Responses to Chopping and Rock Phosphate on South Florida Ranges[1]

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Highlight

Native plants growing on phosphorus-deficient soils in south Florida responded favorably to cross-chopping and fertilizing with ground rock phosphate. Availability of soil phosphate remained high throughout the 5-year study. Chopping effectively controlled saw palmetto and reduced the density of pineland threeawn, while increasing herbage yields, availability, and utilization. Rock phosphate increased herbage yields, raised nutrient levels, and improved palatability of most native plants. These practices offer practical opportunities for improving Florida rangelands.

Brush and low-quality forage are problems in managing pine-wiregrass ranges of Florida and southeast Georgia for grazing and timber. Saw palmetto (*Serenoa repens* (Bartr.) Small), which heavily infests these flatwoods, is the dominant shrub on some 25 million acres of grazing land in Florida (Yarlett, 1965). It suppresses yield and availability of better forage plants, interferes with tree planting, and contributes to fire hazards in timber stands.

Limited forage quality of the native grasses occurs because the fine sand soils are commonly deficient in major plant nutrients, including phosphorus and calcium (Gammon et al., 1953). Although nutrient content varies seasonally and among species, native forage seldom fully meets cattle needs for phosphorus, calcium, and protein (Davis and Kirk, 1952; Halls et al., 1957; Hilmon and Lewis, 1962). Without supplements, cattle on wiregrass[3] range often develop symptoms of phosphorus deficiency (Becker et al., 1933).

In an effort to resolve these problems, two practices having possible application in both range and timber management were evaluated during a 5-year study in south Florida: (1) roller chopping to control saw palmetto, and (2) applying rock phosphate to enhance plant growth and improve forage quality. This paper reports on the range aspects, presenting effects of treatments on soil phosphorus, kind and amount of herbaceous vegetation, and palatability and chemical composition of the herbage.

Methods

The study was conducted on the Caloosa Experimental Range in Charlotte County, Florida, a site representative of the cutover pine flatwoods of south Florida. The vegetation had been burned about every 2 years and intensively grazed for many years. The Leon and Adamsville fine sand soils are nearly level, moderately wet and acid (pH 5.7) in the surface horizon. Treatments were applied in the early summer of 1959 on sites burned the previous November.

Four 3-acre plots were laid out, and one-half of each plot was cross-chopped. Each split plot was then divided into three ½-acre subplots, one receiving no fertilization, another receiving 1 ton of rock phosphate per acre, and the third receiving 2 tons per acre. These treatments were applied in a randomized, complete block design.

The cross-chopping was a twice-over treatment. The second chop, which was at right angles to the first, was performed with a roller-chopper (described and illustrated by Yarlett, 1965) that cuts and partially uproots the decumbent stems of saw palmetto.

The rock phosphate was applied to the soil surface after the chopping. This was a finely ground, Florida, pebble phosphate rock containing 31% phosphate (P_2O_5), 48% calcium oxide (CaO), and small amounts of potassium, magnesium, sulphur, iron, copper, zinc, molybdenum, and boron.

Available soil phosphorus was determined by using Bray's strong (0.03N NH_4F in 0.1N HCl) extraction solution (Bray & Kurtz, 1945) modified to remove interference by fluoride ions (Kurtz, 1942). Soil samples were taken from the 0- to 4-inch level annually in June through 1964.

Herbage production and utilization were determined by clipping a series of caged and uncaged circular areas, each comprising 9.6 ft^2, on each subplot during March, June, September, and December of each year. Samples of the clipped material were ovendried at 70 F and analyzed for major nutrients by standard proximate analysis. The following five species or groups of species were sampled: pineland threeawn (*Aristida stricta* Michx.), goobergrass (*Amphicarpum muhlenbergianum* (Schult.) Hitchc.), bluestems (*Andropogon* spp.), panicum grasses (*Panicum* spp.), and all other herbage. Shrubs were not included in herbage samples. Yields were summarized for pineland threeawn and all other herbage; utilization was computed on total herbage.

The number of shoots per acre and percent crown coverage of saw palmetto were determined before treatment, 2 months after treatment, and annually in December of 1960 through 1964. Plants were counted in two 6-foot by 100-foot transects per treatment subplot. Coverage (crown intercept) was measured to the nearest 0.1 foot along the center of each transect.

Results

Soil Phosphorus

The effects of adding rock phosphate to an acid flatwoods soil were both immediate and lasting

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[3] The term "wiregrass" generally refers to *Aristida stricta* but frequently includes *Muhlenbergia capillaris, Paspalum monostachyum, Rhynchospora* spp., and similar species with involute leaves.

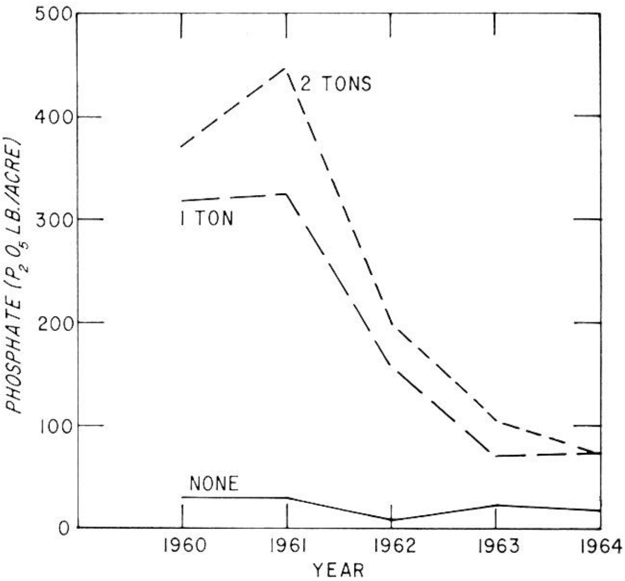

FIG. 1. Available phosphate (P_2O_5) in the 0- to 4-inch layer of soil after application of ground rock phosphate at 1 and 2 tons per acre in July 1959. Readings were taken in June in each of 5 years.

FIG. 2. Grazing was light on chopped, unfertilized area in the foreground but was heavy on phosphated area in the background. Photographed just prior to weaning on September 1, 1963.

(Fig. 1). Differences between the 1- and 2-ton rates were highly significant until June 1964, when the differences disappeared. However, at the end of 5 years available phosphate was still 4 times higher than on untreated soils. Longevity of availability of phosphate remains to be determined. Hodges et al. (1967) reported highly beneficial effects 12 years after the last application of rock phosphate on pastures of pangolasgrass (*Digitaria decumbens* Stent.) in Florida. Lang (1953) reported a response to residual rock phosphate by forage crops in Illinois after 25 years of regular cropping without additional phosphate fertilization.

Herbage Utilization

About 20 cattle on the surrounding 300-acre range unit sought out and closely grazed the 12-acre study area (Fig. 2), even though portions of the surrounding range were burned yearly in November and January. Separate grazing management of the study area was not feasible. Beginning the second year, cattle were rotated to another range during June, July, October and November, but overuse of the study area continued, especially on phosphated plots.

Over the 5 years, utilization of total herbage was about twice as heavy on chopped plots as on unchopped plots, and about twice as heavy on phosphated plots as on unphosphated plots (Fig. 3). The pattern of overall use was strongly influenced by pineland threeawn, the dominant grass before treatment, which becomes unpalatable with advancing maturity. Accordingly, use on all treated plots was highest in 1960; thereafter, pineland threeawn became increasingly unpalatable and was utilized very little. This pattern was reflected on untreated plots, where pineland threeawn remained dominant. After the first year, the only detected use of these plots occurred during years of low forage yields, 1962 and 1964.

Chopping increased utilization in two ways: (1) by killing some pineland threeawn plants, which were generally replaced by more palatable species, and (2) by removing clumps of palmetto and thus making the forage more available to cattle. These influences were reflected in the chopped-only treatment (Fig. 3). Here, utilization of total

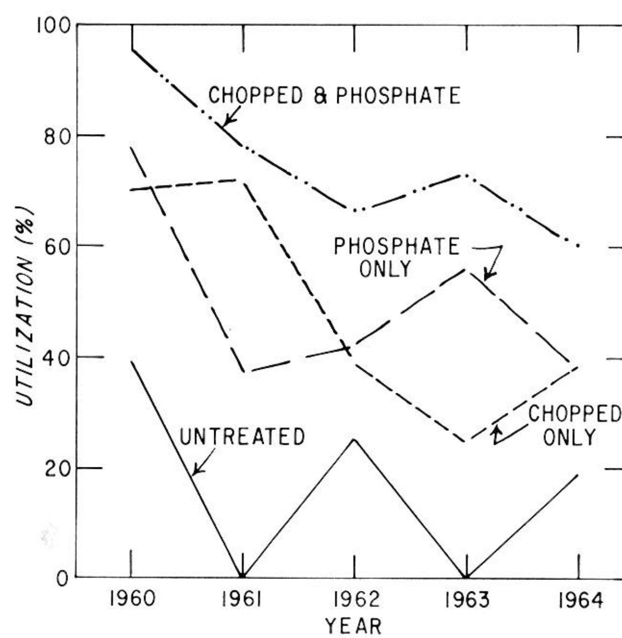

FIG. 3. Utilization of treated plots by cattle with free access to the study area.

herbage during the last 3 years was only moderate because of the remaining threeawn plants, which were unutilized and were recovering from the initial treatment effects.

Phosphate markedly increased palatability of all herbage except pineland threeawn. On phosphated but unchopped plots, initial heavy utilization dropped abruptly after the first year as pineland threeawn became unpalatable. However, all other plants continued to be grazed heavily except those growing in dense clumps of palmetto. On plots that were both chopped and phosphated, all herbage was fully utilized the first year, and use remained intensive throughout the study.

Grazing undoubtedly influenced species composition, herbage yields, and forage nutrient levels in this study. Although the precise influences could not be fully evaluated, they will be considered as these aspects are discussed.

Species Composition

Saw palmetto and pineland threeawn were the predominant plants on the study site. Other commonly occurring species were goobergrass, broomsedge bluestem (*Andropogon virginicus* L.) arrowfeather threeawn (*Aristida purpurascens* Poir), panicum grasses, razorsedges (*Scleria* spp.), common yelloweyedgrass (*Xyris elliottii* Chapm.), and numerous incidental forbs (Table 1). These plants are typical of pine-palmetto flatwoods in south Florida.

Chopping effectively reduced the amount of saw palmetto, as will be discussed later. It also somewhat reduced the amount of pineland threeawn, although this plant was still common on chopped plots. Disturbance of the soil by chopping commonly increased panicum grasses and various forbs.

Adding rock phosphate without chopping had minor effect on species occurrence. The common forage plants generally persisted on these unchopped plots, particularly when protected from heavy grazing by clumps of pineland threeawn or saw palmetto. Increases in common carpetgrass (*Axonopus affinis* Chase), bluestems, lovegrasses (*Eragrostis* spp.), barestem paspalum (*Paspalum longipedunculatum* LeConte), flatsedge (*Cyperus polystachyos* Rottb. var. *texensis* (Torr.) Fern.), and miscellaneous forbs occurred in spots where grazing and trampling were particularly heavy.

The most drastic changes in species composition occurred on plots that were both chopped and phosphated. These plots received extremely heavy grazing, which evidently caused much of the species changes. Pineland threeawn, goobergrass, and bluestems were greatly reduced during the first year. These plants were largely replaced by common carpetgrass, big carpetgrass (*Axonopus furcatus* (Flugge) Hitchc.), knotroot bristlegrass (*Seteria geniculata* (Lam.) Beauv.), lovegrasses, gaping panicum (*Panicum hians* Ell.), barestem paspa-

Table 1. Occurrence (percent[1]) of important species on chopped and unchopped areas in September 1959 and 1964.[2]

Species	1959 Unchopped	1959 Chopped	1964 Unchopped	1964 Chopped
Grasses (33)[3]				
Amphicarpum muhlenbergianum	56	42	83	67
Andropogon capillipes	2	2	10	2
" *stolonifer*	8	4	19	4
" *virginicus*	29	19	48	44
Aristida purpurascens	21	0	6	2
" *spiciformis*	12	17	0	4
" *stricta*	88	40	94	79
Axonopus affinis	0	0	10	27
" *furcatus*	0	0	0	19
Eragrostis spp.	4	12	42	44
Muhlenbergia capillaris	2	12	2	2
Panicum chamaelonche	12	8	0	8
" *hians*	14	19	19	31
" *pinetorum*	10	0	19	0
" *polycaulon*	58	35	12	0
" *tenerum*	17	4	0	0
Paspalum longepedunculatum	2	6	38	52
Setaria geniculata	0	0	12	12
Sporobolus junceus	0	0	10	0
Grasslikes (15)[3]				
Cyperus polystachyos var. *texensis*	0	0	35	69
Fuirena scirpoidea	10	14	0	0
Scleria ciliata	10	2	0	0
" *georgiana*	23	31	2	0
" *hirtella*	23	10	12	0
" *muhlenbergii*	19	17	27	21
Forbs (39)[3]				
Bigelovia nudata	10	2	0	0
Chaptalia tomentosa	10	8	8	8
Chrysopsis nervosa	0	0	21	12
Cynoctonum sessilifolium	23	8	0	0
Pluchea foetida	0	0	23	35
Pterocaulon undulatum	6	6	19	10
Sabatia brevifolia	14	2	2	6
Utricularia cornuta	10	2	0	0
Xyris elliottii	25	14	4	4
" spp.	8	21	2	2

[1]Percentage occurrence on 48 sample quadrats.
[2]Includes only species that (a) contributed to herbage yields, and (b) occurred on at least 10% of the subplots in one category in 1 year.
[3]Total number of species observed in this category.

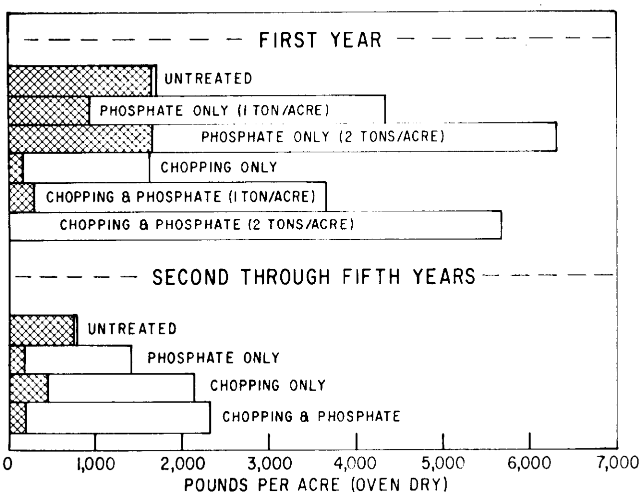

FIG. 4. Average yield of pineland threeawn (shaded area) and other herbage (unshaded area) in 1960 and 1961–64 after chopping, fertilizing with rock phosphate, and heavy grazing by cattle. Differences between the yields at the two phosphate rates were statistically significant only during the first year.

lum, flatsedge, and several forbs. Much of the ground was covered by carpetgrasses and decumbent, mat-forming forbs such as coastal waterhyssop (*Bacopa monnieri* (L.) Pennel) and figwort (*Hemianthus glomeratus* (Chapm.) Pennel). Many weedy invaders, such as dogfennel (*Eupatorium* sp.), were utilized heavily on the fertilized plots; some notable exceptions were flatsedge, goldaster (*Chrysopsis nervosa* (Willd.) Fern.), and stinking fleabane (*Pluchea foetida* (L.) D. C.).

Herbage Yield

Average herbage yields for the first year and for the second through fifth years are shown in Fig. 4. Yields the first year are considered most representative of those to be expected from chopping and applying rock phosphate to native ranges in south Florida under appropriate management. A general decline in yields in subsequent years is believed to be primarily attributable to excessive grazing pressure. Weather might have been a contributing factor because April–May rainfall was unusually low in 1962 and 1964.

Chopping generally increased herbage yields except during the first year, when yields reflected the initial reduction in pineland threeawn, a bunchgrass which is very slow in revegetating. As other species replaced pineland threeawn and saw palmetto and fully occupied the sites, herbage yields were higher on chopped plots. The competition from pineland threeawn, along with selective grazing, apparently suppressed other herbage on untreated plots.

Adding rock phosphate to native range more than doubled herbage yields the first year by increasing growth of palatable species other than pineland threeawn. The combination of phosphate and chopping produced highest yields in subsequent years.

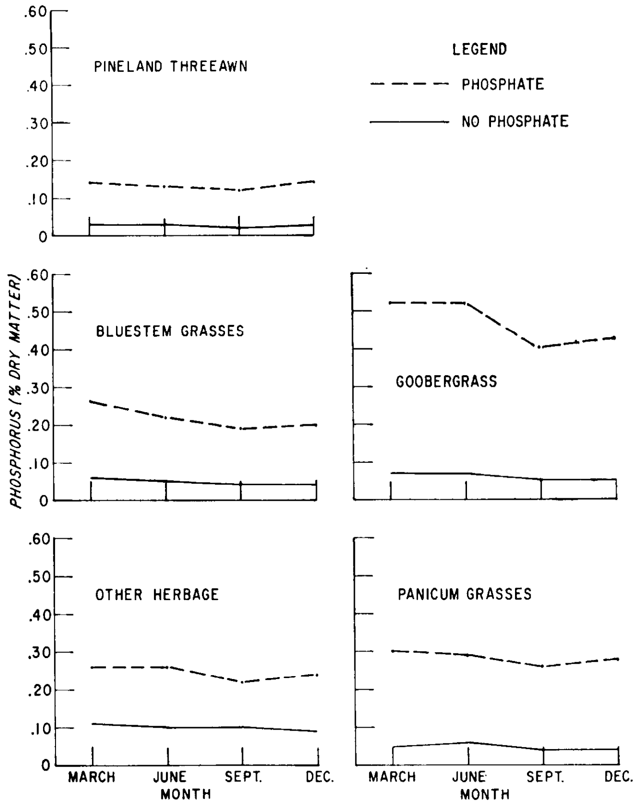

FIG. 5. Average phosphorus content of important native forage plants after fertilization with rock phosphate.

Herbage Nutrient Content

The chemical composition of forage was investigated for separate species groups rather than for total herbage. The phosphate treatment significantly influenced chemical composition, and species response differed widely, but the chopping treatment had little effect. Chopping, however, did influence quality of total herbage by changing the species makeup. It should also be noted that the forage analyzed was primarily regrowth on grazed vegetation protected by cages for a 3-month period. The grazing probably increased nutrient levels somewhat for all species groups except pineland threeawn, which was not grazed appreciably after the first year.

Phosphate application increased forage phosphorus, calcium, and protein, as illustrated in Figs. 5, 6, and 7. These present average values for the 5 years and both rates of phosphate application, because differences between years and rates were seldom significant or consistent. For other chemical components, no important effects of treatment were detected: ash percentage tended to increase and ether extract tended to decrease with phos-

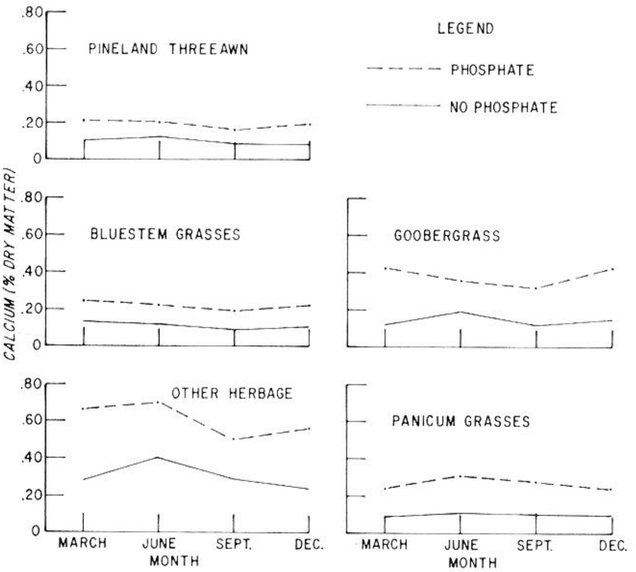

FIG. 6. Average calcium content of important native forage plants after fertilization with rock phosphate.

phate treatment, but lignin, cellulose, and other carbohydrates showed little change.

The response of forage to phosphate application varied widely among species, phosphorus content being about 4 times greater for goobergrass than for pineland threeawn (Fig. 5). For other species groups, responses were intermediate. On phosphated plots, levels of phosphorus in each forage species except pineland threeawn exceeded at all seasons the minimum levels (0.18%) required by beef cows with nursing calves (NAS-NRC, 1963). Without phosphate application, none of the forage met this requirement. Similar responses were reported by Killinger (1948) who, sampling 7 months after treatment, found phosphorus in both burned and unburned wiregrass vegetation to be increased by application of ground rock phosphate.

The application of rock phosphate, which contained 48% CaO, generally increased the calcium levels in all plant groups (Fig. 6). Again, pineland threeawn showed least response. On phosphated plots, it was the only species that failed to meet minimum calcium requirements (0.24%) for beef cows with young calves (NAS-NRC, 1963).

The application of rock phosphate, even though it contains no nitrogen, increased forage protein (Fig. 7). However, increases in protein content varied greatly by plant species. In decreasing order of protein, the species groups ranked as follows: goobergrass, panicum grasses, miscellaneous species, bluestems, and pineland threeawn. Minimum recommended levels of crude protein are 7 to 8% (dry weight) for mature cows with nursing calves and 6 to 7% for other mature cattle (NAS-NRC, 1963). These levels were attained only by the better forage classes, and only in spring and summer.

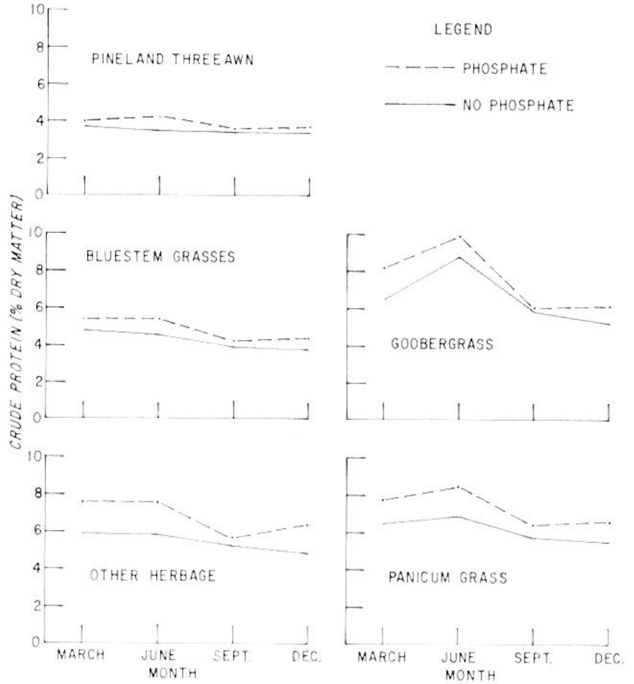

FIG. 7. Average crude protein content of important native forage plants after fertilization with rock phosphate.

Palmetto Response

Before treatment, crown cover of saw palmetto averaged 10% and plant numbers averaged 11,000 per acre. This amount is typical of cutover flatwoods range in south Florida, where palmetto coverage of 5% or less is considered sparse and 20% or more is considered dense.

Cross-chopping gave very satisfactory control in this study (Fig. 8). Crown cover, which averaged 10% before treatment in June, was reduced to 0.5% in August of the same year and remained at neg-

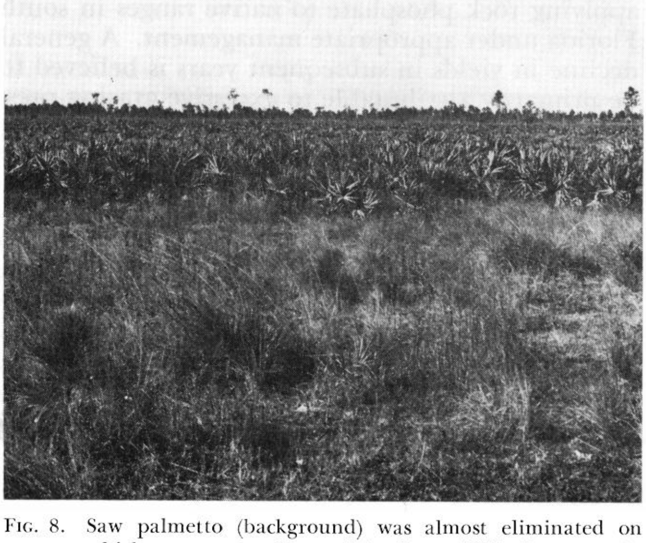

FIG. 8. Saw palmetto (background) was almost eliminated on areas which were cross-chopped in June 1959 (foreground). Photographed in December 1961.

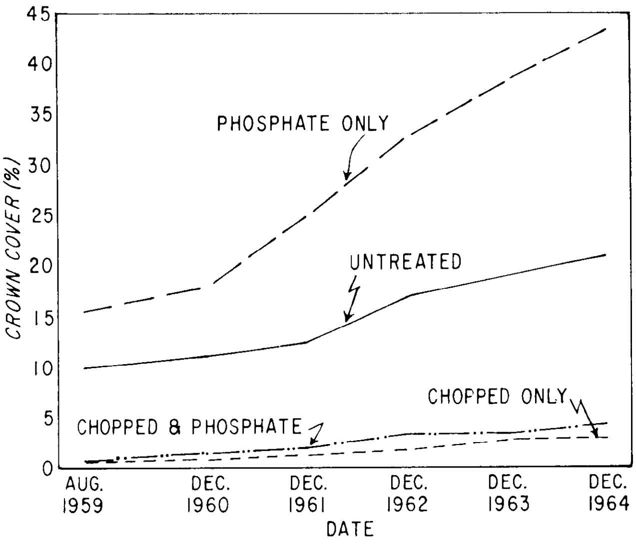

FIG. 9. Crown cover of saw palmetto after chopping and fertilizing with rock phosphate.

ligibly low levels (Fig. 9). In contrast, the initial crown cover doubled during the 5 years on untreated plots and quadrupled where phosphate was applied without chopping. Numbers of palmetto plants per acre changed little on subplots without treatment but increased about one-fourth with phosphate treatment. On chopped plots, about one-fourth of the initial number persisted—approximately 3,000 per acre.

The outstanding growth response of unchopped palmetto to phosphate fertilization resulted in clumped masses of fronds and barbed petioles that were virtually impenetrable. Reduction of herbage yields under these dense clumps appeared substantial but was not measured.

Discussion

Both chopping and rock phosphate application offer real promise for improving grazing values on cutover flatwoods ranges in south Florida. Their higher-level and longer-lasting benefits offer attractive alternatives to the limited and short-term effects of frequent burning, which is commonly employed for this purpose.

Reducing the dominance of pineland threeawn seems necessary for effective improvement of flatwoods ranges. This species is only palatable and useful for about 3 months, and only when burned (Hilmon and Hughes, 1965); yet it makes up more than three-fourths of the range herbage (Hilmon and Lewis, 1962). Since it is not readily replaced by its herbaceous associates even when burned or grazed, other means of encouraging the more palatable and nutritious native species are called for. Both chopping, or similar mechanical treatment, and phosphate fertilization have this effect. The better species evidently recover from chopping disturbance more quickly than does pineland threeawn, which reproduces slowly. Also, pineland threeawn is less responsive to improved fertility than are associated better species. Such differences between species in response to phosphate levels are not uncommon (Bradshaw et al., 1960). Unhappily, saw palmetto responded also.

The continuing increase of palmetto cover, both without treatment and with phosphate, illustrates the necessity for controlling this species. Burning every 2 or 3 years reduces the size of saw palmetto plants and keeps crown cover fairly constant, but it does not kill the plants (Hilmon and Hughes, 1965). Chemical control is possible (Burton and Hughes, 1961; McCaleb et al., 1961; Altobellis and Hough, 1968) but not widely practiced because of expense and varied success. Mechanical methods, such as disking, root plowing (webbing), and roller-chopping are used most. The latter method controlled palmetto satisfactorily in this study.

The foregoing considerations suggest that application of either treatment alone could be worthwhile in particular circumstances. Rock phosphate alone could be very effective when pineland threeawn and palmetto are not too dense. Singly, it should be the most valuable treatment because of its favorable influence on chemical composition and palatability as well as on botanical composition and total yield. Whenever palmetto is a problem, however, chopping or comparable mechanical treatment is indicated. Generally, the combination of both treatments would likely give best results.

Control of grazing to avoid continued overuse of desirable species will be necessary if full benefits are to be obtained. Intensive overuse of the more palatable and nutritious species undoubtedly curtailed yields in this study, particularly after the first year. The magnitude of this grazing effect is, of course, conjectural. However, no other reasons are apparent for the failure to maintain the productive advantage of the phosphate treatments at levels approximating those of the first year. On less severely grazed plots that were chopped but not phosphated, yields increased beyond the first year. A similar continuing response would logically have been expected on the phosphated plots if they had not been abusively grazed.

The need for feeding phosphorus and calcium supplements to cattle could evidently be largely eliminated by application of rock phosphate. The group of cattle with access to the study area was observed to consume less mineral supplement than other groups even though the phosphated area provided a relatively small portion of the total diet. Phosphate fertilization has also been found to be an effective substitute for feeding phosphorus supplement on south Texas range (Reynolds et al., 1953).

Although not yet demonstrated, potentials for increased livestock production should be at least proportional to the increase in herbage yield, because forage quality also improved. Appropriate grazing management for obtaining maximum benefit from chopping and phosphating has not yet been defined. Presumably, it might incorporate (1) relatively heavy grazing to utilize mediocre species and (2) rest periods adjusted to benefit the most desirable species.

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Annual Meeting
AMERICAN SOCIETY OF AGRONOMY
Tucson, Arizona, August 23 to 28, 1970

On August 26, 1970 a half-day symposium is planned on the subject Range Research and Range Problems. The tentative program is as follows:

Introductory Remarks—M. J. Wright, Cornell University, Ithaca, N.Y.

The Western Range and the Livestock Industry It Supports—G. W. Thomas, New Mexico State Univ., Las Cruces, N.M.

Range Forage and Animal Nutrition—R. J. Raleigh, Oregon State Univ., Squaw Butte Exp. Sta., Burns, Ore.

Nutrient and Botanical Composition of the Diet of Cattle Grazing Native Range—C. B. Theurer, Univ. of Arizona, Tucson, Arizona.

Effects of Poisonous Plants on the Range Industry—W. Binns, USDA, Logan, Utah.

Weed and Brush Control for Range Improvement—H. L. Morton, USDA, Tucson, Arizona.

Seeding Western Rangelands—C. H. Herbel, USDA, Las Cruces, N.M.

Fertilization for Range Improvement—G. A. Rogler, USDA, Mandan, N.D.

Summary and Prospects—W. Keller, USDA, Logan, Utah.

Members of the American Society of Range Management are invited to attend the ASA meeting as well as the symposium.