Proper Burning Intervals for Tobosagrass in West Texas Based on Nitrogen Dynamics

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Highlight: The time required for re-establishment of pre-fire nitrogen levels in tobosagrass (*Hilaria mutica*) communities in the Rolling Plains of West Texas was studied on five different ages of burns over a 2-year period. Time elapsed after burns varied from one to five growing seasons for both convex and concave topographic sites near Colorado City, Texas. Standing old growth-N returned to pre-fire levels by the end of the third growing season. However, litter-N on the soil surface took 5 years to reach pre-fire levels on concave sites and an estimated 8 years on convex sites. High variation prevented the recognition of any meaningful trends in root or soil nitrogen levels. Based on this data, tobosagrass should not be burned more frequently than 5 to 8 years, depending on the site.

Fire has many beneficial effects in tobosagrass (*Hilaria mutica*) communities. It removes dead, standing mesquite (*Prosopis glandulosa* var. *glandulosa*) stems, which often pose an obstacle to the working of livestock. It has some value for control of unwanted plants such as mesquite, cactus, and cool season forbs such as annual broomweed (*Xanthocephalum dracunculoides*) (Wright 1972). But, probably the most dramatic benefit following fire for the rancher is the two- to three-fold increase in grass production (Wright 1969, 1972) and the 10- to 15-fold increase in utilization (Heirman and Wright 1973) during the first growing season after burning. Reports of these benefits during years with average to above-average precipitation have greatly increased rancher interest in burning programs. Thus, the use of prescribed fire in tobosagrass communities can be expected to increase substantially in the near future.

Although the benefits of controlled fire have been well documented, a management recommendation concerning how often tobosagrass communities can be burned without adverse effects has not been reported. A recently completed study (Sharrow and Wright 1977) indicates that higher tobosagrass yields following fire are accompanied by a reduction in the amount of nitrogen stored in the soil. Thus, too frequent burning may deplete the soil nitrogen reserves and reduce future plant growth. This concept is further supported by our observation that areas which are reburned within 2 or 3 years after the first burn do not produce as much herbage as areas which are burned for the first time. This would tend to indicate that a burning freqency of one fire every 2 or 3 years is potentially damaging t the future productivity of tobosagrass.

The objective of this study was to estimate the proper burnin interval for tobosagrass communities based on the amount c nitrogen contained in current growth, standing old growtl litter, roots, and soil. This approach was taken for two reason: First, nitrogen, which is easily consumed by fire (Sharrow an Wright 1977), often limits plant production in grassland com munities (Power and Alessi 1971); and second, the stability c the nitrogen cycle within an ecosystem is often indicative of th stability of the ecosystem as a whole (Pomeroy 1970).

Methods and Procedures

Two replications of five different aged burns on convex and conca topographic sites, ranging from one to five growing seasons, we sampled for nitrogen content in July, 1973, and again in July, 1974, c the Spade Ranch near Colorado City, Texas. Elevation is 633 m ar annual precipitation is 48 cm.

Prior to prescribed burning treatments, the experimental plo supported a typical herbicide-sprayed mesquite-tobosagrass com munity in the Rolling Plains. The vegetation consisted of a dense star of tobosagrass with a fairly open overstory of mesquite trees. Both t tobosagrass and the mesquite were more dense on the concave site which receive more runoff water than the more xeric, convex site which lose water as runoff during rainstorms (Fig. 1). The mesquite c all plots was top-killed with 2,4,5-T in 1966, but resprouts from bas buds had grown over 5 ft high by the time this study was initiated 1973. The soil on all sites was a Typic Chromustert (heavy clay of tl Stamford series) with pronounced vertic (shrinking and swellin properties.

For convenience of study, the nitrogen content of these plots w subdivided into five increments: (1) current growth, (2) past year standing old growth, (3) litter, (4) coarse roots, and (5) soil (include fine roots). All aerial plant parts produced from April through July the current growing season were included in new growth. Old grow consisted of all dead standing vegetation produced prior to the curre growing season, while material lying at or near the soil surface w considered litter if it was easily recognized to be of plant origin. Sc included both mineral soil and organic matter which was too decon posed to be easily recognized as a plant organ as well as fibrous gra roots which were too fine to be hand sorted from soil samples. Roo included only the large rhizomes and the coarse fibrous roots tobosagrass. No tree or shrub roots were encountered during samplin

During 1973 and 1974 plant material was collected down to the so surface from twenty 0.09-m^2 rectangular quadrats in each replicatio This material was hand-sorted into current tobosa growth, past year standing old growth, and litter. The sorted material was oven drie (60°C for 36 hours), weighed, and ground in a Wiley mill to pass #40 screen.

Five soil nitrogen samples and 40 root nitrogen samples we

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Fig. 1. *Concave tobosagrass sites (immediate foreground) reach pre-fire litter-N levels in 5 years, whereas convex sites (distant background) require 8 years to reach pre-fire litter-N levels. This photo was taken 3 years after a prescribed burn.*

collected on each replication to a depth of 5 cm. Soil samples were oven dried (60°C for 36 hours), weighed, and ground with a mortar and pestle to pass a 1-mm sieve. All soil was washed off the roots for root nitrogen samples. Roots were then oven dried (60°C), weighed, and ground in a Wiley mill to pass a #40 screen. Total nitrogen was determined for every soil, plant, and root sample using a Coleman nitrogen analyzer.

Nitrogen in current growth, past years' standing old growth, litter, and roots was separately calculated by multiplication of their standing biomass by their percent nitrogen content (based on oven-dry weight).

Soil nitrogen was converted from percent oven-dry weight to kg/ha by multiplication of percent nitrogen times soil bulk density, times the appropriate conversion constant (cc/ha for a 5-cm soil depth). Total nitrogen contained in each plant or soil increment of a burn was compared to an unburned area to determine the length of time required for the re-establishment of pre-fire nitrogen levels.

The effectiveness of all treatments was determined statistically by Snedecor's *F*-test. Treatment means were separated using Duncan's multiple range test. The critical region for all tests was at the .05 level.

Results and Discussion

Precipitation during 1973 was 46% above the long-time average for Colorado City, Tex., with 34 cm falling during the winter-spring period (January 1 to July 1) and 36 cm falling during the summer-fall period (July 1 to December 31). However, precipitation during the period of most rapid growth in May and June was less than 50% of normal. This rainfall pattern (high winter precipitation and low spring precipitation) permitted plant growth to be slightly above normal. In contrast, precipitation in 1974 was 54% below average until August 1, with only 11 cm falling during the winter-spring period. Thus, in determining the long-term effects of fire on plants and soil nitrogen in tobosagrass communities, a wetter than average year is contrasted with a dry year.

The amount of nitrogen contained in the new growth-N increment of a plant community is a direct expression of the current productivity of that community. Fortunately, the productivity of tobosagrass-mesquite communities following prescribed burning has been well documented. Wright (1972), working on areas intermediate to the concave and convex sites examined in this study, reported that burning dramatically increased tobosagrass production during years of average or above-average precipitation. He further noted, however, that during dry years, production either did not increase or was actually reduced by burning. Several other authors have reported a similar pattern of increased tobosagrass yields during normal or wet years (Heirman and Wright 1973) and reduced yields following burning during dry years (Dwyer 1972). Thus,

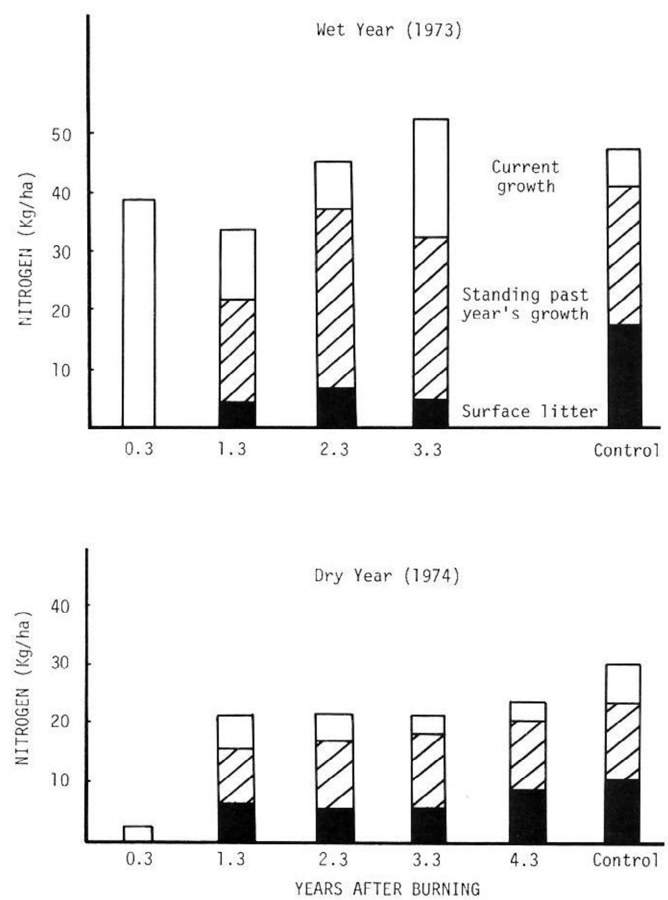

Fig. 2. *Nitrogen content of tobosagrass material in July, 1973 and 1974, on* convex *topographic sites for five different ages of burns and on unburned control near Colorado City, Texas.*

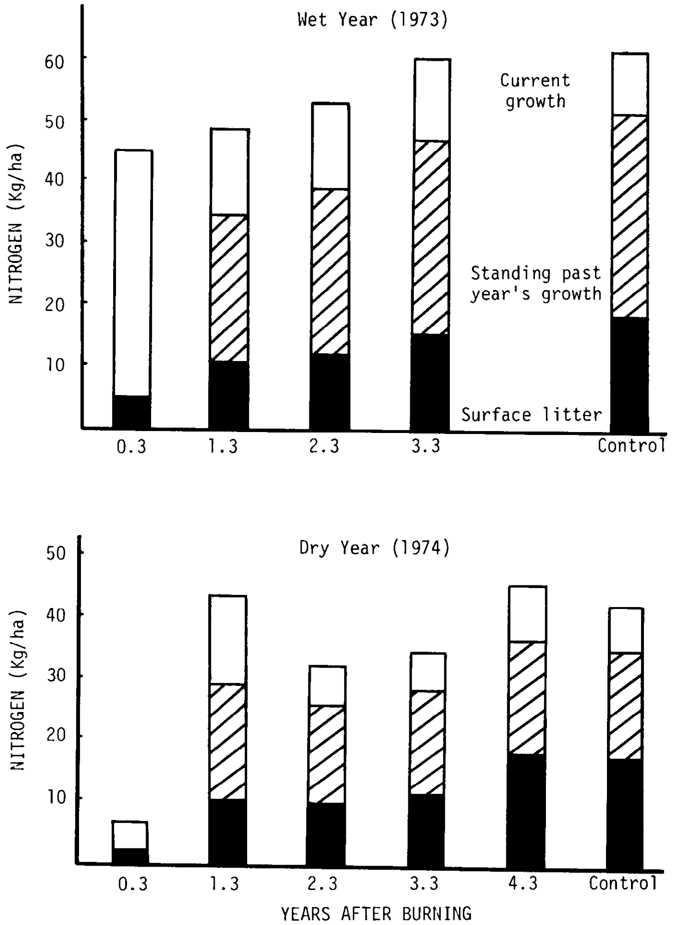

Fig. 3. *Nitrogen content of tobosagrass material in July, 1973 and 1974, on* concave *topographic sites for five different ages of burns and an unburned control near Colorado City, Texas.*

this wet year-dry year response pattern appears to be typical for tobosagrass. One might well expect that this same pattern would be evident in new growth-N levels. This was indeed the case (Figs. 2 and 3).

During a wet year, 1973, new growth-N levels dramatically increased the first growing season following fire. During a dry year, 1974, fire reduced new growth-N levels the first growing season. In addition, there appeared to be a residual effect which tends to sustain increased new growth-N levels during wet to normal years and to depress new growth-N levels during dry years for 3 or 4 years following burning. Other workers (Wright 1972; Neuenschwander and Wright 1974) have also noticed this residual effect and arrived at a similar estimate of its longevity. It therefore appears that regardless of the initial response to fire, new growth-N usually returns to pre-fire levels by the end of the third or fourth growing season.

Litter and old growth often play an important role in regulating the productivity of grassland communities (Ehrenreich and Aikman 1963; Old 1969). Together, they form an insulating layer which can effectively reduce the rates of spring soil warm up (Ehrenreich and Aikman 1963; Weaver and Rowland 1952), delay fall soil cooling (MacKinney 1929), reduce evaporative water loss from the soil surface (Weaver and Rowland 1952; Glendening 1942), and protect the soil surface from erosion (Whigham and Ueckert 1975). In addition, they may serve as an important nitrogen reserve which can become available for future plant growth through the processes of organic decay, nitrogen mineralization, and nitrification.

Fire removes almost all of the litter and old growth, leaving behind a thin layer of ash and charred material (Sharrow 1975). Thus, old growth-N is reduced almost to zero the first growing season following fire. Relatively high new growth-N produced the first two growing seasons after prescribed burning contributed substantially to old growth-N measured in succeeding years (Figs. 2 and 3). Increased plant productivity following the fires restored old growth-N to pre-fire levels by the end of the third growing season. Similarities between the time required for both new growth-N and old growth-N to recover from fire support the theory that old growth plays an important role in regulating the productivity of tobosagrass communities.

Fire removed a large portion of the accumulated litter-N originally present. Litter-N then gradually accumulated during the first four growing seasons. During the fifth growing season, litter-N abruptly increased to pre-fire levels on concave sites, but had not reached equilibrium by the fifth growing season on the less productive, convex sites (Figs. 2 and 3). A similar trend in litter accumulation was observed on convex tobosagrass sites by Whigham and Ueckert (1975).

The longevity of tobosa culms most likely produces the following pattern of litter accumulation. Culms produced following a fire will stand erect and live for several years before they die, break off, and contribute to the litter layer. Thus, during the first four growing seasons following fire, few dead stems are available and litter fall condists mostly of dead leaf blades. By the end of the fourth and fifth growing season, many stems have died and are sufficiently decomposed to fall as litter.

Of all the nitrogen increments examined, the litter-N increment was the last to recover following burning. The apparent susceptibility of litter-N to consumption by fire, its relative slowness to reaccumulate following fire, and its possible importance as a transition increment between the old growth-N and soil-N increments makes the re-establishment of litter-N our best indicator of community-N recovery following fire.

Table 1. Nitrogen content (kg/ha) of the upper 5 cm of soil in July of 1973 and 1974 measured on two topographic sites for five different ages of burns and an unburned area, near Colorado City, Texas.[1]

	Year of sampled/site			
	1973		1974	
Year burned	Convex site	Concave site	Convex site	Concave site
1974	—	—	655[a]	1036[ab]
1973	624[a]	802[b]	964[b]	1112[abc]
1972	1005[a]	857[b]	1045[b]	916[a]
1971	692[a]	527[a]	869[ab]	934[a]
1970	819[a]	1185[c]	1045[b]	1334[bc]
Unburned	704[a]	1237[c]	874[ab]	1174[bc]

[1] Means in a column not sharing a common letter are statistically different at $P = 0.05$. All data have been adjusted to a common bulk density.

Table 2. Nitrogen content (kg/ha) of tobosa roots in the top 5 cm of soil in July, 1974, measured on five different ages of burns and an unburned area, near Colorado City, Texas.[1]

	Topographic	
Year burned	Convex site	Concave site
1974	22.3[a]	23.2[a]
1973	26.3[a]	21.5[a]
1972	17.9[a]	42.1[c]
1971	21.6[a]	26.4[ab]
1970	19.0[a]	36.7[bc]
Unburned	19.0[a]	21.5[a]

[1] Means in a column not sharing a common letter are statistically different at $P = 0.05$.

Soil and tobosa root nitrogen contents in the upper 5 cm of soil are present in Tables 1 and 2. Sharrow and Wright (1977) reported decreased total soil nitrogen levels during an entire year on burned compared to unburned tobosagrass plots. Here, however, no meaningful soil-N or root-N patterns were observable, perhaps because of the high variation between the areas sampled and the relatively large amount of nitrogen stored in the soil increment.

Management Implications

The foregoing observations suggest that tobosagrass communities on concave sites in the Rolling Plains generally can be burned at 5-year intervals without depleting the community nitrogen reserves. Convex sites are slower to recover from fire and probably should not be burned more frequently than once every 7 or 8 years (Fig. 1).

A management plan which observes these proper burning intervals should allow ranchers to reap the benefits of prescribed burning without depleting the community nitrogen reserves. However, the actual time required for the community to recover from fire will probably vary somewhat with yearly precipitation patterns. A series of dry years will likely delay recovery, while a series of wet years should hasten recovery. As with most range management practices, precipitation patterns should be taken into account when a management plan is executed.

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