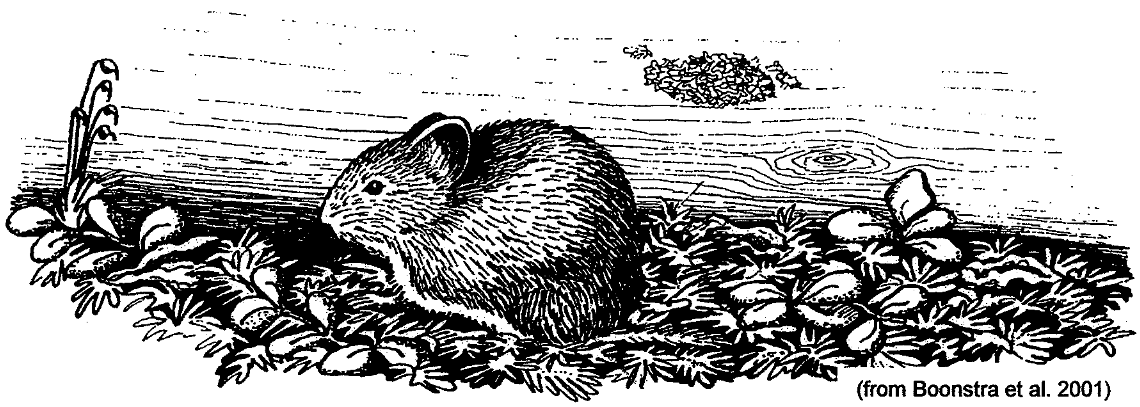

(from Boonstra et al. 2001)

Small Mammal Response to Habitat Change Following Fire in the Taiga of Southeastern Manitoba

By

Monica Reid-Wong

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

Department of Zoology
University of Manitoba
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FACULTY OF GRADUATE STUDIES

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Abstract

Small Mammal Response to Habitat Change Following Fire
in the Taiga of Southeastern Manitoba

by

Monica Reid-Wong

The influence of fire on small mammal populations was investigated in the taiga of southeastern Manitoba. Small mammals were sampled by annual removal trapping in six different habitats over twenty-five years at Taiga Biological Station (TBS). Changes in temporal patterns of short-term abundance and long-term population synchronicity were investigated for fluctuating numbers of small mammals. The southern red-backed vole (*Clethrionomys gapperi*), the deer mouse (*Peromyscus maniculatus*), and the masked shrew (*Sorex cinereus*), were the three most common small mammals captured.

Examination of population fluctuations revealed that while fire-induced changes in food availability, cover and moisture were likely responsible for differences in small mammal abundance, populations of individual species were alternatively affected by unknown, large-scale, synchronizing influences. This discovery became evident through the common occurrence of similar peak abundance years for *C. gapperi*, regardless of habitat-type or distance between sampling sites. Additionally, the examination of annual combined small mammal biomass revealed a distinct pattern, with a repetitive maxima occurring every 3- to 4- yrs at TBS across all six sites.

The response of small mammal communities to habitat succession was assessed through changes in species richness, diversity and trophic structure over time. Species richness and diversity among the small mammal communities increased during the initial five years following fire, but declined during subsequent years across most sites. The granivore-omnivore, *P. maniculatus*, and to a lesser extent the grazer-omnivore, *C. gapperi*, were very responsive to the recently burned habitat through their rapid increases in numbers on several of the sites. The insectivore, *S. cinereus*, responded to conditions on severely burned sites through a reduction in its numbers across many of the plots, for several years following the fire.

Finally, the influence of biotic and abiotic factors on small mammal distribution and abundance was examined. Individual microhabitat variables surrounding each trapping station were identified and quantified through percent cover estimates to determine if they had an effect on small mammal capture rates. While several microhabitat features appeared to be associated with a particular small mammal species, overall macrohabitat (i.e., the entire area encompassed by the trapping grid) characteristics were better determinants of species presence and abundance.

Acknowledgements

This project became a reality through the encouragement, advice and assistance it received from a variety of sources. I would like to express my gratitude to Dr. W. O. Pruitt, Jr., my primary advisor, for providing both the spark and incentive to study in the boreal forest, and for the opportunity to experience living and working in the taiga of Manitoba. Members of my committee offered helpful advice on the study design and presentation of the project. Help with plant identification was kindly provided by Elizabeth Punter, University of Manitoba. Karen Johnson, Manitoba Museum, offered informative descriptions of the changing landscape around TBS following the 1980 fire. Dennis Murphy, University of Manitoba, provided statistical service and support.

My initiation into field research began with the deposition of Brian my son, Sasha my dog, and me, along with all of our food and equipment at the mouth of the Blind River in late April, by Bill Conley and his ATV. Bill's parting comment after assessing the dubious nature of the river ice (and after providing Brian with a long pole to test the ice before he took another step) was, "good luck lady".

To the many visitors I have had during my time at the station, thank-you for your good company and cheerful help with the myriad of camp chores. To my family, thank-you for your patience and support. Financial assistance for this project was provided by the Taiga Biological Station Research Trust, the Orville Erickson Memorial Scholarship Fund (Canadian Wildlife Federation), and the Richard C. Goulden Memorial Scholarship (Manitoba Chapter of the Wildlife Society).

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General Introduction

The boreal forest or taiga forms a broad circumpolar belt between 47^0 to 70^0 north latitude encompassing an area of 14.7 million km^2, approximately 11% of the earth's land surface and about 35% of Canada's land area (Kimmins and Wein 1986; Bonan and Shugart 1989; Bourgeau-Chavez et al. 2000). The North American segment of this circumboreal forest is the most extensive forest ecosystem of our continent and probably the least understood, especially in terms of the effects from perturbations on the structural and compositional complexity of the forest (Schmiegelow et al. 1997). A mixture of coniferous and deciduous tree species, the boreal forest covers an east-west region from Newfoundland, across central and northern Canada, westward to the Rocky Mountains and northwestward to Alaska (Rowe 1972; Scotter 1972). Much of this biome is populated by inherently flammable plant material (Auclair 1983) providing fire an evolutionary opportunity in boreal ecosystem development (Mutch 1970; Rowe 1983).

Fire influences floristic and faunistic diversity through ecological disturbance of the landscape (Rowe and Scotter 1973). Disturbance regimes created by fire operate at different spatial and temporal scales and provide heterogeneity to the environment through the production of stand patches of different age and size, vegetation structure and floristic composition (Heinselman 1970; Morneau and Payette 1989; Payette et al. 1989). Plant and animal species' distribution are often modified by such disturbance regimes (Payette 1992) and many changes may occur in the community ecology of small mammals during post-fire vegetative succession (Fox 1983). Difficulty arises in any attempt to pinpoint cause and effect relationships between the action of fire and the response of small mammals to habitat change, in part, because of the multitude of variables in the environment that have now been altered (Bendell 1974).

Boreal forest small mammals have evolved in an environment characterized by periodic ecosystem disturbances. Species will respond positively or negatively to habitat change, depending upon whether changes in the physical and biological environment are towards or away from the creature's optima, in terms of its survival requirements (Kirkland 1990).

This thesis investigates the effects of fire on patterns of small mammal abundance, distribution and community composition through time, following the May 1980 forest fire at Taiga Biological Station, Wallace Lake, MB.

Thesis Background and Objectives

Small mammals comprise a significant proportion of the faunal biomass in forest communities (Hamilton and Cook 1940) and are an integral base of the forest consumer food chain (Golley 1960). The small mammal community is an important component of the forest ecosystem in its consumption of primary production and for its contribution to secondary production as producers of animal protein for higher trophic levels (Pruitt 1966; Maser et al. 1978; Rose and Birney 1985).

An advantage of research on small mammals is that their populations can be readily sampled with standard trapping techniques and they provide many different opportunities for measuring species responses to habitat change (Tevis 1956; Ahlgren 1966; Naylor and Bendell 1982; Martell 1984; Clough 1987). Small mammals such as the southern red-backed vole (*Clethrionomys gapperi*) have been used as indicator species for old-growth (stable-aged) forests (Nordyke and Buskirk 1991) and in the assessment of habitat required by animal species classified as *sensitive*. Some of these sensitive species include the northern flying squirrel, *Glaucomys sabrinus* (Payne et al. 1989), the hoary bat, *Lasiurus cinereus* (Franklin et al. 1981) and amphibian species such as the giant salamanders, *Dicamptodon spp.* (Blaustein et al. 1995). Therefore, small mammals allow us to enhance our understanding of forest ecosystems through their association with a particular habitat type and/or condition.

The six study plots for small mammal research were originally established in 1977 at Taiga Biological Station (TBS) to track species and populations over time. They have been used also for studies on the effects of subnivean CO_2 on small mammals by Penny (1978). The morphometric data on the small mammals presented in this thesis were collected over this period of twenty-five years by a dedicated group of volunteers with varying degrees of trap-setting experience. The vegetation data presented are from plant surveys conducted during three separate time periods (1976, 1982 and 2000) of TBS history. Major emphasis was placed on plant data collected during the most recent vegetation survey of the small mammal study plots. However, the primary focus of this thesis will be on the small mammal communities inhabiting the six study plots at TBS.

The main goals of the thesis are:

(i.) to investigate the long-term response of small mammal populations after fire through the changing patterns of species distribution and abundance over twenty-five years;

(ii.) to examine the influence of habitat succession following fire on small mammal community structure across sequentially shorter intervals of time;

(iii.) to identify factors within the microsite or immediate trapping area that may affect small mammal activities and capture rates.

The information obtained in this thesis is largely the result of a retrospective survey of small mammal trapping records collected over twenty-five years. The analyses of the data are intended to be exploratory. Cause and effect relationships (as derived through controlled experimentation) cannot be shown between habitat variables and population response. However, it may be possible to describe factors that are important in predicting structure and diversity of small mammal communities (Carey and Johnson 1995) and relating those measurements of habitat properties to the distribution and abundance of the communities at TBS.

SECTION I.

Patterns in the Distribution and Abundance of Small Mammals

Section I. Abstract

Populations of small mammals were sampled annually by removal trapping in six different habitats over a twenty-five year period (1977-2001) near Wallace Lake, Manitoba. A total of 2,384 small mammals and 179 sciurids representing 14 species were captured in 43,800 trap-nights. The three most common species captured, in descending order of abundance, were *Clethrionomys gapperi* (southern red-backed vole), *Sorex cinereus* (masked shrew) and *Peromyscus maniculatus* (deer mouse). Changes in small mammal populations following fire were observed over time and the temporal patterns of short-term fluctuation and long-term synchronicity were examined.

Deer mice increased in number within the first few years following the burn to population levels above pre-fire levels; subsequent trapping sessions were unable to duplicate these early post-fire capture levels for *P. maniculatus*. Red-backed voles also increased in abundance within three months after the fire on most sites, but they soon experienced a rapid decline in numbers until their short-term recovery during the mid- to late- 1980's.

Similarities in the fluctuating abundance of red-backed voles were noted across several of the sampling plots at TBS, providing some evidence to suggest that extrinsic agents are affecting *C. gapperi* populations through the synchronous occurrence of peak abundance years. Additionally, evidence of synchrony in small mammal biomass production was noted, with peak accumulations every 3- to 4- yrs among the fauna at TBS.

Section I. Patterns in the Distribution and Abundance of Small Mammals

Introduction

Population variations or cycles occur when the temporal abundances of small mammals change. Temporal abundance is influenced by spatial patterns of distribution. Small mammals are often distributed in clumps or patches of aggregations - the result of response by the animals to habitat differences, stochastic events, reproductive patterns and social behaviour (Smith 1996). The field records at Taiga Biological Station suggest that populations of small mammals fluctuate considerably over time and space with little evidence of periodicity (regularity) in most species. Studies of microtine rodent (voles and lemmings) cycles showing regular and/or extreme density fluctuations have been well documented in the past (Elton 1942; Kalela 1962; Koshkina 1965; Fuller 1969). In central and northern Fennoscandia (Hansson and Henttonen 1985; Marcstrom et al. 1990) and in the coastal tundra of Barrow, Alaska (Batzli et al. 1980), vole populations are considered to be cyclic with a 3- to 4-year periodicity.

A number of theories have been advanced regarding rodent cycles because "of their enigmatic appeal to ecologists since such phenomena seem to violate balance and equilibrium" (Sandell et al. 1991, p 281), and because of the controversy surrounding the origin of forces behind cycling hypotheses in small mammals (Krebs 1996). Distinctions occur between the factors affecting population increase in small mammals: theories that stress extrinsic agents (weather, food supply, predators, parasites) and theories that stress intrinsic agents (hormonal, genotypical, behavioural) (Krebs et al. 1973; Begon et al. 1990).

The primary aim of this section is to investigate the response of small mammal populations after fire, through the examination of species distribution and abundance in six different habitats over twenty-five years. Specifically, this section will (1) compare long-term small mammal population fluctuations among study plots to check for any apparent patterns of co-occurrence of periodicity between species; (2) attempt to identify large-scale patterns of synchronicity among individual species.

Literature Review

Temporal and spatial processes:

Temporal and spatial processes that impact population demography and determine species abundance, assemblage and distribution are still poorly understood (Brown and Heske 1990; Steen et al. 1996; Peles et al. 1999). Most organisms live in spatially heterogeneous environments (Diffendorfer et al.1999) that are distributed neither uniformly nor randomly, but instead, often form aggregates called patches (Legendre and Fortin 1989; Bowers and Matter 1997). Consequently, the temporal abundance of small mammals can exert a strong influence on the community in which they live, and in turn, on the breeding success and survival of many of the terrestrial and avian predators dependent upon this food base (Hamilton and Cook 1940).

Small mammal distribution across the landscape is affected by their selection of habitat. The distribution patterns of northern small mammals depend in large part on differential habitat use (Adler and Wilson 1987; Wywialowski 1987; Barry et al. 1990). These small-bodied, short-lived species, with high reproductive rates and high habitat specificity, when found in small patches of disturbed forest, often show strong, short-term density responses to fragmented landscapes (Martell and Radvanyi 1977; Monthey and Soutiere 1985; Sullivan et al. 1999).

Understanding the methods by which animals select habitat may be useful in predicting changes in community structure that follow alterations of