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MINNESOTA PRAIRIE MANAGEMENT TECHNIQUES AND THEIR WILDLIFE IMPLICATIONS[1]

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This paper reports on the wildlife management aspects of an investigation to determine the effects of four treatments—spring burning, fall burning, grazing and mowing—on the flora and fauna of prairie habitat in northwestern Minnesota.[1]

The tall grass prairies of northwestern Minnesota lie in a tension zone between the deciduous forest on the east and the short grass prairies to the west in the Dakotas. In some places the transition from forest to prairie is clearly defined and in others it is diffuse. The topography of the landscape at this transition in northwestern Minnesota is gently rolling. Originally marshes, potholes and wet prairies were common throughout the region. These prairies near the woodland edge were inhabited by Indians prior to about 1900. According to Buell and Facey (1960) prairie fires, which frequently swept the up-

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land areas in the spring and fall, helped to maintain the grassland in the face of westward invasions by trees and shrubs.

When settlers began farming in this area agriculture brought about marked changes in the landscape. Farmsteads were established with plantings of trees to serve as windbreaks and a network of roads developed. Fires were reduced in extent and frequency. In much of the area cultivated crops were successful and consequently many prairies were broken for agricultural purposes.

At the present time the agricultural operation in this area is relatively intensive. Most of the tillable land is being cropped and a recently accelerated program of planned drainage along with newly-bulldozed deep highway borrow pits is rapidly eliminating the marshes and potholes. Where drainage is difficult a few tracts of native prairie remain. Some of these are owned by farmers or other individuals and are usually grazed or mowed. Others have been acquired by the Minnesota Department of Conservation or other organizations interested in preserving natural areas. The proposed program of wetlands acquisition by the U. S. Department of the Interior may place many more of the remaining prairie tracts under government ownership and presumably assure their protection from the plow.

It is apparent that these publicly owned natural prairies must be managed to preserve their original status for research and aesthetic values as well as to provide the desired conditions for such wildlife as prairie chickens (*Tympanuchus cupido pinnatus*) and waterfowl. We hope that this report will provide information which may be useful in the formulation of sound management plans.

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METHODS

This report is based on field studies conducted during the five summers of 1957 through 1961. A detailed description of the site and of most of the methods used in this study has been published (Tester and Marshall, 1961). Summary statements will be given here.

A total of 70 acres of relatively undisturbed native prairie was selected for study from the approximately 250 acres of unplowed land which lies within a 640 acre tract known as the Waubun Prairie Re-

reach Area. The area is located eleven miles southwest of the town of Mahnomen in Section 33, Township 143 North, Range 42 West of the 5th Principle Meridian. The tract was acquired by the Minnesota Department of Conservation in 1954 and has been reserved for basic research and experimental land management.

Seven ten-acre plots were selected on the study area on the basis of topography and history of land use, particularly mowing. The selection of the treatments for each plot was made subjectively and was based on the location of the plots with respect to potholes and roads, and the nature of use of adjacent agricultural land.

Two plots were used as controls and are designated Control I and Control II. One plot (Fall Burn) was burned on October 28, 1957. Two plots (Spring Burn I and Spring Burn II) were burned on April 11, 1958. One plot (Graze) was grazed during the summers of 1958 and 1959.

The hay crop on one plot (Mow) was to be harvested each year in September. The harvest proceeded as planned in 1957. However, in March 1958, a wildfire burned most of this plot and in September, 1958, the harvest was only partially completed. This plot was dropped from the study.

Discussions on the effects of mowing will be based primarily on the differences between the two groups of plots which were observed before treatments started. Control II and Spring Burn II were in a part of the prairie which was of lower elevation and which had more soil moisture. This site had not been mowed since 1951. The remaining five plots were in an area which had been mowed annually in late summer before 1957.

The non-woody upland vegetation was studied by means of rectangular quadrats 1.0 by 0.5 meter in size. The effects of grazing on woody vegetation were evaluated by means of 60- by 60-foot quadrats in 1958 and 1959. In 1959 ten 2- by 60-foot transects were added to the study. Data in quadrats and transects were recorded by 0-2 foot, 2-4 foot, and 4+ foot height classes for aspen (*Populus tremuloides*) and willow (*Salix* spp.). In addition to these quantitative methods, photographs were taken periodically from permanent stations during the study and subjective evaluations of certain conditions were made in the field.

Censusing of song birds was accomplished by the territory-mapping technique. Indices of population density of small mammals were obtained by snap-trapping. Indices of the population density of Orthoptera and Coleoptera, the two groups of insects likely to be most abundant in a prairie (Smith, 1940), were obtained by sweep sampling.

Many other larger species of animals live on or range over Waubun

Prairie. Censusing these forms was beyond the scope of this investigation and unfortunately most game species must be included in this category of animals. However, evaluation of the management practices in terms of greater prairie chicken, waterfowl, and predators is made on the basis of "preferred" habitats as reported in the literature.

REACTION OF COMMUNITY TO TREATMENTS

Data on litter, dominant grasses, and certain animals will be briefly summarized here to provide background for the management discussion which follows. The woody plants and shoreline vegetation not previously reported on will be treated in detail.

Litter.—The most pronounced changes in the community in response to the treatments were in the depth and areal cover of the litter. We believe that these changes in the vegetational component of the community were responsible to a large extent for observed shifts in the animal populations.

In 1957 litter was sparse on those plots which had been mowed annually and was dense in those plots which had not been mowed since 1951. Burning in fall of 1957 and spring of 1958 reduced litter cover markedly in the Burn plots. Light grazing in 1958 did not have a noticeable effect on litter in the Graze plot. In 1959, grazing on this plot was moderate to heavy and caused pronounced changes in litter. Most areas were heavily trampled, and litter was only a few centimeters deep, but small patches of untrampled litter were present throughout the plot.

The data indicate that protection after burning or mowing would result in an accumulation of litter in two or three years which is similar in depth and percentage of cover to that in an area such as Control II which had been undisturbed for eight years. These findings support those of Ehrenreich (1957) and Dix (1960) who studied litter accumulation rates on Iowa and North Dakota prairies, respectively. It appears that on prairies in the north-central states a condition of equilibrium is reached two to six years after protection from burning or mowing begins — in this condition the annual increment of new litter seems to be balanced by the decomposition of old litter.

Upland grasses and forbs.—Approximately 100 species of grasses and forbs were present on the upland areas. The dominant species in the community were big bluestem (*Andropogon gerardi*), little bluestem (*A. scoparius*), Indian grass (*Sorghastrum nutans*) and needlegrass (*Stipa spartea*). Following treatment changes in the contribution of these species to the cover were small. No attempt was made in this study to determine the actual amount of forage produced under the various treatments since we considered areal cover to be the phyto-

sociological character which would provide the best measure of each species with regard to the community.

In general the cessation of mowing on four plots allowed the mid- and late-summer aspects of the vegetation to mature and produce seed for the first time in many years. However, no striking changes in species composition were noted during the course of the investigation. Weaver (1954) states that the removal of vegetation by mowing after maturity has no harmful vegetational effect. If mowing occurs before maturity the competitive abilities of some species may be reduced (Curtis, 1959).

Both spring and fall burning resulted in an advance of 10 to 20 days in the development of plants on the Burn plots. In addition, new growth on these plots was more luxuriant and removal of the thick mat of litter seemed to "release" many of the forbs such as yellow stargrass (*Hypoxis hirsuta*), stiff goldenrod (*Solidago rigida*), frostweed aster (*Aster ericoides*), and pasque flower (*Anemone patens*). Many species produced more abundant seed crops after burning. This response has also been observed by Evans and Grover (1940), Ehrenreich (1957) and Aikman (1955).

Burning did not bring about any noticeable shifts in species composition. Dix (1960) found a similar situation in comparisons of burned and unburned prairies in North Dakota. Fire can be used to control or reduce the density of certain undesirable species not considered native to prairie as shown by Curtis and Partch (1948) and Aldous (1934). Literature regarding effects of burning on yield and/or cover is contradictory. Increases after burning are reported by Aikman (1955) and Kelting (1957) whereas Hervey (1949) and Hopkins *et al.* (1948) found smaller yields. Ehrenreich (1957) found no difference in total yields on burned and non-burned prairie in Iowa.

Usage of the forage on the Graze plot was light in 1958 and moderate with small areas of heavy use in 1959. Much of the growing vegetation was removed by the cattle. However, no change in species composition in this plot was observed. We believe that the low to moderate utilization of the forage and the intermittent grazing program used account for this lack of change. Launchbaugh (1955) found that periodic moderate grazing allowed for vegetational composition similar to that in ungrazed areas and Weaver (1954) states that grazing by wild animals had little effect on the composition of grasslands because it was both widespread and intermittent. Heavy, prolonged grazing, on the other hand, causes reduction in cover of native grasses, increases in undesirable species and compaction of soil (Ehrenreich, 1957; Kucera, 1956 and 1958; Weaver, 1954).

Woody plants.—Only those woody plants which are considered to be

"invaders" on natural prairie will be discussed here. On Waubun Prairie these are limited to six species of willow (*Salix bebbiana*, *S. discolor*, *S. gracilis*, *S. humilis*, *S. interior*, and *S. rigida*), which will be treated as a group, and quaking aspen.

Numerous investigators have reported on the invasion of prairies by trees and shrubs. Moss (1932) found aspen invading grasslands in the prairie provinces of Central Canada when fire was kept out and Bird (1961) states that aspen replaces prairie in the parklands of western Canada if there is sufficient moisture and if fires are not "too frequent." Prairies in Wisconsin (Dix and Butler, 1960) and Iowa (Moyer, 1953) are currently being invaded by willow, aspen and other woody species. Mixed hardwood and brush stands found on the prairie soils of northwestern Minnesota have been described by Ewing (1924) and aspen and aspen-oak groves in the same area are discussed by Buell and Facey (1960).

Ecesis of aspen seedlings on prairie is difficult because of the dense sod and shading by the grass (Bird, 1961). However, once a plant is established it has great potential to spread into surrounding areas by means of rhizomes or propagating roots (Buell and Buell, 1959).

Quaking aspen clones are scattered over Waubun Prairie. The age of these clones varies from 1 to ca. 20 years (M. L. Partch, unpublished data). We have observed development of new thickets from seed on sites which have been undisturbed for as short a time as two years. Figure 1 illustrates the establishment of aspen by natural seeding on a site which had been mowed annually prior to 1957. The stems in the 1958 photograph had developed in two growing seasons. By 1961 numerous plants exceeded 60 inches in height.

Prairie willow (*Salix humilis*) occurred only as isolated plants scattered on the upland. The other species of willow were generally restricted to wet areas or the borders of potholes.

Annual hay harvesting precludes the ecesis of aspen and willow on sites that can be mowed. If three to five or more years elapse between hay mowings aspen and/or willow may become established and grow to such size that the stems cannot be cut off with a hay mower. In this event the farmer usually mows around the clone each year. This allows the woody plants to increase in size and density but restricts their spread.

Burning has a wide range of effects on willow and aspen. The effect is primarily determined by the date, duration and intensity of the fire. Aspen is fairly susceptible to fire with plants being killed in some cases or with bark damage which occurs under less severe burns allowing the entrance of wood-rotting fungi or disease (Strothmann and Zasada, 1957; Stoeckeler, 1948).

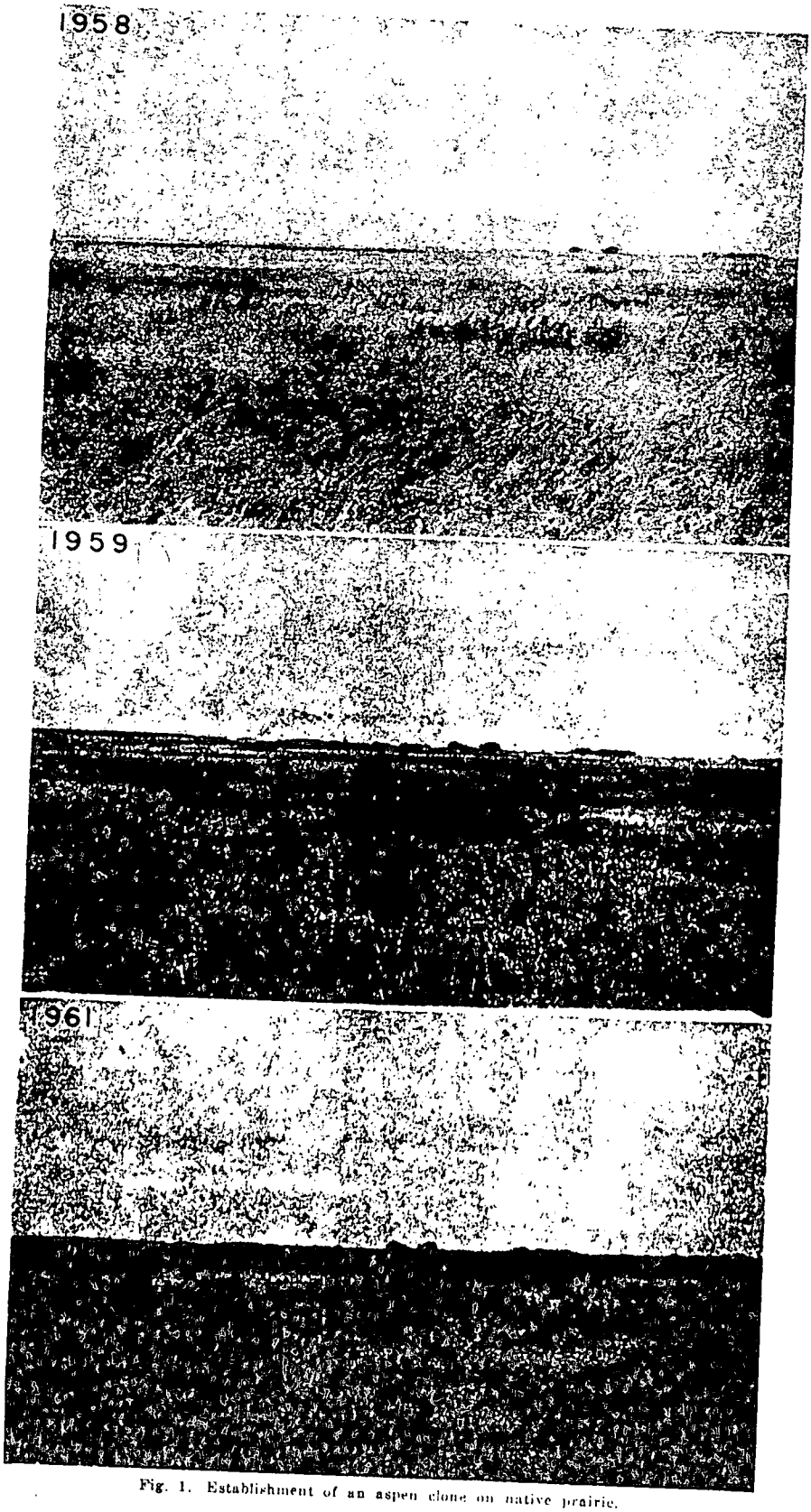

Fig. 1. Establishment of an aspen clone on native prairie.

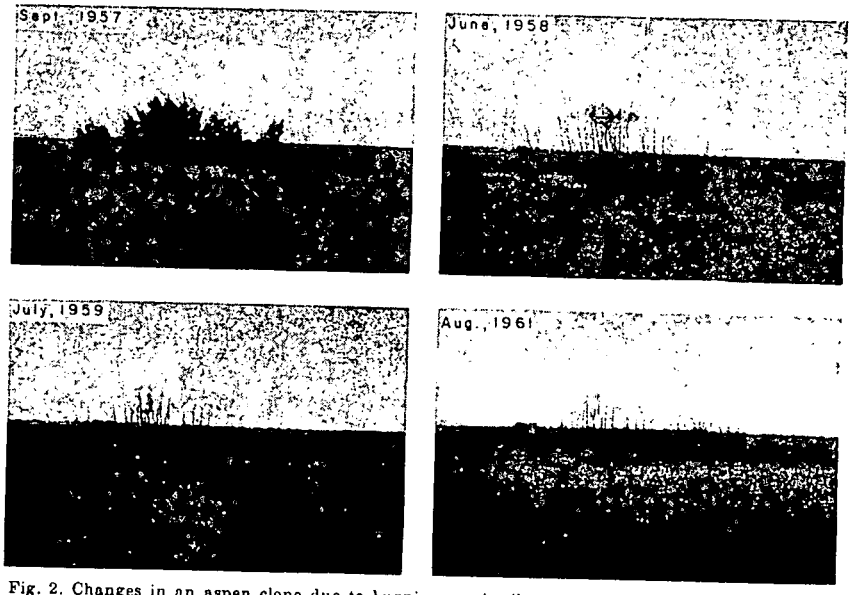

Fig. 2. Changes in an aspen clone due to burning on April 11, 1958. See text for explanation.

Aspen clones were present on both Spring Burn plots on Waubun Prairie but none was located on Fall Burn. Several small plants less than 35 centimeters high were scattered in the burn plots, but numbers were too small to be of use in evaluating the effects of fire.

The changes in the aspen clone on Spring Burn I are illustrated in Figure 2. This stand was located near the center of the 10-acre plot which was burned when fuel was abundant and very dry. A wind estimated at 15-20 miles per hour by the Beaufort Scale at the time of burning resulted in a fire which was hot and fast.

The photograph of September 5, 1957, shows the thicket before burning. The next photograph, June 5, 1958, was taken about two months after the fire and shows that all the aspen smaller than 11 feet in height were killed and that leaves on larger trees were present only above 11 feet. These leaves dried up in approximatly six weeks and the photo one year later on July 4, 1959, shows that all of the trees are dead. On this same photo new aspen sprout growth can be seen behind and to the right of the dead trunks. Two years later, as illustrated in the photo of Aug. 27, 1961, this new growth is over six feet high in places and the thicket again appears as a prominent feature of the landscape.

Figure 3 illustrates the effects of fire on the aspen thicket located 10 feet in from the west edge on Spring Burn II. Fuel and wind

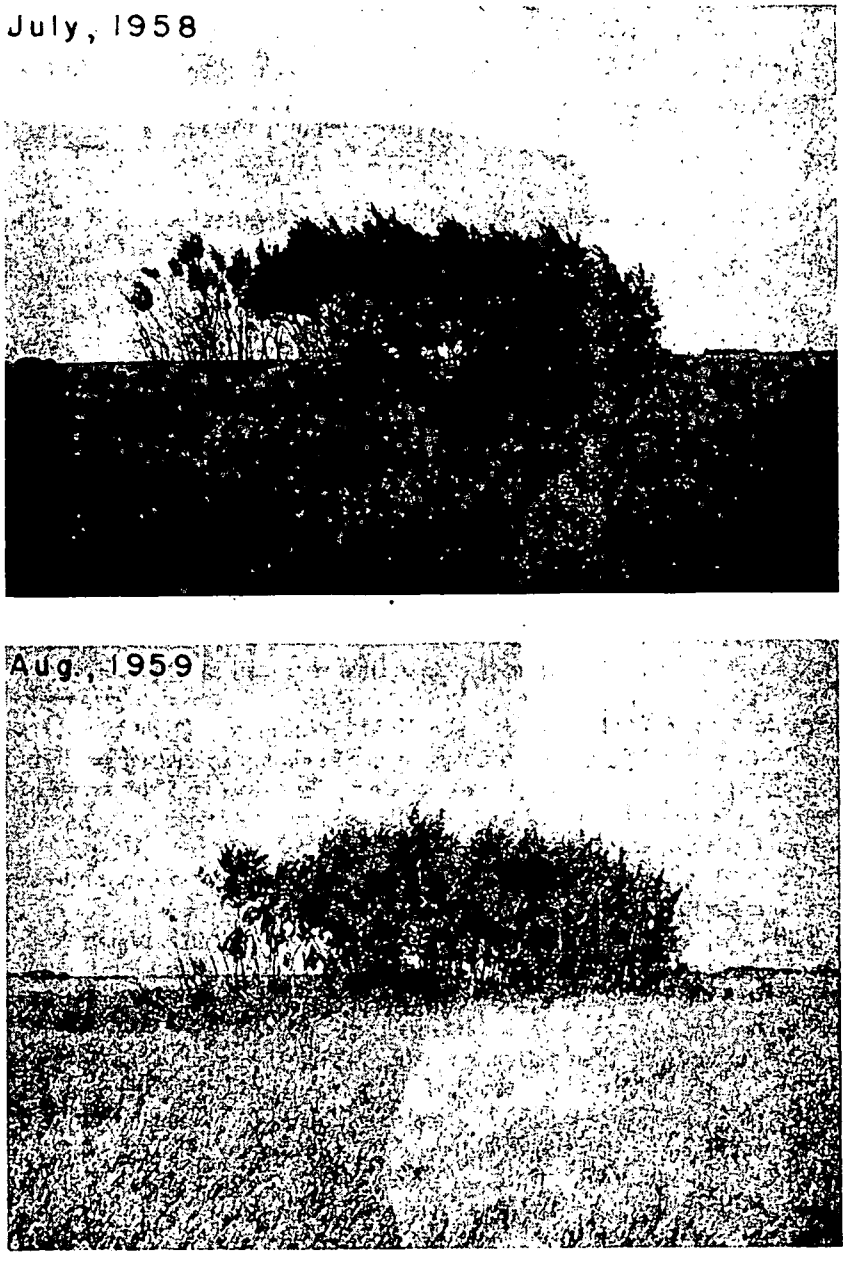

Fig. 3. Effect of fire on an aspen clone. See text for explanation.

conditions for this burn were nearly identical to those on Spring Burn I. The clone was located close to the edge of the plot from which the fire was started. Fuel within the thicket was not as abundant as in the surrounding grassland and since the fire had just burned a few feet from its starting point it did not carry through the stand with uniform intensity. Only about 15 per cent of the trees were killed and these were mostly on the west edge.

A few clumps of willows were located around potholes and in each of the thickets on the Burn plots. In every case the parts of the plants above ground were killed by the fire but abundant sprouting occurred during the first growing season. Ewing (1924) also found that in wet habitats fire kills the tops of willows but does no apparent harm to underground parts.

The Graze plot contained three thickets of aspen and willow. Data on the effect of grazing on woody plants in the 60- by 60-foot plots and the 2- by 50-foot transects are given in Tables 1-4. In an ungrazed thicket one would expect an increase in the number of stems in each height class due to normal growth and regeneration during the summer. Grazing or browsing on the woody plants would be revealed if this increase did not appear in the data or if fewer stems were present after grazing. Statistical tests cannot be applied to the data in Tables 1 and 4 because no thickets were present in the Control plots for comparison or for determining expected values required in the Chi-square analysis.

Table 1 reveals that, under the light grazing which occurred in Quadrats 1 and 2 in 1958, numbers of aspen shoots increased particularly in the 0-2 foot class. Under moderate grazing in 1959 some of the aspen in these two quadrats was utilized and the numbers of shoots reduced. Quadrat 3 was grazed heavily during both seasons and the aspen in all three size classes showed a marked reduction in number after grazing.

The effects of moderate grazing compared to heavy grazing in 1959 are demonstrated more clearly in the 0-2 foot height class of the transect data (Tables 2 and 3). The location of each plant was recorded when the transect was run before grazing. During the "After" run we determined the effects of the grazing on known stems. The data in the tables are adjusted for growth of new plants and increases in height of plants present before grazing. Analysis revealed a Chi-square of 8.68 between the numbers of 0-2 foot aspen before and after moderate grazing and a value of 34.40 in the transects subjected to heavy grazing. The probability of a greater difference occurring under moderate grazing is 0.13 whereas the difference observed under heavy grazing is significant at the 0.01 level. We have concluded on the basis

TABLE 1. EFFECTS OF GRAZING ON NUMBER OF ASPEN STEMS IN 60- BY 60-FOOT QUADRATS, WAUBUN PRAIRIE, 1958-1959

Quadrat No.		Height of Stems 0-2 ft.		2-4 ft.		4+ ft.		Grazing Intensity
		Before	After	Before	After	Before	After	
1	1958	46	81	89	89	26	35	Light
	1959	64	70	94	67	43	34	Moderate
2	1958	36	67	73	84	13	46	Light
	1959	119	77	95	82	53	51	Moderate
3	1958	511	252	35	10	3	....	Heavy
	1959	243	87	41	20	....	....	Heavy

TABLE 2. EFFECTS OF MODERATE GRAZING ON NUMBER OF ASPEN STEMS IN 2- BY 50-FOOT TRANSECTS, WAUBUN PRAIRIE, 1959

Transect No.	Height of Stems 0-2 ft.		2-4 ft.		4+ ft.	
	Before	After	Before	After	Before	After
1	4	1	7	8	2	2
2	3	2	3	2	2	2
3	0	0	4	3	2	3
4	13	6	8	19	1	1
5	7	3	6	5	1	0
6	1	1	2	3	5	4
Chi-square (5 d.f.)	8.68		1.89		1.70	

Chi-square (.05) = 11.07, (.01) = 15.09

TABLE 3. EFFECTS OF HEAVY GRAZING ON NUMBER OF ASPEN STEMS IN 2- BY 50-FOOT TRANSECTS, WAUBUN PRAIRIE, 1959

Transect No.	Height of Stems 0-2 ft.		2-4 ft.		4+ ft.	
	Before	After	Before	After	Before	After
7	28	10	4	2	2	2
8	20	4	1	1	2	1
9	29	15	11	7	2	2
10	11	5	2	0	1	1
Chi-square (3 d.f.)	34.40		4.45		0.5	

Chi-square (.05) = 7.81, (.01) = 11.34.

TABLE 4. EFFECTS OF GRAZING ON NUMBER OF WILLOW STEMS IN 60- BY 60-FOOT QUADRATS, WAUBUN PRAIRIE, 1958-1959

Quadrat No.		Height of Stems 0-2 ft.		2-4 ft.		4+ ft.		Grazing Intensity
		Before	After	Before	After	Before	After	
1	1958	127	241	28	63	2	6	Light
	1959	231	283	76	84	7	13	Moderate
2	1958	105	329	115	140	7	13	Light
	1959	782	451	203	177	1	3	Moderate
3	1958	56	39	....	....	....	....	Heavy
	1959	65	23	....	....	....	....	Heavy

of these findings that annual heavy grazing might control aspen invasion of grassland.

Willow stems were counted in the 60- by 60-foot quadrats in both years (Table 4). Numbers of stems were less after moderate grazing in Quadrat 2 in 1959 and after heavy grazing in Quadrat 3 in both

years. Observations in Quadrat 3 after grazing revealed that the grass was eaten to an average height of 7-10 centimeters and the only plants which were not heavily utilized were several species of goldenrod (*Solidago* spp.) and willow. Although these data cannot be tested further, we feel that they indicate that cattle will utilize some willow on heavily grazed areas.

Effects of grazing on aspen and willow have been reported from other localities. Baker (1918) found that if all new aspen suckers are destroyed by mowing or heavy grazing for three successive years food materials in the roots become exhausted. With no opportunity for replenishment suckering usually ceases. Annual grazing by sheep completely suppressed aspen development in areas in central Utah (Sampson, 1919) and in aspen groveland in Montana (Lynch, 1955). In southeastern Alberta (Kieth, 1961) observed that cattle prevented willow and aspen growth on some sites where conditions were otherwise favorable. Bird (1961) states that in the parklands of Canada trampling and browsing of young aspen by livestock or big game may prevent regeneration. Snowshoe hares (*Lepus americanus*) and bison (*Bison bison*) may have been important in controlling the spread of aspen in prairie (Moss 1932).

Shoreline vegetation.—Some information was obtained during this investigation on the effects of the treatments on vegetation growing at the edges of the potholes. The dominant species occurring here were cattail (*Typha latifolia*), hardstem bulrush (*Scirpus acutus*), cord grass (*Spartina pectinata*), and marsh groundsel (*Senecio congestus*).

It was not possible to mow the shoreline vegetation because machinery could not traverse the soft mucky ground. In other areas, where the ground will support machinery, mowing twice per year has been effective in controlling cattails and some other species (Martin *et al.*, 1957; Martin and Uhler, 1939).

In the Burn plots no changes were noticed in the vegetation around the small potholes which were completely dry at the time of treatment and carried the fire. Apparently not enough fuel was present along the margin of the larger ponds to carry the fire. Martin *et al.* (1957) also found that burning was generally ineffective by itself in control of emergent aquatic species.

Grazing, in contrast to mowing or burning, has pronounced effects on the marsh edge community. The Graze plot on the study area bordered a ten-acre pothole. Light use on the plot in 1958 resulted in limited feeding on and a few trails through the cattail and bulrush. In 1959, when grazing was moderate to heavy, the cattle trampled the marsh edge extensively (Figure 4) and ate substantial amounts of cattail but avoided feeding on bulrush and the other dominant spe-

Fig. 4. Effect of moderate to heavy grazing on shoreline vegetation.

cies. New growth of cattail was often completely eaten. Kieth (1961) found similar effects on grazed marshes in Alberta but mentions that cattle preferred softstem bulrush (*Scirpus validus*) to cattail. In western South Dakota stock ponds Bue *et al.* (1952) found grass type shorelines existing under light grazing and mud shorelines under heavy grazing.

Responses of animals.—The responses of passerine birds, small mammals and two orders of insects on Waubun Prairie to mowing, burning and grazing have been reported (Tester and Marshall 1961) using correlation analysis. The animal populations responded in various ways to the changes in vegetational cover. Some species or groups of related species increased, some decreased or even disappeared from a particular locality, while other populations appeared to be unaffected. Some were affected immediately following application of a treatment and others exhibited a time lag. Summary statements for the components studied are quoted directly:

"There were important changes in the distribution and abundance of breeding pairs of bobolinks (*Dolichonyx oryzvorus*), savannah sparrows (*Passerculus sandwichensis*), and LeConte's sparrows (*Passerherbulus caudacutus*). On the basis of correlation analysis these changes appeared to be most closely associated with changes in litter."

"Changes in populations of the meadow vole (*Microtus pennsylvanicus*) were positively associated with increasing litter. Those of the prairie deer mouse (*Peromyscus maniculatus bairdii*) were negatively associated with increasing litter. Numbers of the masked shrew (*Sorex cinereus*) seemed to be independent of the vegetative characteristics measured."

"Analysis of the data for the two groups of insects indicated that while grasshoppers (Orthoptera) were most abundant where light or moderate amounts of litter were found, large beetle (Coleoptera) populations appeared, on the other hand, to be associated with sparse litter."

MANAGEMENT IMPLICATIONS

On the basis of the findings from this and other studies we feel that proper management of the land for prairie chicken and waterfowl is also the best method for maintaining prairie for research and aesthetic values in this ecotone region. When the habitat requirements of a particular game species are considered the management must be more precise than when only vegetational composition is considered. These requirements and management methods will be discussed for greater prairie chickens, waterfowl production and furbearers.

Greater prairie chicken.—The greater prairie chicken is the upland game species most likely to be benefited by the proper management of grassland areas in this region. This bird requires large sweeps of open prairie unbroken by windbreaks or fence rows. Small areas within this general expanse of grassland must have very short cover which might be the result of burning, grazing, mowing or flattening by snow. These areas are used by the birds as "booming" or courting grounds in the spring (Ammann, 1957; Hamerstrom *et al.*, 1957). The species of grass may not be as important as height, density, growth forms, spacing and growth rate (Hamerstrom *et al.*, 1957); however, Swope (1953) found that prairie chickens appeared to increase on western range land when grazing intensity was reduced and certain grasses increased. Mohler (1952) states that heavily grazed pastures were deficient in tall grass cover and litter and were avoided by prairie chickens.

Nests are most common in mixed vegetation rather than pure stands of grass with some preference being shown for areas with small clumps of brush (Bent, 1932; Hamerstrom, 1939).

Little is known about the relationship between brood behavior or movements and vegetational cover. The need for paths or travel lanes on the ground has been considered by Grange (1948), Baker (1953), Hamerstrom *et al.* (1957), and Hammond (1961). These workers con-

cluded that dead grass or litter must not be too thick or dense and that clump-forming grasses provide optimum cover with bare areas between clumps being used for travel. Baker (1953) states that such bare areas are required for drying-off (sunning) when the grass is wet. Heavy litter may also act as a barrier to feeding (Grange, 1948).

Roosting and loafing habits were studied by Mohler (1952), who found that the birds preferred a dense cover of mixed native grasses with some stems over two feet high and with a dense understory of litter eight inches or more deep. In winter prairie chickens often roost in the snow (Monson, 1934; Bent, 1932) but Hamerstrom *et al.* (1957) found them to use stands of coarse sedges and grasses such as cattail and reed canary (*Phalaris arundinacea*) provided the vegetation is standing up through the snow. This type of vegetation is most common along pothole margins.

Although the diet of prairie chickens varies seasonally, by far the majority of the food is composed of seeds of wild and cultivated plants during the entire year (Martin *et al.*, 1951; Ammann, 1957; Mohler, 1952; and others). Buds and twigs of trees are utilized during the winter (Hamerstrom *et al.*, 1941; Schmidt, 1936). Adult birds may utilize large amounts of animal food at certain times or in certain localities depending upon availability. Young prairie chickens on the other hand are known to require a high proportion of animal food in their diet (Baker, 1953; Hamerstrom and Hamerstrom, 1957). Grasshoppers (Orthoptera) and beetles (Coleoptera) have been shown to be the most important components of the animal food in most parts of the range of the greater prairie chicken (Martin *et al.*, 1951; Baker, 1953; Judd, 1905).

Waterfowl.—Assuming adequate breeding populations, production of waterfowl in the prairies is related to the nature of shoreline cover and its influence on loafing spots and territories; to nesting cover; and to the movement of broods from the nest site to water and between water areas. Numerous studies have shown that breeding pairs are likely to be more abundant on ponds which have a medium amount of shoreline cover (Bue *et al.*, 1952; Glover, 1956; Kieth, 1961). This provides for easy accessibility of loafing spots and an unobstructed view. Bare, muddy shorelines and those solidly filled with emergents such as cattail and bulrush had fewer breeding pairs.

Relationships between nesting and vegetational cover have been reviewed recently by Kieth (1961). The amount and structure of the live and dead vegetation appears to be more important than its species composition. Dead vegetation forms an important part of the actual nest and nest cover in many instances. Mallards (*Anas platyrhyncos platyrhyncos*), pintails (*Anas acuta*) and other early nesting species

make more extensive use of old vegetation than do those such as the lesser scaup (*Aythya affinis*) which nest later in the season.

Hammond (1961) has studied the effects of haying on waterfowl nesting and has concluded that fewer nests can be expected on mowed areas than on unmowed areas, assuming the location of the areas with respect to water is similar. Nest densities were often 3 to 4 times greater on unmowed than on adjacent mowed areas.

Burning generally removes nearly all of the cover from an area and consequently one would expect a minimum number of nests to be present. Pintails have been found nesting in sparse cover and on recent burns (Bent, 1923; Milonski, 1958; Kieth, 1961). Glover (1956) found three nests of blue-winged teal (*Anas discors*) in an area five weeks after burning in Iowa.

The effects of grazing have been observed by numerous workers who conclude that heavy grazing is detrimental to waterfowl nesting and that light grazing may be beneficial (Bennett, 1937; Bue *et al.*, 1952; Glover, 1956; Kieth, 1961). Data are not conclusive with regard to the effect of light grazing but in general these investigators seem to feel that it is not detrimental to duck nesting.

Duck broods may move long distances overland from the place of hatching to water and frequently make extensive movements between water areas (Evans *et al.*, 1952). Kieth (1961) and Mendall (1958) have reported loss of ducklings due to exposure during the first few days after hatching. It is not difficult to imagine ducklings only a few hours old dying from heat exhaustion or exposure to the sun while trying to travel through the dense litter present on the Control plots at Waubun Prairie.

Predators.—Some nest predators have been found to occur more commonly in certain habitat types. For example, Hammond (1940) found that skunks (*Mephitis mephitis*) were more active on mowed areas. Kieth (1961) and Bennett (1938) reported that skunks preferred hunting in heavy ungrazed cover. These observations appear contradictory except that the skunks may be using the mowed areas or areas of sparse vegetation as travel lanes while they move from one area of heavy cover to another. The presence of crows (*Corvus brachyrhychos*) in an area may be determined by the availability of aspen trees which are used as nest sites (Kieth, 1961).

RECOMMENDATIONS

The results of the present study and information obtained from the literature, as presented above, may be used to make certain recommendations for managing native prairie so as to guarantee its maintenance over a period of time.

The ideal management practice for areas such as Waubun Prairie would be a rotation system whereby approximately one-fourth of the area could be burned each year and where portions of the shoreline vegetation could be moderately grazed each year. This rotation should follow a four-year sequence: burn, no treatment, graze, no treatment. The system would be feasible if an area could be divided roughly into quarters, which would be fenced and provided with firebreaks.

In this study temporary measures of controlling fire and grazing were used. Firebreaks were mowed in late summer and backfires were started from them to widen the gap before the major fire was set to burn with the wind. Cattle were controlled by the use of an electric fence on temporarily installed wooden posts. Accurate cost records were not kept but the burning was done in two hours and utilized 11 man hours per 10-acre burn. There was no income from the grazing or mowing because of the experimental nature of the study. In many cases, where larger areas are being managed on a long-time program, some income from both grazing and mowing might be realized.

This type of rotation management would result in a habitat in which most of the cover requirements of prairie chickens and breeding waterfowl would be available on the same area within their seasonal home ranges. In addition the supply of insect food for young prairie chickens would be maintained at a high level.

If only one of the management methods can be utilized on a given area, spring burning appears to be the best. However, during the year following the burn, waterfowl and prairie chicken nesting will probably be at a minimum due to a lack of cover if the entire area is burned. The area will be suitable for these species during the succeeding three years. Insect food supplies will be adequate with this type of management as with the rotation system.

We do not think that annual grazing or even periodic grazing would be a suitable method in itself since light to moderate grazing will not control the invasion of woody species, and moderate to heavy grazing would be required to attain the desired effects on litter and shoreline vegetation. Grazing at this latter intensity could well result in destruction of certain components of prairie vegetation which are considered desirable.

Haying likewise would not be a suitable management tool because it would have virtually no effect on the shoreline vegetation, would result in lack of winter cover each year, would eliminate much nesting cover, and would not control existing thickets of woody species although it may prevent new invasion.

There is, of course, the possibility (not studied in this project) that herbicides could be used to control woody vegetation. However, this

would not have any effect on the litter, grasses, or forbs. We believe that the use of herbicides would not result in maintaining the prairie in its optimum condition.

There is an exceedingly interesting philosophical point in connection with these conclusions. If one reviews the history of our prairies one can only conclude that from time immemorial they have been subjected to periods of drought (due to climate variations), repeated burning (due to natural causes and Indian activity) and repeated overgrazing at intervals (due to mass movements of the buffalo). This is the warp and woof of the environment in which the prairie chicken and prairie waterfowl evolved through time. They were found in tremendous numbers during settlement of the prairie. Is it startling then that fire and grazing are essential to maintaining their habitat?

SUMMARY

A field study to determine the effects of four treatments — spring burning, fall burning, grazing, and mowing — on the flora and fauna of native tall grass prairie was carried on at the Waubun Prairie Research Area in Mahnomen County, Minnesota, from 1957 to 1961. A total of 70 acres of relatively undisturbed native prairie was selected within the 640-acre tract. On five 10-acre plots mowing, grazing, or burning was carried out. Two plots were left untreated and used as controls.

The effects of the four treatments on litter, upland grasses and forbs, upland woody plants, and shoreline vegetation are discussed. The invasion of the prairie by aspen and willow and the effects of burning, grazing and mowing on this invasion are considered in detail.

Based on these data as well as published information on the ecology of both prairie chickens and breeding waterfowl, suggestions for management are made. In brief a four-year rotation of spring burn, no treatment, graze, and no treatment is recommended. We believe such a schedule will maintain the original status of prairie habitats in this ecotone between forest and grasslands.

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DISCUSSION

CHAIRMAN SCHULTZ: Thank you, John. If I am correct, I should mention that the details of this study are available in a publication by the Museum of Natural History, University of Minnesota.

MR. WILLIAM RUTHERFORD [Colorado]: John, does the one-shot removal of woody species, which seems to be the treatment most often applied—that is, burning or spraying with herbicides—actually promote rather than discourage the invasion of woody species?

DR. TESTER: I don't think the one-shot treatment promotes the invasion, and it would definitely not control the invasion unless it is operated on a rotation basis as recommended here. If one burns an area that is being subjected to an invasion by willows or aspen every four years, you will control it because you will kill off the

big four-year-old trees. You will have new ones coming in, but if you burn again four years later they will not grow back. So one can maintain the prairie by this type of rotation, but definitely not with just one burning.

MR. RICHARD HUNT [Wisconsin]: I assume your chickens are resident on the area?

DR. TESTER: Yes, they are.

MR. HUNT: If you were not making these for the resident species, would you recommend a fall burn instead of a spring burn? My reason for this is that I suspect we have some early nesting mallards in some of our prairies in Wisconsin, and I think the fall burn would discourage this.

DR. TESTER: Dick, this would be the only benefit that I could see for fall burning. If the conditions are such that you can burn before the early nesting species gets started, I would still recommend the spring burn. I think there are numerous disadvantages to the fall burn, which I didn't mention, such as subjecting the soil to loss of moisture due to evaporation. When all the litter and vegetation are removed, the moisture in the soil will be pulled out in the wintertime. This wouldn't happen if you conducted a spring burn. Perhaps you'd have erosion problems in some cases, although not on a good prairie site.

MR. R. S. DRISCOLL [Oregon]: Have you evaluated the effects of spring burning on the vegetation composition or production?

DR. TESTER: Yes. Let me say that I am in the process of working with the data. A certain amount of it has been published in the Museum bulletin. I'll just mention that another publication will be coming out on the effects of these treatments on the individual plants in the area.

DR. DANIEL Q. THOMPSON [Wisconsin]: John, what was the picture in these potholes in pre-settlement days? Have you been able to gather any information on that?

DR. TESTER: In regard to what, Dan?

DR. THOMPSON: To willow and aspen invasion around potholes.

DR. TESTER: Oh, yes. I think one can safely say that this area has been subjected to invasion by woody species for hundreds and perhaps thousands of years, but that the invasion was controlled to a very large extent by wildfires which were set both by lightning and by the Indians. This is reasonably well documented in several papers by Dr. Murray Buell.

DR. THOMPSON: I would say that that is pretty much the picture on the Wisconsin marshes in regard to the invasion of willow.