Ennis

THE EFFECTS OF TREE CROWN COVER AND FIRE ON GROUND COVER VEGETATION IN KIRTLAND'S WARBLER HABITAT

The habitat of the Kirtland's Warbler (a Federally-listed Endangered Species) is nearly pure Jack Pine (Pinus banksiana) stands on xeric sites in northern lower Michigan. A comprehensive census conducted annually from 1971 thru 1987 has averaged 207 male KW's concentrated into only 17-23 breeding areas each year. Dense Jack Pine crown cover between 1.3m to 5.0m in height is an important factor for KW habitat suitability (Probst MS). Jack Pine is regenerated naturally or by planting. Natural regeneration may occur with or without fire, but there is more potential to obtain dense stocking with prescribed fire because many Jack Pine cones are serotinous.

Kirtland's Warbler management has incorporated fire as a tool to promote Jack Pine regeneration and to create optimal ground cover. (Byelich et al. 1976). A certain ground cover species composition could be necessary for suitable nest locations (Walkinshaw 1983). Previously, it was shown that KW's were found in adequately-stocked stands on both burned and unburned stands within the appropriate height range (Probst MS) and site quality, so fire may not be necessary to create suitable ground cover for KW's. I report on two related studies on ground cover structural components in xeric jack pine stands in lower Michigan. First, I describe ranges of relative percent cover values for major ground vegetation species and components, and relate ground cover to tree cover in occupied Kirtland Warbler habitat. Second, I test the idea that

dissimilar ground covers under different histories of tree crown cover become more similar (convergent succession) after tree crown removal by wildfire. Thus, I will present evidence that ground cover composition in KW habitat is altered primarily by site quality and tree crown cover, and is less influenced by fire per se. Studies of jack pine communities over a greater range of sites describe the floristic composition of communities in more detail (Abrams and Dickmann 1982, 1984; Abrams et al. 1985).

METHODS

The first study was conducted in occupied KW habitat between August 10 and August 25, 1979-1986. Ground cover vegetation was measured once at five burned sites (three wildfire and one prescribed burn), and five unburned in Crawford and Oscoda Counties. The results of the first study led to a hypothesis, which was tested in the plant succession study following wildfire in three areas with contrasting pre-fire tree-stocking. The most densely-stocked area was regenerated naturally after a 1946 wildfire. The area with the least tree-stocking was harvested in 1964 and the intermediately-stocked area was harvested and prescribe-burned in 1966. All three areas were burned in the Mack Lake Fire of 1980. Vegetation was measured between August 10 and August 25 in the years 1981, 1983 and 1985. An unburned control area, harvested in 1966, was sampled in 1979 and 1986.In both studies, vegetation was measured on two 33m L-shaped line transects each of which was subdivided into two 16.5m segments perpendicular to each other. Ground cover was estimated by foliar cover along the line (Daubenmire 1963, Gregg Smith 1964). For the first study in occupied habitat, tree crown cover was estimated by the line-intercept method (Lindsay 1955). Because tree crowns were destroyed in the Mack Lake

Burn Area, an indirect index of tree crown cover was developed by measuring the height and density of live and dead trees and summing the tree heights (Buech 1980). This index integrates tree size and density, which are related to total tree crown cover. To develop the index, live or dead trees were counted and measured 33m to the outside of the transect to give two areal sample plot 33m and 33m. I attempted to correlate the tree-crown index developed from sum of the tree heights with tree-crown cover using data from the first study in occupied habitat.

Measurements of ground cover components included three non-vegetative elements: litter, patches of bare ground (>3cm), and pieces of dead wood (>3cm). Grass and sedge species were classified into two categories because of structural similarities and difficulty in identifying grasses by vegetative parts. Broad leafed grasses lumped as "coarse grass" were principally bluegrasses (Andropogon gerardii and A. scoparius), or less commonly, Indiangrass (Sorghastrum) or Brome grasses (Bromus sp.), "Fine grasses" included sedges (Carex pennsylvanica), poverty grass (Danthonia sp.), Hairgrass (Deschampsia), Koeleria cristata, and ricegrass (Oryzopsis sp.).

ANALYSIS

Foliar percent cover was converted to percent cover relative to all ground cover components, because relative percent cover is less sensitive to the specific methodology in a single study and allows comparison between past and future studies. Ground cover samples from all stands occupied by Kirtland's Warbler were combined for initial analysis of ground cover for all jack pine stands sampled. For each plot's subsample at each sampling period, the

relative cover of each component was computed. The values for the two subsamples were averaged to arrive at the value for the transect. The plot averages were transformed to stablize their variance using arc sin (relative cover proportion)1/2; this also improves normality of proportions.

The transformed data were then analyzed, when possible, using standard univariate and multivariate ANOVA for repeated measures on each component separately. This analysis provides two ways of looking at plant succession effects and at the History (before 1980) x Succession interaction in the second study. The first perspective is differences among means; the second is existence of linear and quadratic trends. When there was a significant History x Time interaction, further analysis separated what effects History has on successional trends, and what effects Succession has for each plot History. If there was no interaction independent results for History and Succession effects were presented. Multiple comparisons were done with t-tests.

RESULTS

For the initial analysis all transects from all study plots were treated as a composite group for calculations of frequency of occurrence. Ground cover components were ranked by their frequency (Fig. 1) in the following order: moss/lichen, fine grass, blueberry, deadwood, sand cherry, bare ground, sweet fern, coarse grass and bearberry. The ranking of components for percent cover or relative cover (Fig. 2) is somewhat different than for the frequency ranking, indicating some local dominance or a clumped distribution of some components. The 95% confidence intervals (Fig. 2) illustrate the common range of ground cover percentages measured in occupied Kirtland's Warbler habitat.

Blueberry, sweet fern and bare ground were weakly correlated with the tree canopy covers greater than 50% in all stands combined. Similarly, fine grass, sand cherry, bearberry and juneberry were inversely related to the same part of the tree canopy cover range. There was no discernable pattern between tree canopy cover less than 50% and ground cover components. For comparisons among stands, there were no significant differences or trends between burned and unburned stands (Fig. 3, Table 1). Analysis of variance revealed no influence of fire treatment on percent cover of ground cover components alone or in combination with tree canopy cover.

MACK LAKE BURN PLANT SUCCESSION

Stands with higher tree crown cover index had higher percent cover values for some ground cover components that were positively related to tree crown cover in the data set from KW occupied habitat (Fig. 4). Stands with lower tree crown cover index had higher percent cover values for some ground cover components that were negatively related to tree crown cover in the occupied habitat data set (Fig. 5, Appendix). Only some of the means among stands were significantly different for each component. The differences in percent cover of each component among stands diminished between 1981 and 1983, and remained similar to 1983 in 1985 (Table 2,Fig. 4 & 5). There were few significant differences in ground cover between stands in 1983 and 1985 (Table 2). For the unburned control, tree crown cover increased from 15% to 34% between 1979 and 1986. Some individual ground components in the control changed in the direction predicted from their direct or inverse relationship with tree canopy cover.

Effects of Stand History

Stand history represented the combined effects of initial circumstances of stand regeneration in 1946, 1964, and 1966 (see Methods) and the time interval between initial regeneration and 1980. Three components had significantly different plot means in all years (1981, 1983, 1985). Sweet fern had higher mean cover in plots with a double fire history since 1946 and a more pronounced fire history (Table 2). There was more bare ground in the plot with two more recent fires and least in the unburned control. There was more bearberry in the 1946 wildfire plot, but I am unable to relate this fact to biological cause and effect.

Differences in blueberry cover were only significant in the 1946 wildfire plot between 1981 and 1983. Deadwood increased between 1981 and 1983 in the two plots with smaller trees. The amount of deadwood showed a further increase in 1985 in the 1946 wildfire plot, because it took about five years for the large trees in that plot to decay and fall.

Successional Trends

Three ground components had different means between years for all plots considered together. Sweet Fern had more cover in 1981 than in later years. The Sedge and Fine Grass group had lower cover in 1985 relative to earlier years. Bearberry cover was higher in 1983 than in 1981 or 1985.

Three ground components had different means between plots within one or more sample year. There was less lichen/moss in the 1946 wildfire area than in other plots in 1985. The same was true for deadwood in 1981 and 1983.

Successional trends were most complex for Sand Cherry (Fig. 5). In 1981, the 1946 wildfire plot had the lowest Sand Cherry cover, but in 1983 and 1985, the

1964 harvest plot had more Sand Cherry than in other plots. Other differences between years and plots (Fig. 5) were not significant.

In summary, five ground cover component were affected by Plot History differences: Blueberry, Bare Ground, Sweet Fern, Deadwood, Bearberry. Most ground components decreased between 1981 and 1985 except Deadwood and Bearberry. Seven components were influenced by succession: Lichen-moss, Blueberry, Sedge and Fine Grass, Deadwood, Sand Cherry, Sweet Fern, and Bearberry.

DISCUSSION

The plant communities described are similar to others in jack pine barrens in Northern Lower Michigan (Abrams and Dickmann 1982, 1984 and Abrams et al. 1985). Ground covers in mature jack pine on these dry, nutrient-poor sites are usually dominated by blueberry. In areas where the jack pine crown cover was removed by cutting, wildfire or cutting and prescribed burning, the ground cover tends to be dominated by sedge or "wiregrass" (Carex pennsylvanica). Some burned areas maintain blueberry dominance or a mix of blueberry and Carex meadows. The role of fire in regulating ground cover species composition is confounded by the effects of shade. The scarcity of Carex in mature jack pine and the gradual disappearance of blueberry is probably related to their affinities for open versus shaded conditions. Buech (1980) presented data that suggested a positive relationship between tree density, low shrubs and bare ground in young jack pine stands occupied by Kirtland's warblers. Grass-sedge and moss-lichen were inversely related to tree density. If shade can affect ground cover composition even in young jack pine stands, studies comparing burned and unburned cutover stands (Abrams and Dickmann 1982, Abrams et al.

1985) may be confounded by variable, unpredictable jack pine cover regeneration as well as site differences. All the "occupied stands" in the present study were well stocked with jack pine, so the ground cover composition was less variable than in other studies (Fig. 2). However, the ground cover and tree cover relationships were not correlated, presumably because of small site differences and historical factors such as shade, fire or other disturbance. Another factor adding variabililty to ground cover composition is initial composition before disturbance (Abrams and Dickmann 1984). Unburned clearcuts tend to have more grass than burned stands (Table 1), and hot or frequent fires tend to create more bare ground (1966 Prescribed Burn within the 1980 Mack Lake Burn, Table 2). Burning may open up chances for colonists that are not dominant in the pre-disturbance community, or allow a dominant plant to spread.

Successional trends may alter the initial post-disturbance community. Grasses and low shrubs may respond to fire with vigorous growth and then die back (Fig. 4,5). Sedges may increase in unburned areas (Abrams and Dickmann 1984). There was some indication of convergent succession in a simultaneous comparison of different aged burned and unburned stands (Abrams and Dickmann 1982). In the present studies, pattern of convergent plant succession was demonstrated by following the same stands of different shade and fire history through a five year period after wildfire. Cover percentages for most components tended to converge toward the covers in the unburned control and the KW occupied habitats. Within the time frame of the Mack Lake Burn study, all plant species decreased their cover by 1985. However, some components may increase again where jack pine crown cover adds shade to a stand (see 1979-1986 control, Fig. 4,5). It appears that site and history of a stand may be at least as important a factor controlling ground cover as time since disturbance. This is the

probable reason that ground cover vegetation in dry jack pine communities is more similar within stands over time than between stands of the same age (Abrams et al. 1985). The relative influence of disturbances such as fire can only be evaluated by paired treatments in adjacent stands with similar history and current tree stocking.

The need for fire maintanence of ground cover in Kirtland's Warbler habitat is uncertain pending very carefully controlled research. However, the range ofground covers accepted by the Kirtland's Warbler, and the convergence of ground covers after disturbance suggests that some stands should maintain suitable ground cover even if they are not burned every rotation. Guidelines for prioritizing stands for prescribed burning are presented elsewhere (Probst 1988). The primary need for fire for habitat management should focus on regeneration of dense jack pine stands. The shade from adequate tree crown cover should provide a means for preventing Carex dominance. Mechanical disturbance of ground cover could have a similar effect.

Abrams, M. D., and D. I. Dickmann. 1982. Early revegetation of clearcut and burned jack pine sites in northern lower Michigan. Can. J. Bot. 60:946-954.

Abrams, Marc D.; Dickmann, Donald I. 1984. Floristic composition before and after prescribed fire on jack pine clear-cut site in northern lower Michigan. Can. J. For. Res. 14(5):746-749.

Abrams, Marc D.; Sprugel, Douglas G.; Dickmann, Donald I. 1985. Multiple successional pathways on recently disturbed jack pine sites in Michigan. Forest Ecology and Management 10:31-48.

Buech, R. R. 1980. Vegetation of a Kirtland's Warbler breeding area and 10 nest sites. Jack-Pine Warbler 58:59-72.

Byelich, et al. 1976. Kirtland's Warbler:Recovery plan. USDI Fish and Wildlife Service Rep. Washington, D.C. 100pp.

Daubenmire, R. 1966. Plant communities. Harper & Row, Publishers. New York. 300pp.

Greig-Smith, 1964. Quantitative plant ecology. Plenum Press, New York. 256pp.

Lindsay, A. A. 1955. Testing the line strip method against full tallies in diverse forest types. Ecology 36:485-495.

Mayfield, H. F. 1962. 1961 decennial census of the Kirtland's Warbler. Auk 79:173-182.

Probst, J. R. 1988. Kirtland's Warbler breeding biology and habitat management. In:Integrated Forest Management for Wildlife and Fish. USDA Forest Service, NC-122:28-35.

Radtke, R., and Byelich, J. 1963. Kirtland's Warbler management. Wilson Bull. 75:208-215.

Walkinshaw, L. H. 1983. Kirtland's Warbler, the natural history of an endangered species. Cranbrook Inst. Sci., Bloomfield Hills, MI. 210pp.

Table 1. Percent cover of dominant ground components in occupied Kirtland's Warbler habitat

Plot #	SPECIES									
	Moss/ Lichen	Blue-berry	Bare Ground	Fine Grass	Dead-wood	Sand Cherry	Sweet fern	Coarse Grass	Bear-berry	Grass/ Sedge (combined)
B1 Artillery South, 1978	39.8	17.4	8.8	7.2	5.1	0.3	1.0	3.5	0.4	10.7
B2 Pere Cheney, 1979	5.4	14.9	10.6	2.2	3.0	5.1	1.9	0.3	2.6	2.5
U3 Lovells North, 1980	10.0	0.3	2.8	7.4	0.0	0.8	1.9	12.0	0.7	19.4
B5 Mack Lake, 1977	19.6	4.9	0.1	2.8	7.3	2.8	6.1	1.4	0.9	4.2
U6 Mack Lake, 1979	3.7	5.6	4.8	7.5	6.1	5.0	1.3	0.7	2.6	8.2
U7 McKinley 1981	5.8	11.2	8.1	4.2	4.5	1.9	0.4	0.4	0.8	4.6
B8 Rayburn 1983	8.4	2.3	7.5	6.8	3.6	1.6	0.5	2.5	0.9	9.3
U9 Lovells North, 1983	4.3	0.5	5.5	11.6	0.0	6.8	1.1	1.5	0.6	13.1
U11 Mack Lake, 1984	12.7	17.0	7.3	6.3	3.6	4.2	1.0	0.2	0.9	6.5
	$\bar{x}$ = 12.2 (3.7-39.8)	$\bar{x}$ = 8.2 (0.3-17.4)	$\bar{x}$ = 6.2 (0.1-10.6)	$\bar{x}$ = 6.2 (2.2-11.6)	$\bar{x}$ = 3.7 (0.0-7.3)	$\bar{x}$ = 3.2 (0.3-6.8)	$\bar{x}$ = 1.7 (0.4-6.1)	$\bar{x}$ = 2.5 (0.3-12.0)	$\bar{x}$ = 1.2 (0.4-2.6)	$\bar{x}$ = 8.7 (2.5-19.4)

B = Burned
U = Unburned

Table 2. Effects of shade history and succession on dominant ground cover components in the Mack Lake Burn.

	Shade History Difference (Variance Among and Within Study Plots)				Successional Trends (Variance Among Years)		
Components	1979 Control (Unburned 1980)	1964 Harvest	1966 Presc. Burn	1946 Wildlife	1981	1983	1985
Bearberry	A	A[a]	A	B	A	B	A
Coarse Grass	--	--	--	--	--	--	--
Blueberry	--	--	--	(1981/1983)	W vs H,PB,C	--	--
Sweet Fern	A	A	B	B	B	A	A
Sand Cherry	--	--	--	--	W vs H,PB	H vs PB,W	H vs PB,W
Sedge and Fine Grass	--	--	--	--	B	B	A
Lichen/Moss	--	--	--	--	--	--	W vs H,PB,C
Bare Ground	A	A	B	A	--	--	--
Deadwood	--	(1981/83)	(1981/83)	All	W vs H,PB	W vs H,PB	--

A[a] indicates mean significantly lower than B ($p<.05$).
H = 1964 harvest
PB = 1964 harvest, 1966 Prescribe Burn
W = 1946 Wildfire

Figure Legends

Figure 1: Relative frequency of common ground cover components in jack pine habitat occupied by Kirtland's Warbler in Lower Michigan.

Figure 2: Mean and 95% confidence intervals of ground component percent cover in jack pine habitat occupied by Kirtland's Warbler in Lower Michigan.

Figure 3. Percent cover of ground cover components in burned and unburned jack pine habitat in Lower Michigan.

Figure 4. Successional trends of blueberry at Mack Lake Study Areas. Study plots are connected by dotted lines, and permanent plots are connected by solid lines.

Figure 5. Successional trends of sand cherry at Mack Lake Study Areas. Study plots are connected by dotted lines, and permanent plots are connected by solid lines.

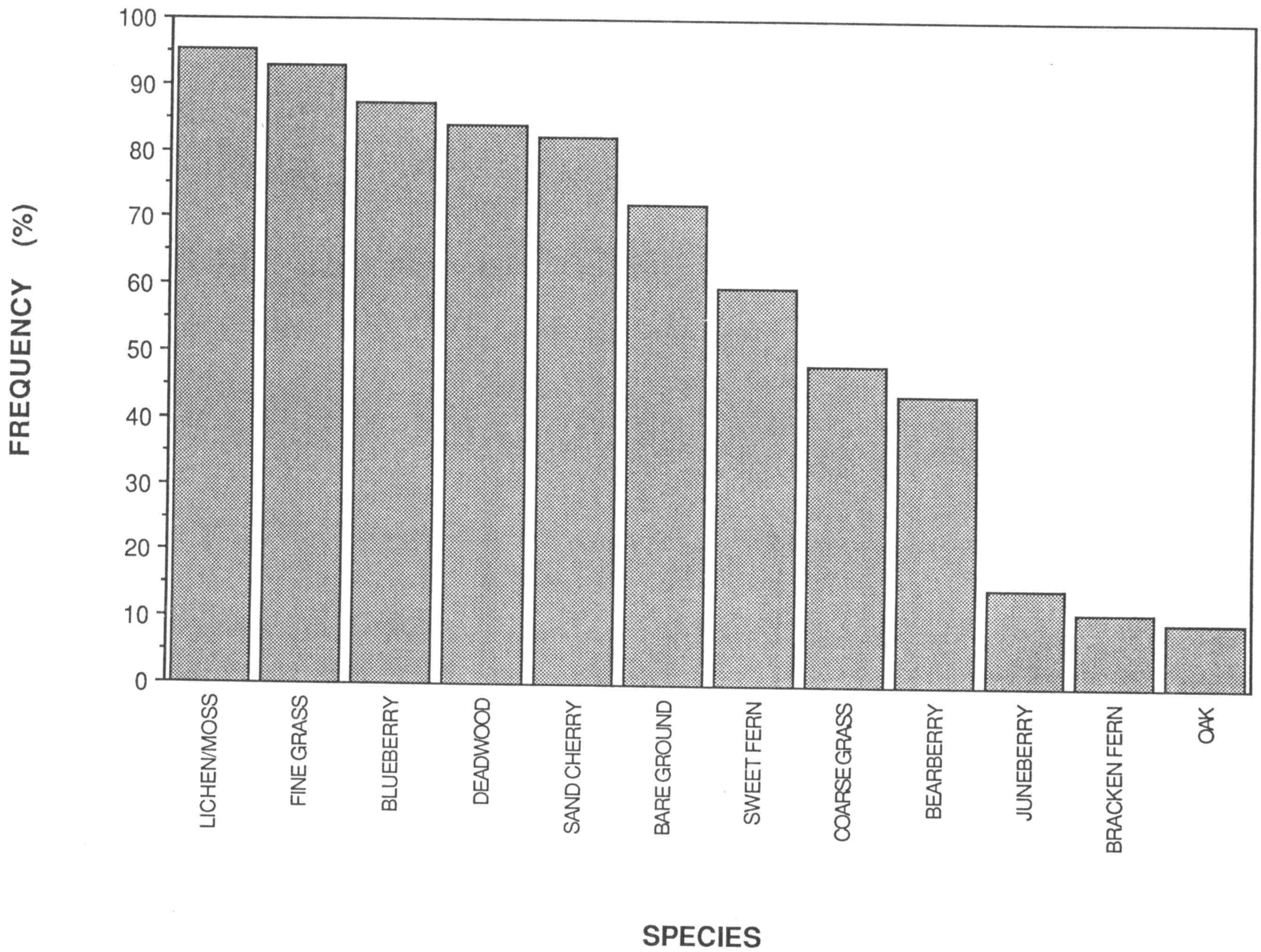
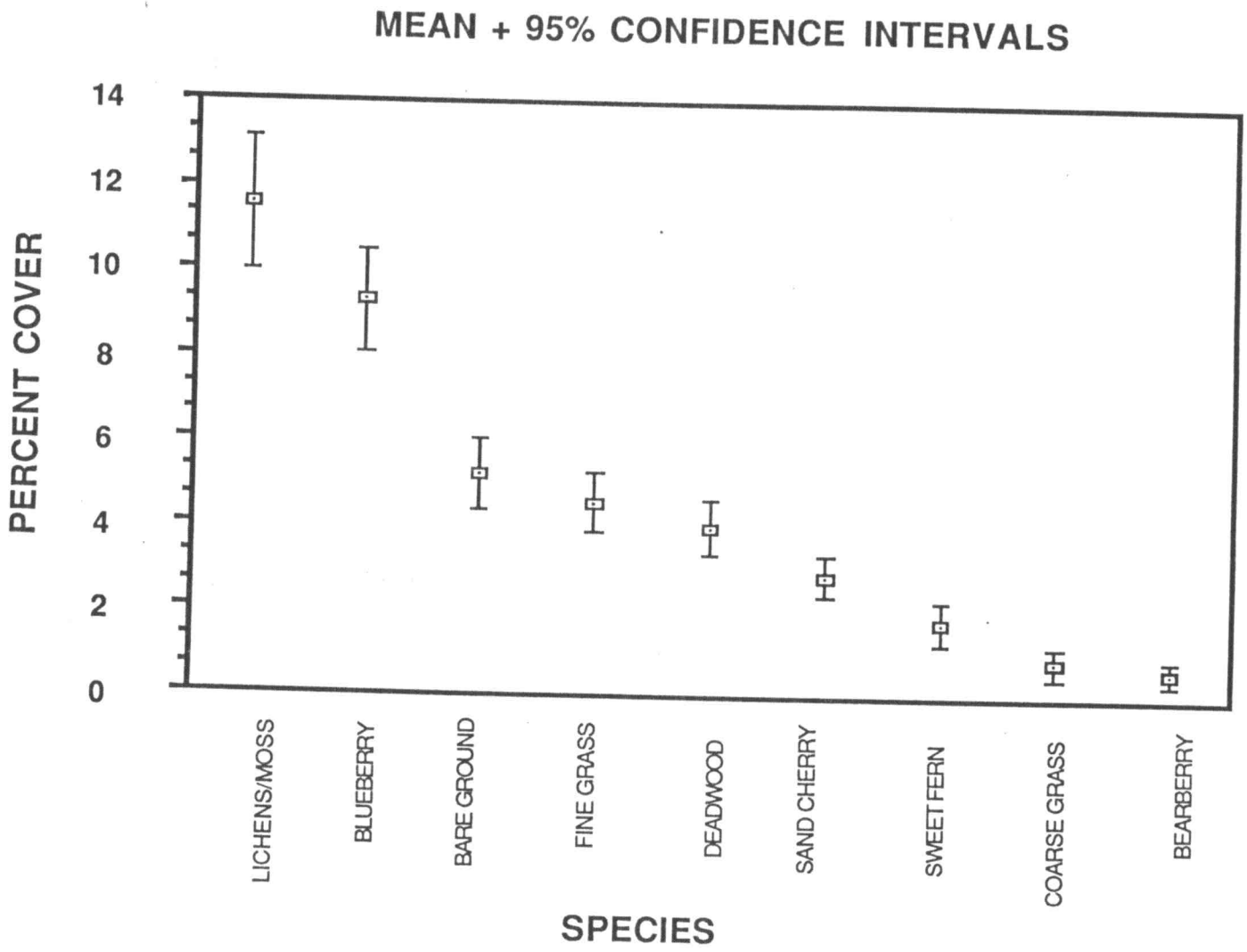

FREQUENCY (%)
100
90
80
70
60
50
40
30
20
10
0
LICHEN/MOSS
FINE GRASS
BLUEBERRY
DEADWOOD
SAND CHERRY
BARE GROUND
SWEET FERN
COARSE GRASS
BEARBERRY
JUNEBERRY
BRACKEN FERN
OAK
SPECIES

FIG. 82


MEAN + 95% CONFIDENCE INTERVALS
PERCENT COVER
14
12
10
8
6
4
2
0
LICHENS/MOSS
BLUEBERRY
BARE GROUND
FINE GRASS
DEADWOOD
SAND CHERRY
SWEET FERN
COARSE GRASS
BEARBERRY
SPECIES

(Fig. 3)

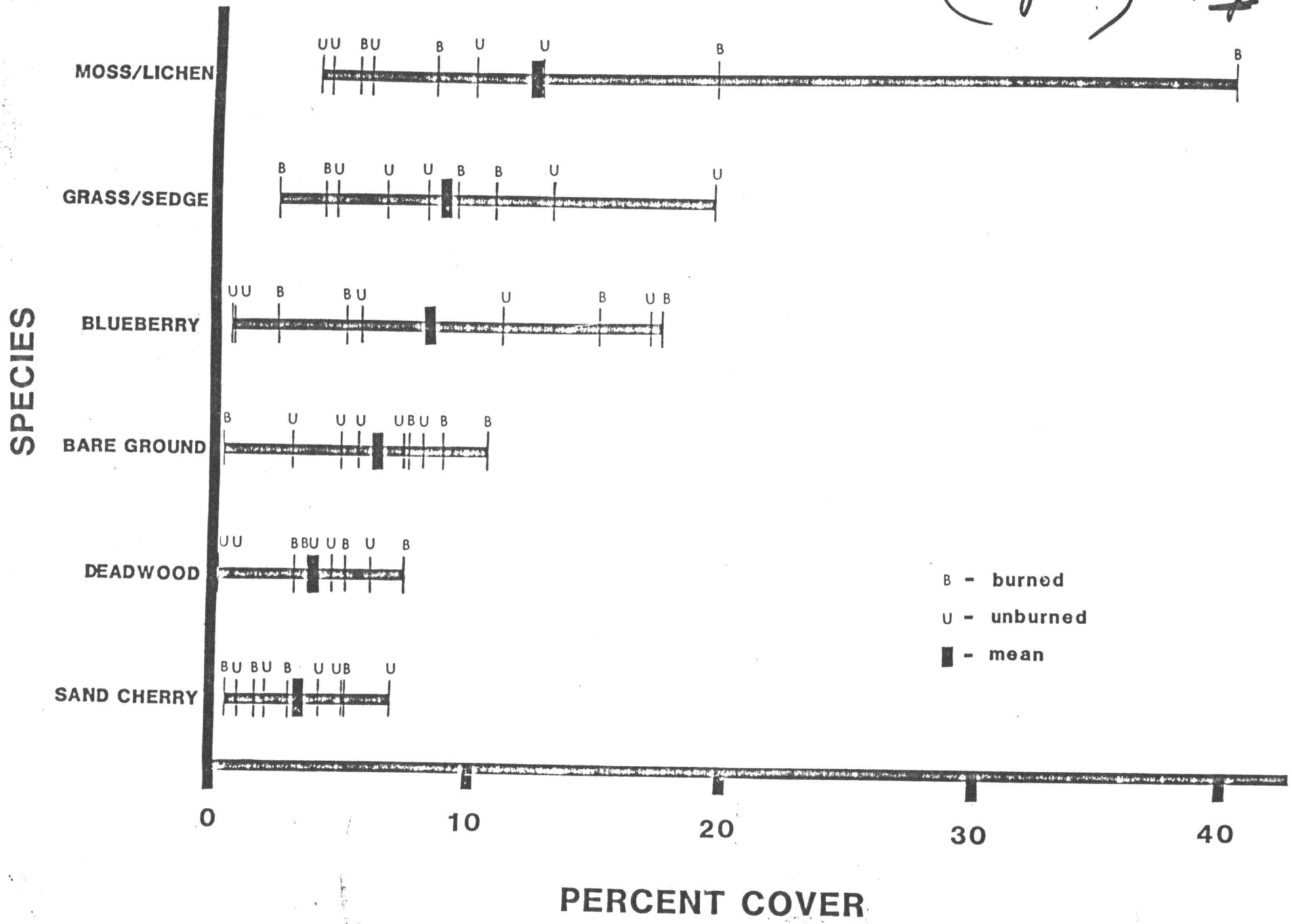

MOSS/LICHEN
GRASS/SEDGE
BLUEBERRY
BARE GROUND
DEADWOOD
SAND CHERRY
SPECIES
0
10
20
30
40
PERCENT COVER
B - burned
U - unburned
▮ - mean

Fig. 34

CHANGES IN BLUEBERRY COVER OVER TIME IN THREE HABITATS

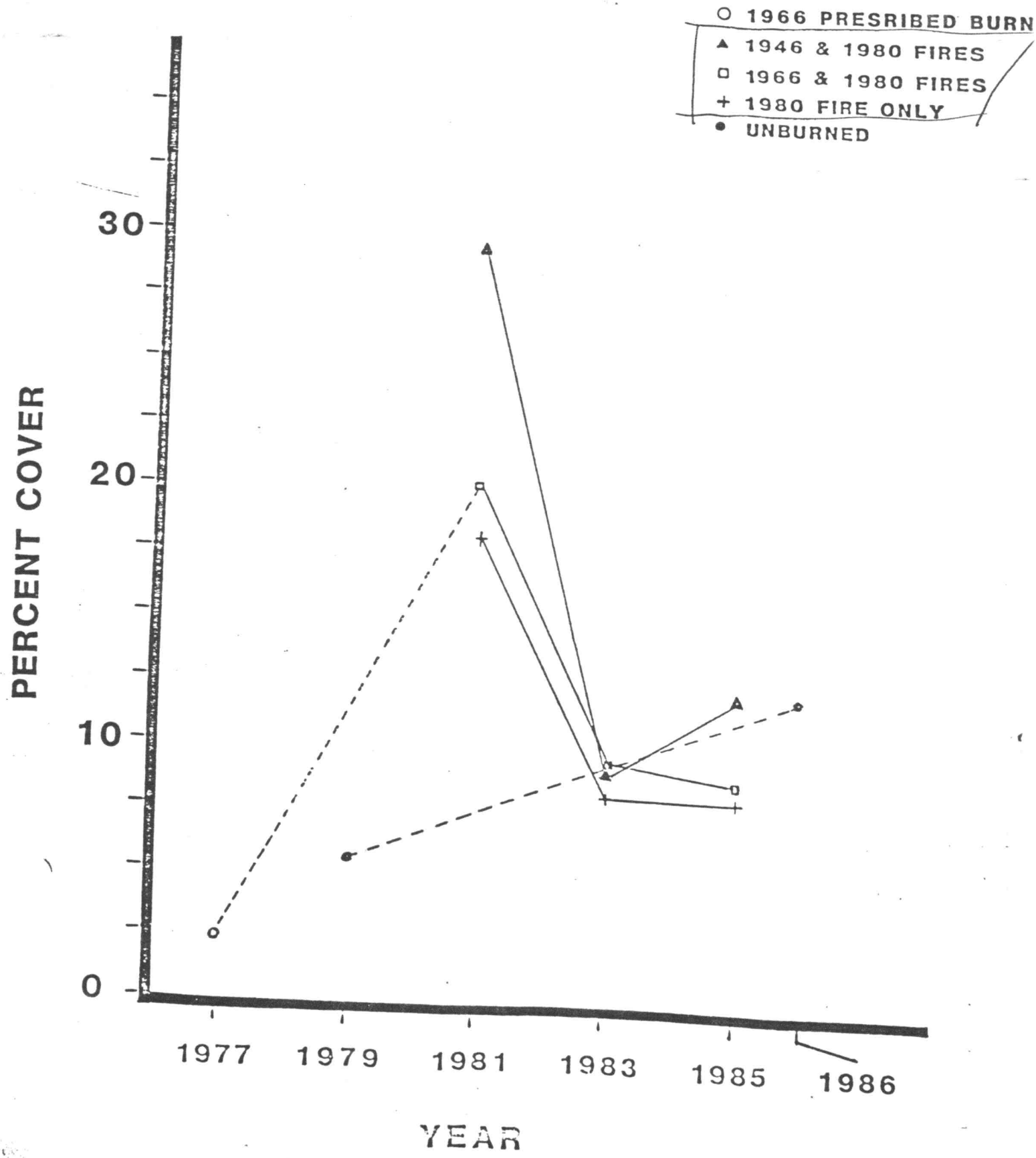
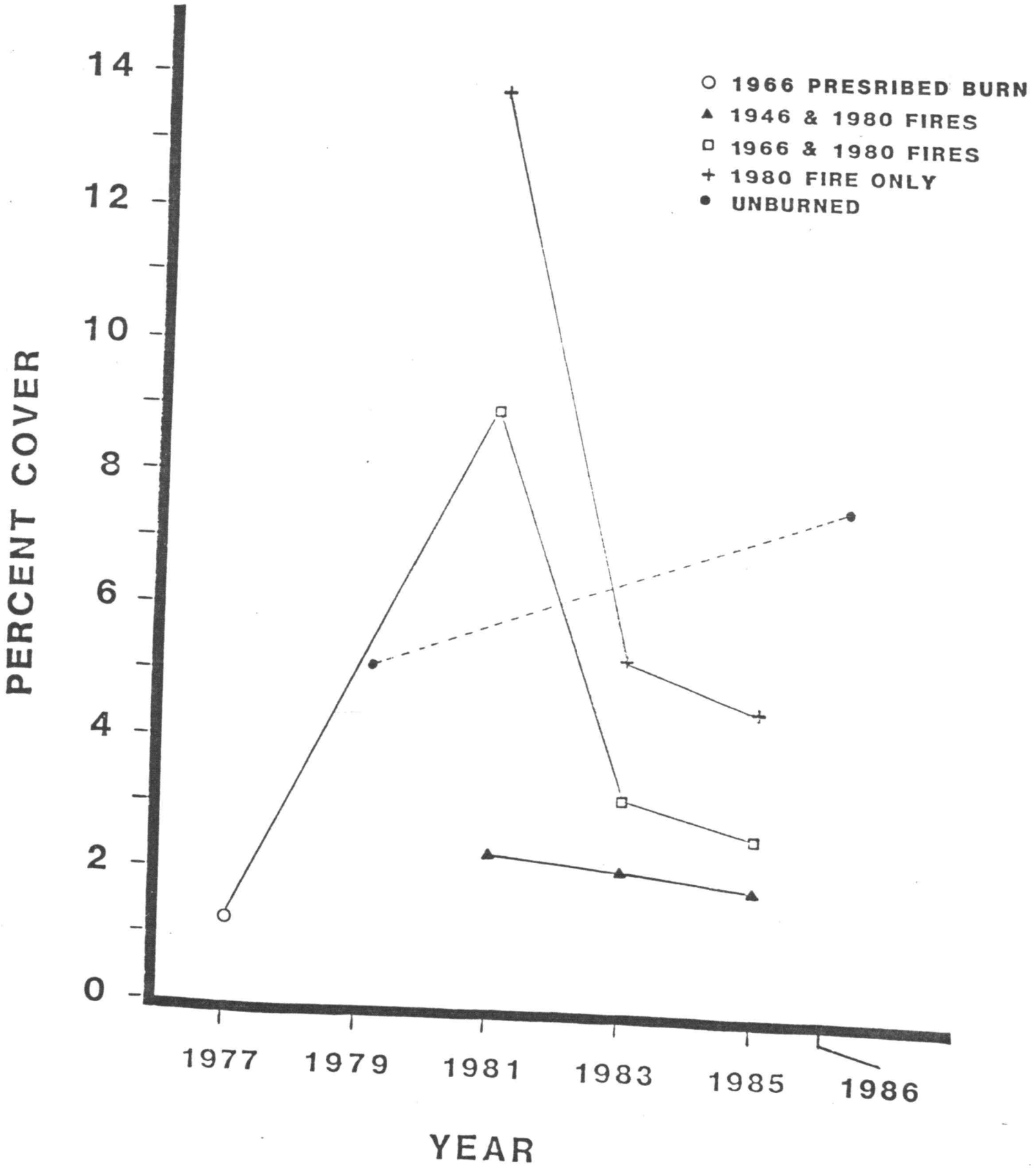


Fig 5

CHANGES IN SAND CHERRY COVER OVER TIME IN THREE HABITATS



Appendix I

Mean relative percent cover of dominant ground components in Kirtland's Warbler habitat with four stand histories in the Mack Lake Burn.

Component	History[1]	1981	1983	1985	1986
Bearberry	1.	1.5	4.9	0.9	--
	2.	1.6	3.0	1.3	--
	3.	4.4	8.1	4.0	--
	4.	--	--	--	0.5
Coarse grass	1.	1.9	2.3	3.6	--
	2.	2.4	5.1	2.2	--
	3.	2.6	3.1	2.0	--
	4.	--	--	--	0.4
Blueberry	1.	26.0	22.7	28.6	--
	2.	28.5	29.4	32.6	--
	3.	41.5	27.1	32.9	--
	4.	--	--	--	13.6
Sweet fern	1.	1.9	1.6	1.8	--
	2.	12.3	5.0	7.1	--
	3.	7.2	5.4	7.8	--
	4.	--	--	--	1.5
Sand Cherry	1.	20.5	16.7	16.7	--
	2.	12.3	9.2	9.1	--
	3.	4.2	6.9	5.3	--
	4.	--	--	--	7.6
Sedge and Fine Grasses	1.	15.8	17.8	6.7	--
	2.	9.5	10.3	5.4	--
	3.	12.1	12.9	7.0	--
	4.	--	--	--	5.9
Mosses/ Lichens	1.	0.4	0.0	11.4	--
	2.	0.0	0.0	9.7	--
	3.	0.0	0.0	0.0	--
	4.	--	--	--	5.0
Bare Ground	1.	26.8	24.0	21.6	--
	2.	16.3	21.0	18.4	--
	3.	26.1	32.2	26.3	--
	4.	--	--	--	5.1
Deadwood	1.	4.4	9.6	6.3	--
	2.	4.6	10.0	6.5	--
	3.	0.5	3.1	9.3	--
	4.	--	--	--	3.6

[1]History: 1. 1964 Harvest
2. 1966 Prescribed burn
3. 1946 Wildfire
4. Unburned Control