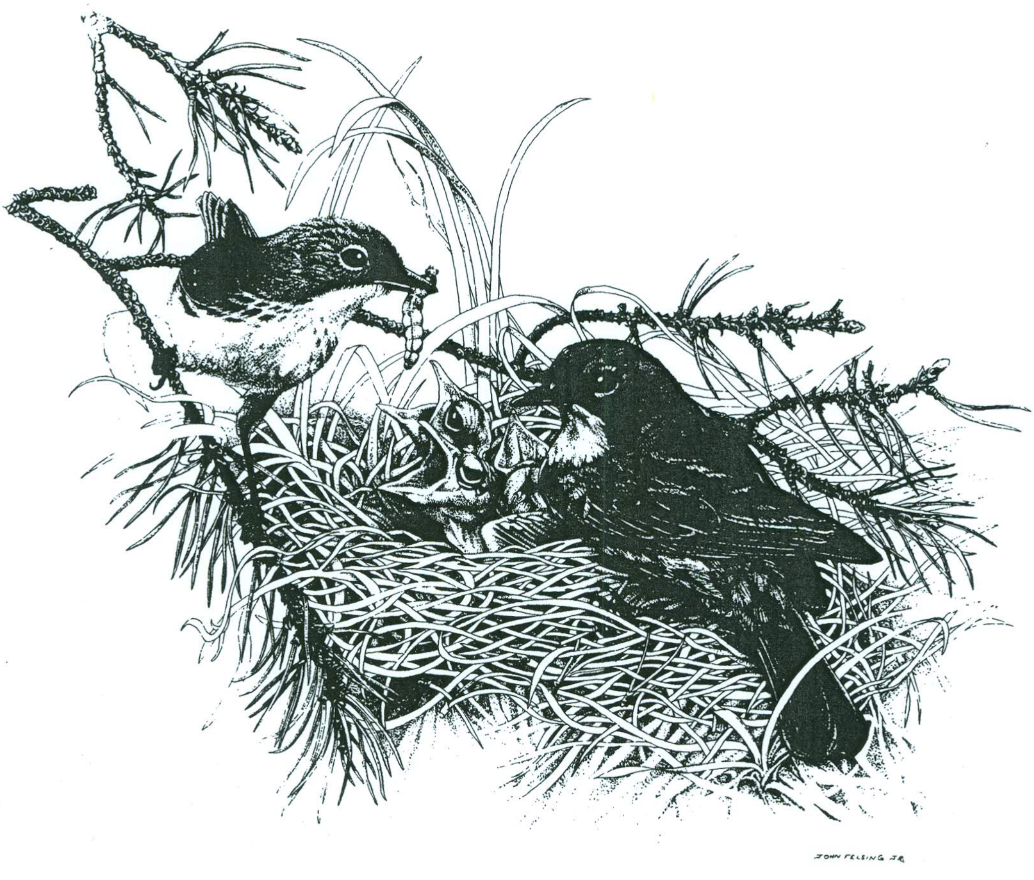


Kirtland's Warblers at Nest. Drawing by John Felsing, Jr.

Vegetation of a Kirtland's Warbler Breeding Area and 10 Nest Sites

Refining our concepts of warbler habitat

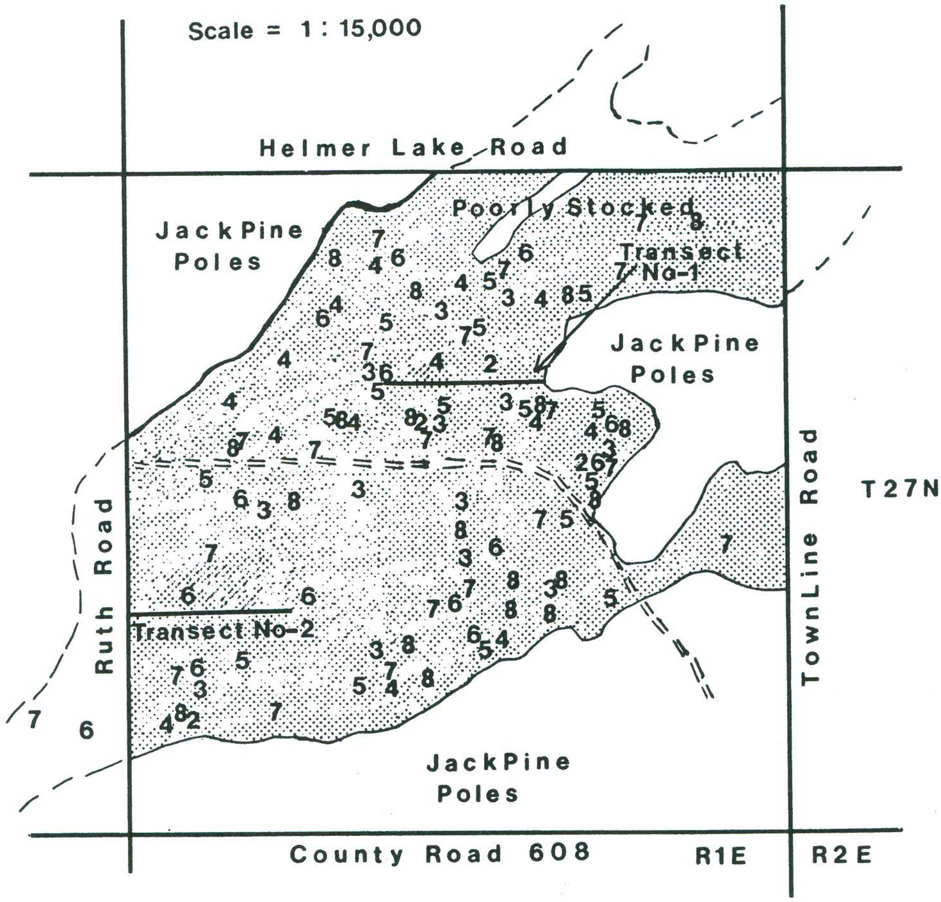
RICHARD R. BUECH

Early observers noted that the Kirtland's Warbler *(Dendroica kirtlandii)* required young jack pine *(Pinus banksiana)* stands of fire origin (Wood 1904, 1926; Barrows 1921; Leopold 1924; Wing 1933). Leopold (1924) observed that they nested in stands about 1 to 3 m tall and that the nest was usually within 3 dm (1dm = 0.1m) of the base of jack pine and well concealed by heavy ground vegetation. Wood (1926) further observed that they favored thick low branches, numerous small openings, and that as the stand matured, its value to the Kirtland's Warbler declined as shade destroyed the ground vegetation. More recently Mayfield (1953) defined their need for homogenous stands of jack pine between about 1.5 and 6 m high or about 7 to 20 years old, preferably in stands larger than 32 ha. In addition, 2 colonies were found in pure red pine *(P. resinosa)* which suggested that the pine life form rather than jack pine per se may be required. Mayfield (1962) also reported that all but a few colonies were located on the Grayling sand soil type. Anderson and Storer (1976) found 90% of nests which fledged warblers to be in stands larger than 80 ha.

Although the general requirements of the Kirtland's Warbler have been characterized, a quantitative description of their vegetative requirements for breeding is lacking. This information is needed for management. We pilot-tested a scheme to sample the character of the vegetation in the general breeding habitat and around the nest sites, hoping to assess the adequacy of the method and improve it for later larger-scale studies.

The area chosen for sampling general breeding habitat was located in Sec. 13, T27N, R1E, near Muskrat Lake in Oscoda County, Michigan (Fig. 1). The area north of the east-west trail bisecting the section was clearcut in strips in the winter of 1962-1963; uncut strips alternated with strips on which the entire overstory was harvested. The entire area south of the trail was harvested by clearcut in 1961. A wildfire originating from County Road 608 subsequently burned both areas in April 1964 and warblers began using it in 1972. Use of the area was greater on the north than the south sides of the trail. Thus in addition to testing the vegetation sampling scheme, this study area provided an opportunity to see how well the scheme could detect qualitative differences in habitat.

Locations of nest sites were not known at Muskrat Lake, but 10 nest sites were located on the Lovells Management Area in Sec. 5, T28N, R1W, Crawford County. The vegetation on this area differed from Muskrat Lake in several important ways. For example the age of the stand was greater (18 years old) and the area was originally open grassland planted to jack pine strips. In spite of the fact that these differences may confound the conclusions, a comparison was made between the vegetation at Muskrat Lake and



Year	Number of Singing Males		
	North of Trail	South of Trail	Both Sides
1972	3	1	4
1973	6	7	13
1974	11	3	14
1975	10	6	16
1976	6	8	14
1977	13	8	21
1978	11	9	20
Total	60	42	102

FIG. 1. Kirtland's Warbler past use of Muskrat Lake breeding area, Oscoda County, Michigan. Area burned by the 1964 wildfire is shaded. The numbers identify the location of singing males and correspond to a year during the 1970's, (i.e., 2 = a singing male at this location during 1972).

that about nest sites on the Lovells Management Area. The results presented here, although based on a limited sampling, are the first quantitative data available on the general breeding habitat of the Kirtland's Warbler.

Methods

Breeding habitat at Muskrat Lake and nest site locations on the Lovells Management Area were sampled from 6-11 August 1976. Two transects, each 420 m long, were sampled at Muskrat Lake. Transect 1 was located north of the trail in the alternate clearcut portion and transect 2 was located south of the trail in the clearcut portion (Fig. 1). Because transect 2 was located in a portion which had no nesting birds until 1976 it may represent incipient habitat and may not be representative of the whole area south of the trail.

Each transect consisted of 210 adjacent plots 1 m by 2 m for sampling trees and 21 plots 1 m by 1 m, spaced 20 m along the same transect, for sampling ground vegetation. On even-numbered tree plots, we tallied the number of stems rooted in the plot by tree species (northern pin oak, *Quercus ellipsoidalis* and scarlet oak, *Q. coccinea* were lumped and termed oak); on odd-numbered plots, we tallied the same information by 1-m height classes and estimated the average height of the lowest live limbs by quarter-meter height classes. For ground vegetation on the 1 m^2 plots, we estimated for each species the percent cover and height by classes. Cover classes applied were 1, 1 to 5, 5 to 25, 25 to 50, 50 to 75, and >75% cover. Heights were measured to the nearest decimeter. With some modification, the data were analyzed following the recommendations of Ohmann (1973).

At nest site locations, ground vegetation was sampled in the same manner as above with a 1 m by 1 m plot centered over the nest. Sample trees were identified by the point-centered quarter method of Cottam and Curtis (1956), with the nest as the center point; the distance to the 2 nearest trees in each quarter was measured to the nearest decimeter. This resulted in a sample of 8 trees about each nest. For each of these trees, the height of the lowest live limb was measured to the nearest quarter-meter height class; the total height of the tree and the greatest and smallest crown width were measured to the nearest decimeter. In addition, the following information was recorded: direction of nest opening, an estimate of tree cover directly over the nest to the nearest 10%, the vegetational composition of the nest and nest canopy, and the distance to and size of the nearest small and large openings. Also, tree stems and crowns on the 6 m × 6 m area centered over the nest site were subjectively mapped.

Results

Muskrat Lake Breeding Area. — The tree data revealed striking differences between transects 1 and 2 (Table 1). Tree stocking, the number of 1 × 2 m plots in which trees were present (percent frequency of occurrence), was 80.5% on transect 1, almost twice that of the 44.8% found on transect 2. Almost all of the stocked plots contained jack pine and few had oak on both transects. Eight times as many tree stems were counted on transect 1 as on transect 2. Very few (0.5%) of the tree stems counted on transect 1 were oak as opposed to transect 2 (27.8%). In spite of the high proportion of oak stems on transect 2, their distribution was highly clumped since only 4.3% of the plots had oak present. Tree density was estimated at 48,520 trees/ha on transect 1 and 5,830/ha on transect 2 and the mean height of jack pine was 1.75 m and 1.69 m respectively. As might be expected from the above data, both the number and mean size of canopy openings on transect 1 were less than those on transect 2. Also the average height to the lowest live limb differed between transects (Fig. 2). This height was less than 5 dm for almost all plots on transect 2, whereas it exceeded 5 dm on almost three-fourths of the plots on transect 1.

TABLE 1. Summary of trees of transect 1 (strip cut portion) and transect 2 (clearcut portion) at Muskrat Lake breeding area after the 1976 growing season.

DESCRIPTIVE CHARACTERISTIC	TRANSECT 1	TRANSECT 2
Percent plots (2 m²) with any tree	80.5	44.8
Percent plots with jack pine*	79.5	41.9
Percent plots with oak**	1.9	4.3
Percent plots with only oak	1.0	2.9
Jack pine density (stems/ha) — all plots	48,260	4,210
Oak density (stems/ha) — all plots	260	1,620
Total tree density (stems/ha) — all plots	48,520	5,830
Mean (± SE) height of jack pine (m)	1.75(±.02)	1.69 (±.09)
Number of openings 1 by 2 m or larger	19	32
Mean (± SE) length of openings (m)	4.3(±1.0)	7.2(±1.6)

**Pinus banksiana*
***Quercus coccinea* and *Q. ellipsoidalis*

The most prominent species in the ground vegetation layer of both transects was *Vaccinium angustifolium* (Table 2). Other prominent components of the ground vegetation layer of both transects included *Danthonia* spp., *Carex* spp., *Comptonia peregrina,* dead wood, and bare ground. In regard to other components, the composition of both transects was very similar, except for a greater diversity of forbs on transect 2, although these were of minor importance as measured by importance values. Overall, the transect totals revealed that frequency, total cover, and average cover were less on transect 1 than on transect 2. By ground vegetation category (Fig. 3), total cover on transect 2 was particularly greater than that on transect 1 for the grass, forb and moss-lichen categories. Based on

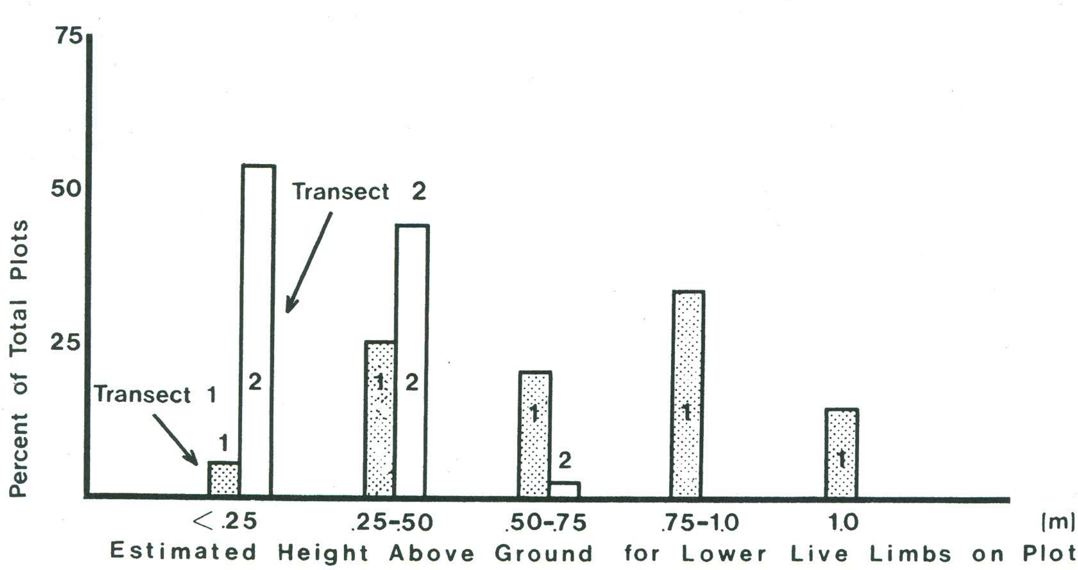


FIG. 2. Distribution of lower live limb height above ground on each plot occupied by trees as a percent of total stocked plots on transects 1 and 2 after the 1976 growing season.

TABLE 2. Summary (Ohmann 1973) of ground vegetation on transects 1 and 2 (21 plots each) of the Muskrat Lake breeding area after the 1976 growing season.

COMPONENT	% FREQUENCY		% RELATIVE FREQUENCY		% RELATIVE COVER		% IMPORTANCE VALUE	
	1	2	1	2	1	2	1	2
Grasses and sedges								
Danthonia-Carex	85.7	100.0	11.0	10.8	8.0	10.8	9.5	10.8
Andropogon	28.6	52.4	3.7	5.6	2.3	5.4	3.0	5.5
Low shrubs								
Vaccinium angustifolium	100.0	95.2	12.9	10.3	36.9	32.5	24.9	21.4
Comptonia peregrina	66.7	71.4	8.6	7.7	8.0	15.2	8.3	11.4
Prunus pumila	52.4	23.8	6.7	2.6	3.1	1.0	4.9	1.8
Apocynum androsaemifolium	—	9.5	—	1.0	—	0	—	.5
Rosa spp.	4.8	—	.6	—	.2	—	.4	—
Prostrate shrubs								
Arctostaphylos uva-ursi	19.0	19.0	2.4	2.0	6.1	3.1	4.2	2.6
Epigaea repens	9.5	9.5	1.2	1.0	1.0	.8	1.1	.9
Gaultheria procumbens	19.0	9.5	2.4	1.0	.1	.2	1.2	.6
Tall forbs								
Pteridium aquilinum	28.6	71.4	3.7	7.7	7.2	4.3	5.4	6.5
Forbs								
Aster laevis	14.3	23.8	1.8	2.6	.2	.4	1.0	1.5
Melampyrum lineare	28.6	19.0	3.7	2.0	.2	.1	2.0	1.0
Solidago spp.	—	9.5	—	1.0	—	.3	—	.6
Mianthemum canadensis	—	9.5	—	1.0	—	.2	—	.6
Hieracium spp.	4.8	9.5	.6	1.0	0	0	.3	.5
Aster spp.	—	9.5	—	1.0	—	0	—	.5
Antennaria spp.	—	4.8	—	.5	—	0	—	.2
Pyrola spp.	—	4.8	—	.5	—	0	—	.2
Unknown	4.8	4.8	.6	.5	0	0	.3	.2
Mosses and lichens								
Lichens	71.4	95.2	9.2	10.3	.8	7.7	5.0	9.0
Mosses	38.1	76.2	4.9	8.2	.4	4.1	2.6	6.2
Dead wood	100.0	100.0	12.9	10.8	17.9	8.1	15.4	9.4
Bare ground	100.0	100.0	12.9	10.8	7.7	5.9	10.3	8.4

*Total cover, all species, was 1851.5 (transect 1) and 2306.0 (transect 2)

importance values (Table 2), both transects can be characterized as low shrub-grass-sedge communities with a sizeable moss-lichen, dead wood, and bare ground component. Prostrate shrubs, tall forbs, and forbs were not very significant.

Ground vegetation layer height also differed between transects (Fig. 4). As measured by the relative percent cover on each transect, more cover was found at greater heights on transect 1 than on transect 2. For example, the highest percentage on transect 1 was found in the 2 to 3 dm category, whereas on transect 2 it was found in the 1 to 2 dm category.

The relative percent cover of the ground layer categories for both transects combined is plotted with respect to the number of tree stems/plot in Fig. 5. This shows that the grass, prostrate shrub, and moss-lichen categories declined in cover with increasing tree density. Conversely, bare ground increased with increasing tree density. While dead wood also increased with increasing tree density, this is a result of the heavy contribution of transect 1 to the high density tree plots which in turn resulted from the 1964 burn in the alternate "leave" strips with its attendant production of much dead wood. The trends for low shrubs, tall forbs, and forbs were not conclusive. Tree density also partially explained the height of the ground

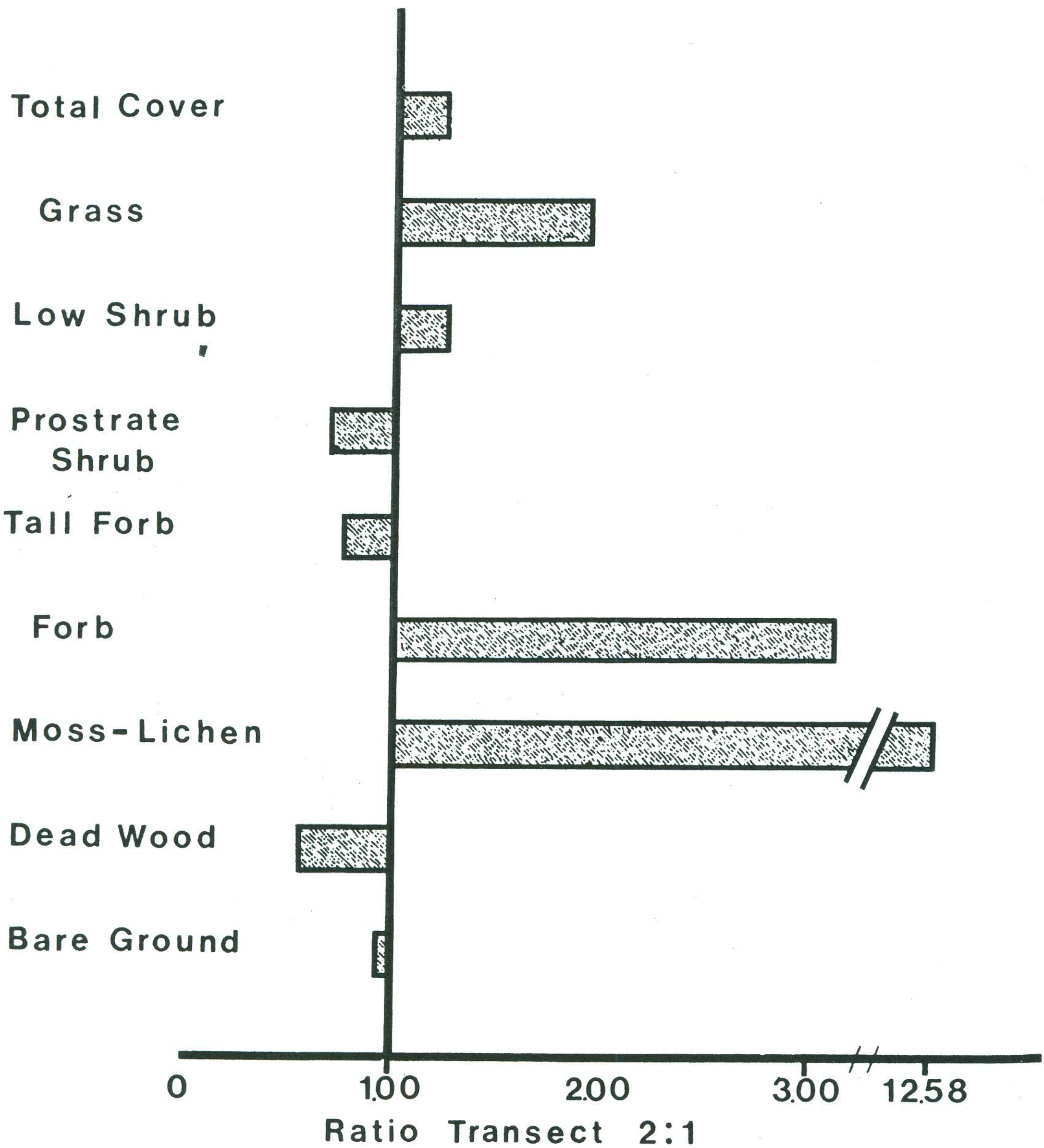


FIG. 3. A comparison of ground cover categories expressed as a ratio of transect 2: transect 1, based on total cover.

vegetation layer (Fig. 6). While a density of 1 to 5 stems/plot (5,000 to 25,000 trees/ha) only slightly affected cover, greater densities resulted in a shift in cover to greater heights, especially the 2 to 3 dm category. It is also instructive to compare the height of cover in the ground vegetation layer with the average height of the lowest live limbs (Fig. 7) to see what parallels exist in response to increased shading. This figure suggests that conditions which permit live limbs within 5 dm of the ground also result in little variation in the height of cover of the ground vegetation layer. However, as the height of the lowest live limb increased to above 5 and particularly above 7.5 dm, the height of the cover of the ground vegetation layer shifted to the higher categories.

Lovells Management Nesting Sites. — Tree density, as determined from a 6 m × 6 m square plot about each of the 10 nest sites, averaged 3,530 (SE ± 330) trees/ha. The first and second nearest trees in each quarter for the 10 nest sites had a mean height of 2.63 m, a crown width of 1.67 m, and a height to the lowest live limb of 0.35 m. The corresponding values for the tree nearest the nest was 2.59, 1.79, and 0.45 m. No significant differences (.05 level) were found between the means for any of the above characteristics for trees nearest the nest as compared to the first and second nearest trees in each quarter. The distance from the nest to the nearest tree averaged 0.79 m, to the nearest small opening 1.1 m, and to the nearest large opening 4.2 m. The mean size of the nearest small opening was 14 m^2 while most large openings exceed 500 m^2. Most nest openings faced either southwest or northeast. Based on percent frequency of occurrence and

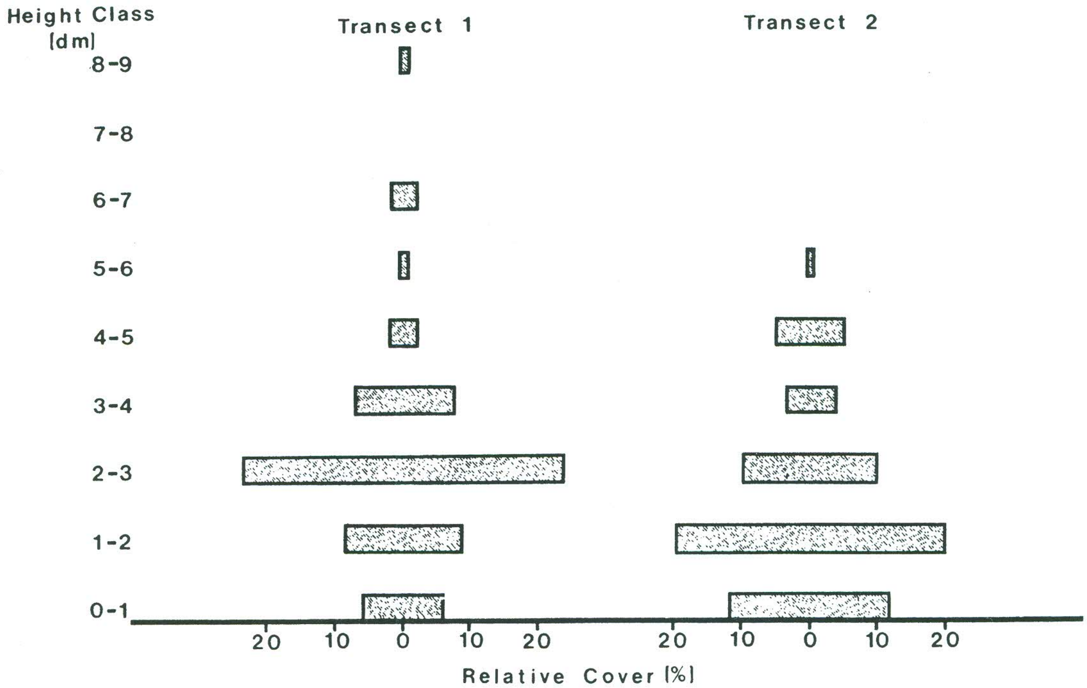


FIG. 4. A comparison of relative cover, in percent, by height classes, of ground cover on transects 1 and 2.

listed in descending order, nest canopies contained *Danthonia* spp., *Carex* spp., *Vaccinium angustifolium, Andropogon* spp., *Prunus pumila, Amelanchier* spp., and *Rosa* spp. The estimated tree cover directly over the nest averaged 66% and that on the 6 m × 6 m grid surrounding the nest site averaged 62%. The estimated tree cover in the plantation using the mean crown width and the number of trees/ha was independently calculated to be 77%.

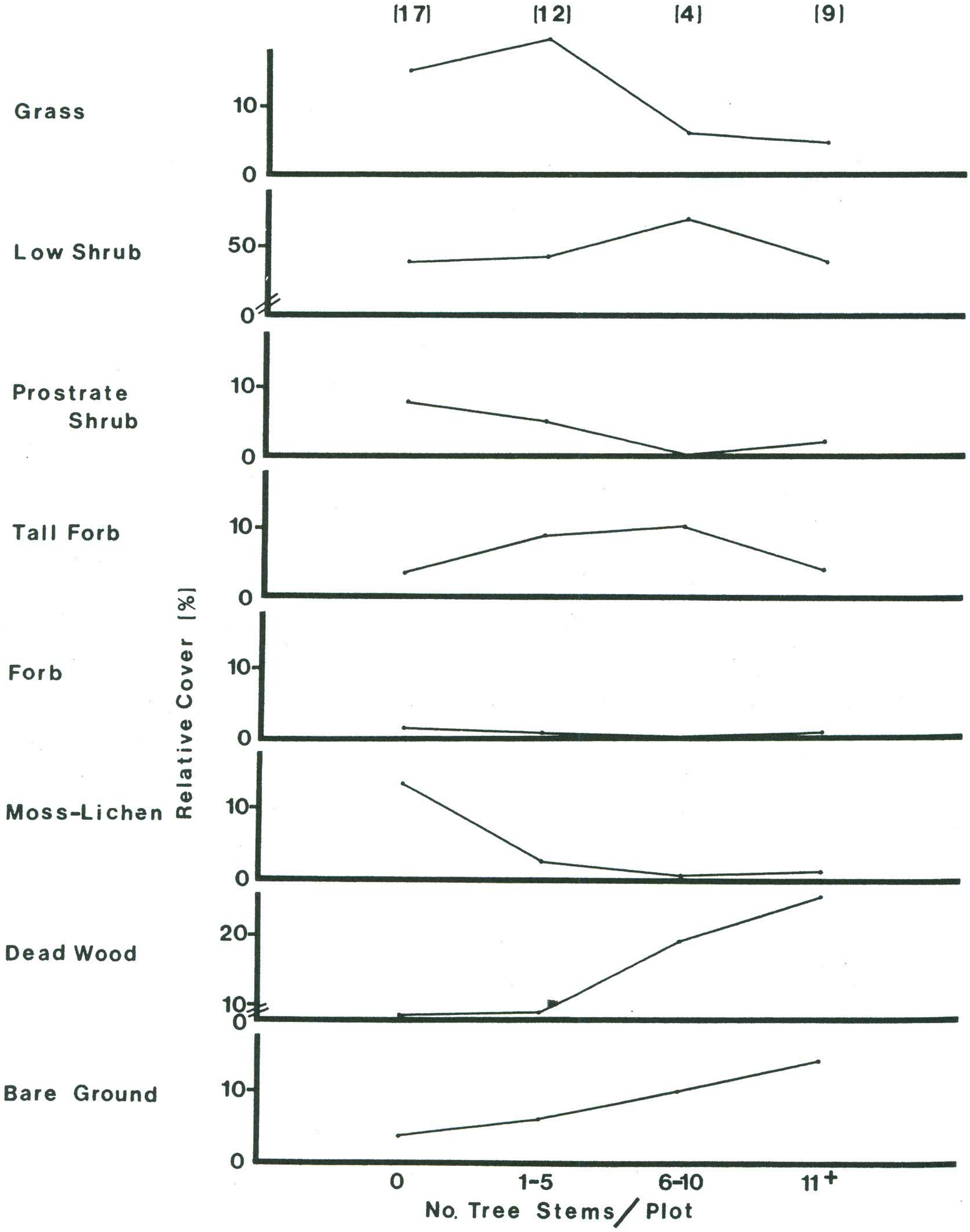


FIG. 5. A summary for both transects combined of the relative percent cover, by ground vegetation category and tree density. The number of plots is in parenthesis.

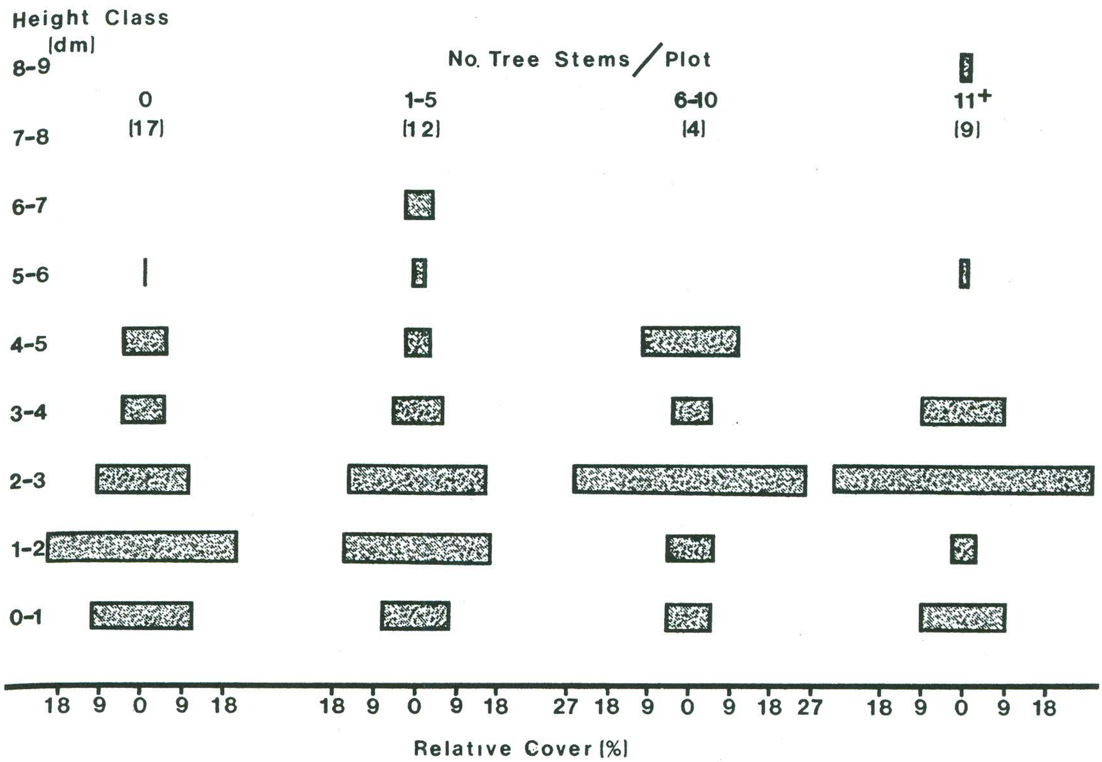


FIG. 6. A summary for both transects combined of the relative percent cover of ground vegetation by height class and tree density. The number of plots is in parenthesis.

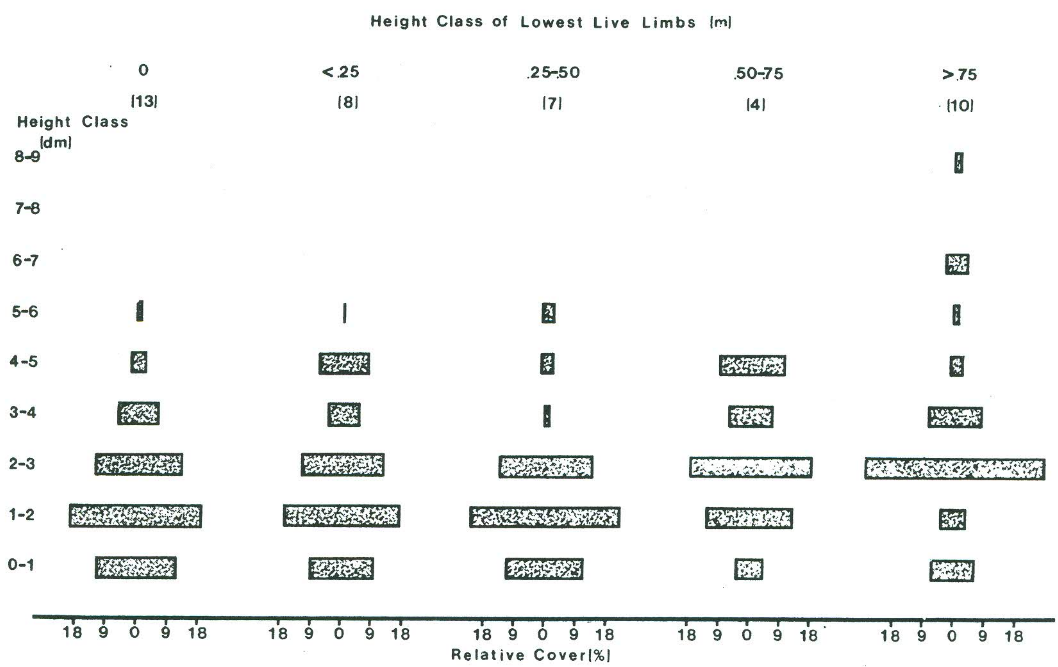


FIG. 7. A summary for both transects combined of the relative percent cover of ground vegetation by height class and height to lowest live limbs. The number of plots is in parenthesis.

The character of the ground vegetation layer on the 1 m × 1 m plots centered on the nest is summarized for all 10 nests in Table 3. The importance values indicated that *Danthonia-Carex* and *Andropogon* spp. predominated followed by *Vaccinium angustifolium, Prunus pumila, Arctostaphylos uva-ursi* and *Comptonia peregrina* in descending order of importance. By vegetative category (Table 3), grasses and sedge dominated, followed by low shrubs and forbs. Most of the ground vegetation cover was in the 2 to 3 dm height range or secondarily in the 1 to 2 dm range with very little cover above 4 dm (Fig. 8).

TABLE 3. Summary (Ohmann 1973) of ground vegetation about 10 nest sites on the Lovells Management Area after the 1976 growing season.

COMPONENT	% FREQUENCY	% RELATIVE FREQUENCY	% RELATIVE COVER	% IMPORTANCE VALUE
Grasses and sedges				
Danthonia-Carex	100.0	11.5	38.8	25.2
Andropogon spp.	100.0	11.5	31.0	21.2
Low shrubs				
Vaccinium angustifolium	70.0	8.0	11.7	9.8
Prunus pumila	70.0	8.0	5.9	7.0
Comptonia peregrina	50.0	5.7	3.7	4.7
Amelanchier spp.	30.0	3.4	3.6	3.5
Rosa spp.	20.0	2.3	.6	1.4
Apocynum androsaemifolium	10.0	1.1	.1	.6
Lonicera spp.	10.0	1.1	.1	.6
Prostrate shrubs				
Arctostaphylos uva-ursi	70.0	8.0	2.0	5.0
Gaultheria procumbens	10.0	1.1	.1	.6
Forbs				
Aster laevis	70.0	8.0	.4	4.2
Aster spp.	30.0	3.4	.2	1.8
Campanula rotundifolia	30.0	3.4	.2	1.8
Viola spp.	30.0	3.4	.2	1.8
Solidago spp.	20.0	2.3	.1	1.2
Mianthemum canadensis	20.0	2.3	.1	1.2
Unknown b	20.0	2.3	.1	1.2
Unknown c	10.0	1.1	.3	.7
Antennaria spp.	10.0	1.1	.1	.6
Hieracium spp.	10.0	1.1	.1	.6
Taraxacum offinale	10.0	1.1	.1	.6
Unknown a	10.0	1.1	.1	.6
Mosses and lichens				
Lichens	60.0	6.9	.9	3.9

*Total cover, all species, was 928.0

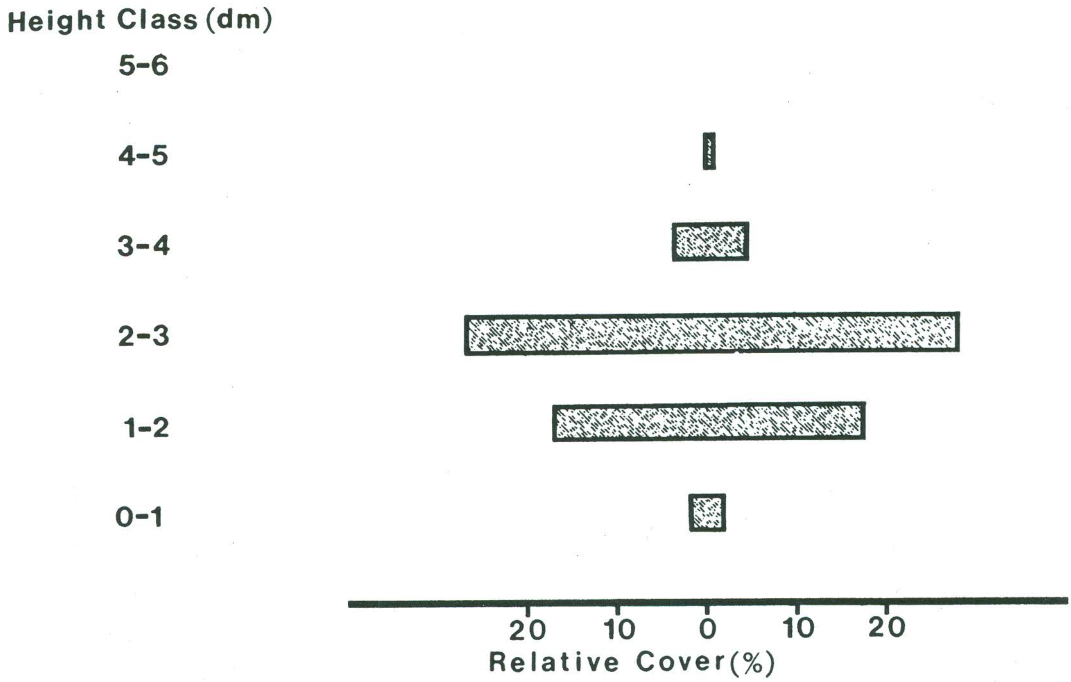


FIG. 8. Relative percent cover, by height class, of ground cover for 10 Kirtland's Warbler nest sites on the Lovells Management Area.

DISCUSSION

Kirtland's Warblers began using the Muskrat Lake breeding area 8 years after it burned. At the time the area was sampled in 1976, warblers had used the area for 5 years and the stand had completed 13 growing seasons. By 1976, about three-fourths of the jack pines were 1 to 3 m high with a mean height of 1.7 m, tree density varied considerably, and most of the lowest live limbs were less than a meter above ground. The understory vegetation was a low shrub-grass-sedge community with small amounts of prostrate shrubs, forbs, mosses, and lichens. Most understory vegetation cover was 1 to 3 dm above ground. As previously mentioned however, warbler use was greater on the northern versus the southern portion. This difference in warbler use might be explained from vegetation differences observed between transects.

In the northern portion where use was greater, the area was characterized by high tree density, comparatively few openings, a lower live limb height which generally exceeded 5 dm, and an average cover of low shrubs, grasses, and sedges of about 50%. Where use was lighter in the southern portion, the area was characterized by lower tree density, comparatively more openings, a lower live limb height which was mostly below 5 dm, and an average cover of low shrubs, grasses, and sedges of about 75%. Because of the lack of quantitative information about the sequence of revegetation of jack pine stands in this area with respect to stand age and density of jack pine, it is difficult to indicate which of these variables may be significant to the Kirtland's Warbler and/or where their absolute values may lie on the scale of warbler acceptability. In addition, given the natural variation within stands, warblers may well find suitable microsites within a stand which on the average seems unsuitable.

Others have pointed out the importance of jack pine density and the presence of openings and their effect on the occurrence of live lower limbs and density of ground vegetation (Van Tyne 1953; Mayfield 1960, 1962; and Radtke and Byelich 1963). In general, stands of natural origin tend to have thickets of jack pine interspersed with openings. In these cases, the thickets provide cover early in the life of a stand, while the presence of openings tends to maintain ground vegetation and lower live limbs about their periphery so that the useful life of the stand for breeding is extended. In contrast, tree density is lower and more uniform in plantations. Here, tree crowns interlace at an older stand age and lower live limbs and ground vegetation rapidly succumb to shade. Thus the period of warbler use in the life of a plantation would generally occur later and be of shorter duration.

A jack pine spacing study near Wellston, Michigan, described by Rudolf (1951), Guilkey and Westing (1956), and Godman and Cooley (1970), also supports the generalization that as stand density decreases use occurs later. From among their descriptions of the degree of interlacing limbs, presence of live lower limbs, and shading of ground vegetation at various densities, I estimated that the conditions most characteristic of good warbler habitat occurred at a density of about 6,000 trees/ha (1.3 m spacing) at the age of 10 years, 2,500 trees/ha (2.0 m spacing) at the age of 15 years, and 1,500 trees/ha (2.6 m spacing) at the age of 22 years.

The tree density of 48,260 jack pine/ha on transect 1 indicated that the tree canopy was very dense in the northern portion. Densities of this magnitude would require the presence of an opening to maintain lower live limbs. Assuming that the dimension of an opening should be about twice the height of the surrounding trees and that the upper limit of acceptable tree height would be about 6 m, this suggests an opening should have a minimum dimension of 12 m to be effective towards the end of the useful life of the stand. About 7% of the total length of transect 1 was in openings with minimum dimension of 12 m, whereas transect 2 had 35%. In spite of this large difference, it is difficult to say if even 7% is inadequate. An important consideration is whether there is a requirement for the presence of lower live limbs throughout warbler habitat or whether it is solely a nest site consideration which could be provided on a more local basis with fewer openings.

The order of abundance given by Mayfield (1960) for ground vegetation in warbler habitat indicates that grasses and sedges are more prominent than low shrubs. While this was also true for ground vegetation about the 10 nest sites which we sampled at the Lovells Management Area, data by Orr (1975) and the data we collected on the Muskrat Lake breeding area indicate that low shrubs (primarily *Vaccinium angustifolium)* were more prominent than grasses and sedges. The difference between the Lovells Management Area and Muskrat Lake might have been expected from the standpoint of cultural history. The Lovells Management Area was created by planting jack pine in open grassland tracts which had a previous history of repeated burning. This consideration, its original planting density of about 5,000 trees/ha, and its older age of 18 years probably contributed to the large grass-sedge component in this area. In contrast, the Muskrat Lake area originated after logging and wild fire in a previously forested area. Here the grass-sedge component was subordinate to low shrub component.

It is apparent that although there may be considerable variation, low shrubs and grasses and sedges dominate the ground vegetation layer of warbler habitat. Other categories (prostrate shrubs, forbs, mosses, lichens, etc.) are clearly minor.

Judging from the vegetative composition of the nest canopy, nest sites are probably not located in relation to a certain species, but partly in relation to the proportion in which they occur. Mayfield (1960) pointed out that since most first nests are built in the spring before the ground vegetation has developed, the primary feature of the ground vegetation layer at this time is dead grass and stems of low shrubs, which are also the primary components of the nest canopy. Since both grasses and low shrubs are utilized in the nest canopy, perhaps the growth form and density, rather than the species, of vegetation is more important to the Kirtland's Warbler.

Mayfield (1960) stressed the importance of ground vegetation which was less than 3 dm tall. Our observations support this assertion since most vegetation was between 1 and 3 dm. Although our data show some variation in the 2 decimeter classes within this range, this is explainable on the basis of tree density and, in the case of the Lovells Management Area, on the basis of the larger proportion in grasses and sedges.

The data showed that not only did tree density affect the height of the lower live limbs on trees, but it also affected the relative percent cover of grasses and sedges, prostrate shrubs, mosses and lichens, bare ground, and the height of ground vegetation. While this might be expected intuitively, further study is needed to understand fully the relationships of tree density, tree height, and the presence of openings to the height of lower live tree limbs and to the density and height of ground vegetation, and to understand which of these variables are important to the Kirtland's Warbler. Studies in all ages of warbler habitat, including those which are too young, too old, and apparently suitable but not used, and on soils other than Grayling sand, will be needed in order to place quantitative values on their requirements. In addition, knowledge of the effects of the cultural history of stands (including the occurrence of fire) would be very useful to managers in duplicating favorable habitat.

Summary

The vegetation on 2 portions of the Muskrat Lake breeding area and surrounding 10 nest sites on the Lovells Management Area was sampled during August 1976. At Muskrat Lake, quantitative differences were found between the northern and southern portions which reflected not only their cultural history but also offered an explanation for differences in past warbler use. Importance values characterized Muskrat Lake understory vegetation as a low shrub-grass-sedge community with a minor prostrate shrub, forb, moss, and lichen component. Tree density was shown to affect the height of lower live limbs on trees and the relative cover of grasses and sedges, prostrate shrubs, mosses and lichens, bare ground, and the height of ground vegetation. The vegetation surrounding the nest sites on the Lovells Management Area was similar except importance values indicated that grasses and sedges were more promi-

nent than low shrubs. Limited data on nest canopy composition suggested that nest sites are not located in relation to certain species, but perhaps in relation to the proportion in which they occur, and that the growth form and density of low shrubs, grasses, and sedges are probably more important.

ACKNOWLEGMENTS

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