Experimental Woodcock Habitat Management, Baring Unit,
Moosehorn National Wildlife Refuge

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INTRODUCTION

The American Woodcock (Philohela minor) is an increasingly popular game bird throughout eastern North America. The 1964 estimated harvest in Maine was 43,800; 10 years later this figure was 124,271. During this period the number of woodcock hunters in the State increased from 10,400 to 26,000 and now outnumber duck hunters (Artmann 1975).

Concurrent with the increased interest in the bird has been a decrease in habitat in the Northeast. Old farms provide ideal woodcock habitat. Unfortunately, most of the marginal farms were abandoned years ago and are now in the late stages of succession or have become part of the urban sprawl. Fortunately, some of these old farms are being purchased for recreation and retirement by nonfarmers. Many of these people have a keen interest in forestry and wildlife management.

In the future, forestry practices will be an important technique to regenerate woodcock habitat. Currently about 500,000 cords of firewood are being cut annually in Maine (Maine Audubon Society 1978). The rapidly increasing demand for firewood coupled with the tendency for shorter cutting cycles and more intensive site management provide an opportunity to coordinate wildlife habitat management with forest practices. Fifty percent of the landowners surveyed in Maine desired help in better managing their woodlots (Metzger 1974).

The overall objectives of this study were to develop woodcock habitat management techniques that: (1) small landowners can apply with a minimum of equipment and money, and (2) can be incorporated with other land management operations such as large scale timber harvesting or small scale cutting for firewood. Specific objectives are discussed in each of the management sections.

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STUDY AREA

The Baring Unit of the Moosehorn National Wildlife Refuge is located in Eastern Maine on the Canadian border near Calais. When the refuge was established in 1937 it was predominantly abandoned farm land or forest that had been logged or burned. Mendall and Aldous (1943) conducted an early study of the ecology and management of woodcock on the refuge. They demonstrated that artificial clearings were used by singing males and clear-cutting and thinning were suggested as techniques for rejuvenating old covers. Follow-up work by Reardon (1950) showed that woodcock preferred the managed areas. From 1953 to 1968 Refuge Biologist Eldon Clark developed a series of experimental cuts for woodcock. Although these areas have grown beyond the optimum stage for woodcock, his plots with known vegetative history have been valuable to the present study.

Today the refuge is more than 90% forested and much of the area has grown past the early successional stages considered optimum for woodcock. Included in the refuge are many natural and artificial impoundments as well as beaver

(*Castor canadensis*) flowages. Blueberry (*Vaccinium angustifolium*) fields, hay fields, and a few natural openings are scattered throughout. The most abundant conifers are white pine (*Pinus strobus*), spruce (*Picea spp.*) and fir (*Abies balsamea*). Predominant hardwood species include white birch (*Betula papyrifera*), gray birch (*B. populifolia*), red maple (*Acer rubrum*) and aspen (*Populus spp.*). Alders (*Alnus rugosa*) are common in moist areas.

EXPERIMENTAL DESIGN

Several different treatments (Table 1) were used to provide or maintain woodcock diurnal cover, singing grounds and summer fields. Specific details of each treatment are discussed in later sections. For all habitat treatments labor, time, and material requirements were recorded. Details are given in Appendix 1 and 2.

Table 1. A synopsis of different habitat treatments used in a woodcock habitat research program at Moosehorn NWR.

Habitat Type	Year	Number Replications	Size	Treatments	Slash Treatments
Diurnal Cover					
	1973	5	10 x 100-200m	clear-cut	pile & burn or chip
	1976	5	10 x 100-200m	clear-cut	pile & burn
	1977	5	10 x 100-200m	clear-cut	pile & burn
	1976	2	10 x 100-200m	herbicide application	N/A
	1977	2	10 x 100-200m	herbicide application	N/A
Singing Grounds					
	1975	4	30 x 30m	clear-cut	none
	1976	7	30 x 30m	clear-cut	none
	1977	2	30 x 30m	clear-cut	none
	1977	15	20 x 60m	clear-cut	pile & burn
Summer Fields					
	1976	1	1.3 ha	clear-cut	50% - none 50% - pile & burn
	1977	2	1.3 ha	clear-cut	pile & burn
	1977	2	2 ha	broadcast burn	N/A
	1978	1	2 ha	broadcast burn	N/A
	1978	1	3 ha	mow & burn	N/A
	1978	1	0.5 ha	broadcast burn	N/A
	1978	2	1.3 ha	broadcast burn	N/A

DIURNAL COVER MANAGEMENT

Woodcock spend the day feeding and roosting in brushy, second growth woodland. In Maine, alders (*Alnus spp.*) are the principal diurnal cover, but hardwood stands and pure softwood stands on old fields are also used (Mendall and Aldous 1943, Reardon 1950). A diversity of age classes and vegetative types is necessary to meet the feeding and roosting requirements of woodcock under a variety of climatic and seasonal conditions.

The Moosehorn National Wildlife Refuge contains a wide diversity of vegetative types; however, age diversity is decreasing. Many alder covers have passed their peak age for woodcock. Five of these alder covers were studied to monitor the changes in vegetation, earthworm abundance and woodcock numbers following strip clearcutting and herbicide treatment.

Methods

Strip Clear-Cuts

Five lanes (Fig. 1), 10 x 100-200m, were clear-cut in each of three different diurnal covers between 1973 and 1977. Slash was piled and burned on most areas. Forty meter strips of untreated vegetation were left between clear-cut lanes.

Herbicide Treatment

During June, strips, 10 x 100-200m, were sprayed with hand operated sprayers using 2, 4-D L.V. Ester, 4 lbs. active ingredient dissolved in water (5% solution). Each strip was separated by 40 m of untreated vegetation.

Figure 1. A strip cut in diurnal habitat, Moosehorn NWR. Slash was piled and burned.

Monitoring Woodcock Use

Modified shorebird traps (Liscinsky and Bailey 1955) have been used since 1962 as part of the Moosehorn woodcock banding program. All diurnal covers subject to management were trapped at least 2 years before experimental management. Three covers were trapped but not treated to serve as controls. Traps were operated from about 1 June to 1 September. Since a modified shorebird trap usually has 2 or more cells, trap success was measured by the number of cells per trap. The basic unit of measurement was the number of woodcock captured/100 cell nights.

Monitoring Earthworm Abundance

Earthworms were extracted using the formaldehyde method developed by Raw (1959). Earthworm lengths were measured and the data transformed into dry weight biomass using a regression formula developed by Reynolds (1972). Ten to 20 samples were taken from each treatment and control area. All sampling was done within 2 days to decrease variability resulting from changes in soil moisture. Soil samples were taken simultaneously and analyzed for pH and soil moisture.

Measuring Vegetative Response

Alder height, number of live stems, number of dead stems, percent ground cover, and percent canopy cover were measured on the experimental strips during August each year after treatment. Soil moisture was measured gravimetrically.

Results and Discussion

Clear-cutting strips through diurnal habitat was one of the most promising management techniques tried. A decrease in woodcock use of these areas was expected since about 20% of the available cover would be temporarily eliminated and the regeneration would probably not reach a stage favorable to woodcock for 7 or 8 years. However, decreasing the size of the cover by 20% did not appear to limit use. Woodcock use of the 3 covers we monitored remained the same or increased after the experimental plots were clear-cut.

One series of strips, Diurnal Cover 5, cut in September and October 1973 showed a significant increase in use. Three years prior to cutting, ground trapping success was not significantly different from other covers (paired t-test, $p > .05$). However, from 1974 through 1978 trapping success remained significantly above the capture success in unmanaged covers (Fig. 2) (paired t-test, $p < .01$). This same trend was noted when strips were cut in a similar alder cover (Diurnal Cover 76) in 1977. Trapping success increased three fold. However, a third series of strips, Diurnal Cover 6, cut in 1976 resulted in little increase in woodcock activity. In fact, trapping success in this cover never did approach the average for other non-managed covers. This can be attributed to the fact that parts of this cover were flooded in the spring and the rest was very wet providing poor nesting and brood habitat. Covers 5 and 76 were on relatively dry soils which provided adequate brood and nesting conditions. No broods were located in or near Diurnal Cover 6; however, 2 nests and 7 broods were located using trained bird dogs or caught in ground traps in the covers on drier sites.

Increased use of the covers is probably related to the singing grounds provided by the clear-cut strips. The number of singing males increased in and around all covers where strips were cut. This increase in courting male activity may have attracted females which nested nearby. These females then raised their young in or near the managed covers. The immature woodcock probably have an affinity for the cover where they were raised. From 1976

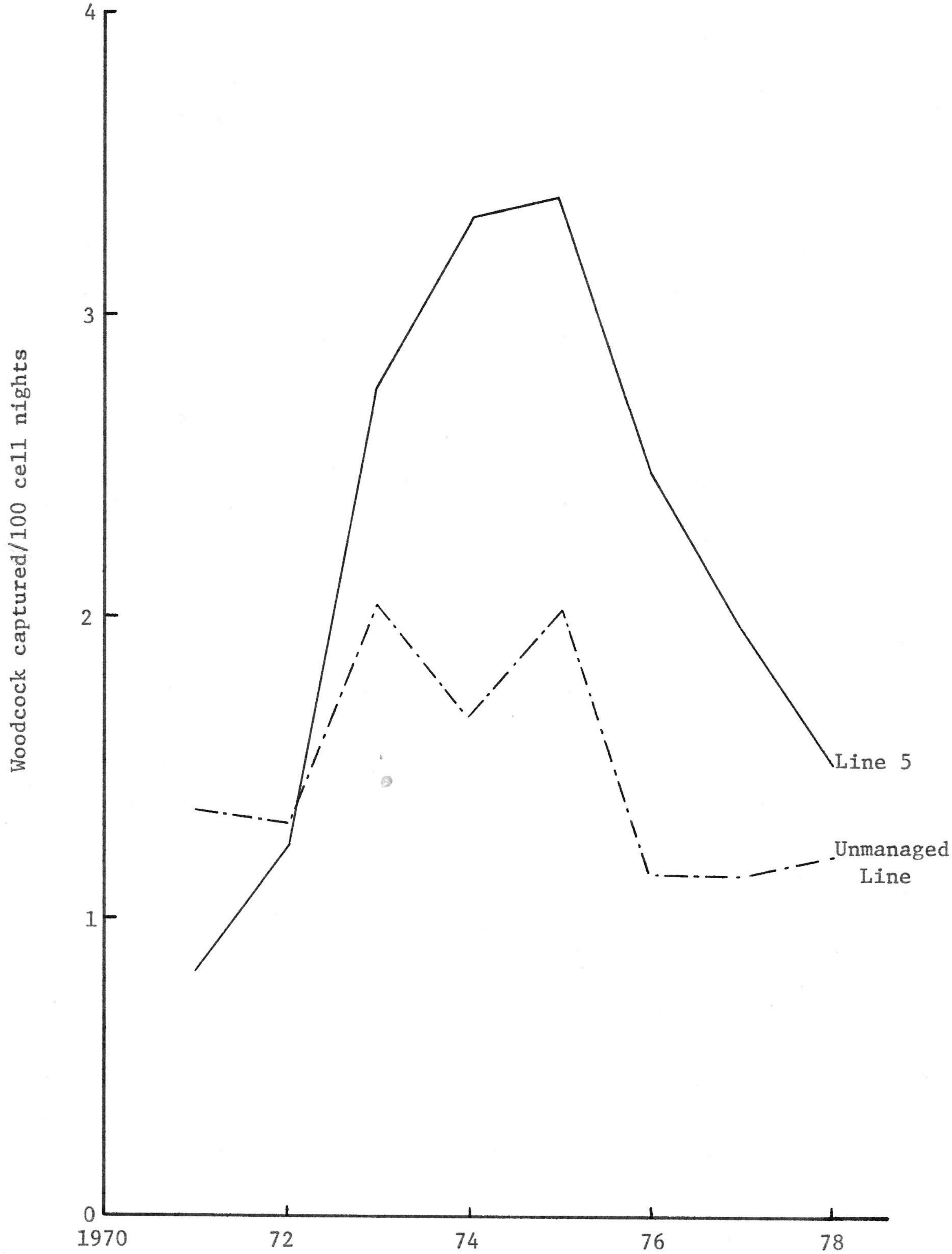

Fig. 2. Ground trapping capture rate for diurnal cover 5 and unmanaged diurnal covers, Moosehorn NWR.

through 1978 several broods were captured using trained bird dogs or ground traps in or near diurnal covers containing traplines. Thirty-six recaptures of these birds were made during the following summers. Twenty-nine (81%) of the captures were in the same or adjacent covers where the woodcock were originally caught as chicks. Dunford and Owen (1973), using radio-marked woodcock in Maine, also found immature woodcock had a preference for one cover.

In addition, we found that significantly (X^2, $p < .005$) more adult females were caught in managed covers containing good brood and nesting habitat than in unmanaged covers. However, in Diurnal Cover 6, where brood and nesting conditions were poor, the female capture rate was the same as that in unmanaged covers (X^2, $p > .05$). Apparently, adult females also have an affinity for the cover where they raised their young. The adult males do not share this affinity; on only one occasion were adult male capture rates higher in managed covers. (See Appendix 3, Tables 1 and 2).

Vegetative Response

Clear-cut strips - In order to properly manage diurnal covers the optimum age of the cover for woodcock use should be known. Liscinsky (1972) felt covers 10 to 20 years old were most attractive to woodcock. In 1976 four ground traps (10 cells) were set in clear-cut strips in the cover cut in 1973. Capture rates are increasing but still are below the rates of traps in the uncut portion of the cover (See Appendix 3, Table 3).

It is too early to fully evaluate the vegetative response of the alder growth after clear-cutting. The rate of height growth of alder is sensitive to moisture conditions. Alders on moist sites, Diurnal Cover 6, attained the same height growth in 2 years that it took alders 3 years to reach on drier soils in Diurnal Cover 5. Ground cover in all covers was dense and there was little stem mortality (Table 2).

Herbicide treatments - One application of 2,4-D from a band sprayer was not sufficient to completely top kill alder because lower branches often blocked the upper canopy from treatment. Where the solution made contact with the foliage, death occurred. The canopy in test covers was significantly less dense (ANOVA, $p < .005$) than in the control strips in both test covers, but complete defoliation was not achieved. The number of live stems, dead stems, and percent soil moisture were greater in the sprayed strips in both covers, but the difference was not significant (See Appendix 3, Tables 4 and 5). We believe a more dramatic vegetative and soil moisture response would have been observed if a more complete top kill had been achieved. In the sprayed strips there probably would have been an increase in: the number of dead stems; the number of live stems due to more vigorous sprouting; soil moisture due to decreased translocation; and soil shading due to increased herbaceous growth and sod cover.

Earthworm Response

About 85% of the diet of a woodcock is composed of earthworms (Pettingill 1936, Aldous 1939). Therefore, the effects of diurnal cover management on earthworm populations are extremely important. In 1978 earthworm biomass, soil moisture, and pH were measured in several covers at the end of June and again at the end of July.

Clear-cut strips - Two covers, one cut in 1973, Diurnal Cover 5, and one in 1976, Diurnal Cover 6, were sampled. There was no difference in pH or moisture between the clear-cut strips and control strips in either cover or during either sampling period. During June earthworm biomass was signifi-

Table 2. Vegetation response in 4 diurnal covers after clear-cutting, Moosehorn NWR.

Cover #	# years after cutting	Ave. alder height (m)	# live alder stems/m^2	# dead alder stems/m^2	% ground cover	% canopy cover	% Moisture[1]
5	5	2.24	1.18	0	88	13	21
5	3	.98	1.70				
6	2	.92	0.83	.11	89	1	33
76	1	.65	2.23	0	72	0	23

[1] samples taken in August 1978.

cantly less ($p < .05$) in the clear-cut strips in both covers, but in July, when the earthworm biomass had declined greatly in all parts of the cover due to drought conditions, there was no significant difference (Table 3).

Clear-cutting has a detrimental effect on earthworm populations. In addition, herbaceous growth is dense and a thick sod cover may develop limiting woodcock use. During the first few years after cutting, these strips apparently provide few earthworms for woodcock.

Herbicide strips - Top killing of alders using herbicides had no effect on soil moisture, pH, or earthworm biomass in the two covers sampled. An increase in light penetration did stimulate herbaceous growth which would make the area less desirable for feeding. The overall impact was less on the herbicide treated strips than on the clear-cut strips. See Appendix 3, Tables 6 and 7 for details.

Moisture Habitat Relationships

Ideal diurnal cover for woodcock results from the interrelationship between soil types, soil moisture, land-use history, earthworm abundance, and vegetation. In the Northeast, old farm land on good soils supporting middle aged alder stands are considered prime woodcock diurnal habitat. Mendall and Aldous (1943), working in Maine, found alder covers to be the most heavily utilized cover by woodcock throughout much of the year. Hardwoods and mixed growth were of secondary importance. Pure softwood stands were not mentioned. Dunford and Owen (1973) found the major summer diurnal cover in Maine was second growth hardwood, alder, and hardwood-conifer cover types. Owen and Morgan (1975) found radio-marked adult woodcock spent 52% of the time in second growth hardwood, 32% in alder, 14% in hardwood-conifers and 2% in conifers during the summer.

Table 3. Soil moisture, pH, and earthworm biomass in diurnal cover 5 and 6 in June and July 1978, Moosehorn NWR

	26 June 1978				20 July 1978			
	Clear-cut strips		Control		Clear-cut strips		Control	
	Cover 5	Cover 6	Cover 5	Cover 6	Cover 5	Cover 6	Cover 5	Cover 6
Soil Moisture (%)	27.9	41.6	25.5	33.2	30.5	22.9	26.1	21.7
pH	4.48	4.65	4.45	4.68	4.46	4.59	4.41	4.47
Biomass (g/m^2)	11.8	3.13	22.9[1]	14.5[1]	6.31	0.25	12.2	1.32

[1] significant, $p < .05$, paired t-test

Most studies of woodcock diurnal habitat requirements were done during years of average rainfall. However, woodcock need different habitats to meet their requirements during a drought. In 1978 average rainfall for May through August was significantly below the 24 year average (Fig. 3). During 1977 and 1978, 10 traplines consisting of 105 modified shorebird traps were run from 1 June to 24 August. These traplines traversed hardwoods, alders, hardwood-softwoods, and softwoods. Capture success for each habitat type was tabulated by 2 week periods. Use in 1977 was similar to other studies; alders (Fig. 4) and hardwood-conifers (Fig. 5) accounted for most of the captures; capture rate in conifers was low (Fig. 6). In 1978 the capture rate in conifers (Fig. 6) was significantly greater (paired t-test; $p < .01$) than in 1977 after 30 June and far greater than the capture rates in other habitat types during the last half of the summer. Assuming that the capture rate is indicative of the number of woodcock using a cover, and that the number using a cover is a reflection on the quality of the cover at that time, then conifers were an important habitat type for meeting woodcock needs during the 1978 drought.

Reynolds et al. (1977), working in Maine, concluded that woodcock abundance is related to earthworm abundance. In June 1978 when there was no woodcock use of conifers, earthworm biomass was 3.05 g/m^2 in the conifer component of Diurnal Cover 1. Earthworm biomass in alder covers ranged from 9.15 to 22.9 g/m^2 at that time. By the end of July earthworm biomass in the alder covers ranged from 1.32 to 12.2 g/m^2. Half the covers had earthworm biomass less than that found in the conifer of Diurnal Cover 1. Soil conditions in conifer stands are apparently more stable than in alder covers. Under normal conditions conifers are not utilized extensively, but are important during a drought. However, before any cover, softwood or hardwood, will be utilized by woodcock it must be on suitable soils. Nicholson (1977), working in Maine,

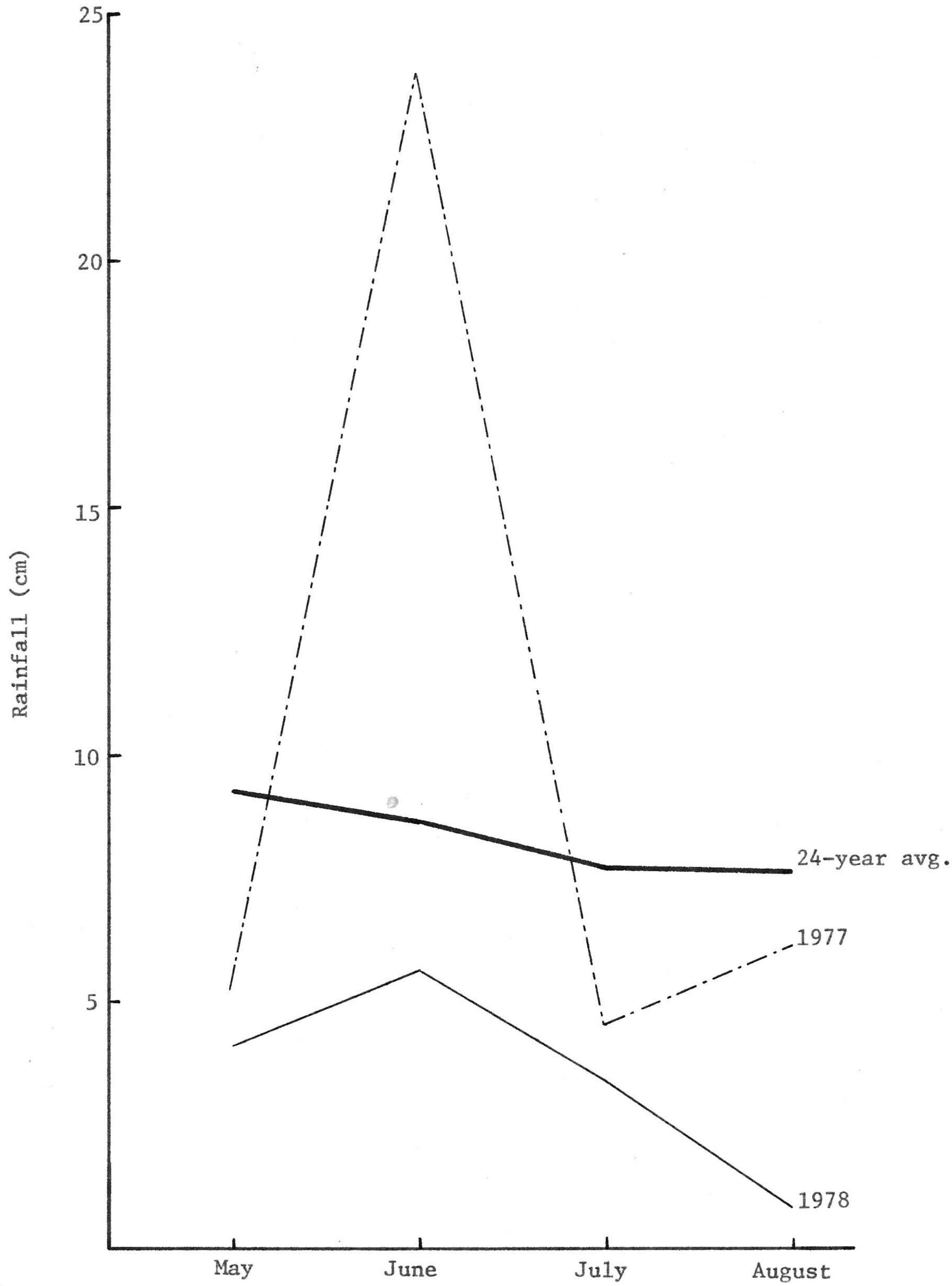

Fig. 3. Rainfall for May - August for 1977 and 1978 compare with 24-year average (1953 - 1976), Moosehorn NWR.

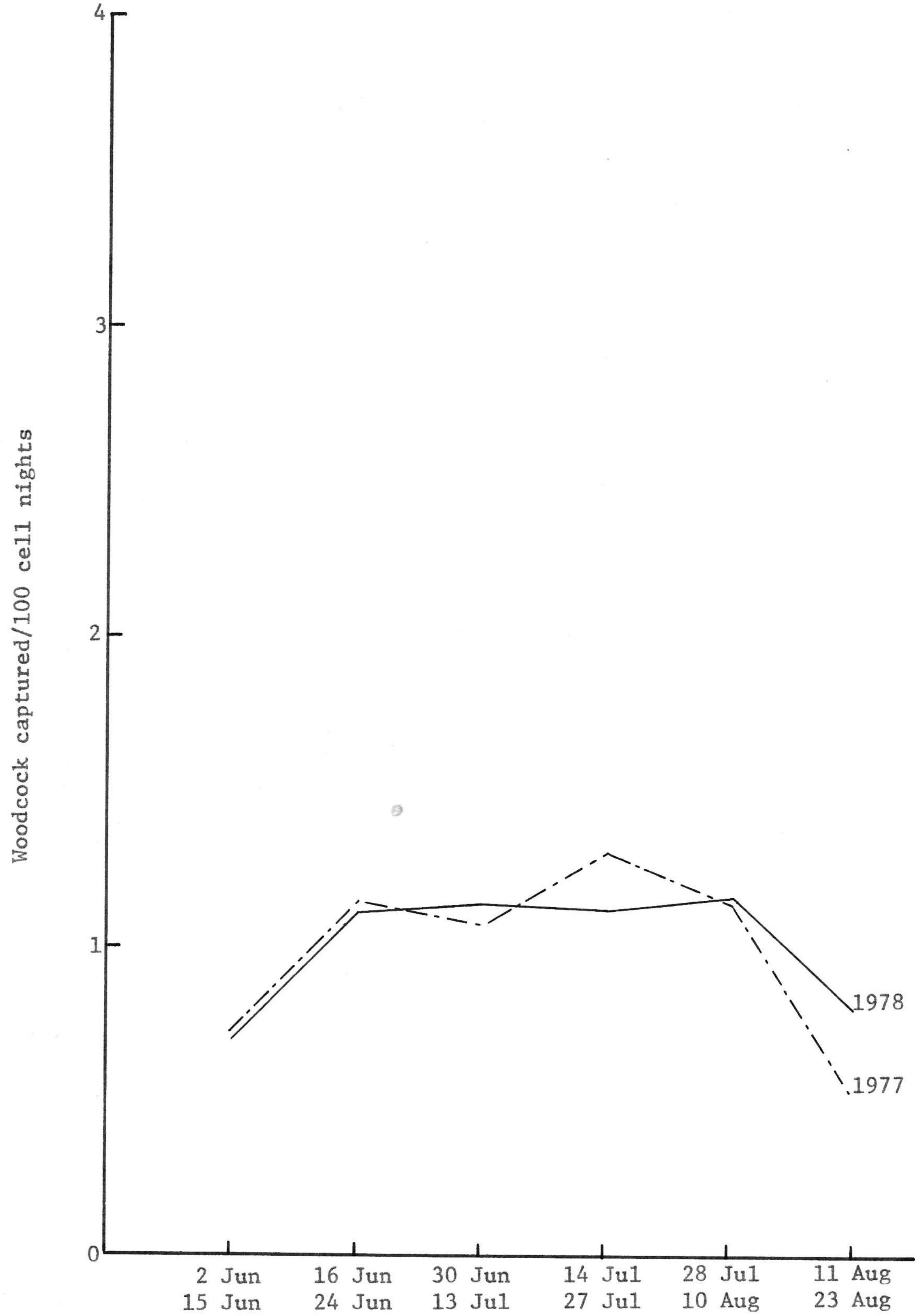

Fig. 4. Woodcock capture rate in alder, 1 June to 24 August, 1977 and 1978, Moosehorn NWR.

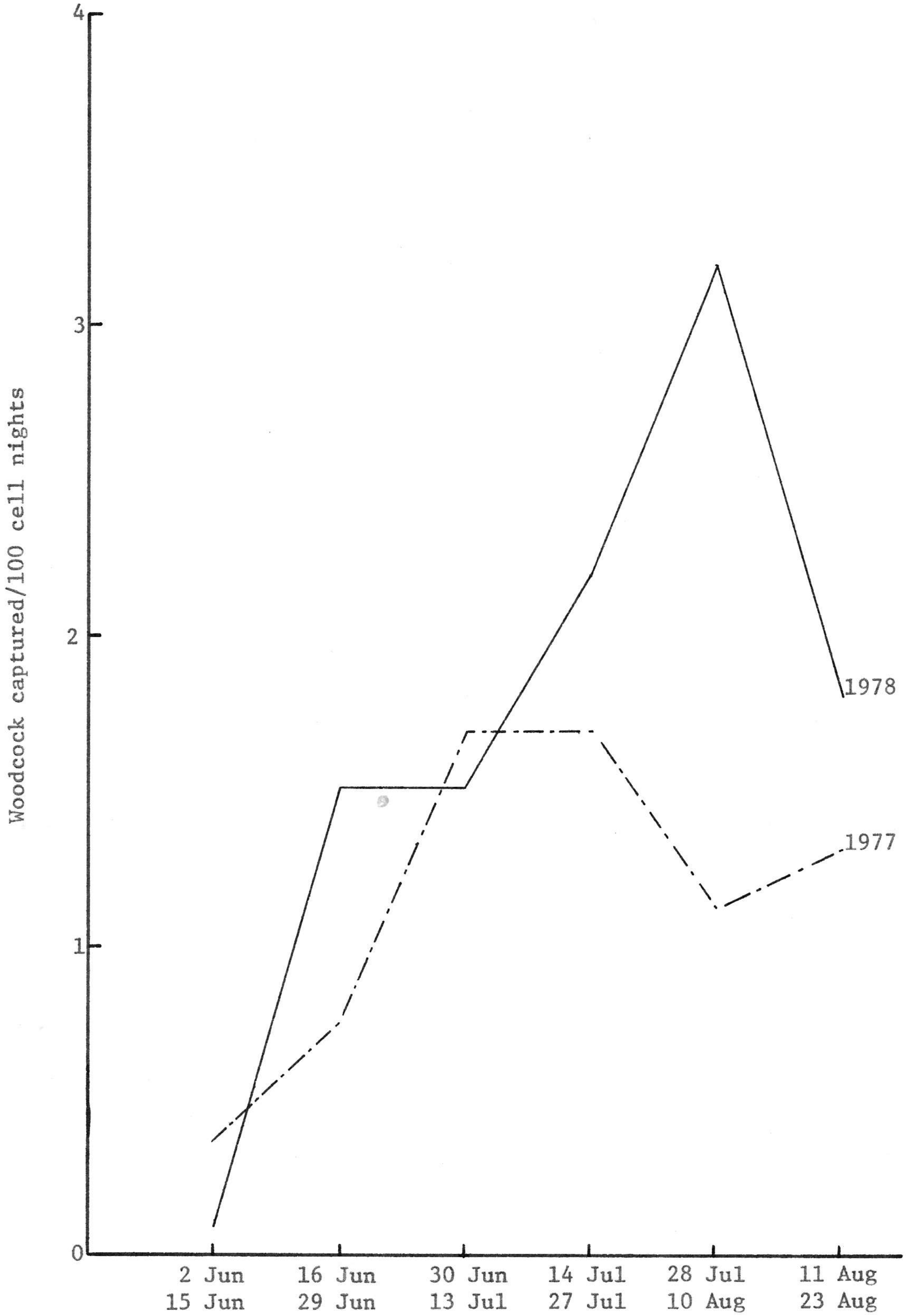

Fig. 5. Woodcock capture rate in mixed growth, 1 June to 24 August, 1977 and 1978, Moosehorn NWR.

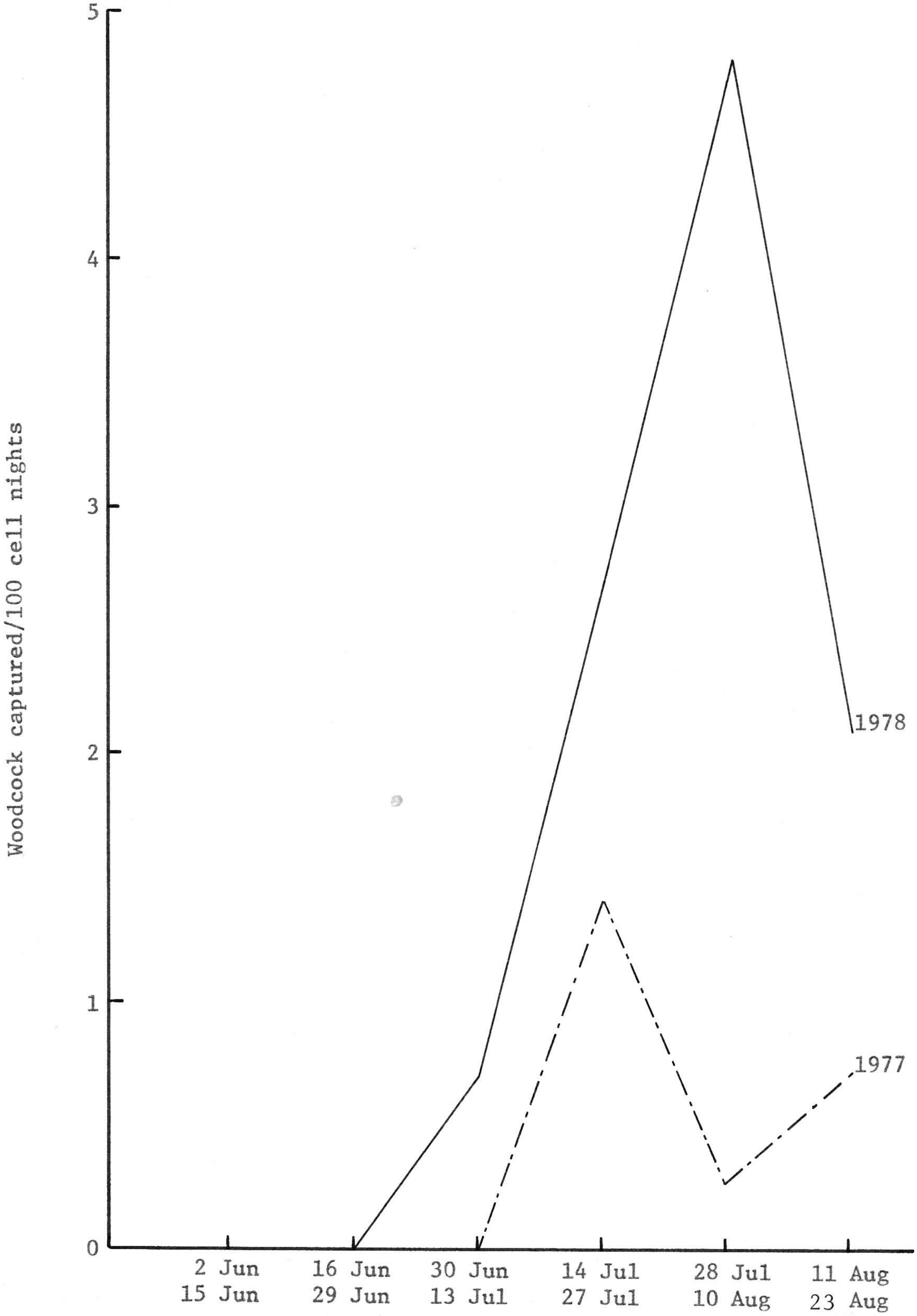

Fig. 6. Woodcock capture rate in conifers, 1 June to 24 August, 1977 and 1978, Moosehorn NWR.

found moderate earthworm populations in conifer stands on previously farmed soils but no earthworms in softwoods on non-farmed soils. There were also fewer worms in non-farmed soils supporting alders than in alder covers on previously farmed soils. Reynolds et al. (1977) reported that moist or dry soils contain few earthworms.

Suitable diurnal cover during a drought may be critical to woodcock survival. Seven woodcock were weighed during the peak of the drought, 18 August through 28 August. All were well below the average weights recorded by Owen and Krohn (1973). Liscinsky (1972) reported that a 40% weight loss resulted in death of 2 captive woodcock. Some of the Moosehorn birds were near that point. Softwoods on suitable soils may help maintain woodcock populations during mild to severe droughts.

Summary

Alder and young hardwoods are the preferred diurnal habitat for woodcock in the Northeast (Mendall and Aldous 1943, Reardon 1950, Weeden 1955, Dunford and Owen 1973). However, certain covers have greater management potential and will yield more woodcock per unit effort. Strips clear-cut through diurnal covers attracted singing males, but only covers that had suitable brood and nesting habitat in close proximity resulted in increased summer use. Covers on poorly drained soils which were wet in the spring showed little increase in woodcock use.

Alders grew faster in all managed covers. Although the density and composition of covers on poorly drained soils appeared suitable for woodcock use, such sites contained few worms. Such covers support low numbers of woodcock compared to sites with better drainage and soils.

Softwoods on old farmlands are important in providing emergency feeding sites during drought. These areas are more stable and low earthworm popula-

tions are maintained. In some cases earthworms are more abundant in conifers during drought than in nearby alders. However, under most conditions alder covers provide better diurnal habitat than softwood covers. Propagation and maintenance of quality alder covers should be a high priority management goal in any plan.

Thus, a diversity of vegetative types and age classes is necessary to provide adequate feeding sites under different climatic conditions. No management plan should stress one plant species at the expense of others.

SINGING GROUND MANAGEMENT

Male woodcock require a clearing or "singing ground" for their mating display. Roads, abandoned fields, cleared fields, pasture land, cuttings and burns may be used (Mendall and Aldous 1943). Openings selected on the Moosehorn NWR vary in size from less than 0.1 ha to fields exceeding 10 ha.

The objectives of this portion of the study were to investigate: (1) the most feasible and economical way of creating singing grounds, (2) the characteristics of singing grounds chosen by males, (3) how many males could be attracted to a 1200 ha contiguous hardwood stand containing few natural openings, (4) what impact an increase in singing males would have on the woodcock population of the refuge, (5) the relationship between use of a singing ground and the distance it was located from an active summer field, and (6) the effect of spring burning on the activity of singing males.

Much more time will be required to test several of these objectives. The experimental design and most of the habitat management has been accomplished and the evaluation is ongoing. Results during the first 1 to 3 years are presented.

Methods

Singing Ground Creation

The total number of singing grounds made is shown in Table 1. Between 1973 and 1977, 21 singing grounds (Fig. 7) (30 x 30m) were cleared in a contiguous 1200 ha hardwood stand containing few natural openings. Most of these clearings were cut by local residents for firewood. These areas were located along refuge roads to permit access and were spaced no closer than 0.3 km except in four instances.

Figure 7. A 30 x 30 m singing ground cleared in 1974, Moosehorn NWR. Deer browsing has retarded regeneration and the site has been used by a singing male for 5 years.

The boundaries of the plots were marked and a 10 dollar fee charged for the removal of up to 3 cords of wood; stumpage rates were charged for amounts over 3 cords. Quality of cutting varied from removal of only a few choice trees to complete utilization of all stems greater than 3 cm. Several plots required additional clearing by refuge personnel especially when the plot contained undesirable firewood species. Slash was left as it fell on most areas.

In four cases a large plot (20 x 60 m) was cut adjacent to a smaller clearing that had not been used for two consecutive years. The slash was piled and burned. These cuts were made to test the effect of clearing size on singing male use.

In 1977, a series of clearings, 20 x 60 m, were cut at various distances (50 m to 1000 m) from active summer roosting fields. Slash on these fields was piled and burned.

Blueberry fields throughout northeastern North America are used as singing grounds by male woodcock. These fields are burned in the spring on alternate years by commercial growers. The effects of burning on male use was monitored on five refuge blueberry fields.

Woodcock Use

Singing males were monitored using a modified singing ground survey (Mendall and Aldous 1943, Clark 1970). Listening stations were located .5 km apart and every part of the refuge that might harbor a singing male was surveyed. Routes were run at least twice in management areas using as many of the same observers as possible.

Vegetative Response

Vegetation changes on singing grounds cut in 1974 and 1975 were monitored yearly (1976-1978) during the woodcock courting period. Ten to 20 random, 1 m^2 plots per singing ground were sampled. Density and height of woody sprout and seedling stems were measured. The height and basal area of trees surrounding each field were measured using a Haga Altimeter and prism, respectively.

Results and Discussion

Hardwood Management Area

Use of singing grounds - There was an immediate increase in the number of courting males utilizing the study area after the first clearings were created (Table 4). Additional clearings did not increase the number of courting males although the percent of males on the study area using the clearings did increase. In 1977 the number of courting males had dropped to 8 in spite of additional clearings but percent use of clearings was high. However, the estimated male population on the refuge had also dropped appreciably. In 1978 the male population had increased, but a late spring with deep snow made many of the singing grounds on the study area and refuge unuseable until mid to late April when most of the males had already established territories.

Vegetation characteristics - Basal area and height of surrounding trees were less (t-test, $p < 0.001$) for clearings used by singing males than for unused sites (Table 5). Sheldon (1967) noted a relationship between clearing size and surrounding tree height. The density of trees around used singing grounds was greater, but the difference was not significant ($p > 0.1$).

Tree sprout and seedling height on the clearings cut in 1974 and 1975 were measured annually. Sprout and seedling height growth on clearings cut in 1974 was significantly (t-test, $p < .001$) less than growth in the 1975

Table 4. Singing male woodcock use of firewood cuts in a large (1200 ha) hardwood stand at the Moosehorn NWR.

	Year				
	1974	1975	1976	1977	1978
Number of singing males	6	13	11	8	8
Number of clearings	0	4	11	13	21
Number of woodcock using clearing	0	3	6	5	4
% of woodcock using clearings	0	23	54	62	50
Number of singing males on entire refuge study area		102	98	78	70
% of singing males in hardwood stand		12.8	11.2	10.3	11.4

Table 5. Vegetative and physiognomic characteristics of artificial clearings cut in 1974 and 1975, Moosehorn NWR.

	Artificial clearings used by woodcock (n = 6)	Artificial clearings not used by woodcock (n = 5)
Basal area of trees surrounding clearing	$20.4\ m^2/ha \pm .38$[1]	$23.3\ m^2/ha \pm 1.35$[2]
# tree stems surrounding clearing	823 stems/ha ± 111	1242 stems/ha ± 262
Clearing size	$1594\ m^2 \pm 110$	$1228\ m^2 \pm 78$[3]
Surrounding tree height	11.6 m ± .54	12.6 m ± .95[2]

[1] $\bar{x} \pm$ S.E.

[2] significant difference, $p < .05$

[3] significant difference, $p < .001$

clearings (Table 6). The clearings cut in 1974 were browsed heavily by deer and some openings are almost devoid of hardwood growth (Fig. 7). Browsing on the 1975 clearings was less intense probably due to the large number of clearings available to the deer. Mendall and Aldous (1943) also noted that deer effectively removed hardwood regeneration from their experimental singing grounds.

Table 6. Average yearly seedling and sprout growth (m) on clearings cut in 1974 (n = 4) and 1975 (n = 7) in a mature hardwood stand at Moosehorn NWR.

Year Cut	Height growth (m) in the spring					
	1976		1977		1978	
	sprouts	seedlings	sprouts	seedlings	sprouts	seedlings
1974	.03±.01	.04±.01	.46±.16	.39±.08	.89±.29	.62±.19
1975	.01±.01	.05±.04	.77±.05	.26±.03	1.21±.11	.80±.13

<u>Singing ground sizes</u> - Throughout the study area, courting male woodcock utilized the larger clearings more often (t-test, $p < .05$) (Table 5). In 1977 four larger clearings were placed next to clearings which had never been used to help understand the relationship of clearing size to use. Unfortunately, the late spring and heavy snows of 1978 prevented assessment of this project. Work is continuing in this area.

<u>Singing ground age and age of courting males</u> - Nearly all singing males using newly created and established singing grounds were captured and aged (Table 7). Significantly more first year courting males were found on new sites than older sites (X^2, $p < 0.025$). Older males often return to the same field year after year. Younger birds are probably more exploratory and are known to make extensive flights during the summer (Dunford and Owen 1973). These birds are probably more apt to find newly created clearings.

Table 7. Age distribution of courting males on established singing grounds and newly created singing grounds (1976-1978) on the Moosehorn NWR.

	Numbers of courting males captured		
Age	established singing grounds	newly created singing grounds	Total
ASY[1]	52 (58%)	9 (36%)	61
SY[1]	37 (42%)	16 (64%)	53
Total	89	25	114

[1]ASY - after second year; SY - second year

Relationship of singing ground to summer fields - We believe that large summer roosting fields act as focal points from which young birds make exploratory flights to new covers. During this period woodcock encounter new roosting areas which will make suitable singing grounds the following spring. If this is true, it would influence the planning of the spatial distribution of summer fields and singing grounds. Several singing grounds were cut in 1977 to test this hypothesis but again the late spring in 1978 prevented the use of any of these clearings. This aspect of the study will be continued by personnel at Moosehorn NWR.

Influence of Burning on Singing Ground Use

Spring burning of hay fields is a Maine ritual and commercial blueberry fields are burned on alternate years. Most burning takes place in the spring during the peak of courtship activity. The effect of burning an active singing ground has never been assessed. In 1977 and 1978 five fields, which served as singing grounds, were burned in April (Fig. 8). Four of the fields were occupied by courting males within one day and the other field was occupied within a week after the burn. One negative aspect of spring burning is that early nests may be destroyed (Mendall and Aldous 1943).

Figure 8. Spring burning of a large singing ground, Moosehorn NWR. The males returned the following night to court.

NOCTURNAL ROOSTING COVER MANAGEMENT

In the northern portion of their range woodcock prefer to roost at night on or near open areas. In June the birds begin to concentrate and spend the nights in clearings (Dunford 1971, Krohn 1971, Caldwell and Lindzey 1974, Whitcomb 1974). Dunford and Owen (1973) found woodcock using fields, power-line rights-of-way, highway medians, woods roads, bogs and forest openings. However, 90% of the usage was of pastures, abandoned fields and Christmas tree plantations. Krohn (1971) found that fields in Maine with low ground vegetation interspersed with taller cover were used more often than fields with tall dense ground cover. The best areas contained small pockets of short vegetation surrounded by tall cover. Commercial blueberry fields in Maine provide excellent nocturnal habitat. The objectives of this portion of the study were to: (1) test the feasibility of creating summer roosting fields, (2) monitor the vegetative response on these fields and (3) measure the changes in woodcock use and vegetation resulting from prescribed burning of active summer roosting fields.

Methods

Creation of Summer Fields

Three 1.3 ha fields were cleared in a large contiguous hardwood (1200 ha) stand (Fig. 9). One of these fields was cleared in 1976. Slash on half of this field was piled and burned (Fig. 10), slash on the other half was broadcast burned in April 1978. The other 2 fields were cleared in 1977. Slash was piled and burned on both areas. One field was then broadcast burned after slash removal in April 1978.

Figure 9. A 1.3 ha summer field cleared in 1976, Moosehorn NWR.

Figure 10. YACC crew piling and burning slash on a 1.3 ha summer field, Moosehorn NWR.

Summer Field Maintenance

Moosehorn has several active summer roosting fields (Fig. 11). Past maintenance has included none on some fields, periodic burning on others, and annual to occasional mowing on still others. Two 2 ha blueberry fields separated by a gravel road and 50 m of forest were chosen for a prescribed burning program similar to commercial blueberry management. Neither field had been burned for at least 5 years, but both had been mowed occasionally. One field was broadcast burned in April 1977 (Fig. 8) and the other in April 1978. A 2 ha blueberry field which was maintained only by hand cutting invading woody growth was burned in April 1977. In addition, a 3 ha field which contained 1.5 m tall hardwood growth was mowed in August 1977 and burned in April 1978. No additional fuel (i.e. hay) was added to the fields before burning. All fields were back fired when possible.

Vegetation Monitoring

Vegetative features of all fields were analyzed before and after burning. Data were collected during the peak of woodcock use, 20 June to 10 July. The number of stems by species, percent cover and average vegetation height were recorded. Prior to cutting of new fields the shrub and tree components were sampled.

Monitoring Woodcock Use

Mist netting (Sheldon 1961, 1977) was used to capture woodcock as they flew into the fields to roost. Each field was netted once a week from 1 June to 24 August. The larger fields contained as many as 22 nets; small fields had as few as 6 nets.

Night-lighting (Riefenberger and Kletzly 1967) was also used to determine field usage. This technique provided a rough estimate of the number of birds

Fig. 11. Active summer roosting field, Moosehorn NWR. Fields are burned to maintain low ground cover.

present. A field was not night-lighted more than once a week.

Results and Discussion

Woodcock Response to Prescribed Burning

Prescribed spring burning of blueberry fields resulted in increased woodcock use of the fields the summer immediately following the burn. Two fields, Blueberry Fields 1 and 10, separated by only 50 m of second growth hardwoods and a gravel road and maintained in the past by occasional mowing were burned on alternate years. The field that was burned had significantly greater woodcock use (Wilcoxin text, $p < .05$) the year of the burn than did the neighboring unburned field (Table 8).

Table 8. Capture rate of woodcock by mist netting of Blueberry Field 1 and 10 in 1977 and 1978 Moosehorn NWR. Field 1 was burned in April 1977, Field 10 in April 1978.

	Number of woodcock captured / net			
	Field 1		Field 10	
Date	Summer of burn (1977)	Summer after burn (1978)	Summer before burn (1977)	Summer of burn (1978)
6/12-14	.18	.13	.12	.06
6/20	--	.32	--	.50
6/23-28	.32	.36	.06	.44
7/4-6	.26	.05	.06	.38
7/10-14	.48	.59	.12	.88
7/17-19	.13	.05	.12	.18

A third field, Blueberry Field 36, which was maintained previously by hand cutting of invading brush, was burned in April 1977. Woodcock use of this field was significantly greater in 1977 than during the same period in 1978 (paired t-test, $p < .05$) while woodcock use of a nearby unburned field remained the same.

In 1977 a fourth field, Blueberry Field 7, was mowed using a tractor drawn rotary mower. Woody vegetation 1.5 m high covered much of the field. Woodcock use was restricted to the eastern third where vegetation was less dense. In April 1978 the field was burned. Woodcock use was greater that summer following the burn than a year with no treatment (Wilcoxin test, $p < .05$).

Vegetation Response to Prescribed Burning

The impact of fire on vegetation is the key to explaining woodcock preference for newly burned fields. After burning, the number of blueberry stems increased, but in all but one instance the percent cover remained constant. The amount of bare ground also increased (See Tables 8 - 11 in Appendix 3 for details). In fields where sweet fern (*Myrica asplenifolia*) was common, fire had an initial positive affect by providing areas devoid of vegetation for roosting. However, sweet fern sprouted vigorously after fire. In one field, 1 year after burning, sweet fern covered 34% of the area in the burned section, but only 11% in the unburned parts. Each sweet fern stem destroyed by fire resulted in numerous vigorous sprouts. Further burning would probably make the field completely unsuitable for woodcock use.

Creation of Summer Fields

No woodcock have been observed using the three fields created in a mature hardwood stand. Apparently vegetation on these fields has not reached the stage preferred by roosting woodcock. The blueberry component has increased, but so has sprout growth. Moose (*Alces alces*) and deer (*Odocoileus virgineanus*) have helped to keep sprout growth down, but eventually the area will revert to forest without further management. Broadcast burning of slash on one field 2 years after cutting resulted in high sprout and root mortality in areas of high fuel concentration but little mortality elsewhere. Burning the year after cutting when more natural fuel was present would have been more effective.

Summary

Newly burned blueberry fields consistently contained more woodcock than adjacent unburned fields and field use after burning was usually greater than before burning. Burning increases the amount of bare ground and decreases the number of horizontal stems. However, the benefits of burning may be short term. Sweet fern sprouts vigorously after fire. The stems are mostly vertical the first year, but begin to branch later. Field 36, the year following burning, was difficult to walk through and there were few places for woodcock to land due to the vigorous response of sweet fern. Any management of fields using fire where sweet fern grows must include some type of strategy to suppress sweet fern. Commercial blueberry management includes control of sweet fern by mowing and/or herbicides.

Burning blueberry fields benefits woodcock by maintaining the vegetation in an early successional stage. Softwoods are prevented from invading and sprouts are killed, but the fire is usually not hot enough to kill hardwood root systems. Hardwoods can be eliminated in newly created fields if slash is broadcast burned within a year of cutting. Three or four years of consecutive spring burning should also eliminate hardwood growth in fields, but this method has yet to be tested.

The success in creating new summer fields in a large hardwood stand devoid of roosting fields has yet to be evaluated fully. There may be a lag time between creation of a roosting field and bird usage. This may be due, in part, to the time required for favorable vegetation to become established on the site and the time required for the birds to learn that the site is available.

MANAGEMENT RECOMMENDATIONS

Diurnal Cover

Lack of diurnal cover may be a major factor limiting woodcock numbers. During this study we did not attempt to create diurnal cover where none existed before, but we have tried different techniques to regenerate existing covers. The most promising technique is to clear-cut strips through pure and/or mixed alder covers. Liscinsky (1972) postulated that alder covers between 10 and 20 years old are most attractive to woodcock. He, therefore, recommended a cutting rotation of approximately 25 years with a portion of the cover cut every 4 to 5 years. We duplicated this type of cutting and found it satisfactory. We also recommend a 20 to 25 year rotation, cutting strips at least 10 m wide with one of the following strategies: (1) If the cover is located on soils of varying moisture content, the strip should be positioned to bisect the moisture gradient. Differences in moisture result in varying densities and rates of alder growth. Thus, a diversity of stem density and height growth is promoted within each strip providing open areas for singing grounds on drier sites (Fig. 12) and good alder regeneration on moist areas (Fig. 13). (2) Cut 20% of the cover every 5 years and treat the stumps in part of each strip with ammunium sulfanate within 5 days of cutting. This will keep part of each strip open longer and also increase diversity. (3) Or cut 10% of the cover every 2 years or whenever needed to provide a continuous supply of singing grounds. Covers selected should be on soils supporting high earthworm populations. Covers on poorly drained, muck soils will have few earthworms and management will result in only a small increase in woodcock numbers. High priority should also be given to covers which are relatively dry during the nesting period. Slash disposal is desirable but not necessary. Lack of disposal may discourage singing male use of the strips,

Figure 12. An alder strip cleared in 1973 and photographed in 1977, Moosehorn NWR. The strip is located on a relatively dry site and has been used as a singing ground for 6 years.

Figure 13. An alder strip cleared in 1973 and photographed in 1977, Moosehorn NWR. This strip is located on moist soils and was no longer used by singing males in 1977. Note the alder regeneration as compared to Figure 12.

but careful felling to provide slash free areas or spot clearing of slash will provide courting sites. Once the alders in the strip have regenerated enough to provide suitable diurnal cover most of the slash will have decayed.

Patches of softwoods growing on abandoned agricultural land should be considered an important component of diurnal habitat. Softwoods can be encouraged by weeding, thinning, or planting near alders to provide feeding cover during warm weather and extended droughts. However, in areas where conifers constitute the climax vegetation, an effort must be made to insure that they do not invade and overtop important alder stands.

Diurnal covers can also be regenerated with herbicides. The herbicide 2,4-D, L.U. Ester, 10% aqeuous solution, sprayed on the foliage will top kill alder and stimulate sprout growth. Two applications at 2 week intervals are necessary for adequate coverage of the foliage. This technique is far less labor intensive (5-10 man-hrs/ha) than clear-cutting strips (400-500 man-hrs/ha) and has no effect on earthworm numbers. However, regeneration using herbicides does not provide the very important but temporary singing grounds that clear-cutting provides. Our data suggest that these singing grounds make the alder covers more attractive to nesting females and broods.

Singing Grounds

The creation of singing grounds will usually increase the number of courting males using an area if the surrounding brood and nesting cover is suitable. Our first suggestion is to cencentrate on creating strip clear-cuts in diurnal cover, thus meeting two needs, providing singing grounds and rejuvenating the cover. In mature forests, clearings should be approximately 1600 m^2 or larger in areas where snow remains late in the spring. Clearings with short surrounding vegetation can be as small as 1200 m^2. Where possible clearings should have a southern exposure and be rectangular in shape.

The number of singing grounds required per unit will vary with the quality and quantity of other nearby woodcock habitat. The optimum number of singing grounds can be determined by cutting 1-2 clearings/year and observing the yearly response by singing males. Eventually the number of males using the area will stabilize. Care should be taken to maintain all the singing grounds in optimum condition during this period.

The length of use of a singing ground can vary greatly. If the clearing is cut in a hardwood stand, sprout growth will soon make it unsuitable as a courting site. Sprout growth can be slowed by cutting the clearings in the summer when sprouting vigor is less. Sprout growth on isolated clearings is often eliminated by browsing deer. If a clearing is to be maintained, treatment of the sprouts with herbicides, fire or cutting annually for 3 or 4 years will eliminate growth and decrease future maintenance. On the other hand, a yearly program of singing ground creation will eliminate the need for annual maintenance and increase the diversity of the area as the vegetation in the clearings regenerates producing brood and nesting habitat.

As in the alder strips, large amounts of slash may discourage singing male use of clearings. Complete slash disposal is desirable; however, if this is not possible the removal of slash from 2-3, 25 m^2 areas per clearing will suffice. Careful felling of trees will also provide slash-free areas in a clearing without additional labor.

We believe that three criteria are necessary to make clearings in hardwood areas a successful management tool: (1) Preferably, there should be a few singing males present before cutting; (2) There should be good diurnal cover within 1 km of any clearing; and (3) The clearings must be adjacent to good brood and nesting cover.

Nocturnal Cover

Fields provide nocturnal roosting cover for woodcock. At the Moosehorn NWR, blueberry fields are used most heavily, hay fields on poor soils and pastures are used by a few birds, and fields productive for hay are rarely used. Blueberry fields are maintained by burning in the spring on alternate years. This kills encroaching woody vegetation and increases the amount of bare ground. Periodic burning of fields where sweet fern is common will result in the proliferation of this species. Fields with a heavy sweet fern component are unattractive to woodcock. Frequent mowing or herbicide application will be necessary to control this plant.

Mowing is an alternative to burning. However, it serves only to remove encroaching vegetation. Other features of the vegetation such as density and distribution will remain unchanged.

We also created fields using clear-cuts in mature hardwood stands. Further monitoring will be necessary to ascertain the value of these potential summer roosting fields. Sprouts are a problem in such new fields. Part of one field where slash was allowed to remain where it fell was broadcast burned. Where the fire burned slowly and hot, there was virtually no sprout growth. If the slash was piled and burned and then the entire field broadcast burned, rapid sprout growth occurred, especially if much aspen was present. Blueberries are increasing in all newly cleared fields including portions of the fields that were not burned.

CONTINUING WOODCOCK RESEARCH AT THE MOOSEHORN NWR

The 3 years allotted this study were not sufficient to monitor the effects of many of the management techniques we tried. Additional work is necessary and will be carried out on a long term basis by Refuge personnel. These avenues of research include:

1. Evaluation of prescribed burning to remove slash and control sprout growth.
2. Testing methods to control sweet fern.
3. Study of alder regeneration and woodcock use of alder covers subjected to herbicide application.
4. Monitor brood and nest locations in relationship to managed areas.
5. Study of the effect of slash disposition on courting male use of clearings.
6. Measurement of seasonal changes in earthworm abundance in various cover types.
7. Determination of the relationship of singing ground use to distance from summer roosting fields.
8. Evaluation of optimum singing ground size.
9. Study of the relationship of woodcock use to age of alder stands.
10. Measurement of the lag time between summer field creation and use by woodcock.
11. Study the relationship of age of singing grounds to age of courting males.
12. Continue to monitor woodcock use of all artifically created singing grounds.

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Appendix 1: Types of Labor Utilized for the Woodcock Management Study at the Moosehorn NWR.

Washington County Vocational Technical Institute (WCVTI) - WCVIT has a program designed to teach wood harvesting skills. The refuge provides areas for cutting and detailed cutting specifications. WCVTI pays current stumpage prices and is responsible for cutting to specifications. Clear-cutting is utilized most often, but certain tree species and unique areas of value to wildlife are left. Commercial harvesting techniques and machinery are used making it possible to treat about 40 ha/year.

Youth Conservation Corps (YCC) - Each year (during July and August) the refuge has hosted a 40 member, 8 week YCC camp composed of youths 15 through 18 years old. This work-learn program has provided a means to manage woodcock habitat which could not be treated otherwise because of its low commercial or firewood value.

This group was most efficient when working in stands which contained trees and shrubs with an 8 cm DBH or less since only camp counselors are permitted to use chainsaws. The enrollees can only use axes or similar equipment. About 2 ha/summer were cleared using this group.

Refuge staff - Refuge maintenance personnel cleared undesirable tree species left by firewood cutters and clear-cut strips through alder covers. The rate of work done by this group probably closely approximates that which would be done by a private landowner. Thus, time requirements were recorded for this group.

Woodcock banding crew - Most time and material requirements were obtained from these personnel. Crews of two were used to cut plots; one chainsaw operator and one person to yard logs and pile brush. One person was used to spray herbicides.

Appendix 2: Costs and Materials for Woodcock Habitat Treatments at Moosehorn NWR.

The rate of clear-cutting can vary greatly depending on the experience of the personnel and the number of personnel per chainsaw. We felt the most efficient operation and one that would be most likely used by land-owners would be two people per chainsaw. Using this approach it required 452 man-hours/ha to clear-cut, pile the brush and yard the logs by hand no more than 25 m. An additional 96 man-hours/ha were required to burn the brush piles.

About 125 l of gasoline and 60 liters of bar chain oil were required to cut 1 ha of mature timber. Smaller wood took less fuel. Clearing a strip 10 m x 200 m would require about 100 man-hours of labor, 25 l of gasoline, and 12 liters of bar chain oil. Herbicide application to a strip 10 m wide and 200 m long required about 1.2 man-hours or 6.0 man-hours/ha.

APPENDIX 3

Table 1. Capture rates of adult woodcock in diurnal cover 5 and unmanaged covers from 1974 through 1978 and the number of singing males utilizing the clear-cut strips, Moosehorn NWR.

		No. captures / 100 cell nights			
		Adult Males		Adult Females	
Year	No. of singing males in Diurnal Cover 5	Diurnal Cover 5	Unmanaged Covers	Diurnal Cover 5	Unmanaged Covers
1974	2	.24	.12	.44 [1]	.15
1975	3	.84 [1]	.13	.49 [2]	.24
1976	2	.11	.04	.26 [1]	.04
1977	1	.17	.07	.29 [1]	.13
1978	1	.14	.07	.28	.14

[1] X^2, $p < .05$

[2] X^2, $p < .10$

Table 2 . Capture rates of adult male and female woodcock in diurnal cover 6 and unmanaged covers from 1977 through 1978 and the number of singing males utilizing the clear-cut strips, Moosehorn NWR.

		No. captures / 100 cell nights			
		Adult Males		Adult Females	
Year	No. of singing males in Diurnal Cover 6	Diurnal Cover 5	Unmanaged Covers	Diurnal Cover 5	Unmanaged Covers
1977	1	.12	.07	.12	.13
1978	2	.14	.07	.14	.14

APPENDIX 3

Table 3. Woodcock capture rates in diurnal cover #5 on the clear-cut strips and in the uncut portion of the cover, Moosehorn NWR.

	No. captures / 100 cell nights		
Year	capture rate in clear-cut strips	capture rate in uncut portion of covers	Difference
1976	.39	2.47	2.08
1977	.56	1.96	1.40
1978	.48	1.50	1.02

APPENDIX 3

Table 4. Vegetative measurements taken in 1978 of herbicide treated strips and control areas in diurnal cover 11 two years after herbicide application, Moosehorn NWR.

	Avg. Alder height (m)	# live alder stems/m^2	# dead alder stems/m^2	% ground cover	% canopy cover	% moisture
Herbicide treated strips	5.4 ± 20	2.77 ± .73	.61 ± .07	94 ± 1.42 [1]	37 ± 7.0 [1]	41 ± 20
Control	5.3 ± .20	2.16 ± .84	.43 ± .25	58 ± 7.43	87 ± 5.0	21 ± 12

[1] ANOVA, $p < .05$

Table 5. Vegetative measurements taken in 1978 of the herbicide treated strips and control areas in diurnal cover 6A one year after herbicide application, Moosehorn NWR.

	Avg. Alder height (m)	# live alder stems/m^2	# dead alder stems/m^2	% ground cover	% canopy cover	% moisture
Herbicide treated strips	4.07 ± .46 [1]	2.67 ± 0.71	1.04 ± .24 [1]	78 ± 27.5	23 ± 8.2	33 ± 4.2
Control	5.59 ± .15	1.35 ± .29	.38 ± .05	84 ± 21.8	81 ± 20.4	24 ± 18

[1] ANOVA, $p < .05$

APPENDIX 3

Table 6. Soil moisture, pH and earthworm biomass in diurnal cover 6A, June and July 1978, Moosehorn NWR.

	26 June 1978		20 July 1978	
	Herbicide strips	Control	Herbicide strips	Control
Soil Moisture (%)	32.8	32.6	26.7	20.1
pH	4.72	4.62	4.70	4.71
Biomass (g/m^2)	12.0	12.2	6.65	6.05

Table 7. Soil moisture, pH and earthworm biomass in diurnal cover 11, June and July 1978, Moosehorn NWR.

	26 June 1978		27 July 1978	
	Herbicide strips	Control	Herbicide strips	Control
Soil Moisture (%)	28.9	30.9	27.3	25.9
pH	4.49	4.38		
Biomass (g/m^2)	7.03	9.15	1.93	1.93

Table 8. Selected vegetative measurements on Blueberry Fields 1 and 10, 1977 and 1978, Moosehorn NWR. Field 1 was burned in April 1977 and Field 10 in April 1978.

	Field 1				Field 10			
	# stems/m^2		% Cover		# stems/m^2		% Cover	
	1977	1978	1977	1978	1977	1978	1977	1978
Blueberry	191	376	29.3	54.5	205	446	643	50.3
Sweet fern	4.9	6.5	1.7	2.7	4.5	14.9	2.6	2.3
Grass			20.0	21.4			17.3	10
Bare Ground			24.7	8.3			3.7	28.5
Laurel	0	2.4	0	3.3	2.8	0	1.5	0
Spirea	1.1	.32	0.3	.16	1.4	4.4	0.8	.89
Ave. vegetation height (m)	.18		.16		.23		.16	

Table 9 . Selected vegetative measurements on Blueberry Field 7, 1977 and 1978, Moosehorn NWR. The field was mowed in August 1977 and burned in April 1978.

	June 1977		June 1978	
	# stems/m^2	% Cover	# stems/m^2	% Cover
Blueberry	34.8	18.0	91.2	16.7
Sweet fern	16.6	15.5	33.0	9.7
Spirea	1.8	2.9	0	0
Hardwoods	1.7	2.2	1.6	0.9
Grass		13.8		12.4
Bare Ground		8.4		24.4
Average Vegetation Height (m)	.46		.21	

APPENDIX 3

Table 10. Selected vegetative measurements on Blueberry Field 36, 1977 and 1978, Moosehorn NWR. Part of this field was burned in April 1977.

	30 June 1977				30 June 1978			
	Burned		Control		Burned		Control	
	# stems/m^2	% cover	# stems/m^2	% cover	# stems/m^2	% cover	# stems/m^2	% cover
Blueberry	83.3	22	53.4	21	98.1	20	55.2	21
Sweet fern	30.5	12	11.6	8.0	37.6	34	6.5	11
Spirea	0.7	0.4	1.7	2.0	0.4	0.2	3.2	2.0
Hardwoods	2.9	2.0	3.0	2.0	2.9	3.0	0.4	0.6
Grass		9		24		14		27
Bare Ground		21		4		5		2
Average Vegetative Height (m)	.25		.49		.46		.53	

Table 11 . Selected vegetative measurements on Summer Field 76-7, 1977 and 1978, Moosehorn NWR. The field was created in a stand of mature hardwood.

	July 1977		July 1978	
	# stems/m^2	% cover	# stems/m^2	% cover
Blueberry	5.0	1.3	19.7	5.2
Sweet fern	0	0	0.3	0.2
Gray Birch	3.4	0.5	0.3	0.2
White Birch	0.1	0.04	0.2	0.1
Aspen	2.0	2.0	4.2	10.8
Red Maple	0.7	0.3	2.7	0.8
Bare Ground		8.0		28.0
Grass		1.5		16.6
Average Vegetative Height (m)	.23		.25	

Appendix 4: Estimation of Selected Spring Population Parameters

Management success was measured using various woodcock capture techniques (mist netting, modified shorebird traps and night-lighting) described elsewhere in this text. Data gathered from these efforts provided a basis for measuring different population parameters. In addition, courting males were mist netted on the singing grounds in April and May. Broods were located and captured using trained bird dogs in late May and early June as described by Ammann (1977). Captured woodcock were banded, aged, sexed, and the location and capture method were recorded.

Estimation of the Spring Subdominant Male Population

The status of the spring woodcock breeding population is estimated throughout the woodcock's range using the singing ground survey. About 900 randomly selected routes each with 10 stations, 0.67 km apart are run each spring during the peak of male courtship activity and after migration has ceased. The number of males heard/singing-route is used as an index of the size of the population. The major assumption of the survey is that the number of males heard singing is representative of the population (Kozecky et al. 1954). This concept has been questioned (Godfrey 1975, Owen 1977) recently. A subdominant male population exists which is not measured by the survey. The size of this population may vary greatly with no influence on the survey results. Whitcomb (1974) reported removing courting males from single bird singing grounds in Michigan. All but 3 of the 18 singing grounds were reoccupied with new courting birds the next night. Sheldon (1967) removed courting woodcock from 4 Massachusetts singing grounds and all were reoccupied within a week.

Efforts have been made recently to determine the size of the subdominant male population. Whitcomb (1974) estimated an average of 2.4 adult males/singing ground over a 4 year period in Michigan. In Minnesota, Godfrey's (1975) estimates ranged from 1.1 to 2.0 singing males/singing ground over a 4 year period.

In 1976 we began a program to determine the size of the subdominant male population using the Lincoln-Peterson Index as modified by Chapman (1951). This estimate is based on the following assumptions: (1) the adult male population on the Moosehorn NWR is not subject to immigration or emigration during the spring and summer, (2) adult male mortality is low during the sampling period, (3) equal catchability of adult males during the summer, (4) the number of dominant males is equal to the number of singing males recorded during the spring singing ground survey and (5) a dominant male remains active during the entire spring sampling period. From 1 April to 1 June dominant males were captured on singing grounds, banded, and released (Phase I). At the same time singing ground surveys were conducted to determine the total number of occupied singing grounds on the Moosehorn. From 1 June to 25 August (Phase II) an intensive effort was made to capture as many woodcock as possible using a variety of techniques already mentioned. The following information gained from these efforts was used to estimate the subdominant population. Table 9 gives the values of these variables for each year.

1. Number of dominant woodcock captured in the spring (Phase I) and again in the summer (Phase II) = a
2. The number of adult males caught in the summer which were not caught in the spring as dominant males = b
3. Total number of singing males taken from the spring singing ground survey = c
4. Number of dominant male woodcock caught in the spring (Phase I) = d

Table 1. Spring male woodcock population estimates and sample sizes from 1976 through 1978, Moosehorn NWR.

Year	a[1]	b[2]	c[3]	d[4]	subdominant[6] male pop.	Total male[5] population	No. males/ singing ground	SE[7]
1976	3	23	98	26	83	181	1.85	245
1977	10	25	78	38	49	127	1.62	71
1978	8	29	70	48	136	206	2.94	139
						Average = 2.14		

[1] Number of dominant woodcock captured in the spring and again in the summer.

[2] Number of adult males caught in the summer which were not caught in the spring as dominant males.

[3] Total number of singing males taken from the spring singing ground survey.

[4] Number of dominant male woodcock caught in the spring.

[5] Total male population (c) $= \frac{(d + 1)\ (a + b + 1)}{a + 1} - 1$

[6] Subdominant male population = e - c

[7] SE $= \sqrt{\frac{d^z\ (a + b)\ (b)}{a^3}} \times z$ (Bailey 1951).

The population estimates (Table 1) generated by this technique are quite realistic. At first glance there appears to be quite a variation in population sizes. However, when weather conditions are taken into account these variations are realistic. The winter of 1975-76 was not particularly harsh. Snow was off most clearings by the first of April and production was good. This probably represented an average year. The winter of 1976-77 was severe on the wintering grounds. This was reflected in the low male population (127), but production was good and the male population rebounded to a 3 year high (206). The subdominant population was large and the number of singing grounds at a 3 year low. This was due, in part, to a decrease in the number of available singing grounds as a result of succession, but also, to a late spring. Snow remained on most small clearings well into April making them undesirable as singing grounds. Estimating the status of the population using the singing ground survey would lead to the conclusion that the population is declining. In reality the population seems to be remaining stable if not increasing.

This method has certain advantages not found in other techniques. Whitcomb (1974) used arbitrary spring to fall adult male and female survival rates as part of his calculations. Our technique used only data collected in the field. However, our average estimate of number of male woodcock/singing grounds (2.14) agrees quite closely with Whitcomb's estimate (2.44). Whitcomb's technique also requires a huntable population and there is a longer time between the critical capture and subsequent recapture. Godfrey's (1975) technique simply involves observation of woodcock in and around singing grounds. While this technique is less labor intensive, I doubt that an accurate estimate can be obtained by observation over a large area.

Our technique is limited due to its labor intensive nature. About 1600 man-hours are required during the field season in active capture of woodcock. An additional 400 man-hours are required for maintenance and set-up of equipment. Average yearly equipment costs are about $1500. A banding program, including an intensive spring singing ground survey, at the level conducted at the Moosehorn would cost about $7,000 for start-up funds and a yearly budget of $8,500 which would include materials and labor, exclusive of supervision. This level of activity is necessary to obtain the sample size needed to give realistic estimates.

<u>Singing male courtship longevity</u> - Whitcomb (1974) captured a preponderance of ASY male woodcock (72%) on singing grounds prior to 15 May. After 15 May the majority of courting birds (64%) were SY males. Whitcomb suggested that

older males dominate breeding activity early in the season and gave way to younger birds as the breeding season progresses.

From 1976, 118 dominant male woodcock were captured on singing grounds at the Moosehorn NWR. Overall, the same number of ASY birds as SY males were captured before and after 15 May (Table 12). This difference may be due to an age structure difference in populations. The subdominant component in Maine may contain more ASY birds than in Michigan. Also, the Michigan study was based only on one year's data which may not have been typical.

Table 12. Age of courting male woodcock caught on singing grounds from 1976 through 1978, Moosehorn NWR.

	Before 15 May		After 15 May	
Year	ASY	SY	ASY	SY
1976	12	9	4	1
1977	14	14	6	4
1978	25	24	0	5
Total	51	47	10	10
Percent	52	48	50	50