Southeastern Uplands

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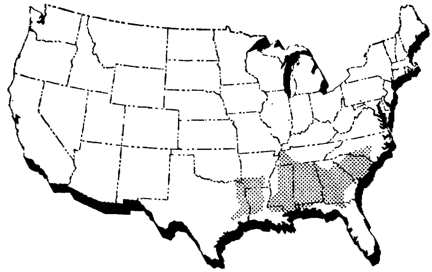


The Southeastern Uplands is one of the oldest major agricultural sections of the country. It produces nearly all of our flue-cured tobacco, about one-third of our cotton, and more than half of our peanuts.

The region has a long growing season and mild winters. The number of frost-free days ranges from 200 in the northern part to 260 in the extreme south. The average winter temperature is about 45° F. throughout the area. The average annual rainfall is 50 to 60 inches in all of the area, except in parts of Oklahoma and Texas, where it is about 35 inches a year.

The distribution of rainfall and the low water-holding capacity of the soils are factors in the crop production potential. Between 50 and 70 percent of the total annual rainfall comes during the cool season, October to March. The frequent shortage of rainfall in the growing season and the restricted water-holding capacity of all but a few soils mean that moisture is deficient for crop growth during some periods in almost every year.

The soils are of the Red-Yellow Podzolic group. They were derived from a variety of parent materials. They developed generally under forest vegetation and in a climate that favored a high degree of weathering and leaching of bases from the profile and prevented the accumulation of sizable amounts of organic matter. Thus the soils are predominantly acid in reaction and low in organic matter and plant nutrients.

The conservation of soil and water is a major problem in a large part of the region. Much of the land is hilly. Many of the soils are naturally erosive. Rains of high intensity occur often in spring and summer.

The problem of loss of soil and water is intensified in the Piedmont, Brown Loam, and the Clay Hill sections of the Coastal Plain. In years gone by, when the agriculture of the Southeast was based strictly on row crops, farmers there often were forced to abandon fields because of severe gullying. The situation has changed. Pulpwood has become a major source of income on rough and eroded areas that would have been useless a generation ago. The expanding livestock production has created a need for more pasture and forage, which have restored many an eroded cultivated field to useful production.

A larger acreage of abandoned land in the Southeast is being restored to useful production each year than is being lost from production because of erosion. The hazard of erosion still exists, however. The continued application of sound principles of land use and soil management will be necessary if the maximum use is to be made of potentially productive soils.

Acreage controls, labor shortages, and other economic factors have built up a tremendous pressure for raising acre yields, especially of cash crops. That and several dry years have focused attention on supplemental irrigation as a way to intensify production of cash crops, provide insurance against crop failures, and even out seasonal irregularities in forage crops and pastures.

Irrigation has a place in intensive crop and livestock production in the Southeast. In dairy farming, for example, great possibilities exist for marked increases in production of temporary grazing crops and for shifting the growing period right into the critically dry fall season.

Crops such as millet and Sudangrass are responsive to nitrogen and moisture. They grow fast and yield well. The use of supplemental irrigation to establish seedings early in the fall and to insure rapid growth can raise yields tremendously in autumn. At Thorsby, Ala., in 1955, for example, Starr millet and alfalfa drilled in alternate rows in late August, irrigated, and heavily fertilized, produced more than 4 tons of high-quality forage in September and October and went into the winter with a vigorous stand of alfalfa.

Supplemental irrigation will undoubtedly be an important factor in the production of such cash crops as cotton, vegetables, fruit, tobacco, and flower bulbs in some localities. It probably will not affect the average level of production of the major crops in the region as a whole in the immediate future, however, because such problems as water supply, cost of installation of irrigation systems, and the high level of management it requires for successful crop production will sharply limit its application.

But the best job of management with respect to fertilization, liming, control of insects, and other practices is essential before supplemental irrigation has a chance of becoming economically sound. Crop yields in the Southeast on the average have been limited by inadequate levels of available plant nutrients, and irrigation can only produce increased yields after these other limiting factors are removed. Irrigation without proper attention to other required practices could actually depress yields. For example, added water usually leads to more luxuriant foliage of cotton plants, and that favors the development of bollworms and weevils.

Another limiting factor is water supply for irrigation. The flow of the many streams in the region often is low during the dry season. The competition of several farmers for water for irrigation from such streams often dries them up.

Wells are not dependable as an economic source of irrigation water in much of the region. Farm ponds can help as an emergency supply, but ordinary ponds cannot provide enough water for full-scale irrigation of field crops. The importance of supplemental irrigation may continue to increase, but locally it will be determined largely by the availability of water.

Rates of fertilizer application on the better managed farms in the Southeast have increased since 1935. This increased rate, the relatively higher proportions of soluble constituents in fertilizers, and the low buffer capacity of many soils lead to another problem—that of the proper placement of fertilizer at planting to avoid seedling damage because of salt injury. Stand and yields, particularly of oilseed crops in much of the Southeast, are lowered when fertilizer is applied directly under the seed instead of at one side.

The question of the most effective placement of lime and starter fertilizer for permanent pasture has received considerable attention, but we do not have the complete answer. Bandseeding grass and legumes for pasture in combination with drilled fertilizer sometimes is superior to broadcast seeding and fertilizer placement, particularly when conditions are adverse to establishment of seedlings. The deep placement of lime and phosphate does not seem to be better than surface application for the maintenance of pasture sod. Of course, basic applications of lime and phosphate in preparation for establishing pasture should be incorporated in the plow layer. Further study of the problem will be necessary, however, before a dependable conclusion can be reached as to the value of building up the nutrient and base status of the deeper soil layers.

The soils of the Southeast and their management requirements differ considerably. Therefore the region has been subdivided into eight physiographic areas, within which the soils and their management problems are more nearly alike.

THE COASTAL PLAIN forms a belt of upland soils 100 to 300 miles wide along the Atlantic and gulf coasts. It includes about 115 million acres. It extends from south-central Texas to north-central North Carolina. It is the heart of the old Cotton Belt.

Considerable differences in rainfall within the geographic range of the Coastal Plain influence strongly the use and potentialities of the soils. Most of the region east of the Mississippi River gets 50 to 60 inches of rain, but precipitation drops off rapidly west of the river to only 31 inches in Guadalupe County in Texas.

The soils were developed from marine sands and clays and are predominantly sandy in their surface horizons. The topography is gently rolling to hilly. Both surface and internal drainage are generally good. Among the extensive series are the Norfolk, Ruston, Orangeburg, Red Bay, and Magnolia soils. The upland soils have light gray to red sandy surfaces, 5 to 10 inches deep, underlain by yellow-red, friable, sandy clay subsoils. The C horizon, beginning usually at 2 to 3 feet, is mottled gray to red, unconsolidated sands and clays.

Most farms in the Coastal Plain are relatively small. The numbers have tended to decline and the size has tended to increase as farm mechanization expands.

Since soils of the Coastal Plain have developed from parent materials that have been subjected to previous cycles of weathering, leaching, movement, and deposition, they are acid in reaction and their native fertility is low.

The relatively high temperatures, the large excess of rainfall over annual evapotranspiration, and the generally good internal drainage have caused rapid weathering and excessive leaching of the bases out of the soil profile. The original pH values ranged generally around 5.0. The same conditions of texture and climate that favored development of highly leached soils have prevented the accumulation of significant amounts of organic matter and nitrogen. The total nitrogen content of soils of the Coastal Plain rarely exceeded 1 thousand pounds an acre even in the virgin state. Actually, soils of the Coastal Plain are exceptionally responsive to fertilization and good management.

There have been marked changes in the levels of the different nutrient elements of these soils since they were first put into cultivation. The phosphorus content has been raised sharply in some areas through the practice of applying several times as much phosphate fertilizer as is removed, especially for cotton, tobacco, and potatoes. There is evidence that improvement in the status of soil organic matter and nitrogen has occurred under good management. Content of potassium, on the other hand, has been decreased, since potassium generally has been applied in relatively low amounts, and it will leach out of the sandy soils.

There has been an improvement in the exchangeable base level of these soils since they were first cultivated. This gain is in danger of being lost because of another factor. Higher rates of nitrogen fertilizer are now used more than ever before, and the trend is toward still larger amounts on a number of crops. Most of these fertilizers are acid forming when applied to the soil. A 100-pound application of nitrogen as urea, ammonium nitrate, or anhydrous ammonia, for example, would require about 200 pounds of limestone to neutralize this residual acidity.

Texture creates serious problems in some places. Lack of sufficient fine material—so that the retention of moisture and nutrients is satisfactory—occurs in the Sandhill section of the Carolinas and Georgia, for example. At the other extreme are the areas of clays and sandy clays, which often do not permit ready infiltration.

The available water-holding capacity of Coastal Plain soils as a whole is low. Several profiles of typical Orangeburg sandy loam in central Alabama have an average water-holding capacity of the surface 2-foot depth of only 2.11 inches. Because corn during its peak period of growth can remove up to 0.4 inch of water a day, that is a very limited supply for crops in an area where 2-week periods without rain are not uncommon in summer.

Another management problem in the Coastal Plain is the control of excessive soil loss by water erosion. Much of this area is rolling or hilly. About 20 percent of the soils have moderately severe to very severe erosion hazard.

In no extensive areas do genetic, or natural, pans or poor structure in the B horizon seriously impede root penetration or the movement of moisture. Induced pans, or compacted layers, are fairly common, however, particularly in the medium-textured soils. Sometimes these compacted layers restrict root development almost entirely to the plow layer. They occur immediately below the plow depth, usually between 5 and 10 inches, and they are easily accessible for mechanical disruption by deep plowing.

Cotton has long dominated the agriculture of the Coastal Plain as a cash crop. Tobacco is important in sections of Georgia and the Carolinas, peanuts in southwestern Georgia and southeastern Alabama, and potatoes in southwestern Alabama, but otherwise general farming based on cotton, corn, and forage crops is the rule.

Average yields of corn tend to be higher in the northeastern end of the region than in the southwest partly because of somewhat more favorable moisture conditions. The average yield in the Coastal Plain probably is no more than 20 bushels an acre—only 30 to 40 percent of potential yields.

Estimated applications of fertilizer in 1956 included 30 pounds each of nitrogen and phosphoric oxide and 20 pounds of potash—a rate of fertilization that would be nearly adequate for phosphorus and potassium on most of the soils long in cultivation; it would provide only about one-fourth of the needed nitrogen, however.

The average yield of cotton in the Coastal Plain is about 250 pounds of lint an acre. The lack of adequate nitrogen is a main limiting factor. It was estimated that 35 pounds of nitrogen, 45 pounds of phosphoric oxide, and 35 pounds of potash an acre were applied in 1954 in the Coastal Plain section of Alabama, which is reasonably typical of the region.

That would be adequate for phosphate (except in places that have not been fertilized for a long time), but it would be inadequate for potash, except maybe on the heavier soils. The amount of nitrogen was less than half as high as it should have been.

Tobacco has received higher rates of fertilization than any crop except potatoes in the Coastal Plain. Repeated, heavy fertilization has left large accumulations of phosphorus in soils of the tobacco areas, where usually more phosphorus than is needed is applied. About 80 percent of North Carolina tobacco soils were high in available phosphorus in 1951.

Peanuts are grown on about 720 thousand acres in southeastern Alabama and southwestern Georgia. Average yields are about 900 pounds an acre. Fertilizer applications have been estimated at 8 pounds of nitrogen, 32 pounds of phosphoric oxide, and 42 pounds of potash an acre. Experiments have shown that little response usually is to be had from phosphate and potassium above the average rates. Apparently one of the chief limiting factors in the production of peanuts is a lack of adequate levels of soil calcium and magnesium.

Production controls on cotton, tobacco, and peanuts, a growing recognition of the importance of grass and legumes in conservation, and favorable prices for livestock products in the postwar years gave impetus to a trend toward farm diversification through an expansion of livestock enterprises. Pasture and forage crops have assumed great importance. The Coastal Plain section of Alabama, which comprises roughly two-thirds of the total area of the State, for example, in 1955 had about 1 million acres each in corn and improved permanent pasture and hay crops and about 250 thousand acres each in cotton and peanuts.

Advances since 1940 or so in pasture and forage crop varieties and management have made possible high levels of beef and milk production through near year-long grazing throughout the Coastal Plain. Many cattlemen from other parts of the country, especially the Southwest, have become interested in this section and have shifted their operations to the Coastal Plain region of the Southeast.

A well-planned fertilization program is essential—especially lime, phosphate, and potash for legumes, and the general use of nitrogen with nonlegumes.

The average use of phosphate and potash on forage crops has been far below the recommended amounts. An average of less than 10 pounds of phosphoric oxide and 5 pounds of potash have been applied in the Southeast, but yield increases of at least 60 percent could be realized by the use of 40 pounds of each to the acre.

Improved permanent pasture is the foundation for any livestock system, but there are periods of low production, such as the coldest part of the winter and the normally dry late summer and fall. The gaps should be filled by supplemental grazing crops, such as small grain, winter legumes, lespedeza, millet, and Sudangrass. Improved varieties of millet and Sudangrass, properly fertilized, for example, can provide 2 to 4 tons of good forage within 8 to 10 weeks after planting when summer rainfall is normal.

Few definite rotations or systematic crop sequences have been used here. Fields well adapted to a given crop are planted more or less continuously to it. Accumulating evidence supports the view that high yields, at least of cotton and corn, can be had over relatively long periods when the crops are grown continuously, if adequate fertilization and other good management practices are observed. Cotton grown continuously since 1896 on Chesterfield sandy loam at Auburn, Ala., for example, averaged 1,200 pounds of seed cotton the last 16 years, compared to 812 pounds during the first 16. Corn grown continuously on a Norfolk sandy loam for 9 years in North Carolina at a high level of nitrogen fertilization produced an average of 85 bushels an acre the last 3 years, compared with 75 bushels at first.

The use of winter legumes as a cover crop has been considered a valuable practice to improve soil structure and add nitrogen to the soil. Fewer and fewer farmers have followed it, however. Perhaps no more than 15 percent of the acreage in row crops in the Coastal Plain was planted to winter cover crops in 1956—probably a reflection of the disease problems of some of the otherwise better adapted legumes and the increasing supplies of relatively cheap commercial nitrogen. Indeed, it is difficult to find evidence in research data that annual winter cover crops have any significant effect on soil properties and subsequent crop yields beyond that of the nitrogen supplied. Experiments have failed to show a buildup of organic matter in Coastal Plain soils beyond that realized through crop residues when reasonable fertilization was used.

The use of annual legumes as cover crops, as an emergency source of grazing during the late fall, winter, and early spring, and then as a green manure crop for the nitrogen gained appears to have considerable possibilities. Actually, the practice of grazing vetch and other such cover crops is fairly common. Its value in providing forage would be almost directly proportional to the earliness of seeding in the fall, since it would depend almost entirely on the growth made before the onset of winter.

The value of the legume cover crop from the standpoint of the nitrogen that it provides for the following crop has been shown to range all the way from practically nothing in unfavorable years to better than 100 pounds of nitrogen an acre in years of favorable temperature and moisture. Furthermore, in most years most of the growth made by the winter cover crop comes in the spring, when the row crops to follow should be planted. Thus there is competition between the need to delay turning the cover crop under as long as possible and the need to plant the row crop on time.

The low content of organic matter of soils of this area and the inability to build it up appreciably (because of the sandy texture of the soils and the high mean annual temperature and rainfall) mean that available native soil nitrogen is always sharply deficient for crop production.

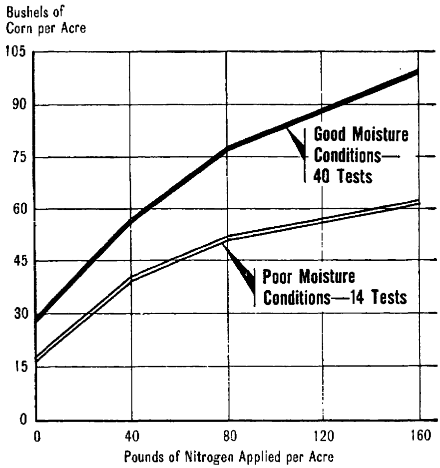
In fact, recommendations as to nitrogen can be made almost without reference to the organic matter but with consideration only of the yields desired. Yields of corn on these soils without nitrogen, either commercial or legume nitrogen, generally do not exceed 25 bushels an acre. With adequate nitrogen and with other recommended practices, most of these soils will produce at least 80 bushels in years of normal rainfall. Even soils that have been cropped for decades without fertilization usually produce remarkably good yields when they are fertilized properly.

The diagram gives the average corn yields when different rates of nitrogen were applied in a large number of field tests in North Carolina in 1944–1952.

Similar responses to nitrogen have been reported throughout the Coastal Plain, although the average top yields tend to be somewhat lower in the central part and are definitely lower in the southwestern part because of less favorable distribution of rainfall.

The important thing, of course, is the fact that corn yields 3 to 5 times above the present average production can be achieved by observing improved management practices.

Some farmers believe that high rates of nitrogen will reduce corn yields in



Response of corn to nitrogen fertilization in North Carolina under both good and poor moisture.

dry years. There is no increase in yield from the higher rates of fertilizer whenever deficiency of moisture limits the yield, but the results of field experiments throughout the Southeast fail to show that yields are reduced.

Observations of the carryover effect of nitrogen from one season to another have raised questions about the commonly held belief that nitrogen is quickly and completely leached out of the profile if it is not absorbed by plants soon after application. Larger amounts of applied nitrogen do remain in the soil for longer periods than people thought, but we cannot draw a definite conclusion because of doubt about the factors that affect conversion of ammoniacal nitrogen and the amount of water that percolates through the profile. We think it is safe to say that (except in years of low rainfall) measurable amounts of nitrogen applied before planting are removed from the root zone in sandy soils before the crop can absorb it.

Even if there were insignificant losses of nitrogen, split applications would still be advisable if high rates are used because of danger of salt damage.

The development of palatable grasses, such as Coastal Bermuda, which have an exceptionally high yield potential and a wide adaptability to climate, and the availability of cheap sources of nitrogen have focused attention on the use of grass sods with high rates of nitrogen fertilization. Preliminary results of studies throughout the Coastal Plain indicate that rates of nitrogen previously considered fantastic may actually be economical.

Nitrogen is also the first limiting factor for cotton production in the Coastal Plain. Average cotton yields of a bale or more an acre are possible on many soils with good management. This would include application of at least 80 pounds of nitrogen. Experiments in 1955 and 1956 showed that with the most intensive practices, including irrigation and soil fumigation for nematode control, there were strong yield responses to rates of nitrogen above 200 pounds an acre. In these experiments, a top yield of 3.8 bales was made with 240 pounds of nitrogen.

Typical of the response of improved grasses to nitrogen fertilization are the following results that F. L. Fisher and A. G. Caldwell obtained with Coastal Bermuda-grass on Lufkin fine sandy loam at College Station, Tex.:

Rate of Nitrogen	*Hay yield*	*Protein yield*
0	3.0	420
100	5.2	690
200	6.2	1,060
400	9.9	1,870
600	11.6	2,600
800	13.0	3,560

(The figures for nitrogen and protein content are pounds per acre. Hay is in tons per acre.)

The conversion of such data to yield of livestock or livestock products involves a number of assumptions, but we have a few figures that show direct evaluations in terms of beef. For example, E. H. DeVane found that the 4-year average beef yields from Coastal Bermuda-grass on a Tifton sandy loam in Georgia in the 6 months from April 1 to October 1 were (in pounds to the acre):

Rate of Nitrogen	*Beef Gain*
50	292
100	453
200	695

In this instance, each pound of nitrogen produced an average of 2.7 pounds of beef. Crimson clover growing with the Coastal Bermuda as the source of nitrogen produced 363 pounds of beef an acre—the equivalent of 74 pounds of nitrogen from commercial fertilizer.

As we indicated, phosphorus fertilization has been generally higher in reference to the requirements than the other elements, particularly in places where cotton, tobacco, and potatoes have been grown. This fact and the immobility of phosphate in the soil have resulted in a marked accumulation of phosphorus in the plow layer of cultivated soils of the Coastal Plain. Rates of application in 1956 therefore generally were nearly adequate for the cash crops but were critically low for pastures and forage legumes. We estimate that 30 to 50 percent of the acreage in "improved pastures" was not fertilized at all.

Because the levels of native soil potassium in the Coastal Plain are low and potassium does not accumulate very much in these light-textured soils, potassium generally is deficient for crop growth throughout the region. The use of potassium on corn, cotton, tobacco, and potatoes in 1956 probably was not far below their requirements, except in the Sandhills and areas where peanuts are grown in rotation. For pasture and forage crops, however, there was undoubtedly a large gap between rates used and needs. Usually 40 to 50 pounds of potash are required for maximum pasture yields in the Coastal Plain. Alfalfa requires four or five times as much.

Soils of the lower part of the Coastal Plain are sandier and contain considerably less mineral nutrients than those of the Clay Hill section to the north. Good forage species, such as whiteclover and alfalfa, grow well with good management in the heavier soils, but they are not well adapted to the sandier areas. The annual lespedezas and sericea are more commonly used there, and they do not respond generally to applications of potash. Thus the question of forage quality and yield level is important in considering the potentials of the area with adequate potash fertilization. In order to establish and maintain stands of the better forage legumes, the use of relatively high rates of potash are necessary. In general, aside from the factor of quality, it appears likely that overall production of forage could be increased by at least 50 percent by the use of about 60 pounds of potash an acre.

In some areas in the Coastal Plain, the exceptionally low content of native potassium and base exchange capacity result in particularly severe deficiencies of potassium. The Sandhill belt of Georgia and the Carolinas is the largest such area. These soils are predominantly deep sands. Experiments extending over 19 years at the South Carolina Sandhill Experiment Station disclosed that yields of cotton improved with high rates of potassium fertilization, but failed to indicate any advantage for split application of the potassium fertilizer.

Boron is often recommended for alfalfa and clovers that are grown for seed. Boron is in short supply in many of the sandy soils of the Coastal Plain and is widely recommended for such crops as alfalfa and clovers.

H. T. Rogers conducted 70 experiments in central and southern Alabama and learned that alfalfa, vetch, whiteclover, red clover, crimson clover, and burclover almost invariably responded to applications of boron. Alfalfa produced an average of 58 percent more hay when boron was applied.

Cotton yields have improved in a number of instances with the addition of boron, manganese, and zinc in South Carolina.

Deficiencies of zinc exist in the Coastal Plain. Instances of marked increases in yields of corn after zinc was applied have been reported.

The soils that might have too little zinc for corn have been hard to identify in advance so that field experiments can be conducted on them. A deficiency of zinc seems to appear one year and fail to show up again in the same field. Zinc deficiency, or rosette, of pecans is much more definite. In a survey of 176 orchards in 20 counties in Alabama, T. B. Hagler found zinc deficiency, ranging from 14 percent within the highest producing group to 57 percent within the poorest producing orchards.

Serious deficiencies of calcium, magnesium, and sulfur also exist here.

An adequate liming program with dolomitic limestone would take care of the calcium and magnesium. Otherwise, or if calcitic limestone must be used, the need to apply magnesium in some other forms may arise. A survey by A. C. McClung in the Sandhills of North Carolina showed that 20 percent of the peach orchards were deficient in magnesium and an additional 20 percent were approaching a deficiency. A deficiency of magnesium also has been identified in cotton from time to time, usually in the sandier soils in places where liming had been neglected for a long time.

Some crops, including the grasses, need sulfur in relatively small amounts.

Others, such as clovers and cotton, require as much sulfur as phosphorus. Because sulfur exists in the soil in organic combination or as soluble inorganic salts, the amount of it in the strongly leached soils of low organic content is small. Serious deficiencies of sulfur undoubtedly would have occurred long ago except for the incidental amounts of calcium sulfate carried in ordinary superphosphate and the widespread use of ammonium sulfate as a source of nitrogen in mixed fertilizers. Concentrated superphosphate, which contains little or no sulfur, has been used more and more in mixed fertilizers. The use of higher degrees of ammoniation and of urea to supply the nitrogen of mixed fertilizers has largely replaced ammonium sulfate. Sulfur therefore has renewed importance. It is significant that in a number of instances crops have responded to sulfur additions 1 to 3 years after farmers started to use fertilizers that contained no sulfur.

The use of lime on soils of the Coastal Plain is far below the needed level.

The need of legumes for lime was recognized and stressed in the past, but little thought was given to the requirements of the row crops. The expanding use of high rates of acid-forming nitrogen fertilizers has put an added strain on the base status of these already acid soils. As a result, the need for lime on many cropped fields has been increasing rapidly.

Furthermore, the use of heavy rates of soluble nitrogenous fertilizers on very sandy soils may markedly acidify the deeper soil layers, where correction by the addition of limestone is impractical. This is another reason why excess acidity should be corrected before extensive changes in soil reaction occur.

Experiments on Norfolk soil in North Carolina showed a net return of 25 dollars an acre from the application of 1 ton of limestone to peanuts when the soil was only moderately acid. Spanish and runner peanuts in southern Alabama responded to applications of lime when the exchangeable calcium level of the soil was below about 700 pounds calcium carbonate equivalent an acre. Increases in yield ranged up to 1,200 pounds of nuts an acre. Yield increases of cotton from lime applications have been relatively lower than those of forage crops and peanuts, but sizable increases have occurred frequently even on moderately acid soils.

THE SOUTHERN APPALACHIAN PLATEAU comprises a series of relatively flat-topped ridges in northeastern Alabama and northwestern Georgia. The mean annual temperature is about 60°. There are about 200 frost-free days a year. Rainfall is fairly well distributed.

Small, family-operated general farms are the rule. The tilled land is intensively farmed. Rates of fertilization and average yields are high.

The soils, developed from interbedded sandstones and shales, are mostly fine sandy loams and silt loams. They are low in organic matter and mineral plant nutrients and acid in reaction. The soils developed from shale tend to be finer and shallower and present more of a problem regarding water infiltration and erosion hazards than those derived from sandstone.

The most important soil series, the Hartsells, has a grayish-brown, very fine, sandy-loam A horizon. It is underlain at 6 to 9 inches by a yellowish-brown, friable, sandy clay B horizon. The weathered sandstone usually occurs at about 2.5 to 3.5 feet.

Of the soils derived from shale, the Enders is probably the most important series. It usually has a loam texture in the surface and is underlain by a clay loam B horizon. It occurs in gently rolling to steeply rolling places and is particularly susceptible to erosion.

The soils from sandstone and shale, because of their high content of silt, form oriented particle crusts following rains and drying winds, often to the extent of preventing emergence of seedlings and reducing penetration of water. The soils, especially the Hartsells, are responsive to management.

Cotton has long been the major cash crop. Acreage was reduced about 25 percent between 1935 and 1956, but increased acre yields more than offset the reduction.

The rates of nitrogen, phosphoric oxide, potash, trace elements, and lime required for maximum yield of the different crops are nearly identical to those of the normal upland Coastal Plain soils, such as the Norfolk.

The production potential for some crops, such as cotton and corn, may be slightly higher than for soils of the Coastal Plain, chiefly because of better distribution of rainfall and fewer insect problems.

THE OUACHITA HIGHLANDS occupy some 11 million acres in north-central and western Arkansas and about 4.5 million acres in east-central Oklahoma. The topography is rugged. The elevation is about 500 feet to more than 2 thousand feet above sea level. The mean annual rainfall is 40 to 50 inches.

More than one-half of the area is in forest. About one-fifth is in pasture.

The soils were developed from sandstones and shales. Areas of shallow, stony soils are extensive, but about 30 percent of the area has deep, medium-textured soils of good productivity.

Hanceville and Conway soils, typical of the agricultural soils, are relatively deep and light-gray to grayish-brown, sandy-textured, surface soils, underlain by friable sandy clay to clay subsoils.

The soils developed from shale are somewhat finer in texture than the ones from sandstone. Most of these soils have good internal drainage.

The upland soils have a low inherent fertility, but they are fairly responsive to management. Poor distribution of rainfall and deficiency of plant nutrients limit crop production.

The alluvial soils of the area are not very extensive but are highly productive. Farming is mostly in the relatively level valleys, which make up only about one-third of the area of the region. More than one-half of the total area is in timber. About 20 percent is in pasture. Farms generally are small and are devoted to general agriculture.

The pattern of farming, the susceptibility to erosion, and the problems of soil management are much like those in the Coastal Plain.

Cotton, corn, and pasture and meadow crops are grown on most of the farms. Cotton is the major source of income. Fruit and truck crops are grown in some localities.

The soils are reasonably responsive to treatment and have good production potentials if they are managed well. The major problem is to control erosion and maintain adequate levels of plant nutrients.

THE SOUTHERN PIEDMONT extends from North Carolina southwestward through South Carolina and Georgia into Alabama.

Its soils were developed from igneous rocks and range in texture from sandy loams to clay loams. Cecil is the most extensive series. Other important soil series are Madison, Lloyd, Davidson, and Appling.

Most of the Piedmont is hilly. Because of the steep slopes and the erosive nature of the soils, erosion has been severe.

Most of what is now mapped as Cecil clay loam was developed from crystalline rocks that contained large amounts of quartz. Erosion has removed the sandy surface from a large part of the area, however, and the exposed subsoil is now designated as Cecil clay loam instead of an eroded phase of Cecil sandy loam.

The inherent mineral nutrient level of the Piedmont soils is fairly high. The total potash in the surface 6 inches ranges from about 5 thousand to 15 thousand pounds an acre. Soil tests of 11 thousand samples in North Carolina revealed that available potassium was higher in Piedmont soils than in those of the other areas of the State.

The soils were generally deficient in phosphorus when they were brought into cultivation, but considerable phosphorus has accumulated as a result of past fertilization. Even though these soils have a high ability to fix phosphorus, experiments at the Alabama Agricultural Experiment Station showed that the accumulated phosphorus has an important residual value.

The nitrogen status of the Piedmont soils is like that of other soils in the Southeast in that satisfactory yields of nonlegumes cannot be produced without commercial or legume nitrogen.

These soils have an adequate supply of most trace elements, although boron is generally recommended for alfalfa throughout the area. Zinc deficiency has been observed on corn grown on the coarse soils.

Because erosion has removed the surface soil in many places, subsoils are now frequently farmed. Because the subsoils usually are high in clay, problems of workability and water infiltration occur.

Places where the surface soil has been removed are called galled spots. Because of their poor physical condition, they usually are unproductive. A study of the relative productivity of A, B, and C horizons of a Cecil sandy loam, when exposed by erosion, showed that the A horizon was more than 3 times as productive as the B horizon and 11 times more productive than the C horizon.

Drainage usually is not a problem here except in numerous small bottoms.

Galled spots become hard and compacted if they are not stirred frequently. The ground does not crack appreciably upon drying. Infiltration is slow when the spots become hard, and the soil may be wet to only a couple of inches by the intense, frequent thundershowers. It is hard to get a satisfactory stand or yield of most crops in such places. The low yields are probably due to the droughty condition brought about by slow intake of water.

The galled spots respond to lime and fertilizer. The addition of manure or crop residues along with lime and fertilizer is more effective. Mulching the eroded areas with crop residues helps increase stands and reduce runoff.

Cotton, corn, forage crops, and oats are leading crops in the Piedmont. The acreage of cotton in the Piedmont area of Alabama has been reduced by about 73 percent since 1935, and the acreage devoted to improved pasture and forage and woodland has increased.

This change to forest and livestock is desirable from the standpoint of the erosion hazard and the best long-term use of the more susceptible areas.

The soils are moderately acid. Twenty-one samples of Cecil sandy loam and clay loam from Alabama had a pH range of 4.68 to 6.25. The average was about 5.5. Lime requirements for the same soils ranged from 1 thousand to 6 thousand pounds an acre.

Cotton in the Piedmont area of Alabama receives an average of about 40 pounds of nitrogen an acre, 44 pounds of phosphoric oxide, and 30 pounds of potash. That is somewhat less than the amounts generally recommended for cotton. Other crops are not fertilized so well as cotton.

Yields are relatively low. In the Piedmont of Alabama, the average yield of cotton is about 300 pounds of lint; corn yields are 15 to 20 bushels.

Satisfactory yields of most adapted row crops can be made on the Piedmont soils that are suited to cultivation despite their critical management requirements and poor moisture relationships. Corn yields at the Piedmont substation, at Camp Hill, Ala., ranged from 30 to 80 bushels in 1949–1955. Moisture was a limiting factor in most of those years. Oats yielded 60 to 100 bushels an acre and grass-clover mixtures about 4 tons of hay.

Potential cotton yields in the Piedmont are also somewhat lower than for most other areas of the Southeast where cotton is grown, and again moisture is probably the main limiting factor. The average yield in experiments in 1949–1953 in the Piedmont section of Alabama, Georgia, and South Carolina was 1,402 pounds of seed cotton. Adequate fertilization and other good management practices were used in the tests. In the same years and at the same locations, the average yield with irrigation was 1,947 pounds.

At Auburn, Ala., corn was a total failure in 1952 and 1954 without irrigation, but produced 54 and 65 bushels, respectively, with irrigation. Tests at Athens, Ga., showed that irrigated corn averaged 84.9 bushels in 1946–1954, compared to 59.4 bushels for unirrigated corn. As a practical matter, however, only a restricted acreage could be irrigated in the Piedmont because of the limited water supply.

Many fields that were not well adapted to the production of row crops have been put into improved pasture and forage crops, such as lespedeza sericea. An average yield of 3 tons of lespedeza hay in 1948–1953 was reported at the Piedmont substation, and alfalfa averaged better than 4 tons an acre in 1953–1954.

Field experiments in Georgia in 1955 proved that Cecil soil has a high yield potential for coastal and common Bermuda-grass and crimson clover when liberally fertilized and properly managed. In the second year after establishment, 17 thousand pounds of clover-grass hay an acre was produced with the application of 400 pounds of nitrogen and 200 pounds each of phosphoric oxide and potash an acre.

Pine for pulpwood is being produced on thousands of acres in the Piedmont that are too steep or stony for other use —another important step in the direction of diversification and application of the principles of good use of land.

THE LIMESTONE VALLEYS contain soils of limestone origin and are mainly in the Tennessee and Coosa River Valleys in Alabama. Small areas are in northwestern Georgia. The soils, predominantly red, have a texture from clay loams to silt loams. The Decatur, Dewey, and Cumberland represent the better soils of the valleys. Their inherent fertility is high.

The topography is level to undulating. Gully erosion is not widespread. Surface drainage is a problem on the more level areas. Water ponds in spots after a hard rain. Most of the area is open land and is well suited to the use of machinery.

Even though these soils were developed from limestone, they have become moderately acid as a result of cropping and intensive weathering. Twenty-two samples of Decatur soils from Alabama had an average pH of 5.48 and a range of 4.95 to 6.30. Their lime requirements averaged 1,635 pounds, with a range of 225 pounds to 3 thousand pounds an acre.

Cotton has been the major cash crop, but (as elsewhere in the Southeast) it is declining in terms of acreage and income. Beef cattle and dairying have become important enterprises.

These valleys are among the best cotton-producing areas in the Southeast. The average yield of lint cotton in 1945–1954 was more than 325 pounds an acre although the cotton received an average of only 25 pounds of nitrogen, 40 pounds of phosphoric oxide, and 20 pounds of potash an acre. That is less than present recommendations, which call for 36 pounds of nitrogen, 48 pounds of phosphoric oxide, and 24 pounds an acre of potash for the more fertile red soils of the valleys. For the less fertile soils, the recommendation is for the same amount of phosphorus, but the nitrogen and potash are each increased to 48 pounds.

The average yield of corn in 1945–1954 was about 25 bushels. That is lower than the land can produce with good management. It has been estimated that the average fertilization for corn amounts to 45 pounds of nitrogen, 30 pounds of phosphoric oxide, and 25 pounds of potash an acre. The use of phosphorus and potash is about in line with recommendations, but the use of nitrogen is only one-half as great as is recommended.

Small grains are extensively grown for grazing and grain. Oats receive an estimated average of 35 pounds of nitrogen, 48 pounds of phosphoric oxide, and 25 pounds of potash an acre. The amount of phosphate is as high as is recommended, but the amount of potash is 15 to 25 pounds less than recommended applications. The amount of nitrogen is less than the 90 to 100 pounds recommended for oats used for grazing and grain.

Alfalfa is well adapted to the limestone valley soils. It is grown primarily for hay and to some extent for alfalfa meal. The soils contain fair amounts of potash, but alfalfa should receive about 200 pounds of potash at establishment and annually thereafter. Severe potash deficiency of cotton has been observed on these soils following alfalfa—an indication that the alfalfa had too little potash. When this condition occurs, exceptionally heavy applications of potash on cotton are needed.

Soils of this area have no peculiar management problems. Good yields can be obtained by proper fertilization and good cultural practices. Yields of cotton and corn without fertilization are higher on these soils than most any other in the Southeast, but yields from fertilized plots are often not so high as yields from other areas. Apparently moisture is often a limiting factor.

Lack of available nitrogen probably is a limiting factor for nonlegumes oftener than other nutrients are. Data from the Tennessee Valley substation at Bella Mina, Ala., showed that 36 pounds of nitrogen increased cotton yields 466 pounds of seed cotton. Phosphorus and potash also are needed, but the response to them usually is lower. Even with good fertilization, cotton yields usually do not go much above a bale an acre.

Average yields of corn on well-fertilized plots have not been high at the Tennessee Valley substation. In 1955, however, corn yielded up to 126 bushels an acre. Moisture was probably the limiting factor in most other years. Average corn production on these valley soils could be increased tremendously by better management practices.

Proof of that was furnished by a study conducted by the Georgia Agricultural Experiment Station. The production practices and yields of farmers in the 100-bushel corn club were compared with usual practices and yields for farmers in the limestone valleys of northwest Georgia. Farmers who followed usual production methods averaged 18 bushels an acre, whereas the farmers using improved practices averaged 119 bushels an acre. They used better seed, much more fertilizer, and an average of 4 tons of manure an acre.

Yields of 100 bushels or more of oats on well-fertilized plots have been obtained frequently. Oats mature at a season when moisture usually is not limiting.

The soils usually require some lime for the best growth of legumes and certain nonlegumes. Two tons of lime an acre is usually adequate for alfalfa. When properly limed and fertilized, alfalfa has produced 4 tons or more of hay an acre. Whiteclover and crimson clover and vetch on the more acid soils should receive 2 tons of lime an acre.

Cotton can be expected to respond to lime on soils more acid than pH 5.5. A condition of cotton known as crinkle leaf has been observed in the Tennessee Valley. It may occur on soils having a pH of less than 5.0. It is probably due to manganese toxicity. The condition can be corrected by liming.

Very likely marked increases in yield of field and forage crops are possible with irrigation. Since there are larger and better distributed supplies of surface and ground water in the valleys than in some other areas of the Southeast, the future of supplemental irrigation here seems promising.

THE BROWN LOAM AREA forms a belt east of the Mississippi River flood plain. It extends from northwestern Tennessee south across Mississippi to the lowlands of the gulf coast.

The area is covered with a mantle of wind-deposited silt over Coastal Plain material. This loess is rather deep (up to 200 feet) along the Mississippi River bluffs, but thins out to the east and finally disappears some 30 to 50 miles from its western edge. The topography ranges from level to hilly.

The principal upland soils are Memphis, Loring, Grenada, Callaway, and Henry—listed in the order of decreasing degree of internal drainage from good to poor. These soils are predominantly silt loams and have well-developed profiles. The surface soil has been lost by erosion from much of the area, and the exposed B horizon has a heavier texture (usually silty clay loam) than the original A horizon.

The area has been intensively farmed for more than 100 years. General farming is based on cotton and corn. The farms generally are small; 83 percent of them had fewer than 100 acres in 1950.

Soils on slopes of 4 or 5 percent or more are subject to severe erosion. Row cropping in the past has resulted in excessive erosion over the entire area. The land surface in some localities is covered with a network of deep gullies.

The soils have been subjected to intense weathering, erosion, and leaching and consequently are low in mineral nutrients and organic matter. They are acid in reaction.

Definite hardpans exist in many of the

upland soils, particularly the Henry, Callaway, and Grenada, in which they usually occur within the surface 18 inches. The pans restrict the movement of moisture and plant roots and intensify the effects of long wet or dry periods. The soils usually have a satisfactory water-holding capacity, but their high content of silt and low level of organic matter sometimes cause low infiltration rates.

The erosion hazard, acreage controls, and difficult problems of soil management have caused a decline in the acreage planted to row crops. A gradual shift has started toward less dependence on row crops and more on livestock.

Rates of fertilization generally have been below satisfactory levels. Corn in the Tennessee Brown Loam area has had only about 8 pounds of nitrogen an acre; the average yield has been about 20 bushels. Cotton has received about 8 pounds of nitrogen and 16 pounds each of phosphoric oxide and potash; the average yield is estimated at about 325 pounds of lint.

Bermuda-grass, annual lespedeza, lespedeza sericea, and crimson clover are commonly grown, but generally low yields reflect the low average rates of fertilization. On the better upland soils of the Tennessee Brown Loam area, for example, it was found that yields of lespedeza averaged only about 1 ton of hay an acre. Yields of permanent pastures also have been low.

The soils, when put to the use for which they are best suited, have good potentials for crop production, however. The first consideration is to fit the cropping system to the soil with respect to its drainage, workability, susceptibility to erosion, and moisture relations.

The hilly phase of the upland soils might well be in forest, the sloping phase in pasture or forest, the gently sloping phase in pasture, the undulating phase in close-growing crops, and the gently undulating to level phase in row crops.

A carefully planned fertilization and liming program is necessary. Studies at the Brown Loam Branch Experiment Station at Raymond, Miss., in 1949 and 1950 showed that 296 pounds of beef an acre were produced between November and May when 100 pounds of nitrogen and 60 pounds of phosphoric oxide were applied on fall-planted oats that were grazed compared to 198 pounds on the check plots. The addition of potash did not improve yields. Later studies with other winter-grazing crops indicated that such combinations as oats and crimson clover or ryegrass and crimson clover produce up to 400 pounds of beef an acre during the cool season.

A number of experiments in Mississippi in 1948–1951 showed yield responses from 36 to 145 percent by permanent pasture on typical Brown Loam soils to phosphate applications; yields were about 6 thousand pounds of dry matter. Coastal Bermuda-grass can be grown well on these soils, although there has been a lag in its use in the area. Its very high potential production makes it one of the most desirable sod grasses here.

Cotton grown on adapted land can produce excellent yields with proper fertilization, insect control, and other required practices. The average potential yield in Tennessee under commercial farming conditions has been estimated to be a bale, or slightly more, an acre; the estimate should also apply to similar soils and management levels farther south. In experiments at four locations in Mississippi in 1954, a very dry year, the average for the highest yielding treatment was a bale an acre.

In these tests, in which the recommended practices were followed, there was no response to potash and little response to phosphate, but the addition of nitrogen brought a large increase in yields.

Corn yield on the upland soils often is limited by inadequate moisture. Yields at the Mississippi Brown Loam Branch Experiment Station were limited by moisture in 1952, 1953, and 1954, when no response was found to more than 60 pounds of nitrogen an acre, although in years of good rainfall as much as 150 pounds is required for maximum yield. Good yields, estimated to average 75 bushels an acre, can be made in most years on the less droughty bottom-land soils, compared to about 45 bushels on the upland soils.

The recommended practices to control runoff are cultivation on the contour, use of sodded waterways, the judicious use of tillage to improve the infiltration rate, and the addition of organic matter to the soil.

When hardpans occur within the upper foot of the soil profile, they can be broken by ordinary subsoiling equipment. Tests in Mississippi indicated that mechanical destruction of the hardpan would be beneficial in the years when moisture is limited but not to the extent of complete crop failure. It would also improve internal drainage and aeration in years of excessive rainfall. The decision whether to subsoil in a specific instance, however, would depend on the depth of the pan at that location, the cost, and the crops to be grown.

THE BLACK PRAIRIE AREA—or Black Belt—is a relatively narrow band of heavy clay soils, about 20 miles wide, that extends from the eastern part of Alabama to the northeastern corner of Mississippi. The land is gently rolling and is well suited to the use of large machinery. The soils are sticky when wet, and large cracks form when the soils are dry.

The area, which comprises about 10 percent of the arable land in Alabama and Mississippi, is different from most of the Coastal Plain in that the soils were formed from chalk and very heavy marine clay deposits. About one-third of the area has calcareous soils, chiefly Sumter and Houston. The rest is made up of gray to red acid clay soils, the more important of which are Vaiden, Eutaw, and Oktibbeha.

Grass was the primary native vegetation, and the area was known as the Black Prairie or canebrakes. A soil survey in 1902 of Perry County, Ala., showed that the Black Prairie soil there was Houston clay. Today most of it would be mapped as Sumter clay, which is generally considered to be an eroded phase of Houston, in which the weathered chalk appears at or near the surface.

Most of the soils were fairly well supplied with native potassium, but deficiencies of potassium have become widespread after long cropping. The virgin soils had too little phosphorus.

The Black Belt for many years was one of the leading cotton-producing sections in the Southeast. The arrival of the boll weevil about 1914 was a serious blow, however, and cotton production declined rapidly afterward. The boll weevil was more serious here than in some other areas because the heavy, poorly drained soils made it almost impossible to plant cotton early enough to reduce damage from weevils to tolerable levels.

The fact that the natural vegetation of the area was grass and clover influenced research workers, when declining incomes and abandonment of land followed the elimination of cotton as a major source of income, to consider means of stimulating the growth of pasture and forage plants and to develop a livestock program to utilize the forage.

Early studies in Alabama and elsewhere have shown that most of the soils responded well to superphosphate but poorly to potash.

The acid soils need lime for most legumes. The chalk that occurs in outcrops and on eroded hillsides may be used as a cheap source of lime. Because it may have a calcium carbonate equivalent of 50 or 60 percent, it should be used at double the rate recommended for good agricultural lime. As a rule, it may be spread at less cost than an equivalent amount of agricultural lime can be spread.

Permanent pastures are an important part of the forage program. Dallisgrass-whiteclover is the main mixture in them. Johnsongrass is used extensively as a hay and pasture crop and often

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is grown with vetch or Caley peas. The legumes extend the length of the grazing season and furnish nitrogen for the Johnsongrass.

Nevertheless, less than one-half of the open permanent pastureland is considered improved, and only about 25 percent of the improved pastures are fertilized regularly. The acreage of pasture that is fertilized receives an estimated average of 10 pounds of nitrogen, 70 pounds of phosphoric oxide, and 25 pounds of potash an acre annually. That means that when the total acreage of improved pasture is considered, the average application is only about 2 to 3 pounds of nitrogen, 18 pounds of phosphoric oxide, and 6 pounds of potash an acre.

Sizable acreages of small grain are grown for grazing and grain, but cotton and corn are not grown to any great extent in the Black Belt of Alabama. A considerably larger proportion of the Black Belt soils in Mississippi are in row crops than in Alabama.

Most forage and pasture crops can be grown successfully with proper fertilization, and the production of forage for conversion to meat and milk could be increased greatly. The improved pastures receive only about 25 percent of the recommended amounts of phosphate and potash. If all the open land were improved and well fertilized, the income from livestock products could be more than doubled.

Some forage plants cannot be grown on the calcareous soils here, although the climate suits them. Crimson clover and annual lespedeza become chlorotic because available iron is insufficient. Sericea has not done well in some places. Alfalfa has yielded well on the calcareous soils, but it is not recommended for the heavy acid soils. Well-fertilized alfalfa grown on limed soil at the Black Belt substation at Marion Junction, Ala., produced nearly 5 tons of hay as an average in 1948–1954.

Liberal applications of superphosphate are necessary for the establishment and maintenance of good clover-grass pastures. As in other areas long in cultivation in the Southeast, considerable phosphorus has accumulated in the older, well-fertilized pastures, and less phosphorus is now required annually for good production. Workers at the Alabama Agricultural Experiment Station discovered that 400 pounds of superphosphate annually increased the yield of beef 119 pounds an acre as an average. Average beef gains in a 3-year period were 366 pounds with superphosphate alone and 435 pounds with superphosphate plus 150 pounds of potash every 3 years.

The lime requirement of the acid soils of the Black Belt is much the same as those of other acid soils of the Southeast despite their high exchange capacity and low pH value. These montmorillonitic soils have a much higher content of exchangeable calcium and a higher percentage of base saturation for a given pH level than the kaolinitic soils of the region. Thus, although some of the soils have a pH as low as 5.0, only moderate amounts of lime are needed for most crops. Even on the more acid soils, an application of 2 tons of lime an acre is usually enough for Dallisgrass-whiteclover pastures.

Some row crops are grown in the area. Branch Experiment Station at Brooksville, Miss., has shown that with power equipment and improved insecticides excellent yields of cotton and corn can be made. Yields of corn in 1949–1955 ranged from 20 bushels an acre in a year of severe drought to slightly more than 100 bushels in years of good rain.

For high yields of corn and cotton, liberal applications of the three major nutrient elements are needed. In years of normal rainfall, corn has responded well to 150 pounds of nitrogen and 60 pounds of phosphoric oxide an acre.

THE HIGHLAND RIM has soils that are derived from cherty limestone and are frequently underlain by fragipans on the more level sites.

They are acid and have low inherent fertility but are responsive to good management. They are well suited to general farming.