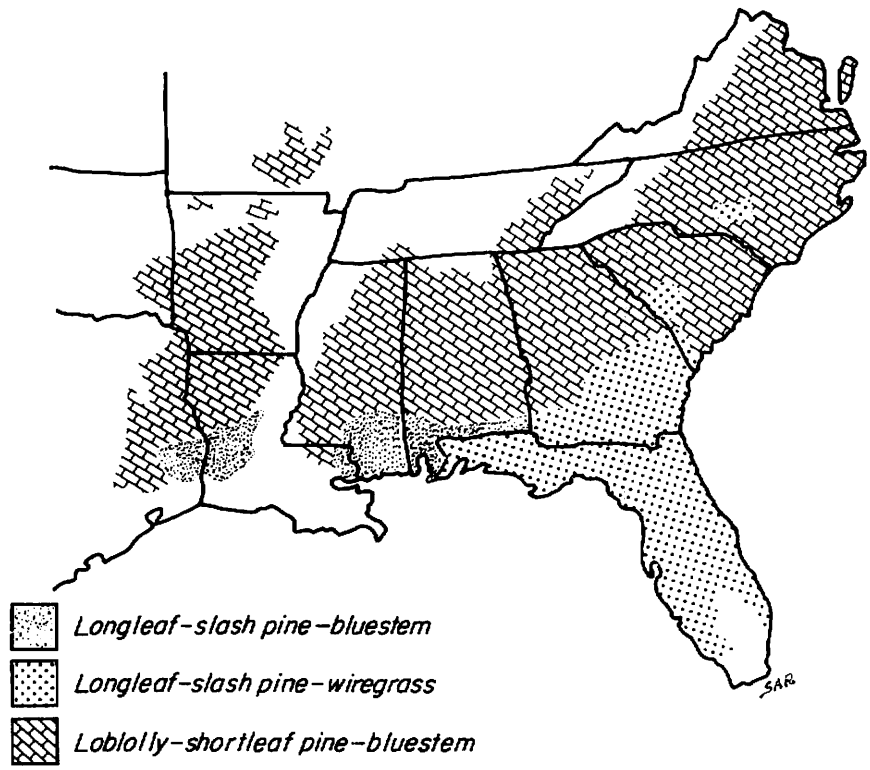
A Review of the

Southern Pine Forest-Range Ecosystem



Southern Pine Range Types

AGRICULTURAL EXPERIMENT STATION

Division of Agriculture

University of Arkansas, Fayetteville

JUNE, 1979 **SPECIAL REPORT 73**

CONTENTS

Agricultural Experiment Station. University of Arkansas Division of Agriculture. Fayetteville. J.E. Martin. vice president for agriculture: L.O. Warren. director. PS1.5M679

A Review of the Southern Pine Forest-Range Ecosystem

By HARLAN R. STOIN
Agronomy Department

In recent years an enlarged concept of range has developed based on both ecological characteristics and land use (8,9). According to this concept, "range" can be considered as "...uncultivated areas that support herbaceous or shrubby vegetation." The range ecosystem includes not only the vegetation and soil, but also the associated atmosphere, water, and animal life. Some areas are both range and forest; the tree overstory may be sparse, or the trees may have been harvested or burned, allowing growth of herbs or shrubs.

Rangelands have many uses and yield a variety of products with livestock and game being the most prominent. Recently, in a study of the nation's range resources (34), the U.S. Forest Service used the term "forest-range" to include "...all land...in native and natural grasslands and commercial and noncommercial forest lands, if at some stage in their natural succession, or if under management, they produce vegetation that is grazeable by livestock." Within the enlarged, modern concept of range, the range resource of the South includes over 200 million acres (34,90,100) extending from Virginia to eastern Oklahoma and Texas. This range resource provides food and habitat for numerous species of wildlife and domestic livestock.

Much of the range resource of the South is on forested land or areas where forest is the climax vegetation. Important among these forest-range areas are the southern pine forest lands which cover over 100 million acres throughout the South and 6.8 million acres in Arkansas (34).

The purpose of this review is to provide background information regarding the range resource on southern pine lands for professionals working in agencies dealing with landowners, and landowners interested in multiple use of the southern pine forest-range ecosystem. This review is concerned mainly with the present use and potential for increased use and productivity of the southern pine forest-range ecosytem for grazing and/or wildlife use and the integration of range use with timber production, which is the primary use on most of these lands.

Cattle have grazed in the open woods and forest lands of the South since the early Spanish explorers brought cattle to southwest Florida some 450 years ago. Following the extensive cutting of timber between 1890 and 1933, large areas of natural herbaceous vegetation developed on the cut-over lands and were used for livestock grazing (33) and by deer and other wildlife (43). Southern forests today generally are the result of natural regeneration following the period of heavy cutting and following the abandonment of marginal farmlands after the Civil War or the onslaught of the boll weevil. Reforestation by planting pine seedlings began in the mid-1920's and is now a common method of forest regeneration.

Many of the second-growth forests now are being harvested and regeneration of the South's third forest has begun. As the second-growth forests and plantations developed on cut-over forests and abandoned farmlands, the trees often grew into dense stands. The intense shade killed much of the understory vegetation and reduced their grazing value.

In recent years the primary emphasis has been on timber production on the southern pine lands; however, more and more emphasis is being given to integrating management of forest and range resources to meet multiple-use objectives in order to respond to environmental and social needs (28, 69, 70, 78, 94). Integrated management of forest-range ecosystems in the South can provide necessary forage including browse for an expanding cattle and wildlife population (100).

Utilizing the range resource on forest lands offers an opportunity to make use of a resource that would otherwise be wasted and can provide cattlemen with a low-cost supplement to improved pasture programs, to fill in gaps in their forage production program or provide a forage reserve for drought or other stress periods (77). Some cattlemen may already own and manage forests that can be managed to produce range forage, or they may have access to nearby forest areas owned by others.

For the forest land owner not in the cattle business, leasing the grazing rights to others could provide some current income to help pay for the cost of growing the timber crop (78).

Managing the forest-range for wildlife also can be beneficial for the landowner's own personal satisfaction or as a source of income by leasing of hunting rights (78,94).

Classification of Southern Pine Range

The Southern pine range can be considered to consist of three main vegetation types (34,90): a) longleaf-slash pine-wiregrass, b) longleaf-slash pine-bluestem, and c) loblolly-shortleaf pine-bluestem. (See Appendix for scientific names of the plants mentioned in this report.) The first two types correspond with the longleaf-slash pine forest type of the southern Coastal Plain but differ in understory vegetation. The wiregrass range generally occurs east of the Apalachicola River, including the pine flatwoods in Florida, southern Georgia, and South Carolina. The bluestem range occurs generally west of the Apalachicola River extending from northwestern Florida and southern Alabama to eastern Texas.

The major understory species in the wiregrass type include pineland threeawn, Curtiss dropseed, several bluestems, carpetgrass, panicums, paspalums, and numerous forbs, legumes, and shrubs such as saw-palmetto, gallberry, and wax myrtle. In the bluestem type the major understory species include pinehill bluestem, slender bluestem, little bluestem, other bluestems, pineywoods dropseed, panicums, paspalums, cutover muhly, and a number of forbs, legumes, and shrubs such as grass-leaf gold aster, gallberry, sumac, and wax myrtle.

The loblolly-shortleaf pine-bluestem range covers both the loblolly-shortleaf pine forest and the oak-pine forest. The loblolly-shortleaf pine forest consists of more than 50 percent loblolly, shortleaf, and other southern pines except longleaf and slash pines, while the oak-pine forest consists of more than 50 percent hardwoods but also 25 to 49 percent southern pines. The loblolly-shortleaf pine-bluestem range is the most extensive in the South, extending in a band north of the longleaf-slash pine types from eastern Texas to northeastern Virginia and reaching into southeast Missouri and Tennessee. This range is the southern pine range type that occurs in Arkansas, where it occurs in the Coastal Plain, the Ouachita Mountains, and some parts of the Arkansas Valley and Ozark Highlands.

The understory vegetation in this range type includes mainly little bluestem, pinehill bluestem, broomsedge bluestem, other bluestems, longleaf uniola, spikeleaf uniola, panicums, paspalums, cutover muhly, and numerous forbs and shrubs such as dogwood, viburnums, haws, blueberries, American beautyberry, and yaupon. Legumes such as native lespedezas, partridge pea, tephrosia, and tickclover are often plentiful. Shrubs and young trees often form a dense midstory in these forests which drastically intensifies the canopy effect and thus necessitates additional management to maintain range production.

The Forage Resource

In the 1940's and early 50's research workers recognized a number of range problems and areas where research was needed (3,15,17,86). They recognized the need to integrate burning practices for range use with the needs of timber production, as well as the need for control over cattle grazing in contrast to the open-range policy in order to prevent damage to the resource by overgrazing, trampling, and browsing. The seasonal nature of range forage production and quality was recognized and thus the need for supplementing cattle diets with minerals, protein supplements, and/or improved pasture and hay. In addition the value of wildlife as a product and user of southern pine range was recognized. Research has led to the development of a number of sound management practices that successfully utilize the range resources of the South by cattle (14,16,42,52, 61,79,81,92,93,101) and wildlife (1,13,43,44,45,56,65,87,94,95).

Soils in the Southeast generally are heavily leached and rank low in bases, organic matter and several plant nutrients, especially phosphorus and nitrogen. Nevertheless, relatively high yields of forage are possible because of favorable climatic conditions (25). When woody vegetation is sparse, dry weight yields of herbage generally vary from 1,000 to 4,000 lb per acre, depending on the natural productivity of the site. However, forage yields on most range sites are subject to considerable influence of the canopy including both the tree overstory and any brushy midstory that may develop. The overstory also may affect forage quality. In a study in east

Texas, browse plants grown in the open usually contained more crude protein and phosphorus but less crude fiber and calcium than plants beneath a stand of pines (49). Herbage contained less protein and phosphorus and more nitrogen-free extract when in the open compared to that under a cover of young pines in a Louisiana pine-bluestem range study (103).

In the longleaf-slash pine-bluestem range type in Louisiana, Mississippi and Alabama a number of workers have reported an inverse relation between herbage yield and tree basal area or canopy cover (35,37,41,82,83,88,89,103). Yields of herbage generally ranged from 300 lb/acre dry weight in dense pine stands to 3,000 lb in open stands or treeless areas. Several workers reported that 70 percent of the grass was produced during the first half of the growing season (19,88,89). Generally forage quality was adequate to meet cattle needs only during the spring and early summer (17,18,19,71,72,88,89).

In the longleaf-slash pine-wiregrass range type herbage yields generally ranged from about 300 lb per acre dry weight at 40 percent tree canopy to about 2,000 lb per acre in open areas. Most forage production occurred early in the season and quality dropped off rapidly as the grasses matured (50,51).

Similar relationships between forage yield and tree cover have been reported for the pine-hardwood forests of east Texas (5,6,47,54). Grass yields were generally lower than in the more open longleaf-slash pine forests. Browse production also was affected by the density of the tree overstory (46,49,76).

Surveys by range conservationists of the U.S. Soil Conservation Service of forage production in grazeable woodlands of the southern Coastal Plain also indicated the potential production of range forage according to soil mapping units and tree canopy classes (66,67). In southern pine forests, the canopy classes used to rate potential forage production correlated closely with the concept of tree spacing for good timber production. For example, a D plus 4 spacing of a pine forest (distance between trees in feet equals average tree diameter in inches plus 4) produces approximately 50 percent shade compared to a D plus 6 spacing which produces approximately 35 percent shade. Considerable forage can be produced on many sites with 35 to 50 percent shade.

Timber management practices that alter overstories will influence range and wildlife potentials. Clearcutting followed by site preparation for pine planting or seeding is being applied increasingly in southern forestry. Whether these practices are beneficial or deleterious to range use depends on the nature and intensity of practices used, the size of areas to which they are applied, the interspersion of practices within an area, and the animal species under consideration (13,14,21,43,64,76,78,96,97). Spacing of trees in pine plantations can have a major effect on how long the tree canopy remains open enough to produce adequate range forage (45,64,69,70,78). In older stands precommercial and commercial thinning, timber stand

improvement, and brush control will influence the density of the tree cover and thus affect forage production (4,12,36,37,41,74). More extensive use of herbicides in forestry could be expected to have important effects on the canopy as well as on the composition of the understory (75,99). In many cases timber management practices can be modified to the benefit of range use at little cost to timber production (69,70). With good management, ample opportunity exists to utilize and improve the production and quality of the range resource in the southern pine forest-range ecosystem for domestic livestock, wildlife, or both.

Practices To Improve the Range Resource

Fire has been a major factor in ecosystem development in the South and is an important management tool in timber, range, and wildlife management.

Fire is considered by some to be more important in the South in maintaining desirable, productive range than any other factor (69). Herbage yields often decline with fire protection for several years, then improve with the reintroduction of fire, depending on grazing practices and vegetation type (22,23,58,59,71,98). Many plants, such as pine-land threeawn, remain palatable for only a few months after burning, and then become unpalatable until burned again. Burning also improves the quality of range forage (31,38,55,58,59,98), reduces the buildup of pine litter, and helps to control understory brush species (31,36). Fire is used in forestry for understory brush control, disease control, preparing seedbeds, in site preparation for pine plantations, and to reduce fuel buildup to prevent disastrous wildfires. Wildlife also benefit from controlled burning programs ((69,78). Thus fire in range management is compatible with forestry and wildlife if attention is given to the needs of all resources; for example, protecting young pines from fire until they reach a size sufficient to be unharmed by fire.

Fire has been used to adjust cattle grazing and obtain more uniform use of a range area without excessive fencing (31,40) and can be used to draw cattle away from newly planted areas to protect them from damage (69). Duvall and Whitaker (31) found that the heavy utilization that occurred during the first growing season following fire applied at 3-year intervals improved forage palatability and nutritive content. The ensuing two years of lighter use restored plant vigor. Later studies (40) showed that burning one-seventh of a range each year in winter, one-seventh in spring, and one-seventh in summer produced no more gain than did burning one-third of the unit in winter. Burning different portions of a range in winter, spring, and summer did assure adequate protein in the herbage for much longer periods than winter burning alone (38).

To provide an adequate diet for cattle grazing southern pine ranges, it is necessary to supplement the range forage during periods of low quality.

Research has developed programs using mineral supplements and protein supplements and/or using improved pastures or hay to supplement native range for year-long grazing (24,27,30,32,39,72,80,91,92,93). Several workers in Georgia (72,91,92, 93) found that acceptable beef production can be achieved with proper combinations of burned-unburned range during spring and summer, accompanied by adequate feed during fall and winter. Combining improved pasture at the rate of 0.6 acre per cow with native range during the spring and summer or during the summer only boosted calf weights and maintained cow weights, compared to use of range grazing alone during spring and summer. About 10 acres of range were needed to supplement the 0.6 acre of improved pasture. Improved pastures may be in adjoining farmlands or can be provided by firebreaks that have been seeded to improved pasture species and fertilized for good production (11,52). Fall and winter feed may be provided in the form of protein supplementation of native range, improved winter pastures, or hay. Forage quality often is a limiting factor to wildlife populations, also (7,87).

Fertilization of native range also has been used to improve production and quality of range forage. Lewis (68) and Hilmon and Douglass (57) reported that native plants growing on phosphorus-deficient soils in south Florida responded significantly to cross-chopping and fertilizing with ground rock phosphate. Rock phosphate increased forage yields, raised nutrient levels, and improved palatability of most native plants. Halls et al. (48) reported a significant response of carpetgrass-lespedeza on a longleaf-slash pine site to fertilization with phosphorus and potassium. Duvall and Grelen (26) reported that applying 100 lb per acre each of nitrogen, phosphorus (P_2O_5), and potassium (K_2O) on two slash pine plantations increased yield of native forage more than threefold. However, these increases were inadequate to justify costs. Response of native range in Louisiana to fertilization was reported by Peevy (85). Forest-range fertilization could affect the yield and nutrient content of wildlife foods as well as the botanical composition of the community and its change with succession, although specific information regarding these effects is lacking (57). With increased use of fertilization of southern pines for increased timber production there are bound to be interactions with range production and utilization for both livestock and wildlife that must be considered (57).

The potential for using exotic pasture species and/or fertilization in combination with planted pines has been summarized by Burton (11). In early studies exotic forages and pasture plants adapted to the southern climate grew poorly, if at all, unless soil fertility was improved with fertilizers and lime. Grasses like carpetgrass and Pensacola bahiagrass can persist in favored range sites if they become established, but they will contribute little to the range other than better quality grazing in the summer unless they are fertilized. Legumes and some grasses can be established on selected sites without disturbing the soil by broadcast seeding on freshly burned native range. Inoculation of legume seeds, application of adequate amounts of lime and fertilizer, and continued heavy grazing to suppress the native vegetation were required for successful

establishment. Destroying the native vegetation by chopping or disking facilitated the establishment of both grasses and legumes, as did drilling or covering the broadcast seed. If land preparation was not used, the heavy grazing required to suppress native vegetation resulted in poor animal performance and delayed natural regeneration or reforestation of an area.

Research in the Ouachita Mountain area of Arkansas (2) has shown the feasibility of establishing a number of introduced forage species into pine plantations by broadcast seeding following site preparation, which consisted of crushing and burning the hardwoods that were left following timber harvest of the area. Tall fescue, bahiagrass, western wheatgrass, crimson clover, red clover, and sericea and virgata lespedeza were all successfully established.

A long-term study on the integration of livestock and timber on intensively managed improved pastures was initiated in Georgia in 1957 (11,57,63). Slash pines were planted in 1957 at spacings of 12 x 12 ft and 20 x 20 ft and cultivated for 3 years. Improved pastures of Coastal bermudagrass, carpetgrass, dallisgrass, and bahiagrass were then established in open areas with no trees and in the slash pine plantations. Slash pines planted in an undisturbed, unfertilized, cut-over site served as controls. The pastures were fertilized annually with 100-50-50 lb of N-P, O_5-K, O, and burned annually in late winter, and weeds were controlled with herbicides or mowing. Lateral branches of the slash pines were pruned to a height of 8 feet in 1962.

Grazing was started in 1961 when the trees averaged 12 ft in height and was continued through 1971. Steers grazing improved pastures with no trees, trees spaced 12 x 12 ft, and trees spaced 20 x 20 ft made average daily gains of 0.99, 0.86, and 0.77 lb, respectively, and liveweight gains of 247, 178, and 120 lb/acre, respectively.

Seven years after planting, slash pines in the fertilized pastures averaged 73 percent survival, a height of 24 ft, and DBH of 5.8 in, while those in the native range averaged 92 percent survival, a height of 14 ft, and DBH of 3.2 in. After 15 years pulpwood yields averaged 2.7 times more from the fertilized pastures than from the native range. The young, fast-growing pines in the fertilized pastures were found to be more susceptible to attack by insects and disease than those in the native range; this resulted in a higher mortality and more trees with poorly shaped trunks that were often broken over by strong winds or cattle pushing on them. Most of the trees from the fertilized pastures were suitable only for pulpwood.

In a later study tree spacings of 10 x 48 ft and 16 x 30 ft (91 trees/acre) were used with no apparent reduction in forage yield. Harvesting hay instead of cultivating the plantations the first three years before planting the pasture resulted in no differences in tree growth. Other tree spacings and configurations that allow a more open canopy for a longer period presently are being investigated (69).

Animal Damage to Pines

A problem associated with integration of forest and range use is reduced wood production caused by animal damage. Livestock and wildlife decrease reproduction by eating tree seed, and reduce growth by browsing, trampling, and rubbing young trees. Severe damage to pines usually results from overstocking or concentration of animals on an area, but usually it is not excessive if animal numbers and distribution are kept in balance with the available forage, or after trees are 8 to 10 ft tall (10,20,60,62,84,102). Browsing damage to pines by cattle usually is heaviest in late winter or spring when other green forage is scarce. Thus young pines can be given increased protection by withholding grazing until after ample green forage is available in the spring, and removing the animals after frost. Providing ample feed and supplements for cattle held on range year-long will help control pine damage. Fertilization and treatments that remove old grass and stimulate new, such as burning, disking, scalping, and hardwood control, attract cattle to an area. Therefore, if these practices are applied to only part of a forest-range, cattle numbers should be based on the size and distribution of the treated areas in order to prevent damage, or else the treated areas should be protected by fencing. Several repellents have proven effective in reducing damage to pines by grazing animals; however, due to costs, need to apply annually, and/or toxic effects, they have generally not proven practical (102).

Indirect damage to pines through impairment of the physical properties of soils from grazing is possible, but probably this would not be serious with proper management (29,73).

Summary

Southern pine forests being managed for timber production also can provide forage for livestock and/or wildlife. Proper management is the key to utilizing the range resource as part of a multiple-use system where primary emphasis is on timber production. Management for multiple use means giving attention to the needs of all components of the ecosystem: the trees, the range vegetation, the soils, and the animals including livestock, wildlife, and man. Programs to provide a year-long diet of adequate quality must be developed. Proper control of animal numbers, grazing seasons, and animal distribution must be exercised if tree damage is to be minimized and the range resource sustained.

A number of factors, including many that can be altered by management, are known to affect the quantity and quality of forage produced on forest-range ecosystems. Management possibilities exist to improve range resources on timberlands, such as seeding and fertilizing, but further evaluation of these practices is needed. The impact of many present timber management practices, such as clearcutting, site preparation, reforestation, brush control, thinning, short rotations, and

fertilization, on the range resource also needs further evaluation. Finally, the interaction of timber and range practices on the productivity of the whole forest-range ecosystem from both an economic and an ecological standpoint needs to be determined, in order to find the most profitable mix of management practices and product outputs, and also maintain the long-term productivity and environmental quality of the southern pine forest-range ecosystem.

Highlights

There is a long history of cattle grazing in southern pine forests. Often such grazing has been uncontrolled and unmanaged, leading to low productivity and conflicts with other forest uses. However, with controlled grazing and good management, range grazing offers an opportunity to utilize a valuable forage resource that often is found in the forest understory. This range resource is also a valuable asset for wildlife production.

With increasing intensification of forest management on many areas, new opportunities are opening up for increased range management and utilization. Practices such as seeding, fertilization, controlled burning, and brush control can be used to improve the forage resource. Optimum multiple-use forest management will require a full understanding of the many interactions of the different uses of the southern pine forest-range ecosystem.

Literature Cited

1. Arner, D.H. and V.E. Davison. "Wild turkeys on southeastern farms and woodlands," USDA Leaflet 526, 8pp., 1963.
2. Bickel, J.R. "Seeding clearcuts in the Ouachita Mountains of Arkansas to improve forage value," M.S. thesis, University of Ark., 1978.
3. Biswell, H.H., J.E. Forester, and B.L. Southwell. "Grazing in cutover pine forests of the Southeast," J. For. 42:195-8, 1944.
4. Blair, R.M. "Deer forage increased by thinnings in a Louisiana loblolly pine plantation," J. Wildl. Manage. 24:401-5, 1960.
5. Blair, R.M. "Deer forage in a loblolly pine plantation," J. Wildl. Manage. 31:432-7, 1967.
6. Blair, R.M. "Forage production after hardwood control in a southern pine-hardwood stand," For. Sci. 17:279-84, 1971.
7. Blair, R.M. and E.A. Epps, Jr. "Seasonal distribution of nutrients in plants of seven browse species in Louisiana," So. For. Expt. Sta., New Orleans, La., 35 pp. (USDA Forest Serv. Res. Pap. SO-51), 1969.
8. Blaisdell, J.P., V.L. Duvall, R.W. Harris, R.D. Lloyd, and E.H. Reid. "Range ecosystem research - the challenge of change," USDA Agr. Inf. Bul. 346, 26pp., 1970.
9. Blaisdell, J.P., V.L. Duvall, R.W. Harris, R.D. Lloyd, and E.H. Reid. "Range research to meet new challenges and goals," J. Range Manage. 23: 227-34, 1970.
10. Boyer, W.D. "Grazing hampers development of long-leaf pine seedlings in southwest Alabama," J. For. 65:336-8, 1967.
11. Burton, G.W. "Integrating forest trees with improved pastures," *In* Range Resources of

the Southeastern United States, Amer. Soc. Agron. Special Pub. 21, Madison, Wis., pp. 41-9, 1973.
12. Burton, J.D. and E. Shoulders. "Fast-grown, dense loblolly pine sawlogs: A reality," J. For. 72:637-41, 1974.
13. Byrd, N.A., and H.L. Holbrook. "How to improve forest game habitat," For. Manage. Bul. Southeastern Area, State and Private Forestry, USDA For. Service, 6pp., 1974.
14. Byrd, N.A., and C.E. Lewis. "Managing southern pine forests to produce forage for beef cattle," For. Manage. Bul. Southeastern Area, State and Private Forestry, USDA For. Service, 6pp., 1976.
15. Campbell, R.S. "Extension of the range front to the South," J. For. 49:787-9, 1951.
16. Campbell, R.S. "Managing native grasslands for long-season grazing in the southern United States," Ninth Int. Grassland Congr. Proc. 1965:1405-7, 1966.
17. Campbell, R.S., and J.T. Cassady. "Grazing values for cattle on pine forest ranges in Louisiana," La. Agr. Expt. Sta. Bul. 452, 31pp., 1951.
18. Campbell, R.S., E.A. Epps, Jr., C.C. Moreland, J.L. Farr, and F. Bonner. "Nutritive values of native plants on forest range in central Louisiana," La. Agr. Expt. Sta. Bul. 488, 18pp., 1954.
19. Cassady, J.T. "Herbage production on bluestem range in central Louisiana," J. Range Manage. 6:38-43, 1953.
20. Cassady, J.T., W. Hopkins, and L.B. Whitaker. "Cattle grazing damage to pine seedlings," U.S. For. Serv., So. For. Expt. Sta. Occasional Pap. 141, 14pp., 1955.
21. Crawford, H.S., J.B. Whelan, R.F. Harlow, and J.E. Skeen. "Deer range potential in selective and clearcut oak-pine stands in southwestern Virginia," USDA For. Ser. Res. Pap. SE-134, 12pp., 1975.
22. Duvall, V.L. "Burning and grazing increase herbage on slender bluestem range," J. Range Manage. 15:14-6, 1962.
23. Duvall, V.L. "Reactions of longleaf pine-bluestem range to grazing and burning," Ninth Int. Grassland Congr. Proc. 1965:1339-43, 1966.
24. Duvall, V.L. "Comparison of supplementation methods for cow herds grazing pine-bluestem range," J. Range Manage. 22:182-7, 1969.
25. Duvall, V.L. "Climatic factors governing forage quantity and quality", *In* Range Resources of the Southeastern United States, Amer. Soc. Agron. Special Pub. 21, Madison, Wis., pp. 20-24, 1973.
26. Duvall, F.L., and H.E. Grelen. "Fertilization uneconomic for forage improvement in Louisiana pine plantations," So. For. Expt. Sta. New Orleans, La., 3pp. (USDA Res. Note SO-51), 1967.
27. Duvall, V.L., and S.L. Hansard. "Responses of southern range cattle to protein supplementation," J. Range Manage. 20:153-7, 1967.
28. Duvall, V.L., and J.B. Hilmon. "New grazing research programs for southern forest ranges," J. Range Manage. 18:132-6, 1965.
29. Duvall, V.L., and N.E. Linnartz. "Influences of grazing and fire on vegetation and soil of longleaf pine-bluestem range," J. Range Manage. 20:241-7, 1967.
30. Duvall, V.L., and L.B. Whitaker. "Supplemental feeding increases beef production on bluestem-longleaf pine ranges," La. Agr. Expt. Sta. Bul. 564, 18pp., 1963.
31. Duvall, V.L., and L.B. Whitaker. "Rotation burning: A forage management system for longleaf pine-bluestem ranges," J. Range Manage. 17:322-6, 1964.
32. Duvall, V.L., and L.B. Whitaker. "Factors influencing intake of mineral supplements by cattle on southern forest range," J. Range Manage. 23:347-50, 1970.
33. Farley, F.W., and S.W. Greene. "The cut-over pine lands of the South for beef-cattle production," USDA Agr. Bul. 827, 51pp., 1921.
34. Forest-Range Task Force. "The nation's range resources—a forest-range environmental study," Forest Resource Report 19, USDA For. Serv., Washington, D. C., 147pp., 1972.
35. Gaines, E.M., R.S. Campbell, and J.J. Brasington. "Forage production on longleaf pine lands of southern Alabama," Ecol. 35:59-62, 1954.

36. Grano, C.X. "Eradicating understory hardwoods by repeated prescribed burning," So. For. Expt. Sta., New Orleans, La., 11pp., (USDA For. Serv. Res. Pap. SO-56), 1970.
37. Grelen, H.E., and H.G. Enghardt. "Burning and thinning maintain forage in a longleaf pine plantation," J. For. 71:419-20, 1973.
38. Grelen, H.E., and E.A. Epps, Jr. "Season of burning affects herbage quality and yield on pine bluestem range," J. Range Manage. 20:31-3, 1967.
39. Grelen, H.E., and H.A. Pearson. "Liquid supplements for cattle on Southern forest range," J. Range Manage. 30:94-6, 1977.
40. Grelen, H.E., and L.B. Whitaker. "Prescribed burning rotations on pine-bluestem range," J. Range Manage. 26:152-3, 1973.
41. Grelen, H.E., L.B. Whitaker, and R.E. Lohrey. "Herbage response to precommercial thinning in direct-seeded slash pine," J. Range Manage. 25:435-7, 1972.
42. Halls, L.K. "Forage and cattle production in longleaf-slash pine forests." Ninth Int. Grassland Congr. Proc. 1965:1609-12, 1966.
43. Halls, L.K., editor. "White-tailed deer in the southern forest habitat," Proc. Symp. USDA For. Serv. So. For. Expt. Sta., 130 pp., 1969.
44. Halls, L.K. "Growing deer food amidst southern timber," J. Range Manage. 23:213-5, 1970.
45. Halls, L.K. "Managing deer habitat in loblolly-shortleaf pine forest," J. For. 71:752-7, 1973.
46. Halls, L.K. "Deer browse growth reduced by pine overstory," Proc. 27th Ann. Conf. Southeastern Assoc. Game and Fish Commissioners, pp. 304-6, 1974.
47. Halls, L.K., and R. Alcaniz. "Forage yields in an east Texas pine-hardwood forest," J. For. 69:25-6, 1971.
48. Halls, L.K., G.W. Burton, ane B.L. Southwell. "Some results of seeding and fertilization to improve southern forest range," So. For. Expt. Sta., New Orleans, La., 26pp., (USDA For. Serv. Sta. Pap. 78), 1957.
49. Halls, L.K., and E.A. Epps, Jr. "Browse quality influenced by tree overstory in the South," J. Wildl. Manage. 33:1028-31,1969.
50. Halls, L.K., O.M. Hale, and F.E. Knox. "Seasonal variation in grazing use, nutritive content, and digestibility of wiregrass forage," Ga. Agr. Expt. Sta. Tech. Bul. N. S. 11, 28pp., 1957.
51. Halls, L.K., O.M. Hale, and B.L. Southwell. "Grazing capacity of wiregrass-pine ranges of Georgia," Ga. Agr. Expt. Sta. Tech. Bul. N.S. 2, 38pp., 1956.
52. Halls, L.K., R.H. Hughes, and F.A. Peevy. "Grazed firebreaks in southern forests," USDA Infor. Bul. 226, 8pp., 1960.
53. Halls, L.K., R.H. Hughes, R.S. Rummell, and B.L. Southwell. "Forage and cattle management in longleaf-slash pine forests," USDA Farmers' Bul. 2199, 25pp., 1964.
54. Halls, L.K. and J.L. Schuster. "Tree-herbage relations in pine-hardwood forests of Texas," J. For. 63:282-3, 1965.
55. Halls, L.K., B.L. Southwell, and F.E. Knox. "Burning and grazing in coastal plain forests," Ga. Coastal Plain Expt. Sta. Bul. 51, 33pp., 1952.
56. Halls, L.K., and J.J. Stransky. "Atlas of southern forest game," USDA For. Serv. So. For. Expt. Sta., New Orleans, La., 24pp., 1971.
57. Hilmon, J.B., and J.E. Douglass. "Potential impact of forest fertilization on range, wildlife, and watershed management," Proc. For. Fert. Symp., Gainesville, Fla., Publ. TVA Natl. Fert. Center, Muscle Shoals, Ala., pp. 197-202, 1968.
58. Hilmon, J.B., and R.H. Hughes. "Forest Service research on the use of fire in livestock management in the South," Fourth Annual Tall Timbers Fire Ecol. Conf., Tallahassee, Fla., pp. 261-275, 1965.
59. Hilmon, J.B., and R.H. Hughes. "Fire and forage in the wiregrass type," J. Range Manag. 18:251-254, 1965.
60. Hughes, R.H. "Animal damage," *In* A Guide to Loblolly and Slash Pine Plantation

Management in Southeastern USA. W.G. Wahlenberg, editor. Ga. For. Res. Council Report 14. Macon Ga. pp. 160-6. 1965.
61. Hughes. R.H. "Management and utilization of pineland threeawn range in South Florida." J. Range Manage. 27:186-92. 1974.
62. Hughes. R.H. "Response of planted south Florida slash pine to simulated cattle damage." J. Range Manage. 29:198-201. 1976.
63. Hughes. R.H., J.B. Hilmon, and G.W. Burton. "Improving forage on southern pine woodland." Ninth Int. Grassland Congr. Proc. 1965:1305-7. 1966.
64. Johnson. A.S., J.L. Landers, and T.D. Atkeson. "Wildlife in young pine plantations." Proc. Symp. on Manage. of Young Pines. Southeastern Area. State and Private Forestry. USDA Forest Service. pp. 147-59. 1974.
65. Lay. D.W., and W.P. Taylor. "Wildlife aspects of cutover pine woodland in eastern Texas." J. For. 41:446-8. 1948.
66. Leithhead. H.L. 1970. "Soil survey—A guide to forage resources of grazable woodlands in the southern coastal plains" *In* Tree Growth and Forest Soils. Proc. Third N. Amer. For. Soils Conf. Raleigh. NC. 1968. C. T. Youngberg and C. B. Davey. ed., Ore. State Univ. Press. Corvallis. pp. 449-59. 1972.
67. Leithead. H.L. "Soil surveys—guides to forage quantity and quality." *In* Range Resources of the Southeastern United States. Amer. Soc. Agron. Special Pub. 21. Madison. Wis., pp. 25-33. 1973.
68. Lewis. C.E. "Responses to chopping and rock phosphate on south Florida ranges." J. Range Manage. 23:276-82. 1970.
69. Lewis. C.E. "Integrating management of forest and range resources." *In* Range Resources of the Southeastern United States. Amer. Soc. Agron. Special Pub. 21. Madison. Wis., pp. 69-78. 1973.
70. Lewis. C.E. "Grazing considerations in managing young pines." Proc. Symp. on Manage. of Young Pines. Southeastern Area. State and Private Forestry. USDA Forest Service. pp. 159-70. 1974.
71. Lewis. C.E., and R.H. Hart. "Some herbage responses to fire on pine-wiregrass range." J. Range Manage. 25:209-13. 1972.
72. Lewis. C.E., and W.C. McCormick. "Supplementing pine-wiregrass range with improved pasture in south Georgia." J. Range Manage. 24:334-9. 1971.
73. Linnartz. H.E., C.Y. Hse. and V.L. Duvall. "Grazing impairs physical properties of a forest soil in central Louisiana." J. For. 64:239-43. 1966.
74. Moore. W.H. "Some effects of chopping saw-palmetto-pineland threeawn range in South Florida." J. Range Manag. 27:101-4. 1974.
75. Newton. M. "Constructive use of herbicides in forest resource management." J. For. 73:329-36. 1975.
76. Patton. D.R., and B.S. McGinnes. "Deer browse relative to age and intensity of timber harvest." J. Wildl. Manage. 28:458-63. 1964.
77. Pearson. H.A. "Forest-range grazing offers relief to cattlemen." The La. Cattleman 7:7. 1974.
78. Pearson. H.A. "Range and wildlife opportunities." Proc. Symp. on Manage. of Young Pines. Southeastern Area. State and Private Forestry. USDA Forest Service. pp. 19-27. 1974.
79. Pearson. H.A. "Herbage disappearance and grazing capacity determinations of southern pine bluestem range." J. Range Manage. 28:71-3. 1975.
80. Pearson. H.A., and L.B. Whitaker. "Thrice-weekly supplementation adequate for cows on pine-bluestem range." J. Range Manage. 25:315-6. 1972.
81. Pearson. H.A., and L.B. Whitaker. "Returns from southern forest grazing." J. Range Manage. 26:85-7. 1973.
82. Pearson. H.A., and L.B. Whitaker. "Forage and cattle responses to different grazing intensities on southern pine range." J. Range Manage. 27:444-6. 1974.

83. Pearson, H.A., and L.B. Whitaker. "Yearlong grazing of slash pine ranges: Effects on herbage and browse." J. Range Manage. 27:195-7, 1974.
84. Pearson, H.A., L.B. Whitaker, and V.L. Duvall. "Slash pine regeneration under regulated grazing." J. For. 69:744-746, 1971.
85. Peevy, F.A. "Fertilizing and seeding forage on forest range in Louisiana." Agron. J. 45:164-6,1963.
86. Sheperd, W.O. "The forest range in southern agriculture." J. Range Manag. 3:42-5, 1950.
87. Short, H.L. "Ecological framework for deer management." J. For. 70:200-3, 1972.
88. Smith, L.F., R.S. Campbell, and C.L. Blount. "Forage production and utilization in longleaf pine forests of south Mississippi." J. Range Manage. —:58-60, 1955.
89. Smith, L.R., R.S. Campbell, and C.L. Blount. "Cattle grazing in longleaf forests of south Mississippi," So. For. Expt. Sta., New Orleans, La., 25pp. (USDA For. Serv. Occasional Pap. 162), 1958.
90. Southern Section, Society for Range Management. "Range resources of the south." Ga. Agr. Expt. Sta. Bul. N. S. 9, 33pp., 1974.
91. Southwell, B.L., and L.K. Halls. "Supplemental feeding of range cattle in longleaf-slash pine forests of Georgia." J. Range Manage. 8:25-30, 1955.
92. Southwell, B.L., and R.H. Hughes. "Beef cattle management practices for wiregrass-pine ranges of Georgia." Ga. Agr. Expt. Sta. Bul. N. S. 129, 26pp., 1965.
93. Southwell, B.L., and R.H. Hughes. "Beef cattle management practices for burned and unburned pine-wiregrass ranges of Georgia." Ga. Agr. Expt. Sta. Res. Rep. 14, 19pp., 1967.
94. Stransky, J.J. "Integrated deer-habitat management and timber production in the South." The Consultant 16:89-90, 1971.
95. Stransky, J.J. "Managing for quail and timber in longleaf pine forests." Tex. For. Pap. 9, Stephen F. Austin State Univ. School of For., 8pp., 1971.
96. Stransky, J.J., L.K. Halls, and E.S. Nixon. "Plants following timber harvest: Importance to songbirds." Texas For. Pap. 28, Stephen F. Austin State Univ. School of For., 13pp., 1976.
97. Sweeney, J.M., and C.R. Wenger. "Preliminary report on food habits of bobwhite quail in young pine plantations," Ark. Farm Research 26(4):3, 1977.
98. Wahlenberg, W.G., S.W. Greene, and H.R. Reed. "Effects of fire and cattle grazing on longleaf pine lands, as studied at McNeill, Mississippi." USDA Tech. Bul. 683, 52pp., 1939.
99. Walstad, J.D. "Weed control for better southern pine management," Weyerhaeuser For. Pap. 15, So. For. Res. Center, Hot Springs, AR, 44pp., 1976.
100. White, L.D. "Native forage resources and their potential." *In* Range Resources of the Southeastern United States, Amer. Soc. Agron. Special Pub. 21, Madison, Wis., 17pp., 1973.
101. Williams, R.E. "Managing natural vegetation for forage production in southeastern USA." Ninth Int. Grassland Congr. Proc. 1965:1415-8, 1966.
102. Williston, H.L. "Control of animal damage to young plantations in the South." J. For. 72:78-81, 1974.
103. Wolters, G.L. "Southern pine overstories influence herbage quality." J. Range Manage. 26:423-6, 1973.

APPENDIX

Common and Scientific Names of Plants Mentioned in Article

Common Name	Scientific Name
Grasses	
Bahiagrass	*Paspalum notatum*
Bermudagrass	*Cynodon dactylon*
Bluestem, broomsedge	*Andropogon virginicus*
Bluestem, little	*Andropogon scoparius*
Bluestem, pinehill	*Andropogon scoparius* var. *divergens*
Bluestem, slender	*Andropogon tener*
Carpetgrass	*Axonopus* spp.
Dallisgrass	*Paspalum dilatatum*
Dropseed, curtiss	*Sporobolus curtissii*
Dropseed, pineywoods	*Sporobolus junceus*
Muhly, cutover	*Muhlenbergia expansa*
Panicum grasses	*Panicum* spp.
Paspalum grasses	*Paspalum* spp.
Tall fescue	*Festuca arundinacea*
Uniola, longleaf	*Uniola sessiliflora*
Uniola, spikeleaf	*Uniola laxa*
Wheatgrass, western	*Agropyron smithii*
Wiregrass (pineland threeawn)	*Aristida stricta*
Forbs and legumes	
Clover, crimson	*Trifolium incarnatum*
Clover, red	*Trifolium pratense*
Goldaster, grassleaf	*Heterotheca graminifolia*
Lespedeza, native	*Lespedeza* spp.
Lespedeza, sericea	*Lespedeza cuneata*
Lespedeza, virgata	*Lespedeza virgata*
Partridge-pea	*Cassia* spp.
Tephrosia	*Tephrosia* spp.
Tickclover	*Desmodium* spp.
Shrubs	
Beautyberry, American	*Callicarpa americana*
Blueberry	*Vaccinium* spp.
Gallberry	*Ilex glabra*
Haws (hawthorn)	*Crataegus* spp.
Saw-palmetto	*Serenoa repens*
Sumac	*Rhus* spp.
Viburnums	*Viburnum* spp.
Wax myrtle	*Myrica cerifera*
Yaupon	*Ilex vomitoria*
Trees	
Dogwood	*Cornus florida*
Oak	*Quercus* spp.
Pine, loblolly	*Pinus taeda*
Pine, longleaf	*Pinus palustris*
Pine, shortleaf	*Pinus echinata*
Pine, slash	*Pinus elliottii*