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THE EFFECT OF FIREWOOD REMOVAL
ON BREEDING BIRD POPULATIONS
IN A NORTHERN OAK FOREST

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JOHN VICTOR DINGLEDINE

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THE EFFECT OF FIREWOOD REMOVAL ON BREEDING BIRD POPULATIONS IN A NORTHERN OAK FOREST

By

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ABSTRACT

EFFECT OF FIREWOOD REMOVAL
ON BREEDING BIRD POPULATIONS
IN A NORTHERN OAK FOREST

By

John V. Dingledine

Uncertainties in the supply of fossil fuels have spurred more Americans to use wood to heat their homes. Current policies allow the cutting of dead standing trees, called snags, as well as other dead and down woody material. This may significantly impact a number of snag dependent wildlife, especially those bird species which rely on snags for nesting sites and foraging substrate. This study was designed to investigate the effect of intensive firewood removal on bird populations with particular emphasis on the cavity-nesting species.

Six 15-ha plots, located near Big Rapids, Michigan, in the Huron-Manistee National Forest, were selected on the basis of similar forest composition and structure. Plots were dominated by mature oak (Quercus spp.) with small percentages of several additional species. In the fall of

1981, all dead or down woody material was removed from the center 8 ha of 3 of the study plots to simulate intensive firewood removal. A total of 60-65 standard cords of firewood were cut and removed.

A breeding bird census, using the spot-mapping method, was conducted in the spring of 1981, prior to firewood removal, and again in the spring of 1982 following firewood removal. Nest sites of the existing cavity-nesting species were located both years. In addition, vegetation was sampled and snags were measured for d.b.h., height, percent bark cover, and densities.

Snags in all size classes were significantly reduced within the treatment area. Total reductions in snag numbers were not achieved due to new snag generation and the presence of remaining snags deemed unsuitable as firewood. Total bird densities and diversities were similar between control and cut plots with no significant differences noted in cavity-nesting bird densities. Cavity-nesting birds present on these plots appeared to be able to nest in remaining live trees and dead limbs of live trees. Also, the large territory sizes of these birds led to low densities and lessened the observable effect of firewood cutting. These results indicate that within oak forests of this type, it may be possible to harvest firewood from areas up to 8 ha in size without significant changes in bird populations.

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INTRODUCTION

Increasing demand for and dwindling supplies of fossil fuels have led to a greater utilization of alternate sources of energy. Wood, as a home heating fuel, continues to increase in popularity among Americans. A U.S. Department of Energy study stated that, overall, wood energy consumption in 1981 was up 45% from 1974, while residential use rose more than 113%. A survey of Michigan homeowners conducted in 1982 indicated that 3 out of every 10 homes used firewood as some source of heat. Annual consumption in the state was approximately 3 million standard cords (M. Moore, MDNR, pers. commun.).

This increasing demand is reflected in the number of free-use firewood cutting permits being issued by state and federal agencies. Within the Manistee National Forest, issuance of such permits rose 414% since 1978 (Figure 1). This tremendous demand for firewood has already begun to reduce the number of dead standing trees, called snags, in some forested areas of the U.S. (Scott et al., 1980). This is especially true in national forests where firewood removal is usually restricted to snags and other dead and down woody material.

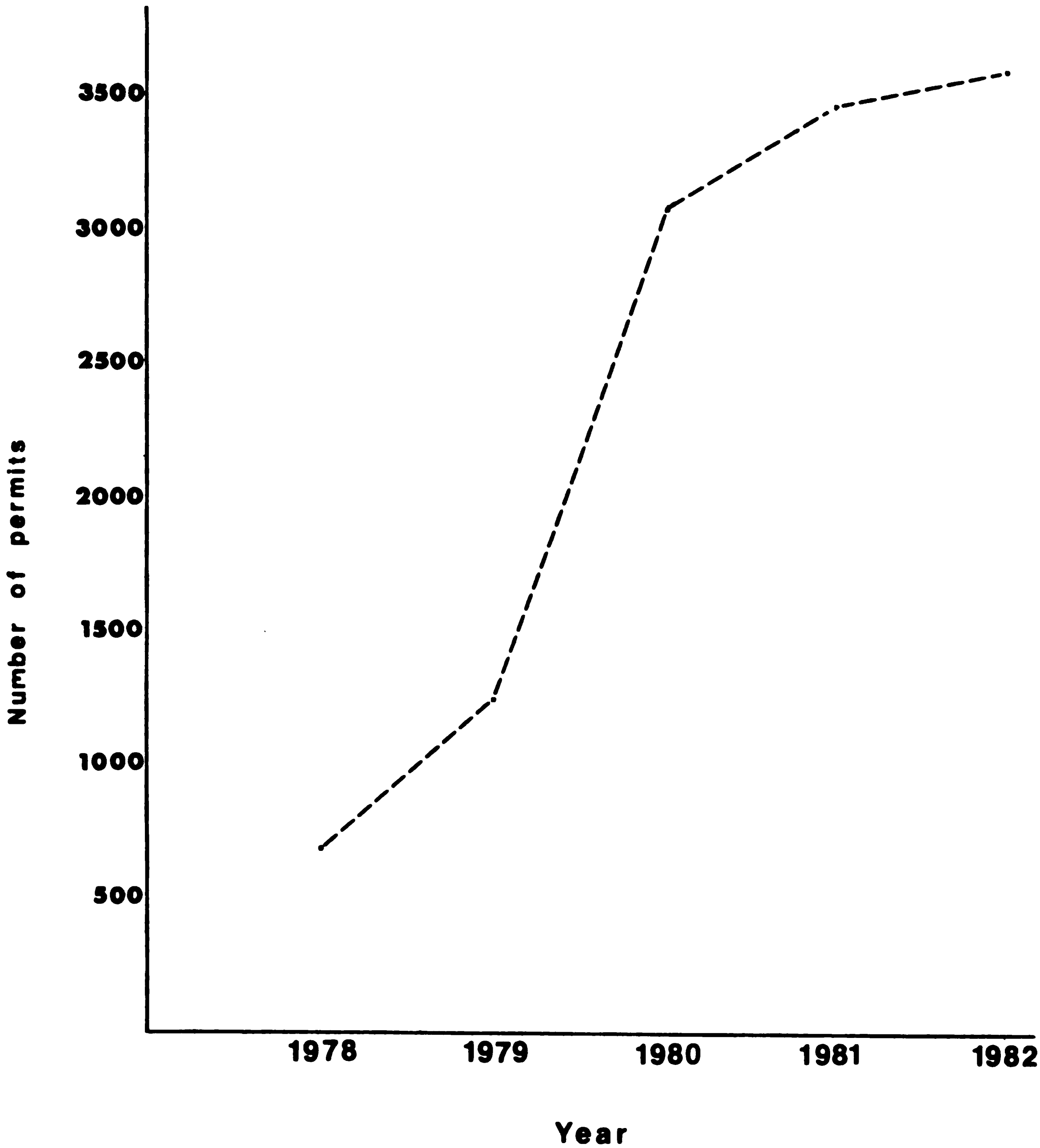


Figure 1. The number of free-use firewood cutting permits issued by the White Cloud Ranger Station of the Manistee National Forest over the past five years.

Snags are caused by such things as disease, lightning, insect infestation and fire. Within a forest community, snags are used by a wide variety of organisms. They can serve as feeding surfaces for invertebrates, as well as escape and hiding cover for mammals such as bats and squirrels.

For various species of birds, snags provide feeding substrate; perches for singing, loafing and hawking; and drumming, roosting, and nesting sites. Cavity-nesting bird species, in particular, are dependent upon snags for feeding and nesting. Of these species, those that excavate holes within a snag for nesting and roosting are termed primary cavity-nesters (i.e., woodpeckers). Secondary cavity-nesters are species that nest or roost in natural cavities or cavities excavated by primary cavity-nesters. Some birds, such as the black-capped chickadee (<u>Parus atricapillus</u>), may be considered as both primary and secondary nesters. There are 85 species of cavity-nesting birds in North America, ranging in size from the turkey vulture (<u>Cathartes aura</u>), to the carolina chickadee (<u>Parus carolinensis</u>) (Scott et al., 1977). Within the forests of north-central United States, 36 species of cavity-nesters are known to occur (Evans and Conner, 1979).

Studies of snags and their relationship to cavity-nesting birds have tended to focus on characterizing their usage by the different avian species (Cunningham et al., 1980; Mannon et al., 1980; Scott, 1978; Hardin and Evans, 1977; Balda, 1975; McClelland and Frissel, 1975). The most important features of snags as nesting sites brought forth in these studies are diameter at breast height (d.b.h.) and height. The surrounding plant community is also an important factor in selection by different species. Physical features of secondary importance are percent bark cover, top condition, and age. Other studies also point to the presence of fungal heart rots as being important in nest site selection (Conner et al., 1976; Kilham, 1968).

Mannon et al. (1980) and Conner and Crawford (1974) have characterized snag use as foraging sites by various cavity-nesting species. As with nest site selection, use of snags as foraging substrate may vary with the surrounding community or habitat type. Conner (1980) concluded from his study of woodpecker foraging habitats of Virginia that these birds rely heavily on dead wood as feeding sites.

Other than the physical features, the density of snags in an area is also an important factor. Information on numbers of snags used by breeding pairs of cavity-nesters has led authors to make recommendations as to the density of snags needed to maintain populations (Evans and Conner, 1979; Conner, 1978). For example Balda (1975) stated that 2.5 snags per acre are necessary to maintain maximum densities and natural species diversity of secondary cavity-nesters in western coniferous forests. Several formulas have been proposed, such as that by Bull and Meslow (1977), to calculate numbers of snags required by a species. These formulas include such variables as the number of snags used per pair of cavity-nesters per year and snag reserves. As few as 1 out of every 15 snags is suitable for use by cavity-nesters (Thomas et al., 1979).

Few quantitative studies have tested the assumption, implicit in these studies, that cavity-nesting birds are limited by suitable nest sites. Scott (1979) examined bird response to snag removal in a Ponderosa pine forest in Arizona. He found a 51% decrease in the number of cavity-nesting birds in a 16 ha area where snags had been removed. Other non-cavity-nesting species also decreased within the area. However, snag removal in his study was accompanied with the harvesting of live trees. His results were based on a comparison of areas where snags had been cut during a timber operation and where they had been left standing following a timber harvest.

A major reason for concern over cavity-nesting birds is that most are insectivorous and play an important role in forest ecosystems (Dickson et al., 1980). Studies of woodpecker predation have shown that birds such as the northern three-toed woodpecker (*Picoides tridactylus*) are responsible for controlling insect pest outbreaks (Koplin, 1972; Koplin and Baldwin, 1970; Shook and Baldwin, 1970; Knight, 1958).

Past forest management practices often involved the removal of snags because they were felt to represent a fire hazard and endanger forestry personnel. But, the recognition of the importance of snags eventually led to the adoption of a national snag policy (U.S. For. Serv., 1977). Increasing demand for firewood, however, poses a renewed threat to the avian community as well as the forest ecosystem. At this time information is needed on how firewood removal will affect bird numbers and diversity within forest communities.

OBJECTIVES

The primary objective of this study was to determine the impact of firewood removal on breeding bird populations inhabiting a northern oak forest in Michigan. This was to include an examination of nest site selection by the cavity-nesting species occurring within this vegetation type. Secondary objectives were to monitor changes in snag densities and characterize snag usage by the avian community.

SITE DESCRIPTION

The study was conducted within the White Cloud Ranger District of the Manistee National Forest in Newaygo County, Michigan. Study plots were approximately 14 km west of Big Rapids, Michigan, within Sec. 9, Sec. 10, Sec. 17, and Sec. 18, T 15 N, R 11 W (Figure 2).

The area is located in the West Central Rolling Plain physiographic region (Sommers, 1977). Surface topography is gently rolling with a mean elevation of 335 m above sea level. Soils are generally deep, dry sands of the Rubicon, Kalkaska, Grayling association. Roselawn fine sand is the predominant soil type (Mick, 1951).

The climate of the area alternates between continental and semi-marine in character due to the influence of Lake Michigan, 72 km to the west. Winds are typically from the west to northwest averaging 16 kmph. Temperatures range from an average daily minimum of -11°C in February to an average daily maximum of 28°C in July. Average temperatures for the months of May and June are 13°C and 18°C, respectively. Mean monthly temperatures of the study period were often below the average (Figure 3), with many areas of the state recording record low temperatures during January, 1982. Precipitation is well distributed throughout the year

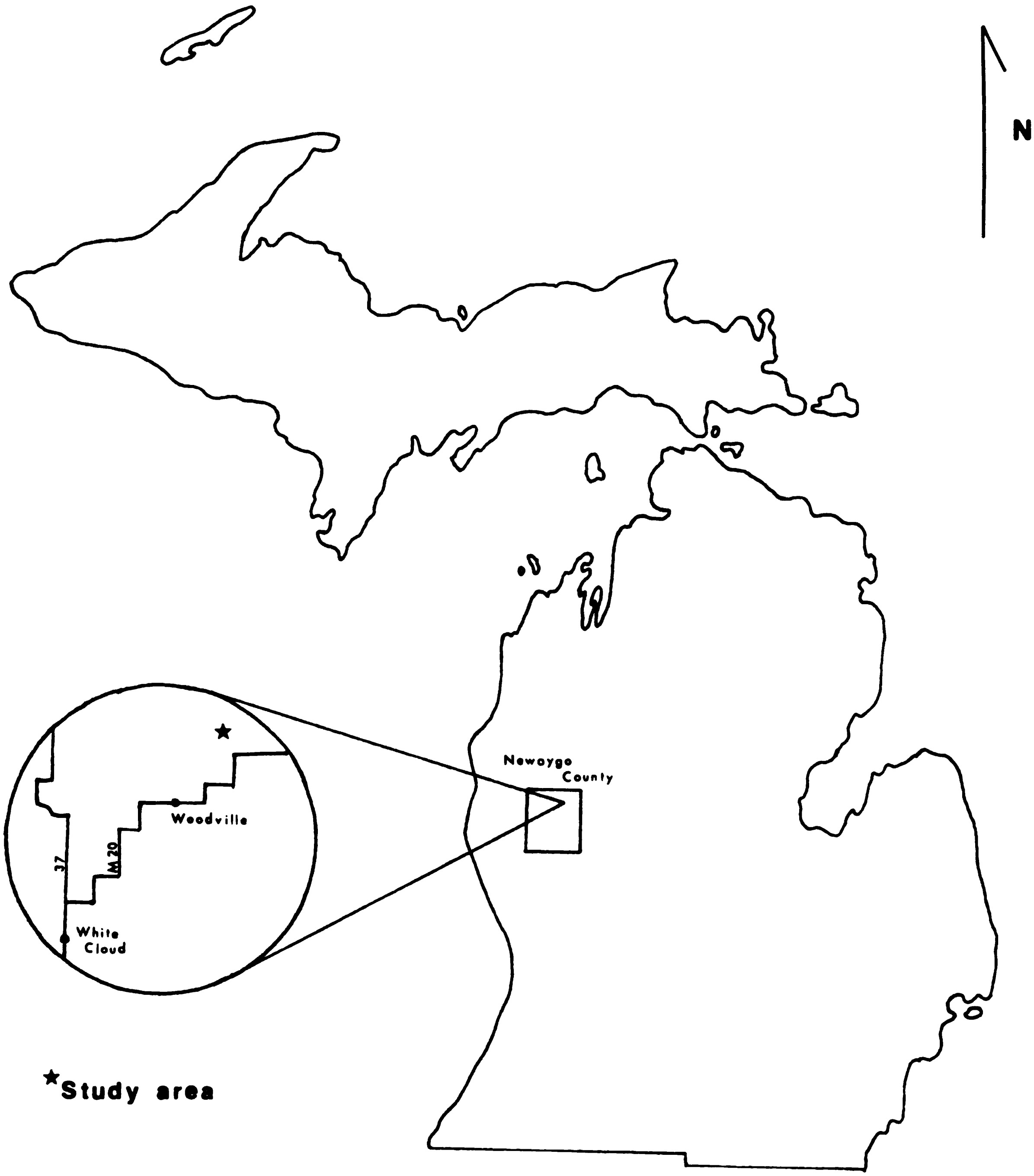


Figure 2. Study area in relation to White Cloud, Newago County, Michigan.

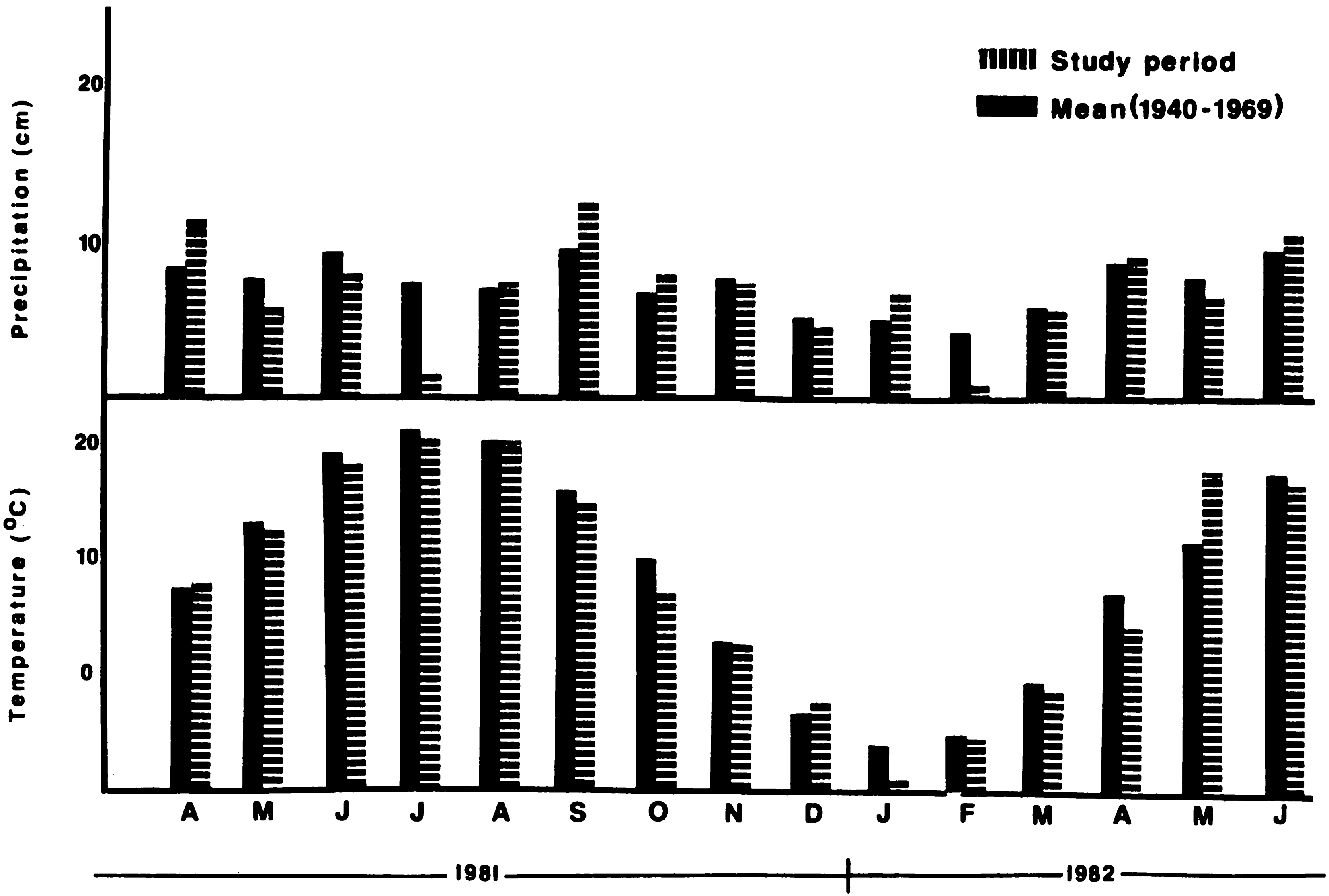


Figure 3. Mean monthly temperature and precipitation values during the study period.

with a mean total of 83 cm (Figure 3). Average annual snowfall is 157.9 cm (Michigan Weather Service, 1974).

Vegetation occurring on the study plots is in a late successional stage. The last tree harvesting occurred in 1917. Overstory vegetation was dominated by mature white oak (Quercus alba) and red oak (Quercus rubra). Other species in the overstory were big-toothed aspen (Populus grandidentata), black oak (Quercus velutina) and red maple (acer rubrum). These trees tend to be randomly distributed and produce a closed canopy over the majority of the plots.

Midstory vegetation was comprised of witchhazel (Hamamelis virginiana), downy serviceberry (Amelanchier arborea), sassafras (Sassafras variifolium) and red maple. A few small clones of young big-toothed aspen were also present.

Understory woody vegetation consisted primarily of low bush blueberry (Vaccinium vacillans) with some high bush blueberry (Vaccinium corymbosum). Sweet fern (Comptonia peregrina) appeared occasionally.

METHODS AND MATERIALS

Experimental Design

This study followed a simple random design with three replications. Six 15-ha rectangular plots were delineated in the general study area on the basis of similar stand characteristics (Figure 4). Plots number 2,3, and 4 were selected for treatment while plots 1,5, and 6 served as controls.

Treatment

Treatment was designed to simulate intensive firewood removal. In August 1981, the center 8 ha of each of the three treatment plots were cleared of all suitable firewood (Figure 5). A 50 m border strip was left uncut so any change in breeding bird distributions could be detected. Crews equipped with chain saws cut all dead standing or dead and down woody material as per Forest Service policy. Only those trees considered too rotten to be valuable as firewood were not cut. Approximately 65 standard cords of firewood were removed.

Vegetation Sampling

Detailed vegetation sampling was conducted to provide a complete description of the vegetation and to identify any significant differences in plant community structure and

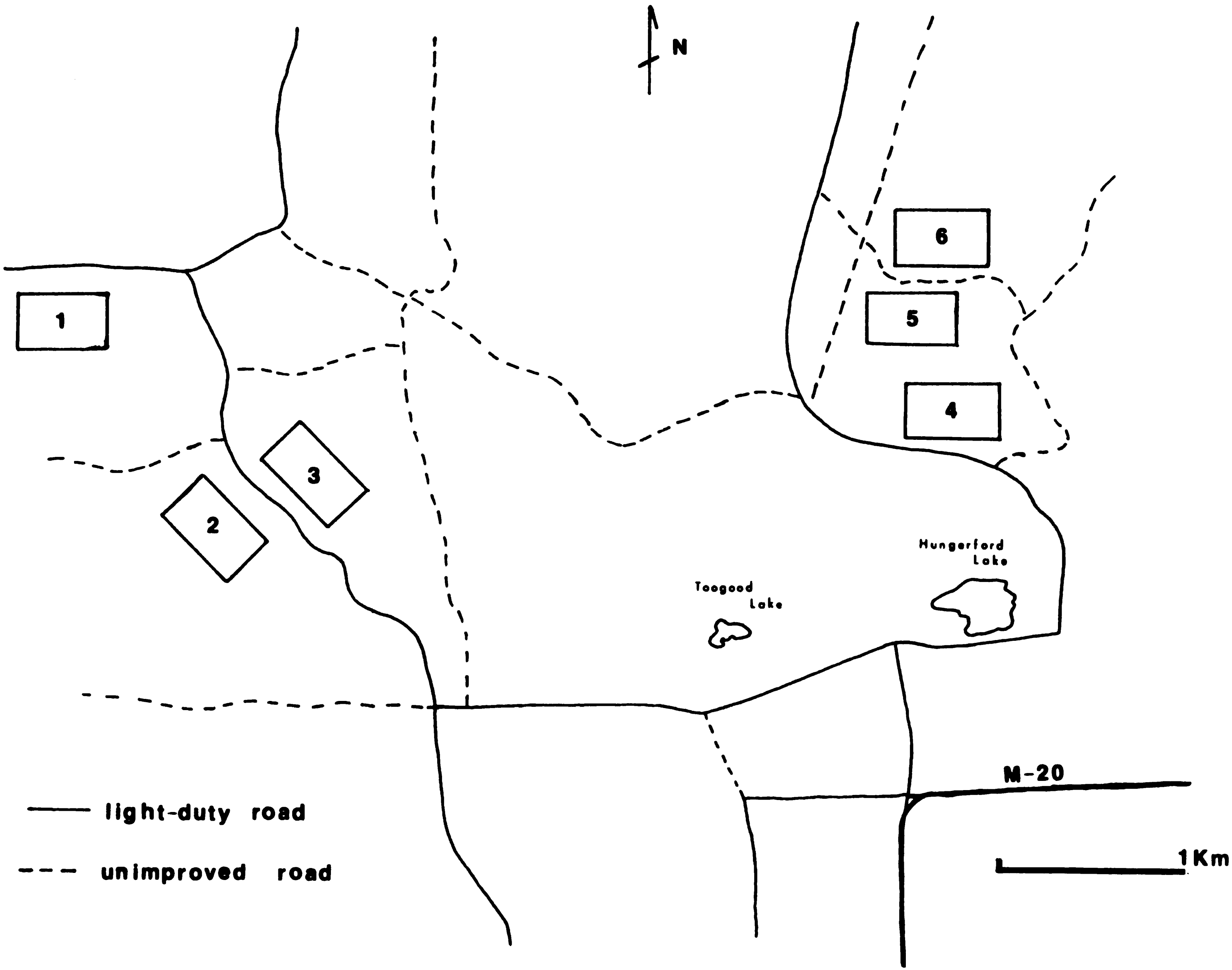


Figure 4. Study area map with plot locations.

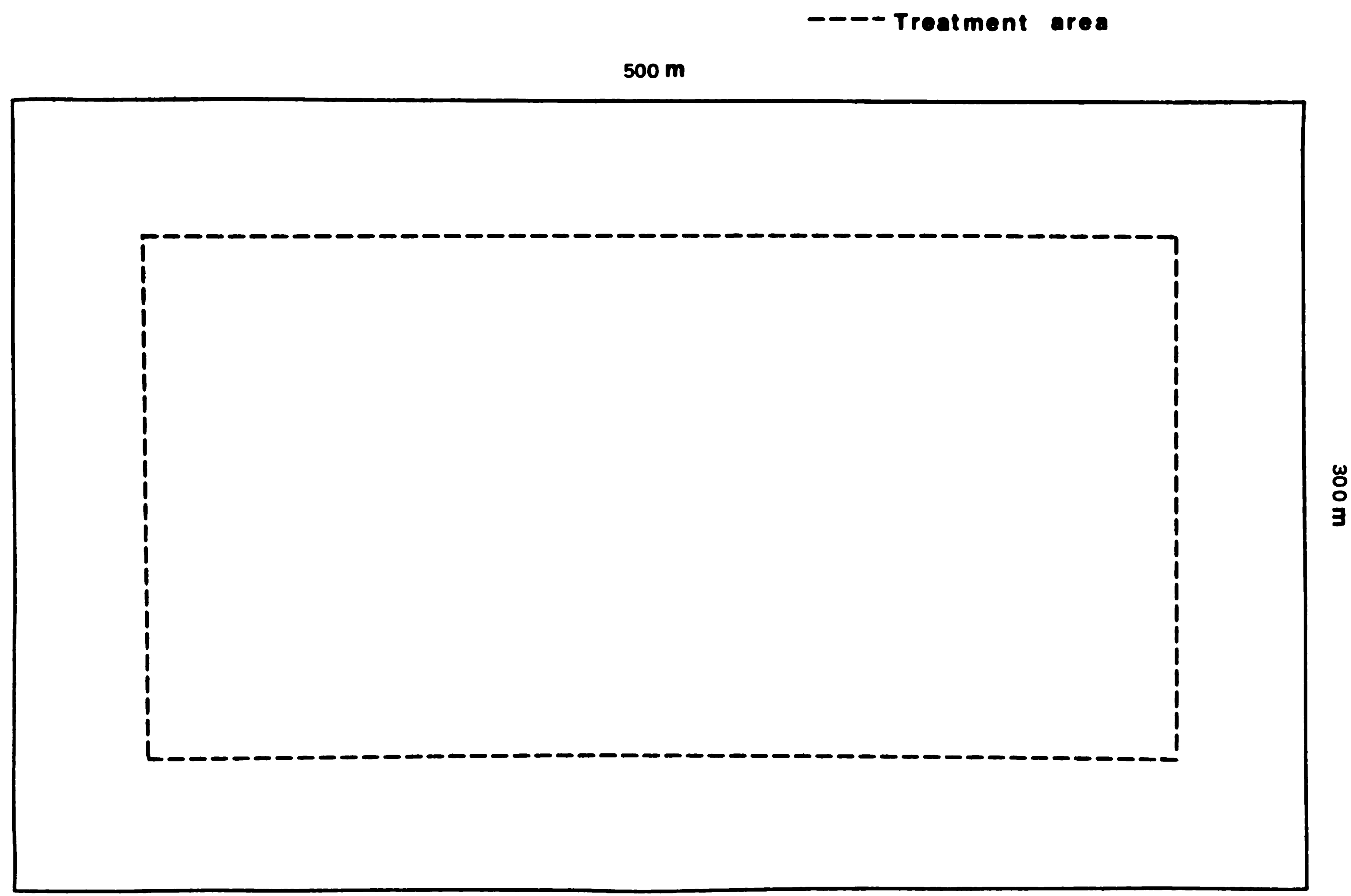


Figure 5. Map of a single study plot indicating the designated treatment area.

composition that might exist between plots. Each method of sampling followed a simple randomized design utilizing two adjacent plot borders as axis from which random sample coordinates were determined. Woody vegetation greater than 5 cm d.b.h. was sampled using the point-center-quarter method (Cotton and Curtis, 1956). Species name, point to plant distance and d.b.h. were recorded for each tree sampled. Midstory and ground layer woody vegetation was sampled using a nested plot scheme. Small trees and shrubs less than 5 cm d.b.h. and greater than 1 m in height were sampled by plots 2 m by 50 m in size. One by 20 m plots were used to sample woody plants less than 1 m tall. Stratified random sampling was used on plot 5 to separately sample three small areas containing stands of big-toothed aspen.

The line-intercept method (Canfield, 1941) was used to measure vertical vegetative cover in three height strata over a 20 m line. The selected strata were 0-1 m, 1-7 m, and >7 m. Cover was measured to the nearest centimeter while gaps in the vegetation less than 10 cm were recorded as continual cover. The directions of the lines from the sampling points were determined by a random selection of a compass bearing.

<u>Bird Census</u>

Breeding bird populations were censused by the spot-mapping method following International Bird Census Committee recommendations (1970). To facilitate the use of the spot-mapping method, a 50 m x 50 m grid pattern was established over each plot (Figure 6). Censusing began at sunrise and was normally completed in 2.5 hours. Birds were not censused on days of rain, fog, or high winds. Observer bias was controlled by continually alternating the census taker of a plot. The starting location and direction of censusing routes were varied for each census of each plot to control the time bias of always censusing the same region of the plot at the same time of day. Birds detected beyond 25 m from the plot border were not included in the census. Following each morning's census, observers located and followed cavity-nesting birds in an attempt to locate active nest sites.

A pretreatment bird census was conducted in the spring of 1981 to document initial bird populations and quantify any possible differences between plots. Censusing began 18 May and continued to 23 June. Within this time period, two observers completed eight censuses per plot.

To evaluate the effect of the treatment on bird populations, a post-treatment census was conducted in the spring of 1982. Between 11 May and 10 June, three observers completed 13 censuses per plot.

Snag Sampling

A survey of all snags on the study area was conducted to characterize snag usage and to quantify the effect of firewood removal on snag numbers. All snags greater than 18 cm d.b.h. and 2 m in height were counted directly and a

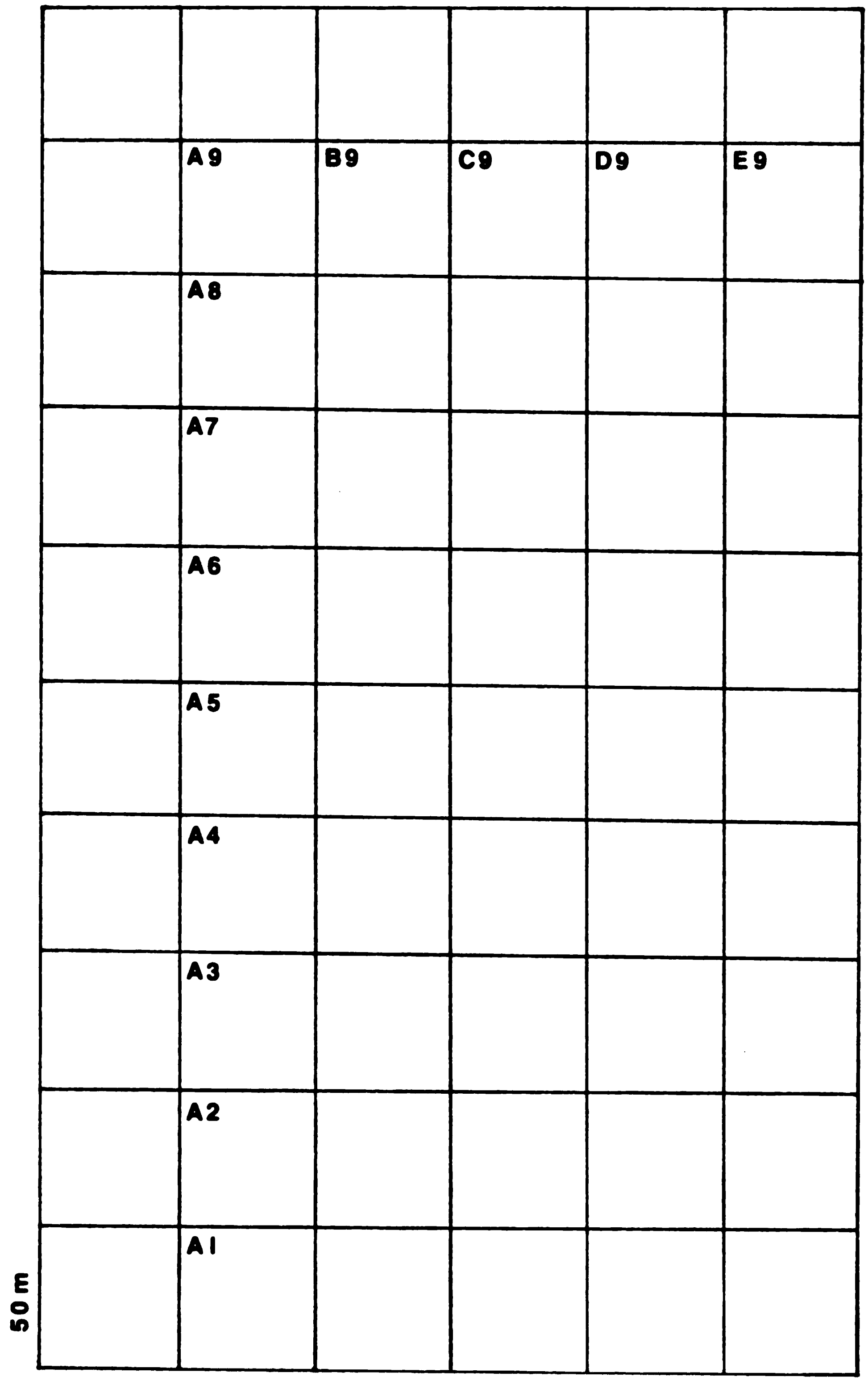


Figure 6. Map of grid pattern established over each study plot.

variety of physical features recorded. Each snag was numbered, mapped, and the features of species, d.b.h., height, percent bark cover, number of branches, and top condition recorded. The presence of cavities or foraging evidence was noted. Snag height was measured with a Haga altimeter and diameter with a d.b.h. tape.

Estimates of the density of snags in the 5-18 cm d.b.h. class were made using a random sampling scheme. Fifty by 50 m plots were selected using the existing grid pattern as plot boundaries. Fifteen samples were collected on each plot. Physical features of each snag in this size class were not recorded.

Data Analysis

Required sample sizes for all methods of vegetation sampled were determined using Stein's two-stage sample equation (1945):

$$n = \frac{T^2 S^2}{d^2}$$

where T = the tabular value of t at the 90% confidence level

S^2 = sample variance

d = sample mean multipled by an allowable error of 20%

Daily bird census visit maps were compiled into species maps for each plot. A minimum of three sightings was necessary for the delineation of a breeding territory as suggested by I.B.C.C. recommendations (1970).

Territories in which more than half of the sightings were outside the plot boundary were not counted. Differences in bird density, richness, and diversity between control and treatment plots were tested by a student's t-test. The cavity-nesting bird species were separately tested for similar differences. Differences were considered significant at $p<0.10$. This level of significance was chosen due to the inherent nature of breeding bird populations which may be variable even over relatively small areas. A 2-tailed F test for homogeneity of variance was used on all data.

Data on snags, such as average d.b.h. and density, were also tested for significant differences between control and treatment plots using student's t-test. Large size class snags (> 18 cm d.b.h.) were categorized into five stages on the basis of percent bark cover, number of branches and top condition, similar to Thomas et al. (1979) (Figure 7). This scheme classifies snags into decay stages based on physical characteristics, and suggests a progression from youngest to oldest, although the age of each snag was not directly measured.

Student's t-tests were also used on data from the various vegetation sampling measures collected on control and treatment plots. The diversity of vegetative cover (foliage height diversity) and bird species diversity were

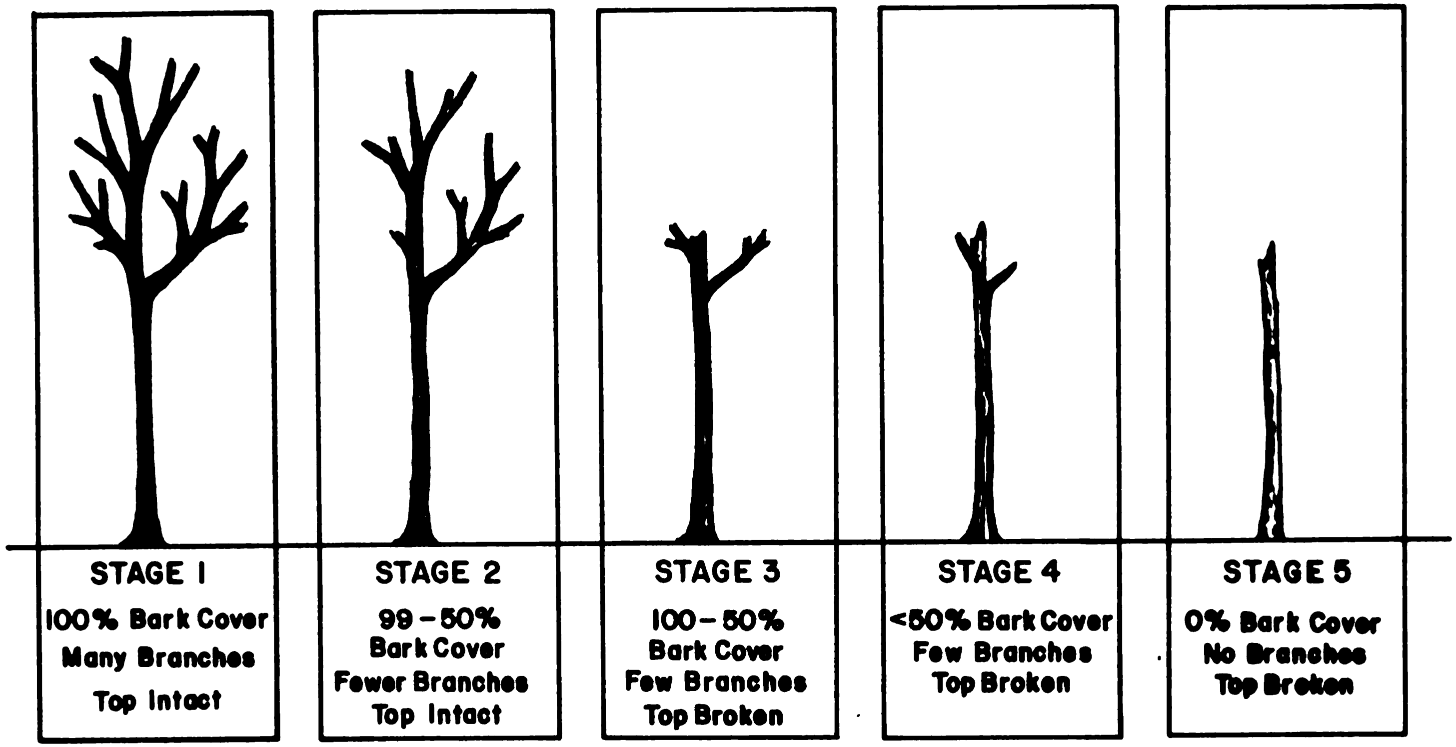


Figure 7. Description of the stages of snag decay based on the characteristics of bark cover, top condition and number of branches.

calculated by the Shannon-Weaver Index (1949):

$$H = - \Sigma Pi \log pi$$

where pi is the proportion of the abundance of the i category (bird species or cover structures).

RESULTS

Plant Community

Results of point-center-quarter sampling indicated white oak as the species with the highest importance value on both control and treatment plots (Table 1). The other species in order of importance were red oak, red maple, black oak, big-toothed aspen, and sassafras.

Nested plot sampling of woody species > 1 m tall and < 5 cm d.b.h. revealed witchhazel to be the most abundant mid-story species in control and treatment plots (Table 2). All species sampled occurred in both treatment and control plots with the exception of maple-leaf viburnum (_Viburnum accrifolium_) which was not sampled on treatment plots. Differences in total stem densities were not significant between controls and treatments.

In the < 1 m tall size class low bush blueberry was found to be the most abundant of the 13 species sampled (Table 3). Total numbers of stems per ha averaged 84,430 and 98,556 for treatment and controls, respectively, but were not significantly different.

The vegetative cover measurements indicated canopy cover averaged 93.1% and 94.7%, while ground layer cover averaged 24.9% and 20% for control and treatment plots

Table 1. Mean importance values and S.E. of woody species (>5 cm d.b.h.) occurring on control and treatment plots in 1981 in oak stands in Michigan.

Species	Relative Density		Relative Dominance		Relative Frequency		Importance Value	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Quercus rubra	26.3 ± 5.3	21.2 ± 2.2	39.4 ± 4.0	36.2 ± 2.4	25.6 ± 4.2	20.5 ± 2.8	91.5 ± 14	77.8 ± 7.1
Quercus alba	36.4 ± 2.5	36.6 ± 3.9	35.9 ± 2.3	34.3 ± 2.3	32.4 ± 0.9	29.9 ± 1.4	104 ± 1.4	100.6 ± 6.4
Acer rubrum	23.7 ± 5.6	23.8 ± 4.2	8.4 ± 3.1	8.5 ± 3.2	24.5 ± 3.4	26.5 ± 3.4	56.7 ± 11.9	58.89 ± 9.6
Quercus velutina	4.5 ± 1.2	7.8 ± 0.4	10.5 ± 2.5	17.8 ± 2.4	6.9 ± 1.8	10.1 ± 0.4	22.1 ± 5.5	35.8 ± 3.2
Populus grandidentata	5.8 ± 2.2	3.6 ± 1.9	5.1 ± 1.2	2.05 ± 0.88	6.9 ± 2.4	4.09 ± 1.7	17.9 ± 5.3	9.7 ± 4.2
Sassafras variifolium	2.9 ± 0.17	2.9 ± 1.6	.35 ± 0.4	0.41 ± 0.26	2.3 ± 0.29	3.8 ± 1.8	4.2 ± 0.4	7.2 ± 3.6

Table 2. Mean and S.E. of densities and frequencies of woody species > 1 m tall and < 5 cm d.b.h. occurring in oak stands in Michigan.

	Density (/ha)		Frequency (%)	
Species	Treatment	Control	Treatment	Control
Hamamelis virginiana	850 ± 138	1128.9± 77	95.6 ± 2.2	98 ± 2.0
Amelanchier arborea	101.8±21.8	159 ± 21	52 ± 5.3	64 ± 14
Acer rubrum	247 ± 59	159 ± 3.5	68.6 ± 9.3	58 ± 5.0
Sassafras variifolium	64 ± 18.5	202 ± 94	36.8 ± 12.1	52 ± 1.7
Quercus alba	55 ± 9.7	79.6 ± 37	29.7 ± 4.2	28 ± 10
Other	42.9 ± 8.7	214.6 ± 25.3		
Total	1360.7	1943.1		

Table 3. Means and S.E. of densities and frequencies of woody vegetation < 1 m tall in oak stands in Michigan.

Species	Density (/ha)		Frequency (%)	
	Treatment	Control	Treatment	Control
Vaccinium vacillans	34,319 ± 12,897	25,464 ± 1,880	95.7 ± 4.3	88 ± 4.4
Vaccinium corymbosum	3,244 ± 479	4,677 ± 551	33.6 ± 6.7	41.6 ± 3.5
Amelanchier arborea	10,378 ± 205	14,169 ± 5,089	100	100
Hamamelis virginiana	8,278 ± 1,695	7,724 ± 1,253	93 ± 3.7	100
Sassafras variifolium	3,267 ± 1,488	4,196 ± 469	73.3 ± 3.7	85 ± 7.5
Quercus rubra	10,211 ± 1,561	15,428 ± 1,109	100	100
Quercus alba	4,967 ± 1,228	6,081 ± 2,539	84 ± 5.9	83.3 ± 13
Acer rubrum	7,122 ± 2,376	14,883 ± 3,639	97.7 ± 2.3	95 ± 2.9
Prunus serotina	1,634 ± 392	5,070 ± 1,297	84 ± 5.9	82.7 ± 3.4
Fagus grandifolia	66.7 ± 19	35.5 ± 6.7	13 ± 3.7	5.3 ± .8
Vibernum acerifolium	611 ± 262	488 ± 127	20	20.3 ± 3.5
Comptonia peregrina	133 ± 19	242 ± 100	7	10.3 ± 2.4
Total	84,330.7	98,457.5		

(Figure 8). Mid-story vegetative cover was significantly greater ($p<.02$) on control plots. Mean foliage height diversity indicies for control and treatment plots were not found to be significantly different (Table 4). Mean values of absolute tree density and basal area derived from the point-center-quarter sampling of control and treatment plots were not significantly different (Table 4).

Breeding Bird Populations

Fifteen species of breeding birds were included in the bird censuses of 1981 and 1982 (Table 5). A number of other species, many of which were migrants, were also identified on the plots but did not appear consistently enough to be counted as a breeding species (Appendix A). The eastern wood pewee was the most abundant species, followed by the red-eyed vireo. Six species of cavity-nesting birds were present, but only three species - the hairy woodpecker, white-breasted nuthatch, and great-crested flycatcher- occurred on all plots both years. The white-breasted was the most abundant cavity-nester. Cavity-nesters made up 14.9% and 12.5% of the total population in 1981 and 1982, respectively, with no significant differences between control and treatment plots.

Prior to firewood removal, breeding bird populations averaged 187.5 individuals per 40 ha. Following treatment, bird populations on control plots were found to be significantly greater ($p<0.10$) than those on treatment plots (Table 6). These differences were due mainly to greater

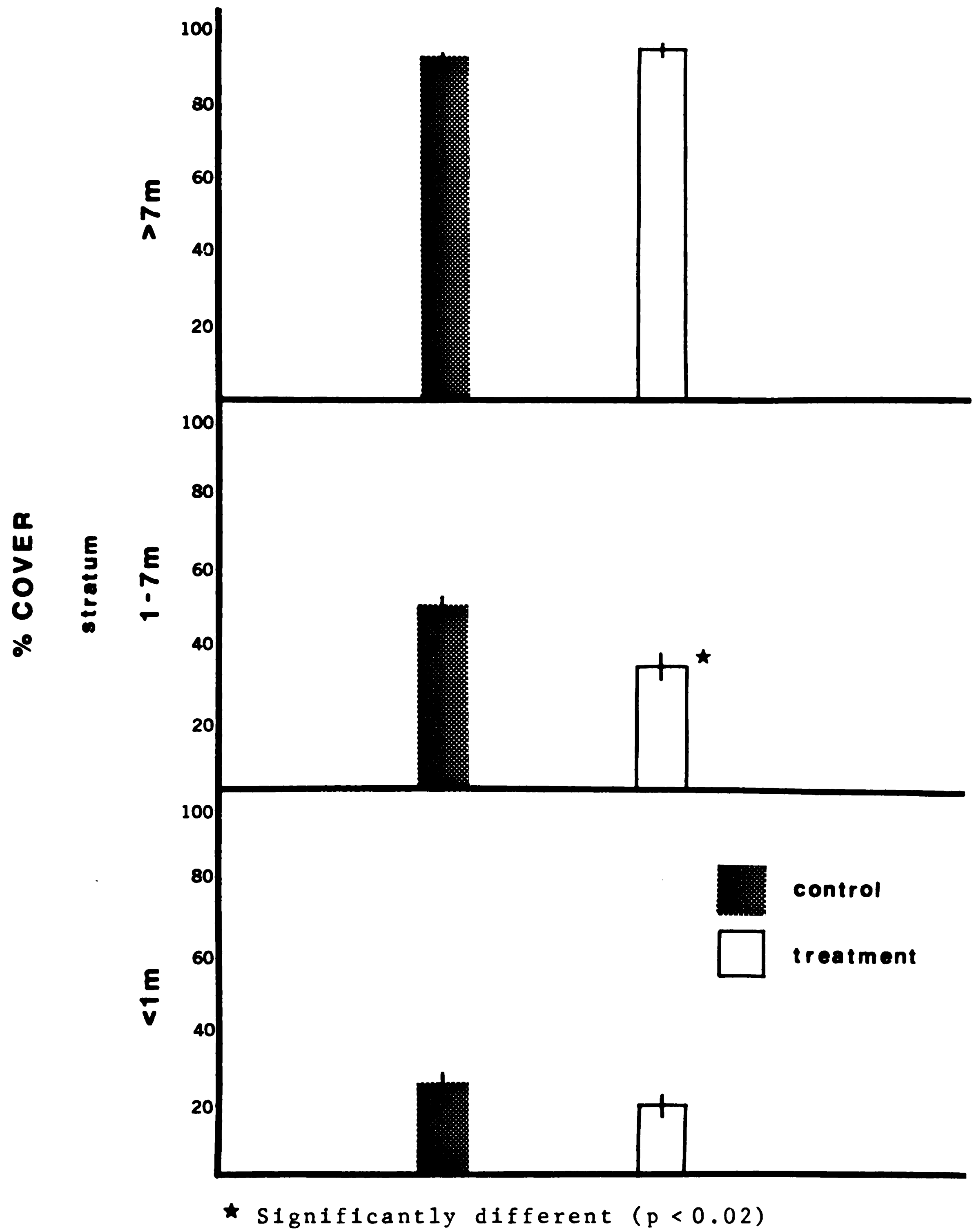


Figure 8. Mean percent vegetation cover by strata for control and treatment plots in northern oak stands.

Table 4. Mean values and S.E. of tree density, basal area and FHD for treatment and control plots in oak stands in Michigan.

	Treatment	Control
Tree density (/ha)	583 ± 52	473 ± 30.5
Basal area (m^2/ha)	26.6 ± 2.7	22.8 ± 1.10
Foliage height diversity	.8341 ± .0221	.9049 ± .0224

Table 5. Average numbers of breeding birds by species before and after firewood removal on 15 ha study plots in northern oak stands in Michigan.

Common name (Scientific name)	1981 Control X ± S.E.	1981 Treatment (pre) X ± S.E.	1982 Control X ± S.E.	1982 Treatment (post) X ± S.E.
Red-headed woodpecker (*Melanerpes erythrocephalus*)	0.67 ± 0.67	0.67 ± 0.67	---	---
Hairy woodpecker (*Picoides villosus*)	3.3 ± 0.67	2 ± 0	2 ± 0	2 ± 0
Downy woodpecker (*Picoides pubescens*)	---	---	0.67 ± 0.67	---
Great-crested flycathcer (*Myiarchus crinitus*)	2.6 ± 0.67	2.6 ± 0.67	2 ± 0	2.6 ± 0.67
Eastern wood pewee (*Contopus virens*)	18.7 ± 0.67	18.7 ± 1.7	16.7 ± 2.9	16.7 ± 1.3
Blue jay (*Cyanocitta cristata*)	1.3 ± 0.67	4.6 ± 0.67	6.7 ± 0.67	4.6 ± 1.3
Common crow (*Corvus brachyrhynchos*)	---	---	---	0.67 ± 0.67
Black-capped chickadee (*Parus atricapillus*)	---	1.3 ± 1.3	2 ± 1.1	0.67 ± 0.67
White-breasted nuthatch (*Sitta carolinensis*)	4 ± 0	4 ± 1.1	4 ± 0	4 ± 1.1
American robin (*Turdus migratorius*)	0.67 ± 0.67	0.67 ± 0.67	1.3 ± 0.67	---
Yellow-throated vireo (*Vireo flavifrous*)	---	---	0.67 ± 0.67	1.3 ± 0.67
Red-eyed vireo (*Vireo olivaceus*)	15.3 ± 0.67	10.7 ± 2.4	16.7 ± 1.3	14.6 ± 1.3
Ovenbird (*Seiurus aurocapillus*)	9.3 ± 1.8	10.7 ± 1.8	12 ± 1.1	8.7 ± 3.3
Scarlet tanager (*Piranga olivacea*)	6.7 ± 1.3	8 ± 2.3	12 ± 1.1	6.7 ± 1.8
Rose-breasted grosbeak (*Pheucticus ludovicians*)	8.7 ± 1.8	8.7 ± 1.8	10 ± 2	11.3 ± 1.8

Table 6. Breeding bird density, diversity and richness for treatment and control plots in 1981 and 1982.

	1981		1982	
	Treatment	Control (pre)	Treatment	Control (post)
Breeding bird density (40 ha)	194 ± 4.67	189 ± 6.33	196 ± 9.94*	2.30 ± 8.67*
Species richness	10 ± .577	9.7 ± .333	10 ± 0	10.7 ± .882
Bird species diversity	2.041 ± .063	1.998±.057	2.086±.102	2.066 ± .079

* significantly different ($p<0.10$).

numbers of scarlet tanagers and ovenbirds. The number of bird species per plot averaged 10.1 and did not change after firewood removal. Bird species diversity averaged 2.0195 and also did not change after treatment. Based on the territorial mapping, the distribution of breeding bird territories on treatment plots in 1982 did not differ from those of the previous year or those on control plots. Numbers of cavity-nesting birds averaged 12 per plot in 1981 and decreased to 8.7 on treatment plots in 1982, but numbers on control plots similarly decreased to 9.3 (Figure 9). None of the differences in numbers of cavity-nesters, either between years or between controls and treatments, were significant.

A total of 14 nest sites of cavity-nesting species were located over the two years of the study, with trees housing white-breasted nuthatches being located with the greatest success (Table 7). No great-crested flycatcher nests were located. Average nest tree d.b.h. was greatest for the white-breasted nuthatch and smallest for the black-capped chickadee. Most nest sites (71.4%) were found in live trees or snags of the oak species. Hairy woodpeckers, however, chose big-toothed aspen more often for nesting even though aspen had the next to the lowest importance value in these stands. In relation to the condition of the nest sites, 86% were in live trees or dead portions of live trees (Table 8). Only two nest sites were found in snags. Red-headed

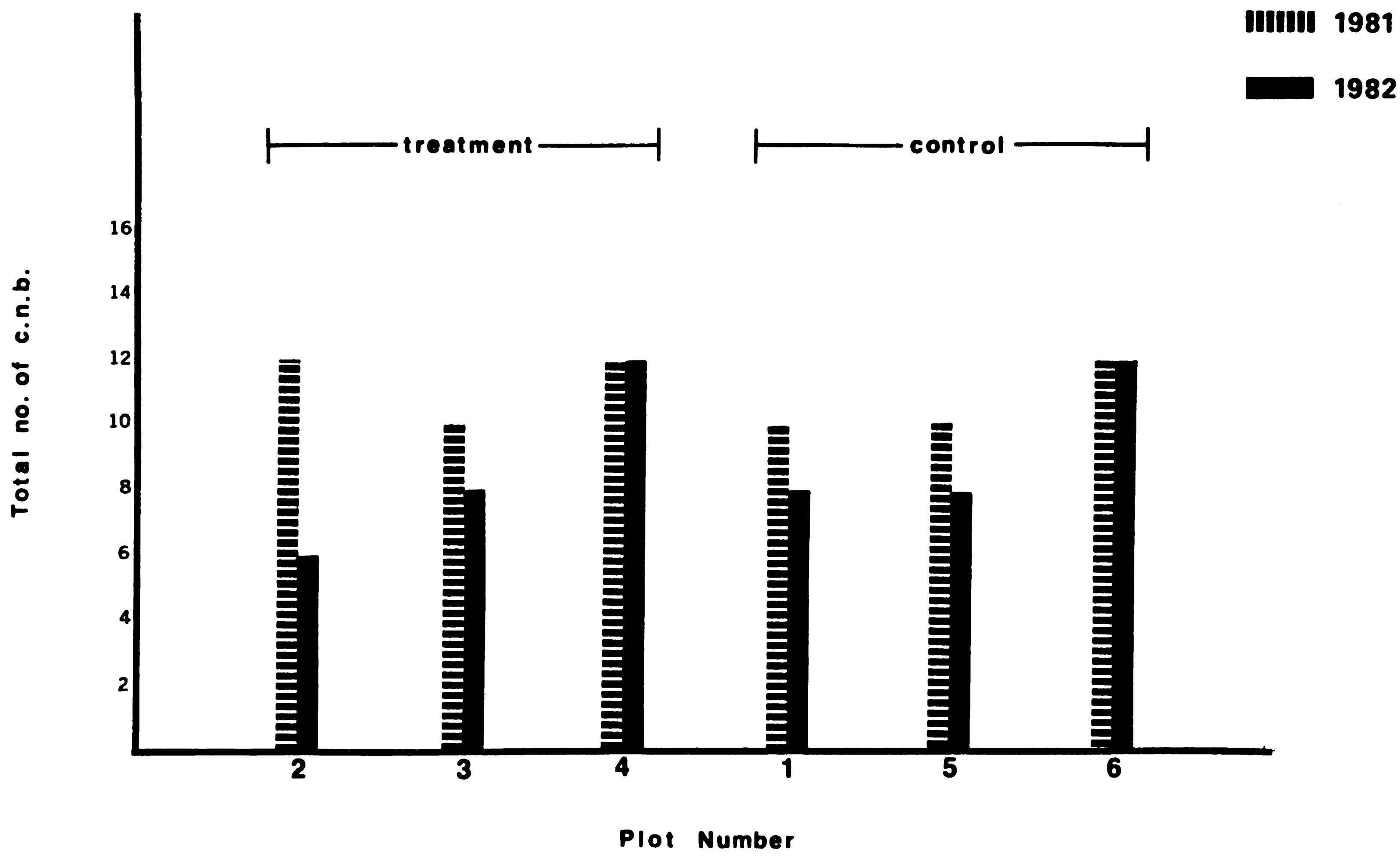


Figure 9. The total number of cavity-nesting birds (c.n.b.) occurring on 15 ha plots in northern oak stands during 1981 and 1982.

Table 7. Average measurements of nest tree characteristics. Ranges indicated by parentheses.

Type of Measurement	SPECIES: Hairy woodpecker	White-breasted nuthatch	Downy woodpecker	Black-capped chickadee	Red-headed woodpecker
No. of nests	4	7	1	1	1
Nest tree d.b.h. (cm)	30.1 (24-35)	33.6 (19-48)	33.5	12.4	24.9
Tree height (m)	20.6 (19-24)	20.2 (15-23)	22.2	7	8.8
Hole height (m)	10.2 (6-15)	5.6 (2-8)	10.7	6.4	8.5
Tree species	*P. grandidentata* (3) *Quercus* spp.	*Quercus* spp.	*Q. rubra*	*Q. rubra*	*P. grandidentata*

Table 8. Condition of nest trees used by cavity-nesting bird species in oak stands in Michigan.

	CONDITION		
Species	Live	Dead portion of live tree	Dead
Hairy woodpecker	4		
White-breasted nuthatch	6		1
Downy woodpecker		1	
Black-capped chickadee		1	
Red-headed woodpecker			1

woodpeckers, which nested in a snag on one of the treatment plots in 1981, were not observed there in 1982.

<u>Snags</u>

A total of 915 snags in the > 18 cm d.b.h. size class was surveyed in 1981, at a mean density of 10.2 snags per ha (Table 9). Diameter at breast height in this size class averaged 24.6 cm and ranged up to 50 cm. For all larger snags examined, 8.8% had some form of cavity, while an average of 45% showed evidence of woodpecker foraging. Aspen snags, in particular, displayed foraging evidence 74.5% of the time. None of the above factors were different between control and treatment plots.

A total of 157 new snags (those trees that died between June 1981 and June 1982) in the size class > 18 cm d.b.h. were counted in 1982 (Table 10). With an average new snag occurrence of 2.1 per ha and an average loss of 1 snag per ha, the mean net change on control plots was an increase of 11.2% (Figure 10). These results were confounded, however, by the occurrence of some uncontrolled firewood removal on plot 5, which decreased the net gain in density. The mean net change, exluding plot 5, was +18.75%.

Average snag densities on the entire treatment plot decreased 34.7% from the densities measured in 1981. Within the 8 ha treatment area, snag densities decreased 68.1%. Snag densities on treatment plots in 1982 were significantly different ($p<.01$) than control plots (Figure 10). Few new snags appearing on both control and treatment plots

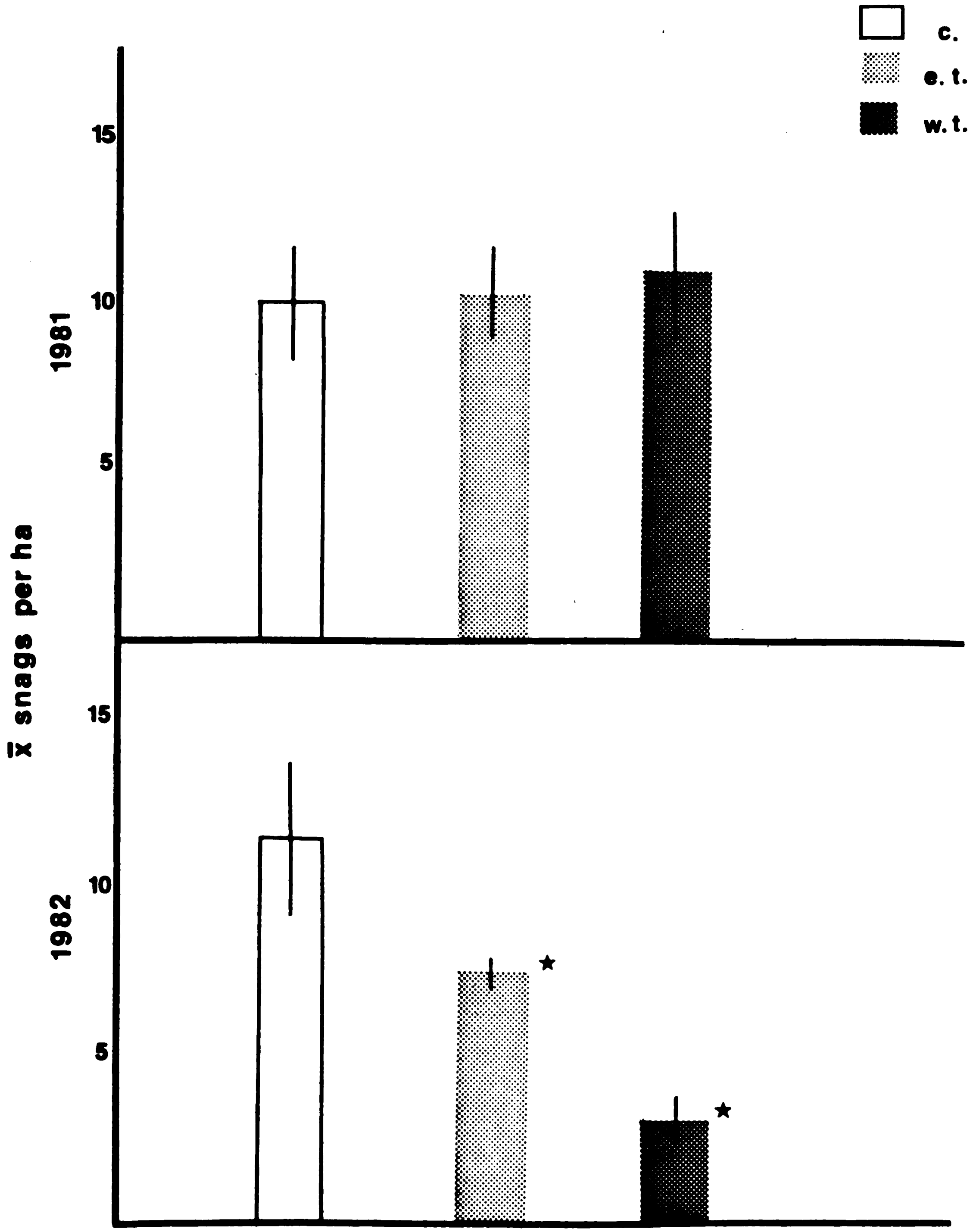
Table 9. Densities and features of snags (>18 cm d.b.h.) surveyed in 1981 in oak stands in Michigan.

Plot Number	Total snags counted	Snags/ha	Mean d.b.h. (cm)	Mean height (m)	Snags w/ Cavities		Snags w/ forage evidence	
					N/ha	% of total	N/ha	% of total
1	198	13.2	24.2	13.7	1.13	8.6	6.44	48.8
2	145	9.6	22	7.89	.53	5.5	3.89	39.3
3	188	12.5	24.4	11.9	2.09	16.7	5.41	43.2
4	128	8.53	24.4	11.9	.28	3.3	4.06	47.6
5	147	9.8	26.5	14.3	1.14	11.6	4.73	48.3
6	109	7.27	26	11.8	.53	7.3	3.0	41.3
Total	915	10.2	24.6	11.9	.95	9.3	4.59	55
Mean	152.5	10.15	24.6	11.9	.95	8.83	4.59	44.75

Table 10. Densities and features of new snags (>18 cm d.b.h.) surveyed in 1982 in oak stands in Michigan.

Plot Number	Total snags counted	Snags/ha	Mean d.b.h. (cm)	Mean height (m)	Snags w/ Cavities		Snags w/ forage evidence	
					N/ha	% of total	N/ha	% of total
1	40	2.7	30.8	11.5	.07	2.5	.81	30
2	38	2.5	20.8	12.1	--	--	.52	21
3	22	1.5	24.1	12.4	--	--	.07	4.5
4	19	1.3	21.9	11.6	--	--	.21	15.9
5	16	1.1	23.1	12.6	--	--	.14	12.5
6	22	1.5	20.4	12.3	--	--	.54	36
Total	157	1.74	24.0	12.1	.01	.63	.39	21.9
Mean	26.2	1.8	23.5	12.1	.012	0.42	.38	19.9

Figure 10. Mean snag (> 18 cm d.b.h.) densities and standard errors for control plots (c), entire treatment plots (e.t.), and within the treatment area (w.t.) before and after firewood removal in oak stands in Michigan.



★ Significantly different ($p < 0.02$) from controls contained cavities (0.63%). Foraging evidence appeared on 20% of the new snags.

Snags in the small size class of 5-18 cm d.b.h. averaged 52.6 per ha in 1981, and decreased significantly ($p<.10$) within the treatment area to 19 per ha in 1982.

The distribution of the density of snags > 18 cm d.b.h., based on the categorization scheme presented in Figure 7, demonstrates a large percentage of snags occurring on the study are in 1981 were in the early stages of decay (Figure 11). In contrast, the percentage of snags exhibiting signs of woodpecker foraging increased with stage (Figure 12). Evidence of woodpecker foraging was found on all snags in stage 5. The largest increase in utilization occurred between stage 2 and 3. Though the percentage of snags with cavities averaged less than 10%, the majority of cavities appeared in snags of stage 3, 4, and 5 (Figure 12). Few cavities were found in stage 1 and 2 snags.

The mean percent of new snags in 1982 with foraging evidence showed a slightly different distribution, with more foraging evidence appearing on stage 2 snags (Figure 13). Densities of stage 2 snags located in 1982, however, were low compared to those of stage 1 (Figure 13).

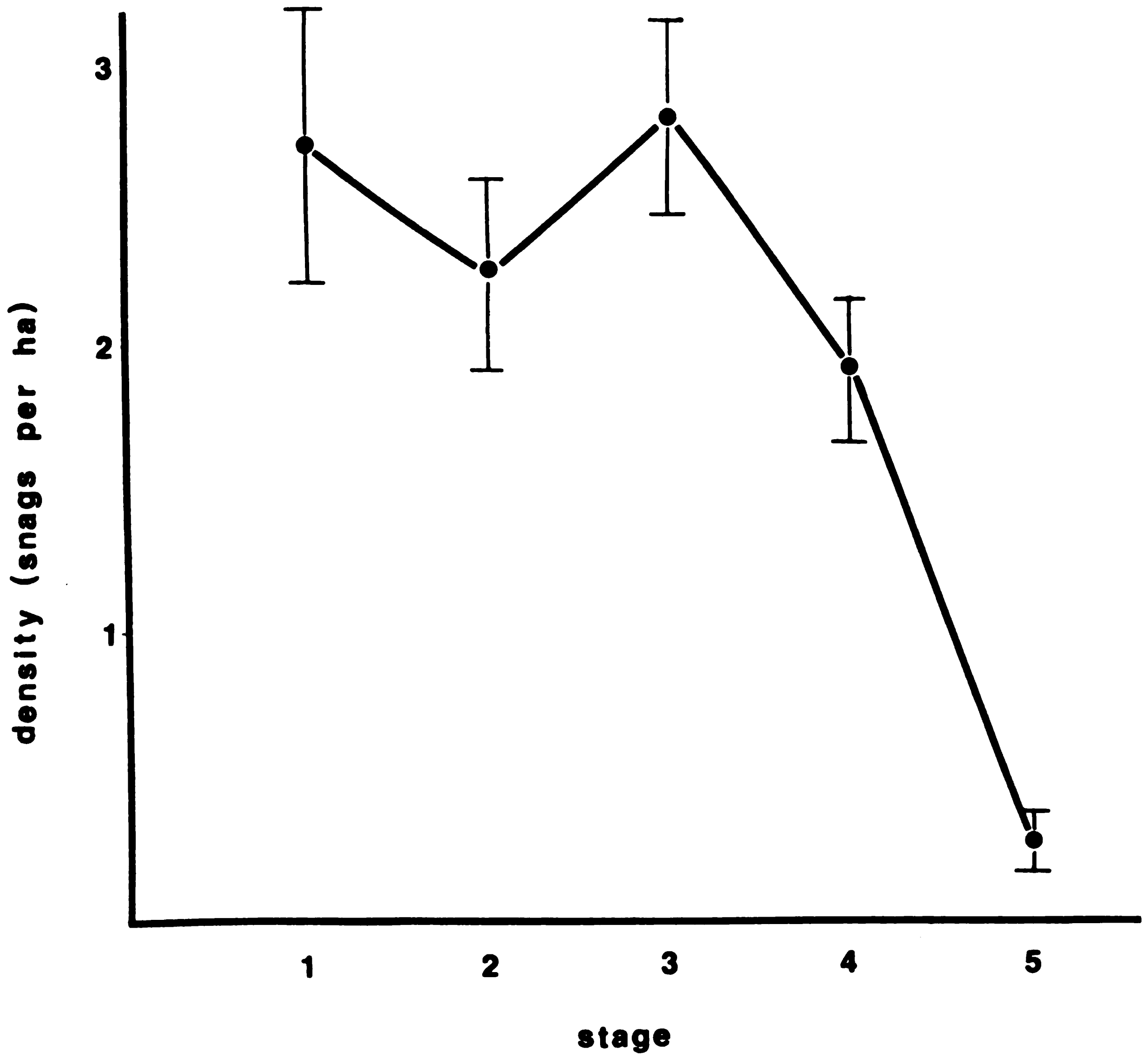


Figure 11. The mean densities of snags (> 18 cm d.b.h.) with standard errors occurring by stage in 1981.

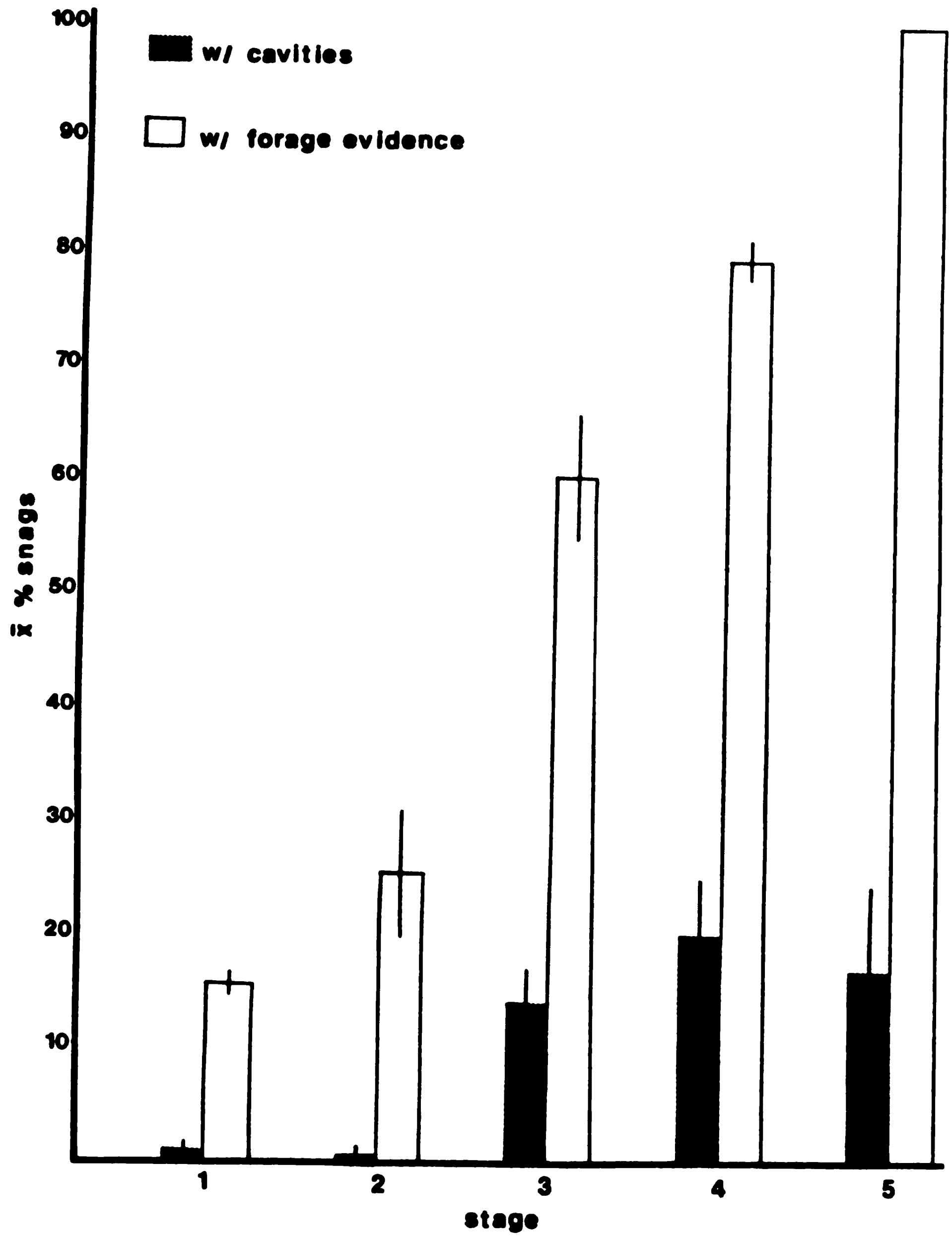


Figure 12. The mean percent of snags (> 18 cm d.b.h.) with standard errors occurring in oak stands in 1981 with cavities and forage evidence.

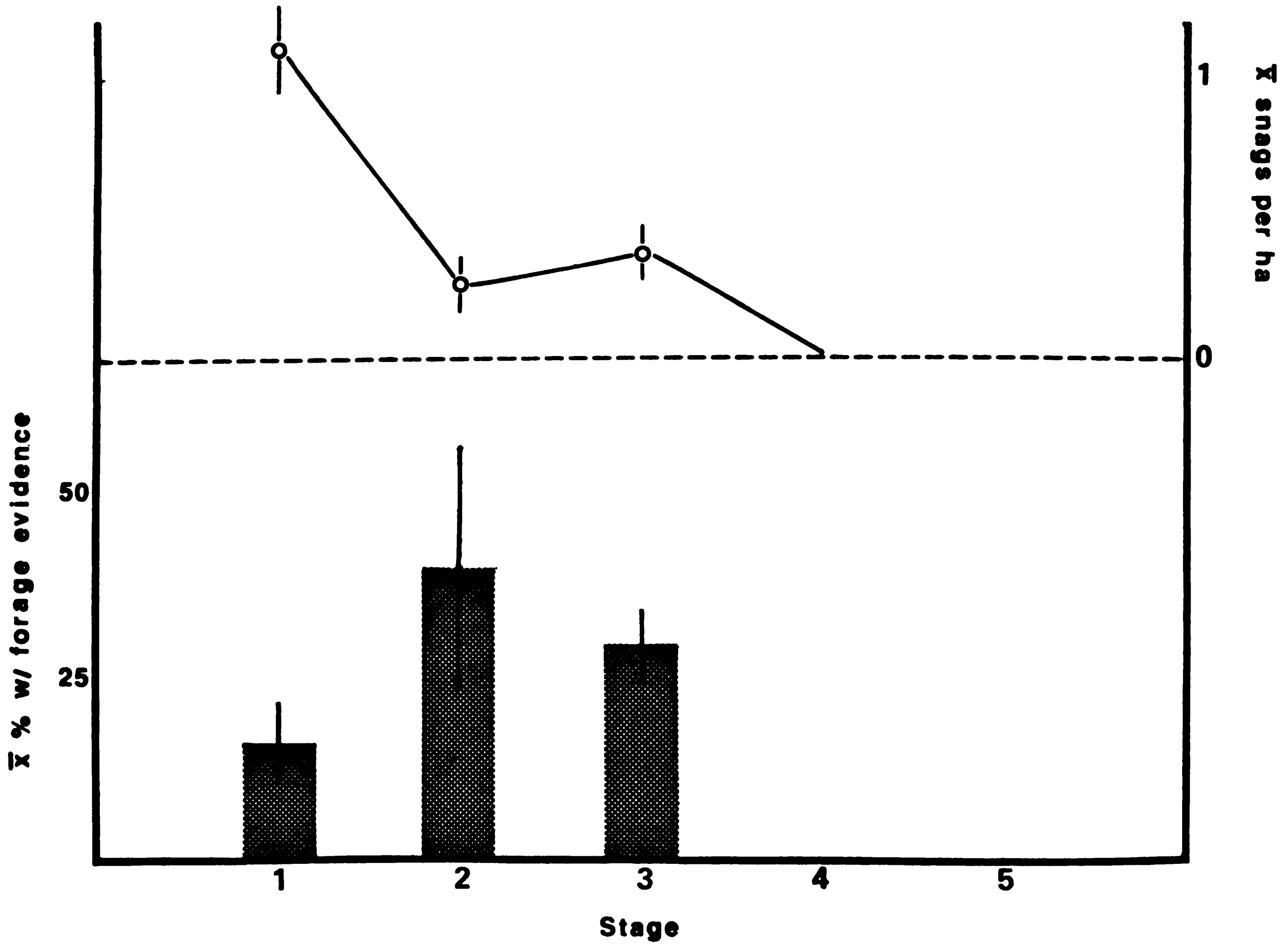


Figure 13. The mean densities of new snags (> 18 cm d.b.h.) and the mean percent of new snags with evidence of foraging in northern oak stands in 1982 (with standard errors).

DISCUSSION

Year-to-year changes in bird populations were monitored by censusing control plots in both 1981 and 1982. Pretreatment populations on treatment plots were censused to be sure that populations were homogeneous prior to firewood cutting. Results of the bird census and snag survey completed in 1981 confirmed that control and treatment plots were not significantly different in terms of snag densities or bird populations. Vegetation sampling completed during the study period also showed no major differences in the plant communities. The significantly lower density of breeding birds on the treatment plots in 1982 is difficult to relate to the reduction in numbers of snags. The species accounting for most of the difference were not cavity-nesters, so a reduction in numbers of snags should not affect their populations. The significantly lower percent of vegetative cover in the 1-7 m strata may be responsible for the difference in bird densities but differences should have also been evident in 1981 since vegetative cover was not affected by the treatment.

The absence of an expected decrease in numbers of cavity-nesting bird species may have been due to several factors. First, the majority of the cavity-nesters inhabiting the study plots appeared to prefer to nest in live trees or dead portions of live trees. Only a few active nests were in snags, and since each snag <18 cm d.b.h. was examined both years, there was a low probability of overlooking nests in snags. The only exception could be nests of the black-capped chickadee which may choose a small snag (<18 cm d.b.h.). The preference for live trees exhibited by the white-breasted nuthatch and hairy woodpecker has been noted by other authors (Kilham, 1968; Lawrence, 1966). The use of live aspen trees by hairy woodpeckers follows with the observations of Lawrence (1966) but is in contrast with those of Conner (1975) in Virginia. The lack of data collected on the great-crested flycatcher made it impossible to determine whether or not it was more often selecting cavities in snags or live trees, but regardless, detections of this species did not decrease following firewood removal. A reported preference for live trees or snags by the great-crested flycatcher was not found in the literature. The one active red-headed woodpecker nest located in 1981 is in concordance with its reported preference for snags (Hardin and Evans, 1976). However, mature northern oak stands are not preferred red-headed woodpecker habitat, and none of these birds were observed on either control or treatment plots in 1982. The low abundance of the downy woodpecker, which is typical of this vegetation type, may have been due to the high percentage of oak snags in the early stages of decay which may have been too "hard" for downies to excavate (Conner, 1978).

Secondly, snag densities present on the study plots before firewood removal were considerably above those recommended by Evans and Conner (1979) for woodpecker species of oak-hickory forests. Reductions in the number of snags were significant, but firewood removal may not have been sufficient to reduce populations. The ranges of snag diameters were also within those used by woodpeckers with the exception of the pileated woodpecker (Dryocopus pileatus). Very few snags of the size required for nesting by this species were present on the study plots, although pileated woodpeckers were observed foraging on snags within the plot boundaries.

The importance of snags as foraging sites was evident by the high number exhibiting signs of use. The large increase in usage of stage 3 snags compared to those in stage 2 indicates the value of snags in this stage as foraging substrate. Aspen snags were present in low numbers relative to snags of the oak species but had a higher degree of use. Due to the poor quality of aspen as firewood, it is usually less often selected by firewood cutters and was often the species not cut in this study. However, as these stands age, aspen will become less frequent due to successional change and birds that feed on snags will have to rely more on other species.

The generation of new snags was clearly evident on the control plots and is a factor which may reduce the impact of firewood removal. Although the trees that died and became snags between 1981 and 1982 were probably not very suitable for cavity nesting or foraging due to their hardness, their value to cavity-nesters will increase in time if they are not removed by additional firewood cutting. However, it would take approximately 4 to 5 years at a generation rate of 2.1 snags per ha per year, to produce recommended numbers of snags (Evans and Conner, 1979) and many more years before these snags decay to the preferred stage.

Results of the snag survey showing more cavities and forage evidence on snags in the later stages of decay point to the value of a snag as it ages. Snags in the condition more important to cavity-nesters may be less sought after as fuelwood since firewood cutters normally prefer hard snags in the early stages of decay. This would indicate that the continual harvesting of firewood may eventually impact, at least, some cavity-nesting species since few snags will be left to age.

A final consideration in the results of this study relates to the dimensions of the plots. Although a 15 ha study plot approached the limit of a manageable controlled firewood removal, large numbers of cavity-nesting birds did not occur on the study plots due to the large territory size of most cavity-nesting species. The effect of firewood removal over much larger areas could possibly have more of an impact since increasing block size will involve more species, but as long as blocks lie within this vegetation type, evidence from this study suggests cavity-nesters will not be significantly reduced. Most cavity-nesting birds utilize snags for feeding to some extent, and the loss of foraging substrate may affect populations but there is no evidence at present to suggest populations are actually limited by the food source snags provide. Further research into this area is needed.

SUMMARY AND RECOMMENDATIONS

Firewood removal did not significantly reduce cavity-nesting bird populations on 15 ha study plots within 65-year old northern oak stands in Michigan due to the extensive use of live trees or dead portions of live trees for nesting. Total bird densities on control areas were significantly greater ($p<0.10$) than treatment areas but these differences were difficult to relate to the loss of snags.

Results of this study suggest that small areas within this vegetation type could be harvested for firewood without significant reductions in cavity-nesting bird populations. This does not exclude the possibility that the loss of snags over larger areas would decrease numbers, but blocks up to 8 ha in size may be harvested over a short time period. If block size is increased, additional cavity-nesting species such as the pileated woodpecker may be affected. This may further increase the special consideration warranted for this species due to the infrequent occurrence of snags large enough to provide adequate nesting sites.

Findings of this study are limited to northern oak stands and should not be applied to other forest types. Cavity-nesting species in other vegetation types may show a different response if they are more dependent on snags, as has been suggested by other authors, than the species observed here. Even in oak forests, continual harvesting of newly formed snags may be detrimental because eventually no snags in the later stages of decay will be present but this aspect will vary with the level of firewood consumption.

The importance of aspen as foraging sites as well as nesting sites in both live and dead trees indicates that at least small percentages of this or other "soft" wooded species should be encouraged in forest stands. Timber harvesting and timber stand improvement practices might be modified to include such considerations.

APPENDIX

Appendix A. Species list of all birds identified on the study area.

Common name (Scientific name)	1981						1982					
	PLOT											
	1	2	3	4	5	6	1	2	3	4	5	6
Pileated woodpecker (*Dryocopus pileatus*)	X		X								X	X
Red-bellied woodpecker (*Melanerpes carolinus*)	X	X		X		X		X	X		X	X
Red-headed woodpecker (*Melanerpes erythrocephalos*)	X		X			X						
Hairy woodpecker (*Picoides villosus*)	X	X	X	X	X	X	X	X	X	X	X	X
Downy woodpecker (*Picoides pubescens*)					X		X				X	
Great-crested flycatcher (*Myiarchus crinitus*)												
Least flycatcher (*Empidonax minimus*)	X			X		X				X		X
Eastern wood pewee (*Contopus virens*)	X	X	X	X	X	X	X	X	X	X	X	X
Blue jay (*Cyanocitta cristata*)		X	X	X		X	X	X		X		X
American crow (*Corvus brachyrhynchos*)										X		
Black-capped chickadee (*Parus atricapillus*)								X		X	X	
White-breasted nuthatch (*Sitta carolinensis*)	X	X	X	X	X	X	X	X	X	X	X	X
Red-breasted nuthatch (*Sitta canadensis*)	X										X	
Brown creeper (*Certhia familiaris*)		X	X	X	X				X	X	X	X
American robin (*Turdus migratorius*)		X	X			X		X	X	X		X
Wood thrush (*Hylocichla mustelina*)		X				X					X	X
Hermit thrush (*Catharus guttatus*)	X		X				X					
Veery thrush (*Catharus fuscescens*)				X						X		
Blue-gray gnatcatcher (*Polioptila caerula*)			X									

Appendix A. (continued)

Common name (Scientific name)	1981 PLOT 1	1981 PLOT 2	1981 PLOT 3	1981 PLOT 4	1981 PLOT 5	1981 PLOT 6	1982 PLOT 1	1982 PLOT 2	1982 PLOT 3	1982 PLOT 4	1982 PLOT 5	1982 PLOT 6
Ruby-crowned kinglet (Regulus calendula)									X			
Cedar waxwing (Bombycilla cedrourum)	X	X		X	X		X	X	X		X	X
Yellow-throated vireo (Vireo flavifrons)									X	X		
Red-eyed vireo (Vireo olivaceus)	X	X	X	X	X	X	X	X	X	X	X	X
Warbling vireo (Vireo gilvus)					X							
Black and white warbler (Mniotilta varia)										X		
Nashville warbler (Vermivor ruficapilla)					X						X	
Black-throated blue warbler (Dendroica nigrescens)		X			X							
Yellow-rumped warbler (Dendroica coronata)	X						X	X		X	X	X
Black-throated green warbler (Dendroica virens)	X						X		X	X		
Blackburnian warbler (Dendroica fusca)											X	
Chestnut-sided warbler (Dendroica pensylvanica)												X
Ovenbird (Seiurus aurocapillus)	X	X	X	X	X	X	X	X	X	X	X	X
Brown headed cowbird (Molothrus ater)		X			X				X			
Scarlet tanager (Piranga olivacea)	X	X	X	X	X	X	X	X	X	X	X	X
Rose-breasted grosbeak (Pheucticus ludovicianus)	X	X	X	X	X	X	X	X	X	X	X	X
Mallard (Anas platyrhynchos)									X			

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