

# Effects of Spring Burning on Yields of Brush Prairie Savanna

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## Highlight

Herbage production the first season after burning was 2,110 lbs. per acre, as compared to 772 lbs. on unburned areas. Burned areas maintained high productivity of grasses and forbs the second year. Dead material comprised about 90% of the total herbage for stands unburned for 25 years, but only 19% on burned stands.

This study was initiated in August, 1959, on Crex Meadows Wildlife Area in the northwestern Wisconsin sand country. The vegetation consists of tall grass, brush prairie savanna—a grassland of big bluestem (*Andropogon gerardi*), Kentucky bluegrass (*Poa pratensis*), *Carex* sp., little bluestem (*Andropogon scoparius*), Junegrass (*Koeleria cristata*), and bluejoint (*Calamagrostis canadensis*), with an overstory of scattered Hill's oak (*Quercus ellipsoidalis*), jack pine (*Pinus banksiana*), hazel (*Corylus americana*), pussy willow (*Salix discolor*), lowbush blueberry (*Vaccinium angustifolium*), and inland ceanothus (*Ceanothus ovatus*). Common forbs include azure aster (*Aster azureus*), stiff sunflower (*Helianthus rigidus*), veiny peavine (*Lathyrus venosus*), and sagewort (*Artemisia ludoviciana*).

The establishment of a fire protection system in the late 1920's led to a general cessation of fires. As a result, tree encroachment has produced a dense even-aged forest of jack pine and oak (Vogl, 1964). In the late 1940's the Game Management Division of the Wisconsin Conservation Department introduced controlled burning to revert the forest growth to brush prairie savanna. The purpose of this study was to determine changes

in productivity resulting from the conversion by fire.

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## Methods

Controlled burning commenced after winter snows dissipated in March and April. Samples of herbage yield were taken the last two weeks of August when plant growth was complete. Only above-ground portions of plants were sampled.

Six sample stands of uniform topography and vegetational composition were selected on undisturbed upland sites at least 25 acres in extent.

Two controls, unburned for 25 years, were located adjacent to four burned stands and were similar to the burns except for treatment by prescribed fire. The burned stands had from one to five controlled fires in the last ten years. Two of the burned stands were sampled at the end of the first growing season and two were sampled two growing seasons following burning.

Each stand was observed for homogeneity of dominant species before selecting an area of uniform vegetation 33 meters square for sampling. Within this square the sample was taken by laying out at random 20 quadrats, each 0.25 meter in size (50 cm on a side). The standing vegetation in each quadrat was hand clipped at ground level and the living

vegetation was divided into grasses, forbs, and shrubs. The dead component was separated into the standing portion and the litter or duff.

After clipping, the green grasses, forbs, and shrubs were separately bagged, labeled, and weighed to the nearest 0.01 gram to obtain fresh weights and then thoroughly air-dried for one month. The entire sample was too large to oven-dry. As a check on the air-dried weights, 17% of the bags were selected randomly and dried in a hot-air oven for 48 hours at 85°C. This revealed that air-drying removed 89.2% of the moisture. Consequently, a correction factor was applied to the entire sample so that all weights were corrected to oven-dried weights and have been converted to pounds per acre.

## Results and Discussion

**Green Herbage Yields.**—The average productivity expressed in pounds per acre dry weight is summarized in Table 1. The yields of burns sampled after one and two growing seasons were averaged separately. The average total green herbage was 772 lbs. per acre in the controls and 2,110 lbs. per acre one growing season after burning. Burning produced a 1,338 lb. per acre gain with a more than three-fold increase in grass and forb yield over that found in the controls.

The average green productivity at the end of two growing seasons (1958 and 1959) still showed a marked increase following the 1958 burning (Table 1). This gain was about 23% less than the increase resulting from the initial first year stimulus. This subsidence was particularly reflected in the shrub yield, implying that woody perennials were the first species to lose the stimulus of burning. The yield of grasses and forbs decreased only slightly when compared to the first year yield, indicating that high annual productivity for

**Table 1. Average yield for burns and controls in pounds per acre dry weight.**

	Green Herbage				Dead Herbage			Green and Dead
	Grasses	Forbs	Shrubs	Total	Stand- ing	Litter	Total	Grand Total
<b>Burns</b>								
1 growing season	1,341	192	577	2,110	80	411	491	2,601
2 growing seasons	1,198	188	237	1,623	617	1,261	1,878	3,501
Controls	312	45	415	772	367	4,613	4,980	5,752

these species was maintained through the second year. Hadley and Kieckhefer (1963) noted a similar decrease in productivity and Ehrenreich and Aikman (1963) found a 15% subsidence in yield the second year after burning.

**Dead Herbage Yields.**—A comparison of controls to one-year burns disclosed that burning reduced dead herbage yields from 4,980 to 491 lbs. per acre. Fire removed 91% of the litter and 78% of the dead standing vegetation. All of the dead standing material was not removed because some dead vegetation accumulated during the first growing season. Most of the prescribed fires were rapidly moving headfires. This type of fire does not always burn clean to the ground or get hot near the soil surface (Davis and Martin, 1960). Consequently, not all of the litter was consumed, particularly some of the heavier fuels which retain more moisture.

There was a pronounced accumulation of dead vegetation at the end of the second growing season following burning, with three times more litter accumulated after two seasons (1958 and 1959) than after one growing season (1959). The build-up of litter in the burns in 1959 was due primarily to the increase in green herbage in the 1958 growing season which had died but not decomposed.

During the second growing season (1959), the burned stands

had almost twice as much dead standing vegetation as the controls. Ordinarily, most of this standing material would have been knocked down and added to the litter by snow cover, but the 1958-59 winter lacked heavy snow.

In the controls or stands unburned for 25 years, the dead herbage comprised about 90% of the total yield. This indicated that in unburned brush prairie savanna most of the nutrients were held in the dead herbage and were only released gradually as the litter decomposed and was incorporated into the light sandy soils.

The mantle of dead and decaying vegetation not only captured most of the nutrients, but also tended to stifle and physically impair vigorous growth (Dyksterhuis and Schmutz, 1947; Curtis and Partch, 1950). The introduction of fire released growth with the removal of this choking cover of litter. When fire consumed the dead herbage, there was an accelerated release of nutrients and in this sense, fire was a form of rapid decomposition which quickly converted the slowly decaying plant material into readily available nutrients.

The dead herbage was converted to ash by the spring burning and was immediately used to produce healthy, abundant growth. In addition, the conversion of the litter layer to a blackened surface of ash stimulated

earlier growth due to warmer surface temperatures in spring (Ehrenreich and Aikman, 1963). Unburned litter, contrarily, served as an insulation that kept the ground cooler until later in the growing season (Weaver and Rowland, 1952). Thus, burning rapidly released the nutrients trapped in the litter layer, transferring them to the standing crop of green plants where they were more readily available to browsing and grazing animals.

**Water Content.**—The average water content expressed as a percent of the total plant weight in the controls was 28.3% for grasses, 11.6% for forbs, and 20.2% for shrubs; in the burns, 40.8% for grasses, 23.9% for forbs, and 25.2% for shrubs. Thus, burning increased the plant water content. Forbs doubled in water content and grasses increased by almost one-half with burning. Woody shrubs had the smallest response with a 25% rise.

Many plant species become more desirable and palatable to herbivores with an increase in percent water content. The greater succulence of grasses, forbs, and shrubs produced by burning often increases utilization. The succulent resprouts of woody perennials, for example, are preferred to older unburned growth by browsers such as deer.

Burned prairie savanna forage was more productive because of increased water content, larger plant size, and greater nutritional value. The removal of litter by spring burning also produced earlier and more readily available herbage for grazing animals.

**Repeated Burning.**—Annual yields of the four burns and two controls are shown in Figure 1. The average pounds per acre are expressed as percentages of the highest value. Each stand is divided into relative percentages of forbs, shrubs, and grasses.

Figure 1 graphically illustrates the increase in annual produc-

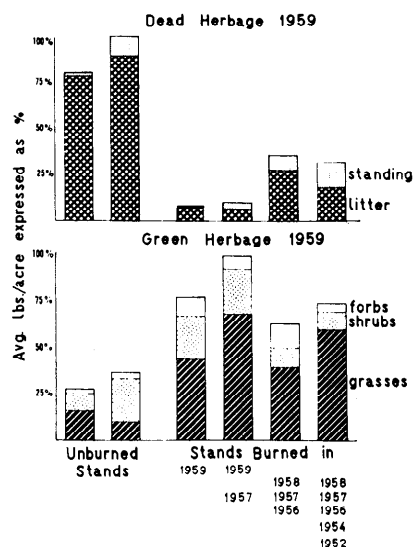


FIGURE 1. Annual yields of dead and green herbage for the two controls and four burns. Dry weights are expressed as percentages of the highest value. Spring burnings occurred in the years listed.

tivity produced by burning, particularly the increase in grass yield. Although more species of forbs were present than of grasses, the latter account for the higher yield because of their larger size and the greater numbers per species.

The percentages of dead herbage (standing and litter), showing the reduction in plant accumulations after burning, are also included in Figure 1. Three of the burned stands had a history of repeated fires. One stand had a total of five spring burns at two year intervals or less. Burning every other year did not appear to have harmful effects on the standing crop. In fact, a sustained high yield of grasses occurred. However, the reduction in shrubs indicated that biennial burning reduced woody plant yields and was harmful despite the fact that some woody perennials were fire adapted by their ability to resprout. This repeated burning also kept the accumulated litter at low levels (Figure 1). The results indicated that burning biennially was not detrimental to the standing crop of prairie plants in this prairie-for-

est border region. In fact, when the quantity of litter exceeded the annual yield, burning was beneficial as it stimulated increased seedstalk production of native grasses (Curtis and Partch, 1950; Ehrenreich and Aikman, 1963). This study indicated that burning can be beneficial and important in the maintenance of tall grass, brush prairie savanna. Fire is effective in keeping the grassland from becoming decadent, in keeping trees suppressed as brush, and in retarding the encroachment of woody plants that might otherwise cause the savanna to succeed to forest.

Spring burning of prairie does not always produce increased yields or have beneficial effects. Reactions to fire vary with the type of prairie, fuel amounts, soils, and moisture conditions. Hopkins et al. (1948) and Launchbaugh (1964), for example, found that short grass prairie yields were reduced by burning. Fire was considered detrimental because it reduced soil moisture and heavy litter accumulations produced hot fires which killed some plants.

*Recovery Time.*—Estimations of time required for brush prairie savanna to revert to a condition similar to that in unburned stands can be made by comparing the rates of decrease in annual productivity and the rates of accumulation of litter following burning. At the end of the second growing season, the annual productivity decreased to one-fourth of the previous year's growth, and the litter accumulated to one-third of the amounts found in the unburned controls. Based on these rates, the ground layer vegetation would probably return to a preburn condition within four years, assuming that the rates continued at the same magnitude. However, rates would presumably decline in succeeding years, and it might take up to six years to revert to

preburn conditions. On Minnesota prairie savanna, an accumulation of litter of preburn depths resulted two to three years after burning (Tester and Marshall, 1961). In Illinois, the restoration of litter levels to those of unburned controls required at least two to three years of non-burning (Hadley and Kieckhefer, 1963). The burned prairie mulch structure in North Dakota completely recovered by the end of the fourth growing season (Dix, 1960). Ehrenreich and Aikman (1963) found that a rapid build-up of tall grass prairie litter occurred for three years with a leveling off by the eighth year after burning.

Certain management suggestions can be made from the preceding results. Burning once every four to six years will help maintain maximum productivity. Fires occurring at less frequent intervals, perhaps once every ten years, are effective in maintaining brush prairie savanna. Generally, there should be enough fuel to carry a fire as hot and as consuming as the initial fire on an area unburned for 25 years after six non-burn years.

#### Summary

Spring burning of brush prairie savanna in northwestern Wisconsin produced more than 1,000 lb. per acre increase in the above-ground portions of green herbage, with a three-fold increase in grass and forb yield. High annual productivity was maintained for grasses and forbs the second season after burning, but shrubs returned to preburn levels. Green herbage was more productive, palatable, and desirable to herbivores when burning increased the water content.

Dead herbage comprised about 90% of the total yield of stands unburned for 25 years and was reduced to 19% by burning. The removal of dead herbage stimulated earlier and more vigorous

growth and made forage more accessible to herbivores.

Repeated burning, up to once every other year, kept litter at low levels, resulted in high annual yields, and produced a rapid cycling of nutrients.

The ground layer vegetation appears to revert to a preburn condition between four to six years.

Periodic burning prevents prairie savanna from becoming decadent, helps maintain maximum productivity, and is important in retarding the woody growth which otherwise enables savanna to succeed to forest.

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