Ecology of the Woodland Jumping Mouse (*Napaeozapus insignis*) in New Hampshire

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Abstract. Population densities of the woodland jumping mouse (*Napaeozapus insignis*) were studied on logged over and control sites in east-central New Hampshire from May 1968 to December 1969 by live-trapping and snap-trapping. Largest numbers were captured on the older (> two years) seral stages and on certain moist uncut areas. Highest population densities occurred where there was low woody vegetation cover, high soil moisture, and abundant invertebrate food. The suggestion that *N. insignis* is excluded from suitable habitat by competition from the redback vole *(Clethrionomys gapperi)* is discussed.

Introduction

As part of an ecological study of small mammal succession following logging in the White Mountain National Forest in New Hampshire (Lovejoy, 1970), observations were made on certain aspects of the ecology of the woodland jumping mouse *(Napaeozapus insignis)*. Data were collected by snap-trapping and live-trapping on six study areas in east-central New Hampshire.

A rectangular plot (0.7 to 2.6 ha.) gridded at a 10 m interval was placed in each study area. The areas were live-trapped for 8-10 days at approximately bimonthly intervals during the snow-free months from May 1968 to December 1969. Wooden multiple catch traps (Burt, 1940) baited with cracked corn were used throughout. Individuals were marked by toe-clipping and released at the point of capture.

Snap-trapping transects located within 250 m of the live-trap grids and on other seral stages provided additional data. Transects usually consisted of 25 stations (two traps per station) spaced at 10 m intervals. Peanut butter sprinkled with oats was used as bait. Each transect was trapped concurrently with the adjacent live-trapping plot for three consecutive days.

Data were also collected concerning the vegetation (particularly as it relates to the provision of food and cover for small mammals) and invertebrate food supply (litter samples processed in Berlese funnels). Microclimate data (air temperature, relative humidity, soil temperature, and soil moisture) were obtained using maximum-minimum thermometers, continuously recording thermographs and hygrothermographs, and a tele-thermometer (see Lovejoy, 1970, for methods and results of the habitat analysis).

Description of Study Areas

The six areas selected for live-trapping were in the northern hardwood forest region (Lull, 1968) at elevations of 430-560 m. Dominant tree species included beech *(Fagus grandifolia)*, yellow birch *(Betula lutea)*, and sugar maple *(Acer saccharum)*. The areas included four post-logging seral stages, an uncut control, and a 3-4 year old burn. All areas were on north-east facing slopes except the 3-4 year stage and the burn which faced southeast.

0-1 Year Stage. Before logging, this area consisted primarily of mature hardwoods and softwoods with beech, sugar maple, yellow birch, and red spruce *(Picea rubens)* as the most abundant species. A locally variable shrub stratum included the above species and hobblebush *(Viburnum alnifolium)*, while the ground stratum included seedlings of the above tree species and starflower *(Trientalis borealis)*. This area was live-trapped twice before logging occurred in October 1968. Following logging, the area

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consisted of a mosaic of slash piles, scattered slash, open spaces nearly devoid of low vegetation, skid trails with exposed mineral soil, and islands of uncut or partially cut forest. In the first post-logging growing season, the ground stratum increased greatly in localized areas, but remained less dense than that on the 1-2 year stage; this reflected the different dates of logging on the two areas.

1-2 Year Stage. Before logging, this area was similar to the 0-1 year stage except for larger numbers of beech in all strata. This difference was due primarily to the relatively drier conditions. Logging occurred in June 1968. In general, habitat conditions were similar to those of the 0-1 year stage, but more slash remained owing to less efficient utilization of timber.

3-4 Year Stage. Before logging, this area consisted largely of red spruce and balsam fir *(Abies balsamea)* with smaller numbers of hardwoods. Heavy logging in the spring and summer of 1965 left only a few seed trees on the area. Two major groupings of vegetation occurred on the live-trap grid: (1) A hardwood area which was dominated by a dense growth of sugar maple (2-4 m high) with small numbers of several other woody species and a sparse ground stratum, (2) A *Rubus* area which was dominated by raspberry *(R. idaeus)* and blackberry *(R. allegheniensis)* with small numbers of young hardwoods (1-3 m high). Both groupings contained abundant slash which was generally covered by vegetation.

Burn. In July 1965, 14 ha. of the above logged area was heavily burned, leaving most of the area almost devoid of slash and doing variable damage to the humus. A mosaic of several vegetation types occurred on this area owing to different intensities of burning. These varied from heavily burned sites supporting a dense growth of bracken fern *(Pteridium aquilinum)* to lightly burned sites supporting saplings of fire cherry *(Prunus pensylvanica)* (2-3 m high) and a variable ground cover including bristly sarsaparilla *(Aralia hispida),* twisted stalk *(Streptopus amplexifolius),* and raspberry, among other species.

15-16 Year Stage. Before logging in 1953, this area supported mature hardwoods. During the study, the tree stratum consisted of a relatively uniform dense growth of beech, yellow birch, sugar maple, and moosewood *(Acer pensylvanicum)* (6-8 m high), with most individuals less than 7.5 cm dbh. A sparse ground stratum consisted primarily of seedlings of beech, sugar maple, moosewood, hobblebush, and red spruce.

Control. The tree stratum consisted of mature beech, yellow birch, sugar maple, red spruce, and hemlock *(Tsuga canadensis).* A sparse shrub stratum included large numbers of beech, while the sparse ground stratum (variable locally) was mostly beech and sugar maple seedlings. Few fallen logs were present, but surface boulders were abundant in some sites.

Results

A total of 105 individuals were live-trapped 163 times during the study. An additional 208 individuals were snap-trapped. Highest population densities of *N. insignis* occurred on moist uncut areas or on those logged areas supporting dense cover in the form of low woody vegetation (3-4 year stage, 15-16 year stage; Table 1). The Burn, recently logged areas, and dry uncut areas supported low populations of this species. In snap-trapping on the 3-4 year stage, most captures were recorded in a dense growth of *Rubus* sp., hardwoods, or in decaying slash piles; *N. insignis* was not taken in partially cut sites with little slash and a sparse shrub stratum. In June 1969, 18 *N. insignis* were snap-trapped in slash and dense shrubs on the 3-4 year stage (24 stations) while only one was taken in a partially cut area (11 stations). Similar results were obtained in other snap-trapping periods but smaller numbers were taken. Relatively low populations were indicated by live-trapping of the 3-4 year stage; competition from the redback vole *(Clethrionomys gapperi)* appeared to be a factor on these sites (see below).

These results support the findings of Brower and Cade (1966) who reported *N. insignis* to select areas with a substantial cover of low woody vegetation. Other workers have reported

TABLE 1. — Relative abundance of *Napaeozapus insignis* on several uncut and logged areas, 1968–1969

Stage[1]	Snap-Trapping			Live-Trapping		
	Trap-Nights	Individuals Captured	Captures per 100 TN	Trap-Nights	Individuals Captured	Captures per 100 TN
1–2 year[2]	1701	24	1.4	5201	19	0.37
3–4 year	1078	34	3.1	1400	2	0.14
15–16 year	761	27	3.5	3987	21	0.53
Uncut 0–1 year[3] (Moist)	1391	45	3.2	1696	48	2.83
Control (Uncut-Dry)	1631	7	0.4	3835	14	0.36
Burn	409	1	0.2	2150	1	0.05

[1]Area of each live-trap grid: 1-2 year, 1.2 ha.; 3-4 year, 0.7 ha.; 15-16 year, 2.6 ha.; 0-1 year, 2.1 ha.; Control, 2.6 ha.; Burn, 1.2 ha.
[2]Composit of data from the 1-2 year stage and the 0-1 year stage in 1969 (one year after logging).
[3]1968 data only (before logging).

an association of this species with water (Snyder, 1924; Hamilton, 1943; Preble, 1956; Whitaker, 1963; Wrigley, 1969). In the present study, standing water was not necessary for the presence of this species, but larger numbers were captured in moist than in dry areas. Snap-trapping of several uncut areas indicated *N. insignis* to be more abundant in moist sites; 43 of 47 captures occurred at such sites ($\chi^2 = 12.71$, $p < .0005$, d.f. $= 1$). Snap-trapping of the 15-16 year stage yielded 9 of 10 captures within 10 m of standing water in 1968; only two of 15 captures occurred at similar sites in 1969, a year of above average moisture.

In 1969, *N. insignis* was generally more widely distributed and abundant on all areas except the relatively moist 0-1 year stage than in 1968. The winter of 1967-8 was one of below normal precipitation (data from Pinkham Notch, 6-21 km from the live-trap grids); in addition, rainfall between May and October 1968 was below normal in each month except June; there was a total deficit of 13 cm during this period (U.S. Dept. Comm., 1968). In the following year, the water content of the snow pack was the greatest on record at Pinkham Notch (U.S. Dept. Comm., 1969) and rainfall was 9 cm above normal from May to September 1969. Therefore, the heavier snowfall in the winter of 1968-9 and above normal precipitation during the summer resulted in relatively higher soil moisture during the second year.

Those areas supporting the largest numbers of *N. insignis* (3-4 and 15-16 year stages, 0-1 year stage before logging) provided a moderate to high invertebrate food supply (Lovejoy, 1970). In addition, the 0-1 year stage (before logging) and 15-16 year stage provided conditions suitable for the growth of *Endogone* and other soil fungi (high soil moisture and organic material; Williams and Finney, 1964). Several workers have reported or suggested *Endogone* may be important in the diet of *N. insignis* (Whitaker, 1962, 1963; Williams and Finney, 1964; Getz, 1968). Whitaker (1963) found *Endogone* to be the single most important food of *N. insignis* in New York; he reported (1962) this fungus to make up 32% (by volume) of the food of 16 *N. insignis* from Coos and Carroll Counties, New Hampshire.

In this study, the presence and abundance of *Endogone* was not determined, but moist areas such as the 0-1 and 15-16 year stages probably had relatively large amounts of this fungus. The 3-4 year stage (which also supported large numbers of *N. insignis*) was less moist, but this area provided more food in the ground and shrub strata (including *Rubus* berries) and more invertebrates than did the other two areas. Invertebrates, seeds, and fruits have been reported to be important food items for *N. insignis* (Burt, 1957; Whitaker, 1963).

The above data indicate cover, food, and soil moisture to be important and interrelated factors affecting the distribution and abundance of *N. insignis* in central New Hampshire. Air temperature, soil temperature, and relative humidity were not important factors influencing the distribution or abundance of *N. insignis* in this study (Lovejoy, 1970).

Competition with the redback vole *(Clethrionomys gapperi)* also appears to have influenced the distribution and abundance of *N. insignis* on some areas. On recently logged sites, slash piles provided conditions favorable for *N. insignis* since they provided adequate food, cover, and soil moisture. Those few individuals captured on recently logged areas were taken in slash piles or in dense woody sites; *C. gapperi* also selected slash piles and was more abundant than *N. insignis* on recently logged areas (Lovejoy, 1970).

Brower and Cade (1966) have suggested (on the basis of temperament of the two species) that *N. insignis* may avoid areas inhabited by *C. gapperi*. Large numbers of both species could not therefore co-inhabit recently logged areas in which their preferred habitat was restricted to small localized sites (slash piles); *N. insignis* would be excluded from these areas by *C. gapperi*.

Of 19 *N. insignis* live-trapped on the two recently logged areas, 12 were taken on the 0-1 year stage in September 1969, one year after logging. By this time, a developing ground stratum was providing more optimal sites for both species throughout the area; as more suitable habitat became available, the species could coexist with less competition. On the 3-4 year stage, large areas of suitable habitat for both species occurred. Large numbers of both species did not occur together in this stage, however; snap-trapping transects generally yielded large numbers of only one of the two species (Table 2), while large numbers of *C. gapperi* and only two *N. insignis* were live-trapped on this area during the study. Similar results were obtained on other areas. Since no differences in type or abundance of cover, moisture, food, microclimate, or vegetation type appeared to exist within or among these areas, exclusion of *N. insignis* from certain sites by a more aggressive *C. gapperi* appears to be the most likely explanation.

TABLE 2. — Captures of *Napaeozapus insignis* and *Clethrionomys gapperi* on snap-trapping transects on the 3–4 year post-logging stage

Date	Trap Nights	*Clethrionomys* captures	*Napaeozapus* captures
July 68	72	6	0
May 69	78	3	0
June 69	210	2	19
July 69	102	12	5
July 69	166	11	1
Aug 69	150	8	1
Aug 69	150	2	7
Aug 69	150	3	1

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