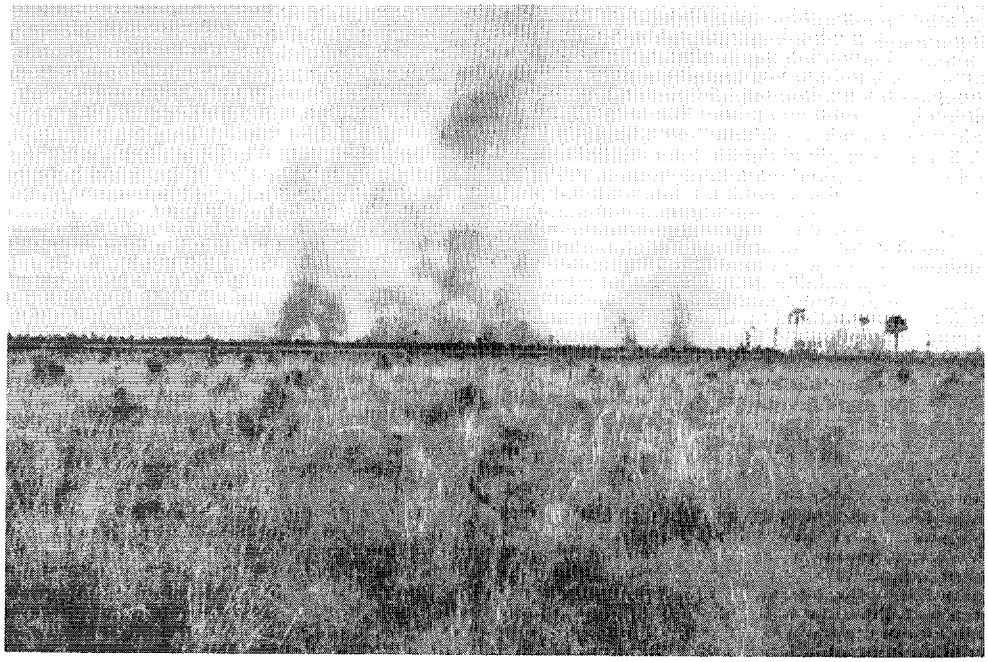
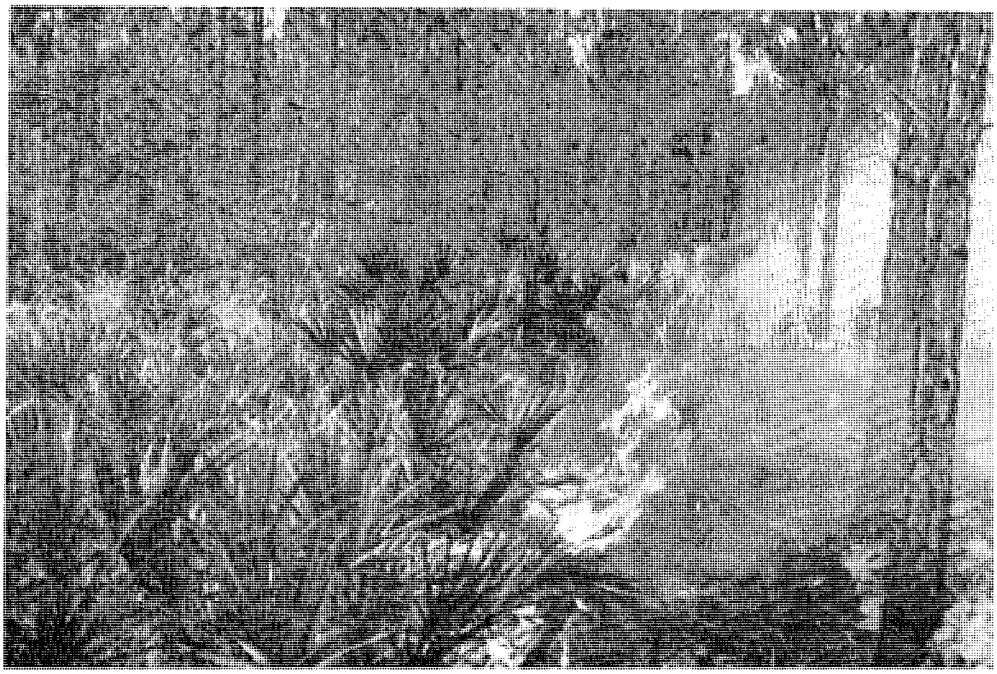


FIG. 1. Extensive areas of cutover forest range in south Florida are burned to "freshen" forage for cattle. U. S. Forest Service photo

FIG. 2. Prescribed burning keeps saw palmetto in check, improves wiregrass forage quality, and reduces wildfire hazard in this 12-year old slash pine plantation on the Corkscrew Experimental Forest. U. S. Forest Service photo



Forest Service Research on the Use of Fire in Livestock Management in the South

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TWO U. S. FOREST SERVICE Experiment Stations serve the South: The Southeastern Forest Experiment Station, Asheville, North Carolina and the Southern Forest Experiment Station, New Orleans, Louisiana. These Stations have laboratories and field project locations throughout the South.

Both Stations were founded in 1921. From the start researchers were involved in the question: "Should the woods be burned?" One of the first reports from the Southern Station noted that a study of the effect of fire upon longleaf pine (*Pinus palustris*) was cut short by fires in the check plot. Wahlenberg *et al.* (1939) summarized the early attitude about fire in the woods: "Fire damage was so conspicuous and its benefits so subtle that exclusion of fire was favored rather than its controlled use." Through the years much research and experience contributed to a change in philosophy. Today the question has become: "How and when can fire be used to the best advantage of all uses?"

During the first 35 years Station authors contributed 194 papers on the use and effects of fire (Bruce and Nelson, 1957). Only 12 papers appeared in the 1920's; then, 59 were published in the 1930's; 51 in the 1940's; and 72 in the first five years of the 1950's. Subject-

wise, these papers considered effects of fire on everything from pines to bacteria and from tree tops to the soil beneath. More than 25 percent of the papers dealt specifically with fire and longleaf pine; the percentage would be much higher if all the papers which discussed this pine with other southern pines were included.

Since time will not permit a thorough review of all aspects of the Station's fire research history, this paper will emphasize studies of the effects of fire on understory plants as determined primarily in forest grazing studies. This subject area has been neglected in earlier reviews, and much has been learned through recent research. For a more thorough coverage of the entire subject, Garren's (1943) review of effects of fire on vegetation of the Southeastern United States, Bruce and Nelson's abstracts (1957), and annual reports of the Southeastern and Southern Stations since 1955 should be consulted.

Forest grazing research has been conducted at five main project locations in three primary types:

Pine-cane:	Plymouth, North Carolina
Pine-bluestem:	McNeill, Mississippi
	Alexandria, Louisiana
Pine-wiregrass:	Tifton, Georgia
	Fort Myers, Florida

PINE-CANE

All the work with cane was concentrated in the North Carolina Coastal Plain, at the old Blackland Station and Hofmann Forest until the late 1940's, and then at the Tidewater Research Station and the Frying Pan Experimental Range until field activities were terminated in 1954. Although work on experimental ranges in this type dates back to 1928, studies on response to burning *per se* were delayed until the 1950's. Observations on accidental burns provided what we knew about cane (*Arundinaria tecta*) response to burning up to that time. Data on controlled use of fire are limited to records taken on a series of small permanent plots before and after burning in 1953 and 1954.

Cane is one of the most nutritious of the native forage plants growing in the eastern United States. Crude protein in the diet of cattle

grazing cane range varies from a high of 20 percent in June, to 14 percent in September and October, and to 12 percent in December (Biswell *et al.*, 1945).

Burning of canebrakes prior to the 1950's was looked upon with scorn for several reasons: (1) The grazing season had to be delayed from one to four weeks to avoid damage to emerging new shoots; (2) foliage produced after a fire was susceptible the following fall to frost damage; (3) the amount of forage produced during the first growing season after fire was less than on unburned areas; and (4) control of cane fires was difficult or impossible because of their speed and severity (Biswell *et al.*, 1945). Subsequent findings tended to dispel many of these earlier views.

Shepherd *et al.*, (1951) observed that cane on the Hofmann Forest quickly regained full foliage cover following fire. Further, in competition with shrubs, cane was favored by periodic fires, particularly if they occurred at intervals of less than 10 years. In the planned

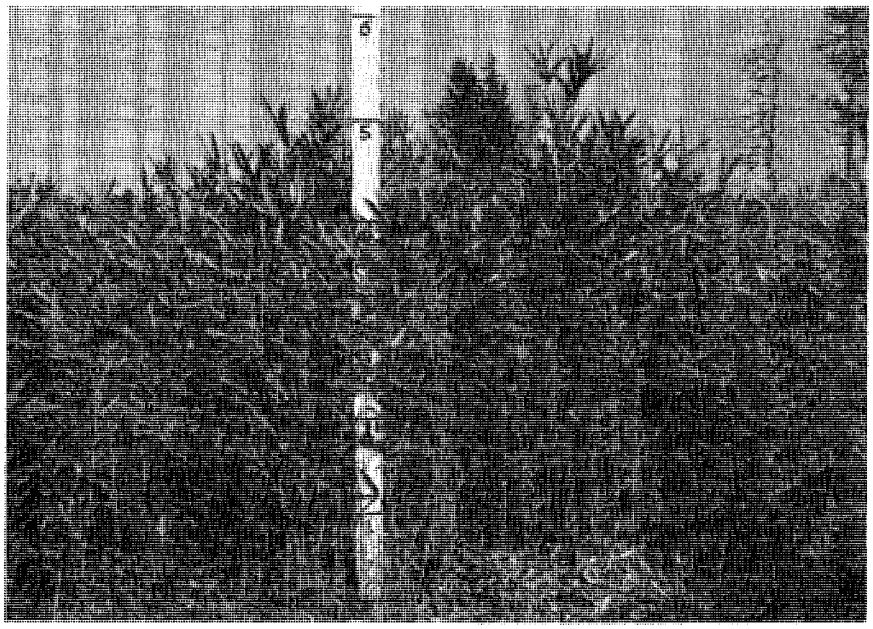

FIG. 3. Fire restores vigor and productivity of cane in the coastal plain. This stand in North Carolina was burned two years earlier. U. S. Forest Service photo

burns at the Tidewater Station, fire served the useful purpose of renovating decadent cane stands, both beneath pond pine (*Pinus serotina*) and in the open (Hughes, 1957). Burning not only restored vigor and replenished productivity, but also reduced the fire hazard and improved accessibility of the range for a period of 1 to 3 years.

Following a winter burn, new stems rapidly replace those destroyed, and during the warm humid days of late May and June make phenomenal height growth. Several marked stems that were measured at Wenona grew as much as 1½ inches in height in 24 hours. These stands were 7 to 9 feet tall and produced over 2 tons (dry weight) of edible herbage per acre annually.

New stems are unbranched and have 10 to 15 large leaves. Simple branches, each with 6 to 8 somewhat smaller leaves are produced the second year. Stems branch in successive years, with about 5 leaves per branch. Hence, leaves are smaller but more numerous as stems become older. Stands are even-aged for 2 or 3 years after burning; then new shoots appear, and the stand becomes uneven-aged. A stem may live 10 years, but average age of a stand remains near 3 or 4 years as a result of gradual mortality and replacement. Dead stems may persist several years.

Cane stands at both Tidewater and Frying Pan thinned out and declined in productivity after a decade of protection from fire. Cane stems protected from fire for 14 years declined 65 percent in number during the final 7 years. Reductions were similar under trees and in the open. Declining vigor of the cane was indicated by loss of stands through disease and by failure of stems to reclaim areas devoid of competing understory vegetation.

PINE-BLUESTEM

Grazing research in this type was started in 1923 with the establishment of studies of the effects of fire and cattle grazing on longleaf pinelands of the Mississippi Agricultural Experiment Station at McNeill. One plot was burned annually for 10 years—the fires were of "uncontrolled intensity"—and one plot was protected from fire. Grazing was allowed on both areas, but ungrazed conditions were also available for study. Little bluestem (*Andropogon scoparius*) and slender bluestem (*A. tener*) are the predominant native grasses on

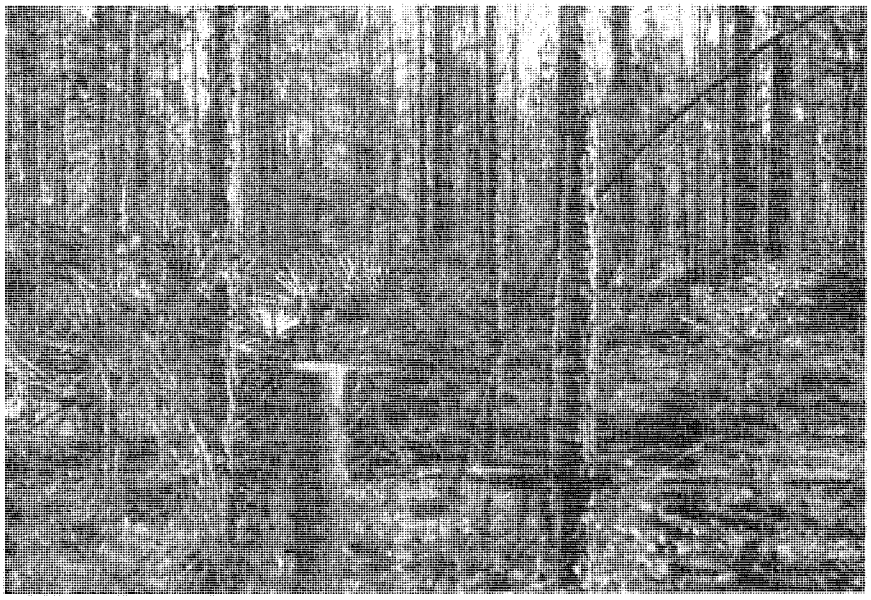

FIG. 4. Slash pine and saw palmetto prevail—most grasses are gone—on this site protected from fire and grazing for 23 years on the Alapaha Experimental Range. U. S. Forest Service photo

southern Mississippi ranges, but 25 species of legumes also were observed at McNeill.

The results of 10 years research, reported by Wahlenberg, Greene and Reed (1939) defined basic ecological effects of fire. The marked decline in total plant cover with fire protection was one of the most striking changes over 10 years. Annual forage production near the end of the study was twice as great on the burned plot (4855 pounds per acre, green weight) as on the unburned plot (2214 pounds per acre, green weight). Protein, phosphorus, and calcium were higher in spring forage from burned areas. Cattle preferred forage on burned areas, and seasonal gains were 37 percent higher there.

Although both principal grasses declined under fire protection, little bluestem declined less and composed 25 percent of the herbage in 1924 and 46 percent in 1933. Slender bluestem, more tolerant of fire than "smothering," declined from 39 percent to 12 percent over the same period. Observations in dense stands of longleaf pine suggested that all forage growth would eventually be eliminated by pine straw.

Burned but ungrazed plots changed little. Little bluestem declined slightly whereas slender bluestem was unaffected by annual burning.

Under grazing, both bluestems decreased in relative abundance, and carpetgrass (*Axonopus compressus*) increased. Slender bluestem was less affected by grazing than little bluestem.

Legumes also benefitted from burning. Sixteen species were found on burned areas and only 11 species on the unburned. The most severe treatment of the four applied was no fire and no grazing:

Treatment	*Number of Legumes per acre*
9 annual fires, no grazing	41,500
No fire, no grazing	17,600
9 annual fires, grazing	35,700
No fire, grazing	27,600

The study provided some data on effects of seasonal burning on areas protected from fire for several years. A 10-acre plot protected from fire and grazing for eight years was burned in October. The bluestems and several associated grasses were almost completely killed out; and over the next few years, these plants were replaced by annual weeds, predominately goldenrod (*Solidago odora*). Although a January burn on a similar plot killed a few grasses, plant response to the winter fire was much less severe.

A study of the effects of burning on soil physical and chemical properties also was included, and the earlier work by Heyward and Barnette (1934) was reviewed. Penetrability of the surface soil was reduced by burning, but the frequently burned over soils were (1) slightly less acid in reaction (2) contained more bacteria and (3) contained greater organic matter, total nitrogen and replaceable calcium. Burning and grazing did not result in serious soil degradation. Similar conclusions have been reached by other workers in Georgia (Suman and Carter, 1954; Suman and Halls, 1955). Metz *et al.* (1961) found no significant effect of annual burning in South Carolina on soil physical properties, whereas content of mineral elements, nitrogen and organic matter improved with burning.

Forest grazing studies were started in 1944 near Alexandria, Louisiana, and in 1946 Alexandria and nearby Palustris Experimental Forest became the primary center of such research in the pine-bluestem type (Cassady and Mann, 1954). Pinehill bluestem (*A. divergens*)

and slender bluestem are the predominant bluestems in Louisiana and the longleaf-bluestem type to the west. Pinehill bluestem declines under annual burning and in this regard pinehill bluestem is similar to little bluestem in southern Mississippi (Langdon *et al.*, 1952).

A number of studies conducted in the 1950's throughout the pine-bluestem type of Mississippi (Smith *et al.*, 1955; Smith *et al.*, 1958) and Louisiana (Campbell, 1946; Campbell and Cassady, 1951; Cassady, 1953; Campbell *et al.*, 1954) depicted grazing values of plants in relation to fire. This research paved the way for development of better systems of cattle management, including improved systems of rotation burning.

Duvall and Whitaker (1964) defined a rotation burning–forage management system for pine-bluestem ranges. In a 6-year experiment, ranges were divided into three subunits of approximately equal grazing capacity; and one subunit was burned per year in a 3-year rotation. Close grazing of new growth kept vegetation palatable and nutritious, and extended the period of animal use. Utilization averaged 78, 31, and 18 percent the first, second, and third growing seasons after fire, respectively. Intense grazing following fire reduced herbage production, but the 2 years of light use restored plant vigor. Herbage produced the final year of the rotation—slightly more than a ton per acre—was the same as production on unburned, moderately grazed range. This study on the Palustris is being continued to appraise long-term effects of rotational burning, and a 4-year burning rotation also is being evaluated. Preliminary results indicate that botanical composition and average yield are unaffected by burning at 4-year intervals (Duvall and Hilmon, 1965).

PINE-WIREGRASS

Forest grazing research was started in this type in 1940 when the Alapaha Experimental Range was established on lands owned by the Georgia Coastal Plain Experiment Station. The importance of fire to forage and timber management was recognized from the start. A prescribed burning program for fuel reduction and forage improvement was begun in 1942 and continues to the present. Burning is practiced beneath slash pine (*Pinus elliottii*) ranging from older natural stands to young plantations 8 to 12 feet in height. Damage to

young trees has been negligible. Data are taken periodically and photo stations are exposed at regular intervals on areas protected from fire since 1934, 1941 and 1954.

Composition of the understory in pine-wiregrass vegetation following fire was reported by Lemon (1949). The flush of herbs which appear after fire peaked the third year. Total herbaceous coverage declined between 3 and 8 years fire protection, but pineland threeawn (*Aristida stricta*) and Curtiss dropseed (*Sporobolus curtissii*), the principal wiregrasses, maintained their dominance on unburned range through an 8-year period. Percentages of ground covered by plants on adjacent ungrazed areas with different fire histories were:

	Number of growing seasons since the last fire			
	1	2	3	8
	Percent			
Principal wiregrasses	18.8	20.2	27.3	15.6
Secondary grasses	2.7	1.8	2.4	3.5
"Fire followers"	20.4	17.6	18.3	8.6
TOTAL	41.9	39.6	48.0	27.7

Secondary grasses—toothachegrass (*Ctenium aromaticum*), Florida dropseed (*Sporobolus floridanus*), cutover muhly (*Muhlenbergia expansa*)—increased only slightly over the 8-year period in terms of ground cover, but doubled their relative abundance. "Fire followers"—the bluestems (*Andropogon* spp.), panics (*Panicum* spp.), and lovegrasses (*Eragrostis* spp.)—were most abundant during the first few years following fire. In subsequent studies over a 12-year period, Halls *et al.* (1952, 1956) observed general decreases in ground cover of grasses on unburned areas whether grazed or not. The tendency to decline with protection from fire was more evident with pineland threeawn than with Curtiss dropseed. The latter species does not extend into the southern half of the pine-wiregrass type, and decadence of pineland threeawn after 8 to 10 years fire protection is especially conspicuous there.

Two 50-acre units at Alapaha were burned last in 1941. Permanent plots in the previously cutover pine-wiregrass type were inventoried in 1942, 1951, and 1963. Forage species declined and brush cover in the understory increased as the "rough" aged beneath the developing natural pine stands. Foliage covers by species and groups were as follows:

Species	1942	1951	1963
		Percent	
Aristida stricta	12	6	1
Sporobolus curtissii	11	13	9
Other herbaceous	16	9	1
Total herbaceous	39	28	11
Ilex glabra	7	14	39
Serenoa repens	Trace	1	2
Other shrubs	1	2	2
Total shrubs	8	17	43

Stocking of pine in 1963 averaged 432 trees per acre; DBH was 5.8 inches, and basal area per acre was 91 square feet.

Grazing research was initiated in south Florida in 1953; the Caloosa Experimental Range became the center of this research in 1956. A unique feature of the pinelands in this area is South Florida slash pine (*Pinus elliottii var. densa*), recognized as a distinct variety of slash pine (Little and Dorman, 1954). Young trees of the variety are more fire resistant than typical slash pine (Ketcham and Bethune, 1963), and in several other characteristics resemble longleaf pine.

Research in the late 1950's showed that the changes in plant cover after fire are similar in Georgia and south Florida. There are two differences, however. Pineland threeawn alone is the dominant grass on most pinelands in southern Florida, and a warmer climate permits some plant growth throughout the winter. Blades of pineland threeawn appear within 3 days after a winter fire. This species comprised 90 percent of the total herbage weight (65 pounds per acre) 3 weeks after a mid-February fire (Hilmon and Lewis, 1962). Panic grasses

and bluestems were widespread, but pineland threeawn comprised half or more of the herbaceous vegetation throughout a 2-year period after burning. On open range, forage production was one ton per acre at one year, and 1¾ tons per acre after two years.

Forage quality is highest immediately after fire, but declines rapidly to borderline for proper cow nutrition 3 months after burning. In this respect, trends in forage quality after fire are similar in the pine-bluestem and pine-wiregrass. Winter burning at Alapaha increased protein and phosphorus content for the March through May period, but forage from burned range had no advantage over unburned range thereafter (Halls *et al.*, 1952).

The data on plant growth and quality help explain adaptability of wiregrasses to the interacting effects of fire and grazing. Cattle graze most herbs on recently burned ranges; but as quality of pineland threeawn and other wiregrasses declines, they seek other forage plants—bluestems, panics, carpetgrasses (*Axonopus* spp.), perennial goobergrass (*Amphicarpum muhlenbergianum*) and forbs—neglecting pineland threeawn until the range is reburned (Hilmon and Hughes, 1965). Pineland threeawn and Curtiss dropseed decreased slightly in ground cover when Alapaha ranges were burned annually and grazed heavily (Halls *et al.*, 1952). Less frequent burning allowed sufficient time for these plants to maintain or increase vigor. Coverage of pineland threeawn was unchanged on south Florida ranges burned biennially and grazed heavily over a 6-year period. Adaptation to sprout quickly from underground growing points after fire and selective grazing, which permits considerable rests, operate to maintain or increase the abundance of the primary wiregrass.

Month of burning also exerts a marked influence on grass growth. Biswell and Lemon (1943) found late spring and early summer burning at Alapaha stimulated seeding of native grasses more than fires in the winter or early spring. Then, Lewis (1964) reported month of burning affected both early forage production and pineland threeawn seed-stalk production on south Florida ranges. Ranges burned in March or May produced twice and four times as much herbage, respectively, in the 60 days after fire as ranges burned in October or November. Pineland threeawn burned in May produced 8.4 seed-stalks per square foot the following fall; plants burned between October and March had few or no seed-stalks. This study on cutover

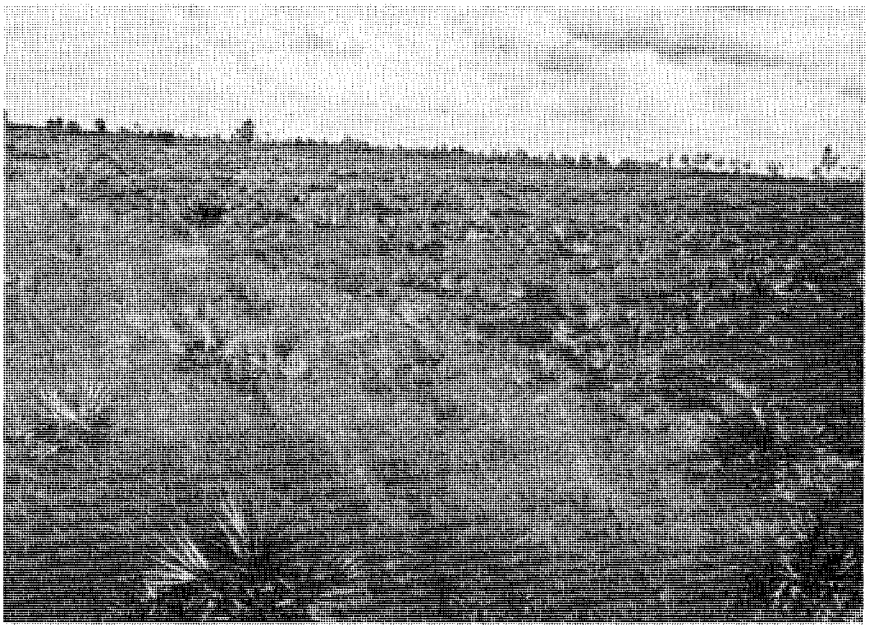

FIG. 5. Wiregrass range burned in May (foregound) produced four times as much herbage two months after fire as the range burned in January (background). Caloosa Experimental Range, southern Florida. U. S. Forest Service photo

forest land will be continued over a 10-year period. A complementary study was started in 1964 to appraise the effects of month of burning on vegetation in 12-year-old pine plantations.

In the late 1950's research at Fort Myers and Tifton was reoriented toward a team approach to fuller understanding of the ecological relationships basic to integrated management of the pine-wiregrass type for cattle forage, timber, and wildlife. Fuller understanding of fire ecology is one of the key objectives of this program.

As a part of this effort, ecological life histories of the two principal shrubs, gallberry (*Ilex glabra*) and saw-palmetto (*Serenoa repens*), were started in 1958. Both shrubs appear to be increasing. To the timberland owner contemplating pine regeneration or to the cattleman seeking greater production of native forage, gallberry and palmetto are undesirable plants. To a hungry deer in the fall or a honeybee in the spring, palmetto, at least, is a welcome sight.

After burning, gallberry sprouts from underground rootstalks; saw-palmetto from partially to completely underground stems. At Alapaha, sprouts from gallberry plants burned in January appear in late February, grow most rapidly between mid-April and mid-May, and by November average about 2 feet in height. New leaves attain half size in April and full size in May.

Palmettoes that are burned in November on the Caloosa Range produce one fully expanded leaf by January, and seven or eight leaves during the first year. Only three or four leaves are produced the second year after fire. With continued fire protection, plants return to a five- or six-leaves-per-year cycle. Palmettoes burned in the late fall are stimulated to grow throughout the winter, whereas unburned palmettoes are relatively dormant vegetatively during this period.

Flowering and fruiting activities also are disrupted by burning. Gallberry plants killed back by fire bear neither flowers nor fruit until the second year, then bear profusely. Burned palmettoes bloom and produce a few fruits the first year. Where continuous biennial burning has been practiced, full palmetto fruit production isn't restored until after 8 to 10 years fire protection.

Vegetatively, palmetto and gallberry are well adapted to a fire subclimax. Sprouts of both species exceed the number of stems present prior to burning. A number of sprouts die the second year, but foliage cover per stem increases gradually with protection from fire. After 2 or 3 years, number of stems and foliage cover return to about the same levels as before the fire.

Annual summer burning was more effective in retarding recovery of gallberry at Alapaha than burns made at other seasons of the year (Hughes and Knox, 1964). However, recovery of carbohydrates occurred within one year regardless of time of year burned or whether plants were killed back to the ground once or in 2 consecutive years

Burning following chemical control of gallberry enhanced recovery of native forage species in areas formerly occupied by this undesirable shrub. Plots containing gallberry and native forage species at Alapaha were sprayed with 2,4,5-T in 1956. Good kills of gallberry were obtained and forage production increased in 1958 (Burton and Hughes, 1961). In subsequent years with continued fire protection,

forage production declined sharply. Half of the plots were burned in January 1964, and forage production was clipped in October 1964. Forage production continued to decline on protected plots, but turned upward on the burned plots. Yields of forage were:

	1956	1958	1960	1962	1964
	Pounds per acre				
Protected	352	1,461	800	789	679
Burned (1964)	377	1,419	936	906	1,017

Results of other recent research have emphasized the intricacy of the relationships between fire, pines, and understory vegetation. Survival of slash pine seedlings planted on a recent burn was 13 percent poorer than survival on a 1-year rough (Hilmon *et al.* 1962). Further study of the microenvironmental changes which may have triggered this response is underway. In addition to this response, which occurred on ungrazed areas, recent burns attracted cattle to plots exposed to grazing, setting up an interaction between age of rough and grazing intensity. Seedling survival was similar on recently burned or unburned areas at zero, low, and medium grazing intensities, but on heavily grazed ranges seedling survival was significantly better on a 1-year rough than on a recent burn.

Two studies are underway which emphasize the wildlife habitat aspect of fire ecology. One will determine the effects of summer or winter fires on plant succession in nine site and stand conditions of loblolly pine (*Pinus taeda*) in the piedmont, with particular emphasis on response of game food plants. Another study in south Florida will appraise the effects of winter fires on forage and habitat in stands of eucalyptus (*Eucalyptus robusta*) or slash pine planted at varying spacings.

OUTLOOK

Our future fire research will be a blend of basic ecological studies of life histories of principal plants of the types and an unraveling of the interrelation between fire and the forage-timber-wildlife habitat resource complex. Not to be omitted, however, are the opportunities for improving forage and habitat by means other than fire. Results of recent research here are most encouraging.

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