SMALL MAMMALS AND VEGETATION CHANGES AFTER FIRE
IN A MIXED CONIFER-HARDWOOD FOREST

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Abstract. Following wild fire in northeastern Minnesota small mammals were snap-trapped
on two burned and one unburned area for three nights each fall from 1955 to 1967. The
deer mouse (Peromyscus maniculatus) was the most abundant species on the two burns the
first 7 yr. Later the vegetation changes apparently produced a habitat less attractive to the
deer mouse, while the red-backed vole (Clethrionomys gapperi) increased. Numbers of
meadow voles (Microtus pennsylvanicus), jumping mice (Zapus hudsonius), and cinereus
shrews (Sorex cinereus) were low and erratic on all areas. Eastern chipmunks (Tamias
striatus) were abundant most years on only one of the burns.

Key words: Clethrionomys; fire; forest; mammals; Minnesota; Peromyscus; vegetation
changes.

INTRODUCTION

Small mammals are an important segment of the mixed conifer-hardwood forest ecosystem. An
understanding of the reaction of these animals to changes in this ecosystem is an important part of
our knowledge of the ecology of the area.

Occasionally, wild fires burn relatively large areas of forest land, or controlled burning is used to pro­
mote tree reproduction; such fires materially change the habitat for all small mammal populations.

Smith and Aldous (1947) examined the stomach content of 30 deer mice (Peromyscus maniculatus)
from a jack pine slash area in the vicinity of the study. They found that 70% of the stomachs con­
tained the remains of jack pine seeds. On prescribed jack pine burn areas in the vicinity Ahlgren (1966)
also reported deer mice consumed quantities of jack pine seed. In Oregon, mice and shrews, mostly deer
mice, destroyed 41% of the seeds of Douglas fir (Gashwiler 1970). Hamilton (1941), in New York,
reported 180 deer mouse stomachs had the following food item frequencies: 73% insects, 44% starchy
matter, most of which was seeds, and 21% green vegetation. In Colorado and Wyoming, the stomach
content of 122 deer mice showed they fed mostly on the interiors and integuments of seeds, chiefly
conifer mast (Williams 1959). Williams also found that 0.1% to 0.2% of the food consisted of insects
and Arachnid remains; grubs and caterpillars were

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Discussion of vegetation changes is limited to those general features that might have a direct effect upon rodent populations. Detailed post-fire vegetation response in these three areas has been published previously (Ahlgren 1960).

**Description of Study Areas**

The study areas are located in Lake County, Minnesota, on the Superior National Forest and lie about 24 km southwest of Ely adjacent to State Highway 1. Each is topographically diverse, with rolling land containing numerous swamps, peat bogs, lakes, and outcrops of bedrock (Miller 1947). The Ahmeek soils are dark colored and are formed from a reddish brown noncalcareous sandy-stoney glacial till (Arneman 1963). Keweenawan basaltic flows, especially Duluth Gabro, predominate (Thiel 1947). From 1950 to 1967, the average mean temperature was 2.4°C and the average mean precipitation was 0.7 m (Ahlgren 1969).

**Control area—unburned**

The control area has a mixed conifer–hardwood second-growth stand (about 70 yr old) of 46% black spruce (*Picea mariana*),

\[23\% \text{ jack pine (} \text{Pinus Banksiana)}\], 23% paper birch (*Betula papyrifera*), 5% balsam fir (*Abies balsamea*), and 3% quaking aspen (*Populus tremuloides*). Shrub species in the

\[3\text{ Scientific names follow Gray's Manual of Botany, Eighth Edition, 1950.}\]

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**Fig. 1.** Unburned control area. The overstory at this location consists mainly of balsam fir and paper birch with shrubs and down trees in the understory. The cord in the photograph marks the location of one of the two trapping transects in the area. (Photo by L. W. Krefting, Fish and Wildlife Service, U.S.D.I.)

**Fig. 2.** Regrowth of natural jack pine and planted red pine on the Heart Lake burn area 14 yr after the fire. Note the dense growth of sweet fern and the clump of mountain alder in the understory. (Photo by L. W. Krefting, Fish and Wildlife Service, U.S.D.I.)
understory include willow (Salix sp.), mountain alder (Alnus crispa), juneberry (Amelanchier sp.) beaked hazelnut (Corylus cornuta), bush honeysuckle (Dier-\textit{vilia Lonicera}), and a pin cherry (\textit{Prunus pensylvanica}) (Fig. 1).

\textit{Heart Lake burn}

On April 28, 1952, 325 ha burned, including 195 ha of spruce-fir, 53 ha of jack pine, 47 ha of bogs and swamps, 16 ha of aspen, and 13 ha of black spruce. The area trapped had been a 10-yr-old jack pine plantation before the fire. At the time of the fire, the ground was cold and moist; consequently, little or no soil burn occurred. Apparently, a strong southwesterly wind caused the fire to move quickly, leaving behind occasional small unburned areas. These patches may have acted as a refuge for some animals. Within a few days after the fire jack pine cones in surrounding, mature burned trees opened and dispersed seeds. In the fall following the fire, red pine (\textit{Pinus resinosa}) trees were planted. When trapping was started, red pine and jack pine seedlings and sprouts of aspen and paper birch were frequent in the area. Common shrubs included mountain alder, beaked hazelnut, juneberry, rose (\textit{Rosa acicularis}), pin cherry, bush honeysuckle, and blueberry (\textit{Vaccinium angustifolium}). In 1967 the burned area had a dense overstory of jack pine and red pine (Fig. 2). One of the most important ground cover plants was sweet fern (\textit{Comptonia peregrina}); other less common shrubs were mountain alder, juneberry, bush honeysuckle, beaked hazelnut, and blueberry.

\textit{Keeley Creek burn}

On July 11, 1955, approximately 12 ha burned (Fig. 3). As in the Heart Lake burn, little or no soil burn occurred even though it was a hot fire. Before the fire, the forest was a mixture of about 35% jack pine, 45% black spruce, and 5% balsam fir, with scattered quaking aspen and paper birch. Understory shrubs included willow, mountain alder, juneberry, beaked hazelnut, bush honeysuckle, and pin cherry. In 1966 the area had a relatively heavy ground cover of sweet fern and patches of blueberry. Scattered sapling-sized trees included paper birch, aspen, jack pine, and smaller black spruce (Fig. 4).
PROCEDURES

We used the North American Census of Small Mammals snap-trapping technique (Calhoun 1948). On each area we established two parallel trap lines 60 m apart and 144 m long. Trap stations were spaced about 7 m apart and totaled 20 per line. At each station we set three mouse traps, one directly on the line, one to the left approximately 1.5 m, and one to the right. Traps, baited daily with homogenized peanut butter, were operated for three consecutive nights in late August or early September (360 trap nights per line each year). For the first night of trapping, the traps were set between 1400 and 1700 hr, and on the following days were tended between 0800 and 1000 hr. Specimens caught were recorded by species, station number, and trap line. Trapping was carried on from 1955 to 1967.

Species composition of vegetation on each study area was obtained from tallies made on 30 permanent circular plots of 10 m² placed 30 m apart. Post-fire vegetation tallies were made on the Heart Lake burn in 1954, 1956, and 1965, and on the Keeley Creek burn in 1956, 1959, and 1965. Similar tallies were made in 1956 and 1965 on the control area.

RESULTS

Small mammal fluctuations

The relative abundance of the small mammals trapped in the unburned control area and the Heart Lake and Keeley Creek burn is graphed on a logarithmic scale (number = Log X + 1) (Fig. 5). The numbers of deer mice (*Peromyscus maniculatus*) and red-backed voles (*Clethrionomys gapperi*) caught were plotted on this scale since populations tend to change by constant percentages rather than by constant numbers. The most common kinds of biological statistics do not apply because, being a population, the numbers are serially correlated.

4Scientific names of mammals follow Miller and Kellogg (1955).
CHANGES IN MAMMALS AND VEGETATION AFTER FIRE

CONTROL AREA — UNBURNED

HEART LAKE BURN

KEELEY CREEK BURN
TABLE 1. Number and percent of red-backed voles and deer mice and other small mammals caught in snap-traps in three areas for the periods 1955-61 and 1962-67

| Area                  | Red-backed vole | Deer mouse | Other small mammals | Total All mammals |
|-----------------------|-----------------|------------|---------------------|-------------------|
|                       | Number | Percent | Number | Percent | Number | Percent | Number | Percent | Number | Percent |
| 1955-61               |        |         |        |         |        |         |        |         |        |         |
| Unburned control     | 167    | 84      | 12     | 6       | 21     | 10      | 200    |          |        |         |
| Heart Lake burn       | 19     | 12      | 90     | 56      | 53     | 32      | 162    |          |        |         |
| Keeley Creek burn     | 38     | 14      | 168    | 62      | 65     | 24      | 271    |          |        |         |
| Total                 | 224    |         | 270    |         | 139    |         | 633    |          |        |         |
| 1962-67               |         |         |        |         |        |         |        |         |        |         |
| Unburned control     | 143    | 92      | 3      | 2       | 9      | 6       | 155    |          |        |         |
| Heart Lake burn       | 100    | 63      | 11     | 7       | 49     | 30      | 160    |          |        |         |
| Keeley Creek burn     | 49     | 42      | 30     | 25      | 39     | 33      | 118    |          |        |         |
| Total                 | 292    |         | 44     |         | 97     |         | 433    |          |        |         |

The graph shows that the cyclic peaks of red-backed voles are fairly synchronous in the different areas, especially in the control area and Keeley Creek burn. Deer mice are less synchronous in all three areas and show a general downward trend in the two burns from 1955 to 1967. The graph and the trapping data in Table 1 suggest that the deer mouse predominated in the first 7-yr period (1955–61) and decreased in the second 6-yr period (1962–67). The red-backed vole increased in the second period, probably in response to the increased cover.

The number of other mammal species caught are lumped in Table 1 and shown in Fig. 5 by capital letters, each of which represents the first letter of the genus. The eastern chipmunks were abundant most of the time in the Keeley Creek burn despite the changes in cover. Apparently the wide variety of seeds available attracted chipmunks to this area. Earlier work in jack pine slash areas in the vicinity revealed that chipmunks feed heavily on jack pine seed (Smith and Aldous 1947). Other species (Fig. 5) that were erratic were the meadow vole (Microtus pennsylvanicus), jumping mouse (Zapus hudsonius), and cinereus shrew (Sorex cinereus).

Vegetation changes

A comparison of the post-fire vegetation in the Heart Lake and Keeley Creek burns reveals obvious differences in species composition (Table 2). These differences may be related to some of the major changes in populations of small mammals, especially red-backed voles and deer mice. Therefore, we must examine the vegetation on the two burns to determine whether it can be related to the abrupt shift of small mammals on the Heart Lake area and the more gradual shift on the Keeley Creek area.

Table 2 lists the plant species present on the two burned areas and their nearby control at intervals after fire. These species have been placed in six groups: Group 1 includes plants that are absent or rare on the control area and that came in abun- 
dantly soon after fire; Group 2, plants that increased on the burn but were also present on the control; Group 3, plants decreasing in frequency after fire; Group 4, plants that did not change in frequency after fire; Group 5, plants completely missing on burned land until the 5th or 10th yr, or later; Group 6, plants that were present before fire and reacted differently on different areas after fire.

On both the Heart Lake and Keeley Creek areas total diversity did not change drastically, but there was an increase in the herb species that reproduce primarily by seed immediately after fire (Group 1). A vegetation-origin transect revealed that seeds of these species were present in the organic layer of the soil before burning; fire created conditions conducive to germination and also made seed readily available as a source of food. On the Heart Lake area, the major Group 1 species important to small mammals soon after burning were bindweed (Polygonum cilinode), sedges (Carex adusta and C. Houghtonii), and pin cherry seeds exposed by fire. These species are temporary and were less frequent on the area or not producing seed by the 10th post-fire year. Among the Group 2 plants, no seed- or berry-producing species increased in this area sufficiently to replace these temporary Group 1 plants as sources of food for deer mice. Hence, the supply of seed and berries for which deer mice show a preference decreased sharply in availability between the 5th and 10th yr.

On the Keeley Creek area, however, large quantities of jack pine seed were released from the burned stand immediately after fire. Such seed-reproducing plants as geranium (Geranium Bick-
### Table 2. Changes in plant species composition following wild fire. Figures represent percent occurrence of the species in thirty 10-m² plots on the control, Heart Lake, and Keeley Creek areas.

| Groups and plant species⁴ | Control area | Heart Lake area | Keeley Creek area |
|---------------------------|--------------|-----------------|------------------|
|                           | Type of reproduction | Not burned | Years sampled (years after burn) | Years sampled (years after burn) |
|                           | 1956 | 1965 | '54(3) | '56(5) | '65(14) | '56(2) | '59(5) | '65(11) |
| **Group 1** | | | | | | | | |
| *Anaphalis margariacea* | S | 0 | 0 | 3 | 7 | 7 | 0 | 10 | 13 |
| *Aster ciliolatus* | V – S | 0 | 0 | 13 | 10 | 40 | 0 | 3 | 0 |
| *Carex obtusa* | V (s) | 0 | 0 | 53 | 10 | 0 | 47 | 10 | 0 |
| *Carex Hoagtonii* | V (s) | 0 | 0 | 37 | 13 | 0 | 13 | 83 | 0 |
| *Comptonia peregrina* | | | | | | | | | |
| *Corydalis sempervirens* | | | | | | | | | |
| *Epilobium angustifolium* | | | | | | | | | |
| *Epilobium glandulosum* | | | | | | | | | |
| *Geranium Bicknellii* | | | | | | | | | |
| *Pinus Banksiana* | | | | | | | | | |
| *Polygonum ciliinode* | S (v) | 0 | 0 | 70 | 43 | 0 | 40 | 47 | 0 |
| *Praunus pensylvanica* | | | | | | | | | |
| *Pteridium aquilinum* | V | 0 | 0 | 7 | 7 | 3 | 0 | 3 | 3 |
| *Solidago canadensis* | S | 0 | 0 | 7 | 7 | 3 | 0 | 3 | 0 |
| **Group 2** | | | | | | | | |
| *Anemone quinquifolia* | V – S | 17 | 17 | 27 | 10 | 57 | 17 | 23 | 27 |
| *Aster macrophyllus* | V (s) | 30 | 33 | 77 | 67 | 87 | 20 | 23 | 57 |
| *Corylus cornuta* | V (s) | 70 | 57 | 80 | 83 | 73 | 0 | 0 | 3 |
| *Fragaria vesca* | S | 3 | 3 | 27 | 33 | 0 | 0 | 7 | 43 |
| *Oryzopsis pungens* | V – S | 13 | 13 | 17 | 7 | 27 | 17 | 16 | 27 |
| *Populus tremuloides* | V (s) | 10 | 3 | 20 | 23 | 3 | 33 | 80 | 67 |
| *Rubus idaeus* | V – S | 23 | 20 | 87 | 70 | 53 | 13 | 60 | 87 |
| *Vaccinium angustifolium* | V (s) | 63 | 40 | 93 | 83 | 90 | 40 | 60 | 60 |
| *Viola incognita* | S (v) | 7 | 3 | 10 | 17 | 0 | 0 | 3 | 17 |
| **Group 3** | | | | | | | | |
| *Aralia nudicaulis* | V (s) | 67 | 73 | 43 | 3 | 10 | 27 | 13 | 10 |
| *Linnaea borealis* | V | 80 | 70 | 43 | 17 | 27 | 10 | 13 | 20 |
| *Malanthemum canadense* | V (s) | 97 | 97 | 30 | 17 | 67 | 33 | 27 | 53 |
| *Pyrus americana* | V – S | 63 | 40 | 27 | 23 | 20 | 0 | 0 | 0 |
| *Rosa acicularis* | V (s) | 50 | 57 | 37 | 40 | 33 | 10 | 10 | 23 |
| *Viola renifolia* | V (s) | 20 | 20 | 10 | 7 | 7 | 0 | 0 | 3 |
| **Group 4** | | | | | | | | |
| *Cornus canadensis* | V (s) | 90 | 87 | 97 | 87 | 87 | 60 | 60 | 70 |
| *Galium triflorum* | V (s) | 3 | 3 | 7 | 3 | 7 | 0 | 3 | 3 |
| *Ledum groenlandicum* | V (s) | 33 | 30 | 23 | 23 | 23 | 13 | 17 | 13 |
| *Ribes glandulosum* | S | 7 | 7 | 10 | 13 | 3 | 0 | 7 | 3 |
| *Spiraea roscus* | V (s) | 7 | 7 | 10 | 13 | 3 | 0 | 7 | 3 |
| *Fraxinus borealis* | V – S | 7 | 10 | 10 | 13 | 13 | 3 | 7 | 7 |
| **Group 5** | | | | | | | | |
| *Chimaphila umbellata* | | 10 | 13 | 0 | 0 | 0 | 0 | 3 | 3 |
| *Cimnna latifolia* | | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cyripedium acaule* | | 10 | 17 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Dryopteris discinuata* | | 7 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| *Dryopteris Phegopteris* | | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gaultheria hispidula* | | 20 | 17 | 0 | 0 | 0 | 0 | 0 | 17 |
| *Goodyera repens* | | 20 | 13 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Polypodium virginianum* | | 7 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Group 6** | | | | | | | | |
| *Alnus crispa* | V | 20 | 23 | 47 | 50 | 37 | 0 | 3 | 3 |
| *Amelanchier spp.* | V | 33 | 47 | 57 | 57 | 60 | 7 | 13 | 3 |
| *Apoecynum androsaemifolium* | V – S | 13 | 10 | 33 | 37 | 47 | 0 | 3 | 0 |
| *Betula papyrifera* | V – S | 13 | 23 | 10 | 13 | 7 | 100 | 100 | 90 |
| *Calamagrostis canadensis* | V (s) | 30 | 30 | 93 | 93 | 97 | 30 | 20 | 30 |
| *Clintonia borealis* | V (s) | 73 | 67 | 77 | 80 | 80 | 23 | 23 | 23 |
| *Diervilla Lonicera* | V (s) | 47 | 43 | 90 | 93 | 93 | 17 | 33 | 43 |
| *Lycopodium obscurum* | V | 10 | 10 | 23 | 20 | 20 | 3 | 0 | 3 |
| *Oryzopsis asperifolia* | V – S | 33 | 53 | 77 | 47 | 80 | 17 | 17 | 23 |
| *Rubus pubescens* | V – S | 33 | 0 | 73 | 70 | 7 | 13 | 17 | 0 |
| *Picea mariana* | S | 67 | 40 | 0 | 3 | 7 | 47 | 87 | 93 |

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⁴ Groups 1–6 have been described in the text.

⁵ S = seed origin; V = vegetative origin; V – S = vegetative and seed origin about equal. The lower case letters in parentheses indicates the less frequent method of reproduction.
nelli), fireweed (Epilobium glandulosum), bindweed, pink corydalis (Corydalis sempervirens), and swarthy sedge (Carex adusta) were also available, as well as pin cherry seed exposed in the burned humus. According to seed trap studies, jack pine seed was less available after the 2nd yr, and the frequency of such species as geranium and narrow-leaved fireweed (Epilobium angustifolium) and Group 2 berry and seed producers, raspberry (Rubus idaeus) and strawberry (Fragaria vesca), increased strikingly. Thus, in the Keeley Creek area, a continuous supply of seeds and berries was available. This difference in seed availability may partially explain the difference in the rate of decline of deer leaved fireweed (Epilobium glandulosum) and strawberry (Fragaria vesca), increased strikingly. This, in the Keeley Creek area, a continuous supply of seeds and berries was available. This difference in seed availability may partially explain the difference in the rate of decline of deer mice on the two areas.

While plant species preferred as food by red-backed voles were available in both areas (succulent herbs as well as seeds—various species in Groups 1, 2, and 3), vegetation (cover density) differences other than the presence or absence of these food plant species may be more important in explaining the different abundances of this vole on the two areas.

Unlike the Heart Lake area, where a 10-yr-old jack pine plantation burned and the trees were completely consumed, a well-stocked forest of jack pine and spruce burned on the Keeley Creek area, and the uprooted stumps and fallen trees, snags, logs, and debris provided a type of cover conducive to red-backed vole activity (Gunderson 1959). Possibly the "carrying capacity" of Keeley Creek was greater in the early years, at least partially because of greater habitat diversity. In later years, a growth of jack pine seedlings and other species provided cover on the Keeley Creek area; on Heart Lake, the natural jack pine and the planted red pine provided a somewhat similar cover.

The percent cover data graphed in Fig. 5 shows variation in trees, shrubs, herbs, wood, rock, soil, and moss on all three areas. Change occurred on all three but was greater on the two burned areas. On both burns the percent cover of trees and shrubs increased. By 1965, herbs decreased in both burned areas although they increased temporarily on the Keeley Creek burn in 1959. Variation in percent cover of wood, rock, soil, and moss are affected mostly by fallen trees and changes in ground cover.

The downward trend in the deer mouse numbers from 1955 to 1967 on both burns suggests that the habitat gradually deteriorated for this species. The increase in the red-backed vole catches from 1962 to 1967 on these burns suggests that the habitat improved for this vole. Availability of food (insects and seeds for deer mice, and herbs and some seeds for the red-backed vole) and cover are important influences on small mammal populations after fire but they affect small mammal species differently. Consumption of seed—notably jack pine by small mammals (mostly deer mice) may also influence the pattern of vegetation changes.

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