herb *Epilobium glandulosum*	Wild Raspberry *Rubus idaeus*	Skunk Currant *Ribes glandulosum*	Bristly Black Currant *Ribes lacustre*	Speckled Alder *Alnus rugosa*
29	.50	.00	.00	.00	.00	.00	.00
30	.83	.50	.00	.00	.00	.00	.00
31	.00	.00	.00	.00	.00	.00	.00
32	.17	.00	.00	.00	.00	.00	.00
33	.00	.00	.00	.67	.33	.33	2.83
34	.00	.70	.00	.00	.00	.00	.00
35	.80	.00	.00	.00	.00	.00	.00
36	.70	.20	.00	.00	.00	.00	00
37	1.00	.80	.00	.00	.00	.00	.00
38	.20	.20	.00	.00	.00	.00	.00
39	1.00	.00	.00	.00	.00	.00	.00
40	1.00	.00	.00	.00	.00	.00	.00
41	.00	.00	.00	.70	.00	.00	22.00
42	.20	.00	.00	.00	.00	.00	1.83
43	.50	.00	.00	1.00	.00	.00	10.00
44	.30	.00	.00	.00	.00	.00	.00
45	1.00	.50	.00	.00	.00	.00	.00
46	.70	.30	.00	.00	.00	.00	.00
47	1.00	.00	.00	.00	.00	.00	.00
48	.00	.00	.00	.00	.00	.00	.50
49	.80	.00	.00	.00	.00	.00	.00
50	.67	.00	.00	.00	.00	.00	.00
51	1.00	.33	.00	.00	.00	.00	.00
52	.17	.00	.00	.00	.00	.00	.00
53	.83	.00	.00	.00	.00	.00	1.00
54	.50	.17	.00	.00	.00	.00	.00
55	.50	.00	.00	.00	.00	.00	.00
56	.00	.50	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Red Osier Dogwood *Cornus stolonifera*	Northern Commandra *Geocaulon lividum*	Wild Red Currant *Ribes triste*	American Mountain Ash *Sorbus americana*	Mountain Avens *Geum canadense*	High Bush Cranberry *Viburnum trilobum*	Paper Birch *Betula papyrifera*
29	.00	.00	.00	.00	.00	.00	.00
30	.00	.00	.00	.00	.00	.00	.00
31	.00	.00	.00	.00	.00	.00	.00
32	.00	.00	.00	.00	.00	.00	.00
33	.00	.00	.00	.00	.00	.67	.00
34	.00	.00	.00	.00	.00	.00	.00
35	.00	.00	.00	.00	.00	.20	.00
36	.00	.00	.00	.00	.00	.00	.00
37	.00	.00	.00	.00	.00	.00	.00
38	.00	.00	.00	.00	.00	.00	.00
39	.00	.00	.00	.00	.00	.00	.00
40	.00	.00	.00	.00	.00	.00	.00
41	.00	.00	.00	.00	.00	.00	.00
42	.00	.00	.00	.00	.00	.00	.00
43	.00	.00	.00	.00	.00	.20	.00
44	.00	.00	.00	.00	.00	.00	.00
45	.00	.00	.00	.00	.00	.00	.00
46	.00	.00	.00	.00	.00	.00	.00
47	.00	.00	.00	.00	.00	.00	.00
48	.00	.00	.00	.00	.00	.00	.00
49	.00	.00	.00	.00	.00	.00	.00
50	.00	.00	.00	.00	.00	.00	.00
51	.00	.00	.00	.00	.00	.00	.00
52	.00	.00	.00	.00	.00	.00	.00
53	.00	.00	.00	.00	.00	.00	.00
54	.00	.00	.00	.00	.00	.00	.00
55	.00	.00	.00	.00	.00	.00	.00
56	.00	.00	.00	.00	.00	.00	.17

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Bush Honeysuckle *Diervilla lonicera*	Black Currant *Ribes cynobati*	Serviceberry *Amelanchier sp.*	Wild Sarsaparilla *Aralia nudicaulis*	Trembling Aspen *Populus tremuloides*	Balsam poplar *Populus balsamerifera*	Common Strawberry *Fragaria virginiana*	Gooseberry *Ribes hirtellum*
29	.00	.00	.00	.00	.00	.00	.00	.00
30	.00	.00	.00	.00	.00	.00	.00	.00
31	.00	.00	.00	.00	.00	.00	.00	.00
32	.00	.00	.00	.00	.00	.00	.00	.00
33	.00	.20	.00	.00	.00	.00	.00	.00
34	.00	.20	.20	1.00	.00	.00	.00	.00
35	.00	.00	.00	.00	.00	.00	.00	.00
36	.00	.00	.00	.00	.00	.00	.00	.00
37	.00	.00	.00	.00	.00	.00	.00	.00
38	.00	.00	.00	.00	.00	.00	.00	.00
39	.00	.00	.00	.00	.00	.00	.00	.00
40	.00	.00	.00	.00	.00	.00	.00	.00
41	.00	.00	.00	.00	.00	.00	.00	.00
42	.00	.00	.00	.00	.00	.00	.00	.00
43	.00	.70	.00	.00	.00	.00	.00	.00
44	.00	.00	.00	.00	.00	.00	.00	.00
45	.00	.00	.00	.00	.00	.00	.00	.00
46	.00	.00	.00	.00	.00	.00	.00	.00
47	.00	.00	.00	.00	.00	.00	.00	.00
48	.00	.00	.00	.00	.00	.00	.00	.00
49	.00	.00	.00	.00	.00	.00	.00	.00
50	.00	.00	.00	.00	.00	.00	.00	.00
51	.00	.00	.00	.00	.00	.00	.00	.00
52	.00	.00	.00	.00	.00	.00	.00	.00
53	.00	.00	.00	.00	.00	.00	.00	.00
54	.00	.00	.00	.00	.00	.00	.00	.00
55	.00	.00	.00	.00	.00	.00	.00	.00
56	.00	.00	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Unidentified Shrubs
29	.00
30	.00
31	.00
32	.00
33	.00
34	1.00
35	.00
36	.00
37	.00
38	.00
39	.00
40	.00
41	.00
42	.00
43	.00
44	.00
45	.00
46	.00
47	.00
48	.00
49	.00
50	.00
51	.00
52	.33
53	.33
54	.00
55	.67
56	.67

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Black Spruce *Picea mariana*	Balsam Fir *Abies balsamea*	Dwarf Raspberry *Rubus pubescens*	Labrador Tea *Ledum groenlandicum*	Leather Leaf *Chamaedaphne calyculata*	Pale Laurel *Kalmia polifolia*	Sheep Laurel *Kalmia angustifolia*
57	1.17	.00	.00	10.83	3.17	.50	5.50
58	.17	.00	.17	2.00	1.33	.17	.17
59	.00	.00	.00	1.17	.33	.33	.00
60	.33	.00	.00	7.17	.00	.00	.00
61	.00	.00	.17	.67	.67	.17	.00
62	.00	.00	1.50	.17	.50	.00	.00
63	.17	.00	.00	3.00	2.00	.50	.83
64	.17	.00	.00	1.67	2.00	.33	.33
65	.00	.00	1.50	.33	.67	.00	.00
66	.00	.00	.33	.00	.17	.00	.00
67	.00	.00	.00	.67	.00	.00	.17
68	.00	.00	.17	.33	.17	.17	.00
69	.00	.00	.00	.83	.00	.00	.00
70	.67	.00	.00	1.83	.00	.00	.33
71	.17	.00	.00	3.33	1.67	.33	.17
72	.17	.00	.00	2.17	2.67	.67	.00
73	.33	.00	.00	3.50	2.17	.00	.67
74	.00	.00	.00	.00	.00	.00	.00
75	.17	.00	.00	.17	.50	.17	.50
76	1.00	.00	.00	2.00	1.33	.00	.67
77	8.50	.00	.00	2.83	.67	.17	.17
78	2.17	.00	.00	5.67	.67	.00	.50
79	1.00	.00	.00	4.67	2.17	.33	.00
80	12.67	.00	.00	2.83	1.50	.00	.17
81	2.17	.00	.00	2.50	3.00	.00	.00
82	6.67	.00	.17	6.00	1.00	.33	.00
83	9.33	.00	.00	4.83	2.33	.00	.00
84	.33	.00	.00	2.33	1.67	.17	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Velvet leaf Blueberry *Vaccinium myrtilloides*	Early Low Blueberry *Vaccinium angustifolium*	Willow herb *Epilobium glandulosum*	Wild Raspberry *Rubus idaeus*	Skunk Currant *Ribes glandulosum*	Bristly Black Currant *Ribes lacustre*	Speckled Alder *Alnus rugosa*
57	1.83	.00	.00	.00	.00	.00	.00
58	.83	.17	.00	.33	.00	.00	.00
59	.83	.17	.00	.33	.00	.00	.00
60	2.67	.00	.00	.00	.00	.00	.00
61	.33	.00	.00	.00	.00	.00	.00
62	.00	.00	.17	.50	.00	.00	.00
63	.67	.00	.00	.00	.00	.00	.00
64	.83	.00	.00	.00	.00	.00	.00
65	.00	.00	.00	.00	.00	.00	.00
66	.83	.00	.00	.00	.00	.00	.00
67	1.17	.00	.00	.00	.00	.00	.00
68	.50	.00	.33	.33	.00	.00	.00
69	1.17	.00	.00	.00	.00	.00	.00
70	1.00	.00	.00	.00	.00	.00	.00
71	1.00	.00	.00	.00	.00	.00	.50
72	.67	.00	.17	.00	.00	.00	.00
73	.83	.00	.00	.00	.00	.00	.00
74	.00	.00	.83	.00	.00	.00	.00
75	.67	.00	.00	.00	.00	.00	.00
76	.00	.00	.00	.00	.00	.00	.00
77	.00	.00	.00	.00	.00	.00	.00
78	.17	.00	.00	.00	.00	.00	.00
79	.50	.00	.00	.00	.00	.00	.00
80	.00	.00	.00	.00	.00	.00	.00
81	.00	.00	.00	.00	1.50	.00	.00
82	.17	.00	.00	.00	.00	.00	.00
83	.00	.00	.00	.00	.00	.00	.00
84	1.67	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Red Osier Dogwood *Cornus stolonifera*	Northern Commandra *Geocaulon lividum*	Wild Red Currant *Ribes triste*	American Mountain Ash *Sorbus americana*	Mountain Avens *Geum canadense*	High Bush Cranberry *Viburnum trilobum*	Paper Birch *Betula papyrifera*
57	.00	.00	.00	.00	.00	.00	.00
58	.00	.00	.00	.00	.00	.00	.00
59	.00	.00	.00	.00	.00	.00	.00
60	.00	.00	.00	.00	.00	.00	.00
61	.00	.00	.00	.00	.00	.00	.17
62	.00	.00	.00	.00	.33	.00	.33
63	.00	.00	.00	.00	.00	.00	.00
64	.00	.00	.00	.00	.00	.00	.00
65	.00	.00	.00	.00	.00	.00	.00
66	.00	.00	.00	.00	.00	.00	.00
67	.00	.00	.00	.00	.00	.00	.00
68	.00	.00	.00	.00	.00	.00	.00
69	.00	.00	.00	.00	.00	.00	.00
70	.00	.00	.00	.00	.00	.00	.00
71	.00	.00	.00	.00	.00	.00	.00
72	.00	.00	.00	.00	.00	.00	.00
73	.00	.00	.00	.00	.00	.00	.00
74	.00	.00	.00	.00	.00	.00	.00
75	.00	.00	.00	.00	.00	.00	.00
76	.00	.00	.00	.00	.00	.00	.00
77	.00	.00	.00	.00	.00	.00	.00
78	.00	.00	.00	.00	.00	.00	.00
79	.00	.00	.00	.00	.00	.00	.00
80	.00	.00	.00	.00	.00	.00	.00
81	.00	.00	.00	.00	.00	.00	.00
82	.00	.00	.00	.00	.00	.00	.00
83	.00	.00	.00	.00	.00	.00	.00
84	.00	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Bush Honeysuckle *Diervilla lonicera*	Black Currant *Ribes cynobati*	Serviceberry *Amelanchier sp.*	Wild Sarsaparilla *Aralia nudicaulis*	Trembling Aspen *Populus tremuloides*	Balsam poplar *Populus balsamerifera*	Common Strawberry *Fragaria virginiana*	Gooseberry *Ribes hirtellum*
57	.00	.00	.00	.00	.00	.00	.00	.00
58	.00	.00	.00	.00	.17	.00	.00	.00
59	.00	.00	.00	.00	.00	.00	.00	.00
60	.00	.00	.00	.00	.00	.00	.00	.00
61	.00	.00	.00	.00	.00	.00	.00	.00
62	.00	.00	.00	.00	.17	.17	.00	.00
63	.00	.00	.00	.00	.00	.00	.00	.00
64	.00	.00	.00	.00	.00	.00	.00	.00
65	.17	.00	.00	.00	.00	.00	.00	.00
66	.33	.00	.00	.00	.00	.00	.00	.00
67	.00	.00	.00	.00	.00	.00	.00	.00
68	.00	.00	.00	.00	.00	.00	.00	.00
69	.00	.00	.00	.00	.00	.00	.00	.00
70	.00	.00	.00	.00	.00	.00	.00	.00
71	.00	.00	.00	.00	.00	.00	.00	.00
72	.00	.00	.00	.00	.00	.00	.00	.00
73	.00	.00	.00	.00	.00	.00	.00	.00
74	.00	.00	.00	.00	.00	.00	.00	.00
75	.00	.00	.00	.00	.33	.00	.00	.00
76	.00	.00	.00	.00	.00	.00	.00	.00
77	.00	.00	.00	.00	.00	.00	.00	.00
78	.00	.00	.00	.00	.00	.00	.00	.00
79	.00	.00	.00	.00	.00	.00	.00	.00
80	.00	.00	.00	.00	.00	.00	.00	.00
81	.00	.00	.00	.00	.00	.00	.00	.00
82	.00	.00	.00	.00	.00	.00	.00	.00
83	.00	.00	.00	.00	.00	.00	.00	.00
84	.00	.00	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Unidentified Shrubs
57	.00
58	.67
59	.33
60	.00
61	.50
62	1.17
63	.67
64	.83
65	2.33
66	.67
67	.00
68	1.00
69	.17
70	.00
71	3.33
72	.17
73	.17
74	.33
75	1.00
76	.00
77	.00
78	.00
79	.00
80	.00
81	.00
82	.00
83	.00
84	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Black Spruce *Picea mariana*	Balsam Fir *Abies balsamea*	Dwarf Raspberry *Rubus pubescens*	Labrador Tea *Ledum groenlandicum*	Leather Leaf *Chamaedaphne calyculata*	Pale Laurel *Kalmia polifolia*	Sheep Laurel *Kalmia angustifolia*
85	2.50	.50	.00	6.83	1.50	.17	.00
86	6.50	.00	.00	8.00	.83	.17	.00
87	1.00	.00	.00	7.50	1.67	.17	.00
88	1.33	.00	.00	9.50	1.67	.67	.00
89	.83	.00	.00	5.83	1.83	.17	.00
90	.50	.00	.00	9.33	1.00	.33	.00
91	1.50	.00	.00	18.33	.00	.00	.00
92	2.83	.00	.00	19.17	.00	.00	.00
93	5.83	.00	.00	7.83	.00	.00	.00
94	4.50	.00	.00	5.17	3.50	.33	.00
95	1.17	.00	.00	5.33	1.67	.33	.00
96	10.17	.00	.00	6.33	1.83	.33	.17
97	1.50	.17	1.00	7.00	2.50	.67	.00
98	7.67	.00	.00	9.83	2.00	.50	.17
99	1.00	.00	.00	5.17	10.17	.83	.00
100	14.83	.00	.00	13.67	1.83	.50	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Velvet leaf Blueberry *Vaccinium myrtilloides*	Early Low Blueberry *Vaccinium angustifolium*	Willow herb *Epilobium glandulosum*	Wild Raspberry *Rubus idaeus*	Skunk Currant *Ribes glandulosum*	Bristly Black Currant *Ribes lacustre*	Speckled Alder *Alnus rugosa*
85	.67	.00	.00	.00	.00	.00	.00
86	.50	.00	.00	.00	.00	.00	.00
87	.33	.00	.00	.00	.00	.00	.00
88	.50	.00	.00	.00	.00	.00	.00
89	.33	.00	.00	.00	.00	.00	.00
90	.17	.33	.00	.00	.00	.00	.00
91	1.67	.17	.00	.00	.00	.00	.00
92	.83	.17	.00	.00	.00	.00	.00
93	.83	.50	.00	.00	.00	.00	.00
94	.67	.00	.00	.00	.00	.00	.00
95	.00	.00	.00	.00	.00	.00	.00
96	.00	.00	.00	.00	.00	.00	.00
97	.00	.17	.00	.00	.00	.00	.00
98	.67	.00	.00	.00	.00	.00	.00
99	.50	.00	.00	.00	.00	.00	.00
100	1.17	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Red Osier Dogwood *Cornus stolonifera*	Northern Commandra *Geocaulon lividum*	Wild Red Currant *Ribes triste*	American Mountain Ash *Sorbus americana*	Mountain Avens *Geum canadense*	High Bush Cranberry *Viburnum trilobum*	Paper Birch *Betula papyrifera*
85	.00	.00	.00	.00	.00	.00	.00
86	.00	.00	.00	.00	.00	.00	.00
87	.00	.00	.00	.00	.00	.00	.00
88	.00	.00	.00	.00	.00	.00	.00
89	.00	.00	.00	.00	.00	.00	.00
90	.00	.00	.00	.00	.00	.00	.00
91	.00	.00	.00	.00	.00	.00	.00
92	.00	.00	.00	.00	.00	.00	.00
93	.00	.00	.00	.00	.00	.00	.00
94	.00	.00	.00	.00	.00	.00	.00
95	.00	.00	.00	.00	.00	.00	.00
96	.00	.00	.00	.00	.00	.00	.00
97	.00	.00	.00	.00	.00	.00	.00
98	.00	.00	.00	.00	.00	.00	.00
99	.00	.00	.00	.00	.00	.00	.00
100	.00	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Bush Honeysuckle *Diervilla lonicera*	Black Currant *Ribes cynobati*	Serviceberry *Amelanchier sp.*	Wild Sarsaparilla *Aralia nudicaulis*	Trembling Aspen *Populus tremuloides*	Balsam poplar *Populus balsamerifera*	Common Strawberry *Fragaria virginiana*	Gooseberry *Ribes hirtellum*
85	.00	.00	.00	.00	.00	.00	.00	.00
86	.00	.00	.00	.00	.00	.00	.00	.00
87	.00	.00	.00	.00	.00	.00	.00	.00
88	.00	.00	.00	.00	.00	.00	.00	.00
89	.00	.00	.00	.00	.00	.00	.00	.00
90	.00	.00	.00	.00	.00	.00	.00	.00
91	.00	.00	.00	.00	.00	.00	.00	.00
92	.00	.00	.00	.00	.00	.00	.00	.00
93	.00	.00	.00	.00	.00	.00	.00	.00
94	.00	.00	.00	.00	.00	.00	.00	.00
95	.00	.00	.00	.00	.00	.00	.00	.17
96	.00	.00	.00	.00	.00	.00	.17	.00
97	.00	.00	.00	.00	.00	.00	.00	.00
98	.00	.00	.00	.00	.00	.00	.00	.00
99	.00	.00	.00	.00	.00	.00	.00	.00
100	.00	.00	.00	.00	.00	.00	.00	.00

Appendix 2. Raw data - average percent cover for shrub layer for each trap station.

TRAP	Unidentified Shrubs
85	.00
86	.00
87	.00
88	.00
89	.00
90	.00
91	.00
92	.00
93	.00
94	.00
95	.00
96	.00
97	.00
98	.00
99	.00
100	.00

Appendix 3. Yellownose vole captures in 1994, 1995, and 1996.

Specimen No.	Trap Station	Trap No.	Date	Sex	Maturity	Length (cm) Full	Tail	Mass (g)
547	2	2C	Jul-94	M	m	12.4	2.2	17.5
802	2	2A	Aug-94	na	na	12.6	2.7	19.5
1070	2	2C	Jul-95	F	p	13.0	3.3	36.5
1111	2	2A	Jul-95	F	m	87.5	1.8	11.0
1263	2	2C	Aug-96	F	m	9.5	2.2	12.0
450	3	3C	Jul-94	M	m	14.6	3.2	35.5
847	3	3D	Aug-94	M	m	12.3	2.5	20.0
1091	3	3D	Jul-95	M	l	9.0	2.4	15.0
591	4	4A	Jul-94	M	m	12.9	2.4	27.0
1022	4	4C	Jun-95	F	p	10.3	2.2	28.5
1071	4	4C	Jul-95	F	p	11.7	3.1	35.5
454	5	5C	Jul-94	F	m	15.1	3.2	32.0
282	6	6C	Jun-94	M	m	14.5	2.6	37.0
852	7	7B	Aug-94	M	m	12.6	2.8	22.5
554	8	8B	Jul-94	F	p	13.7	2.9	30.5
1073	8	8D	Jul-95	F	p	11.0	2.5	26.4
145	14	14B	May-94	F	m	13.5	2.6	46.0
244	14	14B	Jun-94	F	m	15.1	3.1	40.0
375	14	14A	Jul-94	F	m	13.4	3.5	24.0
505	14	14B	Jul-94	F	m	14	3.6	36.5
775	18	18B	Aug-94	M	m	13.1	2.5	27.5
1098	18	18C	Jul-95	F	p	12.2	2.5	30.5
243	19	19A	Jun-94	M	m	13.5	2.1	33.5
512	19	19A	Jul-94	F	m	10.3	2.1	16.0
383	20	20B	Jul-94	F	m	13	2.3	34.0
1052	23	23D	Jul-95	M	m	7.2	2.5	13.5
299	26	26C	Jun-94	F	m	12.9	2	16.5
521	26	26A	Jul-94	F	p	12.5	2.5	42.5
589	27	27A	Jul-94	M	m	14.7	2.8	39.0
1054	30	30A	Jul-95	F	m	na	na	na
23	32	32A	May-94	M	m	14.3	4	36.0
24	32	32B	May-94	F	m	15	3.5	39.5
231	32	32C	Jun-94	F	p	15.4	3.5	50.0
407	32	32B	Jul-94	F	m	14	3.5	30.5
268	33	33A	May-94	M	m	16.6	4.8	47.5
411	34	34A	Jul-94	M	m	17	4.5	51.0
528	34	34A	Jul-94	F	m	12.5	2.7	30.0
302	36	36C	Jun-94	M	m	13.1	2.2	33.5
415	36	36B	Jul-94	M	m	12.2	1.9	29.0
223	40	40A	Jun-94	F	m	16.8	4.1	49.0
274	40	40A	Jun-94	M	m	16	4.3	37.0
426	40	40A	Jul-94	M	m	15	3.6	31.5
427	40	40B	Jul-94	M	m	16.5	3.5	48.5
534	40	40A	Jul-94	F	m	14.7	3.7	31.0
598	40	40B	Jul-94	M	m	14	2.9	31.5
834	40	40A	Aug-94	M	m	13.3	3.7	21.0
843	40	40B	Aug-94	F	m	13.7	3.5	20.5

Specimen No.	Trap Station	Trap No.	Date	Sex	Maturity	Length (cm) Full	Tail	Mass (g)
218	42	42B	Jun-94	M	m	18	4.5	56.0
432	42	42A	Jul-94	M	m	17.4	4.3	46.5
431	42	42B	Jul-94	M	m	14.5	3.8	29.5
536	42	42B	Jul-94	F	p	14.4	3.4	38.0
1065	44	44B	Jul-95	F	p	12.6	3.0	40.5
1021	50	50B	Jun-95	M	m	13.5	2.6	27.3
1269	57	57D	Aug-96	F	i	10	2.7	10.5
1205	65	65B	Sep-95	F	i	11.1	3.1	22.0
285	66	66A	Jun-94	M	m	11.6	2	16.0
1076	69	69A	Jul-95	F	m	14.7	3.0	36.0
1256	76	76D	Jul-96	F	i	9.4	1.8	16.0
755	86	86A	Aug-94	F	m	14.5	3	29.5
292	87	87A	Jun-94	M	m	13.7	2.8	31.0
347	87	87C	Jul-94	F	m	13.8	2.7	34.0
1250	89	89B	Jul-96	F	i	12.9	2.9	34.0
1249	89	89C	Jul-96	M	m	10.5	2.1	14.5
1268	89	89B	Aug-96	F	p	12.6	3	25.5
1200	90	90A	Sep-95	F	p	14.0	2.7	33.5
1258	97	97C	Jul-96	F	i	12.2	2.2	36.0
770	98	98A	Aug-94	M	m	12.8	2.6	23.5
570	100	100A	Jul-94	F	m	13.2	2.5	29.5

F = Female
M = Male
m = sexually mature / reproductive
I = juvenile or no evidence of past or present sexual activity
na = data not available due to the condition of the specimen

TEST TARGET (QA-3)

150mm

6"

APPLIED IMAGE . Inc

1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989