Shrub and Herbaceous Vegetation after 20 Years of Prescribed Burning in the South Carolina Coastal Plain

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Highlight: *Twenty years of prescribed burning at different seasons and different frequencies altered the condition of shrub and herbaceous vegetation in the Lower Coastal Plain of South Carolina. The six treatments consisted of annual winter, annual summer, periodic winter, periodic summer, and biennial summer burning, and a no-burn control. Percentage of ground cover increased with most burning treatments, and herbage yields increased with all burning treatments. Annual summer burning eliminated most shrubs; however, dense stands of sprouting shrubs persisted on the periodic summer and on both the annual and periodic winter treatments. The number of herbaceous species and the density of herbaceous plants increased with burning, especially on the annual and biennial summer treatments where grasses became the dominant plants. Most of these changes appear beneficial for wildlife or grazing.*

Southern woodlands were frequently and repeatedly burned by wildfire before white men came to this continent. Since then, fire has been used in the South for several hundred years as a primary tool in man's management of understory vegetation. Although at times its use has been controversial, modern-day managers of woodlands in the South generally feel fire is essential for managing pinelands and for maintaining grazing resources and desirable habitats for wildlife. Total exclusion of fire produces woodlands with dense hardwood understories that provide little forage for wildlife and domestic animals and make reproduction of pines impossible. The character of natural areas, from which fire was only recently excluded, is greatly altered. Furthermore, as fuels build up, the threat of wildfire destroying the whole plant community increases. Therefore, it is sometimes desirable to manipulate understory vegetation to restrain the successional trend of vegetation for the benefit of timber, wildlife, cattle, recreation, and natural areas. However, little is known about the long-term effects of repeated burning on density and species composition of understory vegetation.

Stoddard (1931, 1935, 1963), Rosene (1954), Lay (1956), and Hewitt (1967) showed that controlled burning can improve the understory vegetation for wildlife habitat. Greene (1935) and Wahlenberg et al. (1939) noted the effects of annual burning on legumes and other herbaceous plants, while Moore (1956), Hodgkins (1958), and Cushwa et al. (1966) observed responses of legumes and other plants to season of burning.

These studies, however, were not concerned with various frequencies of repeated application of fire over many years. The long-term prescribed burning study on the Santee and Westvaco Experimental Forests (Lotti et al., 1960) provided an opportunity to study understory vegetation with a long recorded history of controlled burning. We are reporting on the status of the shrub and herbaceous vegetation after 20 years of repeated summer and winter burning.

The effects of fire on herbage yield are not completely clear, but herbaceous ground cover declined with fire exclusion in south Florida (Hilmon and Hughes, 1965), Mississippi (Wahlenberg et al., 1939), and south Georgia (Lemon, 1949; Halls et al., 1956). Duvall (1962) concluded that preventing litter accumulation, either by grazing or by fire, maintained highest yields on pine-bluestem ranges in Louisiana. Also, yields of wiregrass herbage decreased with fire protection in south-central Georgia, but higher levels of productivity returned with re-introduction of fire (Lewis and Hart, 1972). Burning in late winter or early spring has produced higher herbage yields than fall or early winter fires (Lewis, 1964).

Methods

Study Area

The Santee Experimental Forest is in Berkley County and the Westvaco Experimental Forest is in Georgetown County, South Carolina. The areas are 25 to 30 ft above sea level. The soils are fine sandy loams that are poorly drained with slow surface runoff and medium to very slow permeability. The soil profile is very acid and low in nutrients; organic matter is nearly absent below the surface 3 to 4 inches.

The study plots were installed on previously unmanaged but well-stocked, even-aged loblolly pine stands containing uniformly distributed, heavy hardwood understories. The major hardwood species included sweetgum, blackgum, and various oaks such as post, blackjack, willow, and southern red. Less important trees were flowering dogwood, red maple, American holly, and hickories. South-

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The investigations reported were done cooperatively by the Southeastern Forest Experiment Station; Westvaco Corporation; and the Coastal Plain Experiment Station, College of Agriculture, University of Georgia.

Manuscript received April 28, 1975.

ern waxmyrtle, pepperbush, and gallberry were the most common shrubs. Common and scientific names of the plants encountered on study plots are listed in Table 1.

When the study was begun in 1946, the loblolly pine stands were 39 years old on the Santee and 33 years old on the Westvaco Experimental Forest. Since then, three improvement cuts have been made on the Santee plots and two on the Westvaco plots. These thinnings were mainly from below to remove the smaller, inferior trees.

Treatments

The study on response of woody and herbaceous vegetation to long-term burning was designed as a randomized complete block with five replications of six treatments. These treatments included burning annually in the summer, annually in the winter, periodically in the summer, periodically in the winter, and biennially in the summer, plus a no-burn control. All treatments were continued for 20 years except the biennial summer burn, which has a 16-year history. Treatment plots were sampled the last week in October 1967 after plant growth had ceased.

Fire was applied as soon as the weather permitted after December 1 (winter burns) and June 1 (summer burns). The periodic treatments were burned whenever 25% of certain hardwood stems reached 2.0 inches dbh. Backfires were generally used in winter treatments and headfires in summer. Density and wetness of fuels were causes for occasionally changing the type of burning.

Sampling Techniques

Each treatment plot measured about 104 X 104 ft. A vegetation measurement area of 80 X80 ft was centrally located in each plot and divided into eight alternating rows of 10 X 80 ft for location of line transects and rows of plots for clipping.

Crown spread was measured by species or species group to the nearest 0.1 foot along two randomly selected 80-ft transects in each treatment plot. Coverage was measured by species as the leafy portion occurring below 4.5 ft. Also, the proportion of ground covered by living vegetation below 4.5 ft was estimated on each transect.

Herbage yield was measured by clipping total herbage from three 9.6-ft^2 subplots in each treatment plot; these were randomly selected with the restriction that no more than one subplot could be selected in any row of plots. All herbaceous vegetation on a subplot was clipped about ½ inch above the ground. Herbage yields are reported in ovendry pounds per acre.

The herbaceous vegetation on each subplot was evaluated before clipping to determine each species' contribution to total yield. The five most important species in terms of estimated weight were listed in their order of importance. Then all other species on the subplot were listed. Numerical values were assigned to these ratings beginning with "6" for the most important and decreasing one value for each lesser degree of importance; all species other than the five most important were assigned the value "1." The overall importance of a species' contri-

Table 1. Common and botanical names of plants.

Common name	Botanical name
Forbs	
Beggar-lice	*Desmodium* spp.
Blackroot	*Pterocaulon pycnostachyum* (Michx.) Ell.
Bracken fern	*Pteridium aquilinum* (L.) Kuhn
Bushy aster	*Aster dumosus* L.
Butterfly-pea	*Centrosema virginianum* (L.) Bentham
Centella	*Centella asiatica* (L.) Urban
Dogfennel	*Eupatorium* spp.
Elephant foot	*Elephantopus* sp.
Fleabane	*Erigeron* spp.
Fragrant goldenrod	*Solidago odora* Ait.
Gerardia	*Gerardia* sp.
Hairy trilisa	*Trilisa paniculata* (Walt. ex. Gmel.) Cass.
Lespedeza	*Lespedeza* spp.
Maryland goldaster	*Heterotheca mariana* (L.) Shinners
Meadow beauty	*Rhexia* spp.
Mexican-clover	*Richardia scabra* L.
Milkpea	*Galactia* spp.
Partridgepea	*Cassia* spp.
Pencil flower	*Stylosanthes biflora* (L.) BSP
Roundhead lespedeza	*Lespedeza capitata* Michx.
Sunflower	*Helianthus* sp.
Tephrosia	*Tephrosia* spp.
Grasses	
Arrowfeather threeawn	*Aristida purpurascens* Poir.
Bluestem, big	*Andropogon gerardii* Vitm.
Bluestem, broomsedge	*A. virginicus* L.
Bluestem, bushy	*A. glomeratus* (Walt.) BSP
Bluestem, chalky	*A. capillipes* Nash
Bluestem, Elliott	*A. elliottii* Chapm.
Bluestem, little	*A. scoparius* Michx.
Bluestem, paintbrush	*A. ternarius* Michx.
Cutover muhly	*Muhlenbergia expansa* (DC) Trin.
Indiangrass, lopside	*Sorghastrum secundum* (Ell.) Nash
Indiangrass, yellow	*S. nutans* (L.) Nash
Panicum	*Panicum* spp.
Paspalum	*Paspalum* spp.
Skeletongrass	*Gymnopogon* spp.
Spike uniola	*Uniola laxa* (L.) BSP
Sugarcane plumegrass	*Erianthus giganteus* (Walt.) Muhl.
Sweet tanglehead	*Heteropogon melanocarpus* (Ell.) Benth.
Switchcane	*Arundinaria tecta* (Walt.) Muhl.
Switchgrass	*Panicum virgatum* L.
Grasslikes	
Beakrush	*Rhynchospora* spp.
Bulrush	*Scirpus* sp.
Nutrush	*Scleria* spp.
Woody Plants	
American beautyberry	*Callicarpa americana* L.
American holly	*Ilex opaca* Ait.
Azalea	*Rhododendron* spp.
Blackberry	*Rubus* spp.
Blackgum	*Nyssa sylvatica* Marsh.
Blueberry	*Vaccinium* spp.
Buckwheat-tree, Titi	*Cliftonia monophylla* (Lam.) Britton
Flowering dogwood	*Cornus florida* L.
Gallberry	*Ilex glabra* (L.) A. Gray
Grape	*Vitis* spp.
Greenbrier	*Smilax* spp.
Hickory	*Carya* spp.
Loblolly pine	*Pinus taeda* L.
Oak, blackjack	*Quercus marilandica* Muenchh.
Oak, post	*Q. stellata* Wang.
Oak, southern red	*Q. falcata* Michx.
Oak, willow	*Q. phellos* L.
Pepperbush	*Clethra tomentosa* Lam.
Red maple	*Acer rubrum* L.
Rhododendron	*Rhododendron* spp.
Sassafras	*Sassafras albidum* (Nutt.) Nees
Southern waxmyrtle	*Myrica cerifera* L.
Sumac	*Rhus* spp.
Sweetbay	*Magnolia virginiana* L.
Sweetgum	*Liquidambar styraciflua* L.
Yellow jessamine	*Gelsemium sempervirens* (L.) Ait.

bution to yield was determined by summing these subplot value ratings within each treatment over all blocks.

Frequency of occurrence was not sampled, but relative abundance was determined from occurrence of species on the 15 clipped subplots plus a listing of species (Trace) observed on treatment plots that were not in a subplot. The following rating was used:

Species on 12 to 15 subplots = Abundant
Species on 7 to 11 subplots = Common
Species on 3 to 6 subplots = Infrequent
Species on Trace to 2 subplots = Rare

The data were subjected to analysis of variance and Duncan's new multiple range test (Duncan, 1955).

Results

Ground Cover

Annual summer burns significantly reduced ground cover below all other treatments, while the greatest degree of cover occurred with biennial summer burning (Fig. 1). Ground cover on unburned areas consisted primarily of low-growing shrubs or the lower branches of hardwood trees, while cover on burned areas was composed of herbaceous plants or sprouts of woody species (Fig. 2).

Individual species or groups of species varied in their response to burning (Table 2). Crown spread of most herbaceous species tended to increase with frequent burning while many woody species decreased in coverage.

Grasses were the most abundant herbaceous plants on unburned plots. All burning increased coverage by grasses, but only annual winter fires produced significantly greater cover than was present on the control. Grasses were the dominant plants on the annual and biennial summer treatments.

Forbs provided almost no coverage without burning, but composites such as asters, eupatoriums, fragrant goldenrod, and Maryland goldaster provided considerable coverage on the more frequently burned treatments. Legumes such as lespedeza, beggar-lice, and partridgepea generally increased slightly with burning, but the greatest increases resulted from frequent fires. Significantly greater coverage by partridgepea occurred on the biennial summer treatments even though this plant is usually considered to respond best to annual winter burning. Lespedeza coverage was greatest on plots burned each winter, where it provided the greatest cover of any legume.

The smallest amount of coverage by woody plants occurred with annual summer burns, while greatest coverage occurred with infrequent burning. However, individual species exhibited a great variety of responses to long-term burning. While the annual summer treatment produced the least coverage by each species, sumac had slightly greater cover than occurred on the control. Annual and biennial summer fires produced similar responses in a majority of the species. Most woody plants showed small changes with peri-

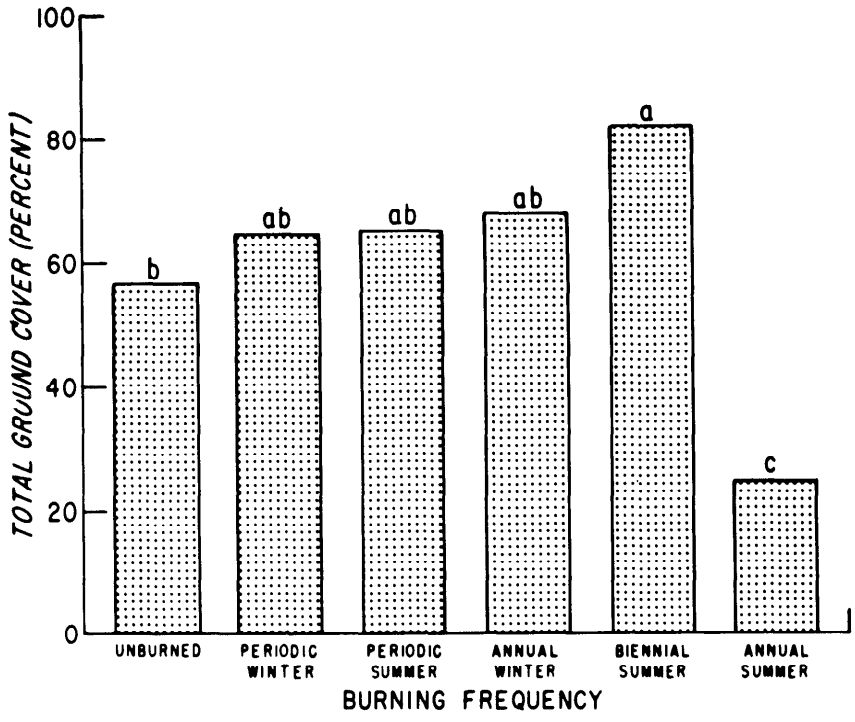

Fig. 1. *Percentage of the ground covered by living vegetation after 20 years of repeated burning. Columns marked with similar letters are not significantly different at the 5% level.*

Table 2. Average crown spread (ft) per 80-ft transect of important species and groups of species after 20 years of repeated burning.

Species	Burning treatment					
	Unburned control	Periodic winter	Periodic summer	Annual winter	Biennial summer	Annual summer
Herbaceous Plants						
Grasses	3.0 a[1]	3.5 a	6.0 ab	9.1 b	7.2 ab	4.2 ab
Beggar-lice	0.0 a	0.2 a	0.5 a	1.2 a	1.2 a	1.1 a
Lespedeza	0.0 a	0.4 ab	0.2 a	1.8 b	0.6 ab	0.1 a
Partridgepea	0.0 a	0.0 a	0.0 a	0.2 a	0.8 b	0.1 a
Composites	0.0 a	0.8 a	0.6 a	5.7 ab	8.8 b	4.6 ab
All herbaceous plants	3.3 a	5.1 a	7.7 a	20.2 b	19.3 b	11.2 ab
Woody Plants						
Blackberry	0.0 a	0.3 ab	1.0 ab	2.7 b	1.4 ab	0.0 a
Blackgum	0.8 ab	2.3 c	1.9 bc	0.7 ab	0.5 ab	0.0 a
Blueberry	7.5 c	4.0 abc	4.6 bc	3.4 abc	0.8 ab	0.3 a
Gallberry	7.3 b	3.3 ab	7.0 b	0.1 a	2.6 ab	0.0 a
Grape	0.2 a	3.6 b	0.3 a	1.0 a	1.5 a	0.0 a
Greenbrier	1.4 b	0.3 a	0.1 a	0.0 a	0.0 a	0.0 a
Oaks	1.6 b	1.6 b	1.2 ab	0.5 ab	0.5 ab	0.0 a
Pepperbush	3.2 b	2.2 ab	1.2 ab	1.4 ab	1.0 ab	0.1 a
Southern waxmyrtle	3.2 b	2.8 ab	6.7 c	0.1 a	0.8 ab	0.0 a
Sumac	0.0 a	0.4 ab	1.0 ab	2.1 b	2.0 b	1.0 ab
Sweetgum	6.8 b	13.3 c	8.0 b	6.8 b	0.9 a	0.0 a
Yellow jessamine	3.4 ab	5.4 b	3.7 ab	0.0 a	0.1 a	0.0 a
All woody plants	36.7 c	40.2 c	37.6 c	19.8 b	12.2 b	1.5 a

[1] Means for a species with common letters are not significantly different at the 5% level.

Fig. 2. *Understory vegetation after 20 years of repeated burning: (a) unburned, (b) periodic summer burning, (c) annual winter burning, and (d) annual summer burning.*

odic summer burning when compared to the control; however, southern waxmyrtle significantly increased coverage. Greenbrier coverage was significantly reduced by all burning treatments. Annual winter fires produced significant increases in coverage by blackberry and sumac but significant decreases by gallberry, southern waxmyrtle, and yellow jessamine. Periodic winter burns had little effect on most species other than sweetgum, blackgum, and grape.

Herbage Yields

Burning treatments increased herbage yields, which were highest on annual winter burns and lowest on unburned plots (Table 3). Yields with annual winter burning were 23 times greater than with complete protection from fire. Periodic winter burning was the poorest burning treatment. These yield data correspond quite closely with the coverage data in Table 1. Since summer burning was done on about July 1, approximately one-half of the year's yield was consumed by fire. Therefore, annual yield from these treatments would be greater than indicated, and biennial summer burning would probably have been the

Table 3. Herbage yields (lb/acre) and an importance rating of the six species contributing most to total yield after 20 years of repeated burning.

Measurement and species	Burning treatment					
	Unburned control	Periodic winter	Periodic summer	Annual winter	Biennial summer[1]	Annual summer[1]
Yield, all species	27 a[2]	88 a	212 ab	608 c	491 bc	209 ab
Importance rating						
Grasses						
Broomsedge bluestem	2	1	1	1	1	1
Little bluestem				5		
Paintbrush bluestem					3	4
Panicum grasses	3	4	3	3	4	6
Spike uniola	5	2	4			
Switchcane	1		2	6		
Yellow Indiangrass		3				
Forbs						
Bushy aster						5
Centella					5	
Dogfennel	6		5	4	2	2
Elephant foot		6				
Fragrant goldenrod		5	6	2	6	3
Lespedeza	4					

[1] Burned on July 1 before being clipped the last of October.
[2] Yields marked with differing superscripts are significantly different at the 5% level.

highest yielding treatment.

Broomsedge bluestem was the most important species contributing to herbage yields on all burned plots and was second in importance on control plots (Table 3). Broomsedge bluestem and panicum grasses were the only species that ranked within the top six in all treatments; switchcane and spike uniola were the next most productive grasses. Grasses generally contributed the most to herbage yields, while dogfennel and fragrant goldenrod were the only forbs that ranked in the top three after any treatment.

Herbaceous Species Composition

Among the 44 species of herbaceous understory plants that occurred on burned plots were 19 grasses, 3 grasslike plants, and 22 forbs (Table 4). The annual summer treatment yielded the greatest species diversity, 29, followed by the annual winter and biennial summer treatments with 26 and 24 species each. Only 11 herbaceous species were observed on the unburned plots.

Broomsedge bluestem, panicum grasses, yellow Indiangrass, dogfennel, and fragrant goldenrod were the only species that occurred after all treatments. Broomsedge bluestem, spike uniola, panicum grasses, dogfennel, and fragrant goldenrod were rated common after some treatments, but only panicum grasses were abundant after any treatment. An abundance rating of infrequent was the highest rating attained by paintbrush bluestem, switchcane, switchgrass, yellow Indiangrass, bushy aster, centella, partridgepea, butterfly-pea, and beggarlice. The other species were rarely observed in any treatment and all were rare on unburned plots.

Season of burning appeared to affect the occurrence of some species. For example, those occurring only on summer burns were paintbrush bluestem, cutover muhly, beakrush, bulrush, bracken fern, centella, hairy trilisa, and tephrosia. Species occurring only on winter burns were Elliott bluestem, skeletongrass, sweet tanglehead, elephant foot, and gerardia. Frequency of fire within a season had little influence on occurrence of species.

Table 4. Relative abundance[1] of herbaceous species on long-term burning treatments.

Species	Burning treatment					
	Unburned control	Periodic winter	Periodic summer	Annual winter	Biennial summer	Annual summer
Grasses						
Arrowfeather threeawn	–	–	R	R	–	–
Big bluestem	–	–	R	R	–	R
Broomsedge bluestem	R	I	I	C	C	C
Bushy bluestem	–	R	R	R	R	–
Chalky bluestem	–	R	–	–	R	R
Cutover muhly	–	–	–	–	R	–
Elliott bluestem	–	R	–	–	–	–
Little bluestem	–	–	–	R	R	R
Lopside Indiangrass	R	–	–	–	–	–
Paintbrush bluestem	–	–	R	–	I	I
Panicum grasses	R	I	A	C	A	C
Paspalum	–	–	–	–	–	R
Skeletongrass	–	R	–	–	–	–
Spike uniola	R	C	C	I	R	–
Sugarcane plumegrass	–	–	R	R	R	R
Sweet tanglehead	–	R	–	–	–	–
Switchcane	I	R	I	I	–	–
Switchgrass	R	–	R	I	–	R
Yellow Indiangrass	R	I	R	R	R	R
Grasslikes						
Beakrush	–	–	R	–	–	R
Bulrush	–	–	–	–	–	R
Nutrush	–	–	R	R	R	R
Forbs						
Beggar-lice	–	R	R	I	R	R
Blackroot	–	R	R	–	R	R
Bracken fern	–	–	–	–	R	R
Bushy aster	–	R	–	R	R	I
Butterfly-pea	–	R	–	I	–	–
Centella	–	–	R	–	I	R
Dogfennel	R	R	I	C	C	C
Elephant foot	–	R	–	–	–	–
Fleabane	–	–	–	R	R	R
Fragrant goldenrod	R	R	I	I	C	I
Gerardia	–	R	–	–	–	–
Hairy trilisa	–	–	–	–	R	R
Lespedeza	R	–	R	R	R	–
Maryland goldaster	R	–	R	R	R	R
Meadow beauty	–	–	R	–	–	–
Mexican-clover	–	–	–	R	–	R
Milkpea	–	–	–	R	R	R
Partridgepea	–	–	–	R	I	R
Pencil flower	–	–	–	R	–	R
Roundhead lespedeza	–	–	–	R	–	R
Sunflower	–	–	–	R	–	R
Tephrosia	–	–	R	–	–	–

[1] – = Not encountered; R = Rare; I = Infrequent; C = Common; A = Abundant.

Discussion and Conclusions

Twenty years of prescribed burning in the Lower Coastal Plain in South Carolina has significantly changed the understory vegetation. All treatments except annual burning in the summer increased the percentage of the ground covered with living plants. Species composition of the herbaceous understory changed dramatically from a few, scattered plants to many species at much higher density. Grasses were dominant on the annual summer and biennial summer plots, while low-growing shrubs were dominant on the periodic summer and on the winter-burned plots.

Depending on the season of treatment, repeated burning over a long period either perpetuates shrubs that sprout or eliminates most of them from the understory. Therefore, controlled burning can establish and maintain desirable food and cover for wildlife or can destroy wildlife habitat, depending on its frequency and season of use. Proper use of fire can be especially valuable for providing good habitat for deer, turkey, and quail by maintaining ideal cover and by increasing yields and boosting quality of foods.

Herbage yields increased with all burning treatments. Partly because of the timing of burning and yield measurement, only the annual winter and biennial summer treatment yields

were significantly greater than that of the unburned control. These increases of over 500 pounds per acre indicate a potential for partial conversion of Coastal Plain forests into grazable woodlands, especially if some improved pasture is provided (Halls et al., 1960; Lewis and McCormick, 1971). Grasses, especially broomsedge bluestem, were the primary contributors to increased herbage yields. Some forbs became fairly abundant after some burning treatments, but most of these forbs are not generally grazed by cattle and most of them are rather unimportant as producers of wildlife food.

Conditions favorable for both domestic and wild animals are best maintained in the South by retaining the understory vegetation in a subclimax condition through the use of fire. Periodic winter burning appeared to produce the best habitat for deer and turkey. However, the best quail habitat was produced by annual winter fires since forbs, especially legumes, were most abundant with this treatment. Forage yields that were best for cattle were achieved by annual winter and biennial summer treatment. However, experience has shown that it is very difficult to burn annually in the winter when southern forests are grazed; therefore, biennial winter burning is most common. This study and experience indicate that good conditions for producing combinations of cattle and wildlife can be maintained by burning every 2 or 3 years during the winter.

In summary, this study shows that species diversity and the abundance of understory plants can be partially controlled by burning, particularly by the season fire is applied. Therefore, conditions for wildlife and cattle can be improved or destroyed, and whole ecosystems can be greatly altered by the planned use of fire.

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Statement of Ownership, Management and Circulation
(Act of August 12, 1970, Sec. 3685, Title 39, United States Code)

1. *Title of Publication:* JOURNAL OF RANGE MANAGEMENT
2. *Date of Filing:* September 30, 1975
3. *Frequency of issue:* Bimonthly
4. *Location of Office of Publication:* 2120 S. Birch St., Denver, Colo. 80222
5. *Location of General Business Office:* Same
6. *Names and Addresses of—*
   Publisher: Society for Range Management, 2120 S. Birch St., Denver, Colo. 80222
   Editor: Elbert H. Reid, 624 S. Shields St., Fort Collins, Colo. 80521
   Managing Editor: David A. Smith, 2120 S. Birch St., Denver, Colo. 80521
7. *Owner:* Society for Range Management, 2120 S. Birch St., Denver, Colo. 80222. A nonprofit corporation; no capital stock authorized.
8. *Known Bondholders, Mortgages, etc.:* None
9. (Not applicable)
10. *For Completion by Nonprofit Organizations Authorized to Mail at Special Rates:* The purpose, function, and nonprofit status of this organization and the exempt status for Federal income tax purposes have not changed during the preceding 12 months.
11. *Extent and Nature of Circulation*

	Avg. for 12 months	Actual for issue nearest filing date
A. *Total copies printed*	6,083	5,900
B. *Paid circulation*		
1. Dealers, counter sales	-0-	-0-
2. Mail subscriptions	5,709	5,775
C. *Total paid circulation*	5,709	5,709
D. *Free distribution*		
1. Samples, complimentary	30	30
2. To news agents, not sold	-0-	-0-
E. *Total distribution*	5,739	5,805
F. *Office use, unaccounted*	344	95
G. *Total*	6,083	5,900

I certify that the statements made by me above are correct and complete.—*David A. Smith,* Managing Editor.