Portrayal of Drainage and Vegetation on Topographic Maps

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ABSTRACT

Accurate measurements of drainage networks are necessary for studies in many scientific disciplines, especially hydrology. To this end, topographic maps must show accurate classification as well as a consistent pattern of the stream network.

A recent study in Georgia has developed two photo-interpretive keys which permit accurate drainage classification during the normal stereo-compilation procedures in map-making. The study was made in the Tired Creek basin in the Coastal Plain, and in the Yellow River basin in the Piedmont Province.

In the Tired Creek basin, the perennial stream channels were associated with blackgum swamps which showed as a characteristic pattern on the aerial photographs of the area. Although the areas were classed as evergreen forest on specially-compiled vegetation maps without field checking, the classification was relatively consistent, indicating that the perennial channels could be identified accurately within the basin.

In the Yellow River basin origins of perennial flow were found in valleys having concave-upward profiles. Valleys with convex-upward profiles remained ephemeral up to their juncture with a larger stream. Field checks indicated better than 80 percent accuracy in delineating these points of origin of perennial flow through stereoscopic viewing of the aerial photographs of the area. Vegetative difference above and below the origins of perennial flow were to subtle to be readily discerned on the photographs. Errors in classifying vegetation on special maps were attributed mainly to inexperience and to faulty criteria for for classification.

Proposals are presented to improve portrayal of both drainage and vegetation on topographic maps. The proposed drainage criteria suggest portrayal of all perennial streams as well as ephemeral drainage below the first branching. The proposed vegetation criteria suggest classification of forest and shrubs, with further sub-division of distinctive patterns of vegetation easily recognized on the aerial photographs.

INTRODUCTION

Topographic maps have an important effect on our way of life. Many people rarely use a topographic map, yet every day they come in contact with some form of our culture which in some way depended on a topographic map for its beginning. The location of a superhighway or the development of a subdivision are two familiar examples of project that often begin with the preliminary consideration of the "lay of the land" as shown on topographic maps. Other uses are much more personal or individualistic. A college professor uses a topographic map to find secluded fishing streams on his annual vacation in his native West Virginia. A Boy Scout, as part of his training, studies a topographic map, learns the meanings of the map symbols, and then follows a course laid out on the map.

Each use of topographic map, whether lay or technical, requires a degree of accuracy of the features portrayed on the map. The user reads and interprets these features according to his needs. As the complexities of our society increase, our interpretations of map features become more technical, and we continually seek more accurate and precise standards for portrayal of these features on maps.

Purpose.-

Many scientific and engineering disciplines depend upon topographic maps for data on streams and other hydrographic features. This particularly true of hydrology and geomorphology, where quantitative measures of stream parameters often supply the basic data upon which technical studies are made.

Hydrologic investigations are currently providing important clues to the understanding and intelligent management of water as a basic natural resource. As the demands for this resource increase, the demands on the hydrologist for more detailed evaluation and extrapolation of existing hydrologic data also increase. To meet these demands, the hydrologist attempts to relate existing streamflow data to measurable characteristics of the drainage area contributing to the streamflow. Having successfully developed this relationship, the hydrologist is then able to predict within calculable limits the behavior of an ungaged stream by considering the characteristics of the drainage area.

Many characteristics of the drainage basin have been successfully related to hydrologic data. Benson (1961) has shown that the magnitude and frequency of flooding in New England is related to such topographic measurements as basin area, the area of lakes and ponds in the basin, and the slope of the stream. A similar study (Benson, 1962) for the arid Southwest added basin length as another significant topographic factor affecting floods in that area. Stall and Bartelli (1959) related the length of non-incised drainage channel in the basin to the rate of sediment deposition in reservoirs. Other investigators, such as Morisawa (1959), have used various ratios of topographic factors to explain variations in hydrologic data.

Basin characteristics are usually determined from maps rather than by field observations. For most hydrologic studies, field observations are impractical because of the sizes of the areas involved. Topographic maps, on the other hand, provide an easy, rapid method of obtaining the necessary data in the office.

However, topographic maps currently in use show only a representative network of streams on the map. This network is selected by editing the compiled drainage and therefore represents only a part of the entire drainage. The use of this edited network or extensions thereof provides the hydrologist with estimates, often biased or even erroneous, of the morphometric measurements he is seeking. This point will be discussed more fully in a later section of this paper.

Topographic maps, to meet the ever-increasing needs in water resources and other studies, must portray streams and other hydrographic features as completely and accurately as possible. The blue lines shown on topographic maps must either indicate all drainage channels, or be related to the total drainage of an area in a consistent manner, so that comparisons of measured stream lengths between areas will be valid. The classification of a stream as ephemeral or perennial needs to be accurate because of the different hydrologic significance of each of these types of channel. Only through such accurate portrayal of hydrographic features can meaningful morphometric measurements be made.

Foresters and botanists are dependent upon topographic maps for much information concerning the environments in which plants grow. Physical characteristics of the environment such as altitude, topographic form, and angle and orientation of slopes are readily determined from topographic maps, eliminating laborious determination of these features in the field. These physical characteristics control many of the environmental variations to which the plant cover must adjust through physiological processes. Thus, the establishment of relations between a particular kind of physical environment and a particular kind of plant cover in the field often permits the forester or botanist to predict the nature of vegetation in adjacent areas by means of a topographic map.

The physical environment not only affects the distribution of plants, but is also in turn affected by the vegetation. Thus, the vegetation growing in a drainage basin affects the hydrologic characteristics of that basin. For example, destruction of forest by logging or burning increases runoff (Bates and Henry, 1928; Hoyt and Troxell, 1934; Hoover, 1944). Conversely, reforestation of grassy fields decreases runoff (Schneider and Ayer, 1961).

Although existing topographic maps show several kinds of vegetation, this information is of less value to students of plant cover than the environmental data this is presented. Except for scrub vegetation of arid regions and mangrove, no attempt is made to indicate differences in species composition. The rest of the wild vegetation is mapped solely on the basis of height and density, within rather wide limits. Thus, woodland may range from Artic willows no more than 6 feet tall to a mature forest of Douglas fir more than 300 feet tall. Furthermore, the density of trees in an area mapped as woodland may be as low as 20 percent areal cover. These criteria satisfy the requirements of the military, who must evaluate terrain in terms of troop concealment, but are of limited use to the botanist or hydrologist concerned with the relation between plant cover and the hydrologic characteristics of drainage basins.

The original goal of the current study in the Yellow River and Tired Creek basins in Georgia was the improvement of criteria for portrayal of streams on topographic maps. Improvements in criteria were sought which would increase the accuracy of both the amount of drainage portrayed and the classification of this drainage as ephemeral or perennial. Any improvements in the criteria, however, must be realistic and be adaptable to current mapping practices without excessive increases in current map costs.

During the study, the inter-relation between the hydrology and the plant cover of the areas become increasingly apparent. For this reason, the plant cover of the two basins was studied and mapped in support of the principal purpose of improving the portrayal of drainage on topographic maps.

Acknowledgements.-

The study was sponsored by the Interdivision Committee on Water Resources Features on Topographic Maps. The Committee, composed of members of the Topographic and Water Resources Divisions of the Geological Survey, was organized in March 1958. At its meeting in November 1959 the Committee considered a proposal to study the representation of streams on topographic maps, and subsequently sponsored a project to carry out the proposal.

The overall responsibility for the project was assigned to the Topographic Division and the Water Resources Division. The Topographic Division assumed responsibility for the compilation of special drainage and vegetation maps, including the procurement of the aerial photography to be used in the compilation. The Water Resources Division assumed responsibility for the hydrologic studies.

Data on streamflow in the study areas were obtained from the Atlanta District office of the Branch of Surface Water, Water Resources Division. Personnel of the Atlanta office provided valuable advice and assistance in the field studies. O. J. Cosner, geologist, was especially helpful with detailed information the geology and hydrology of the Yellow River basin.

R. S. Sigafoos, botanist, Branch of General Hydrology, Water Resources Division, first suggest to the Committee the possible relationship between

the classification of stream flow and vegetation, and submitted the proposal for vegetation mapping to the Interdivision Committee. He also assisted in the evaluation of the vegetation maps.

E. V. Giusti, Engineering Aid, Branch of Surface Water, made the study of the effect of different map scales and map-making agencies on the portrayal of drainage on maps.

PRESENT MAP TREATMENT

Drainage.-

Drainage as considered in this report consists of the network of streams in an area. It does not include consideration of shorelines of lakes and ponds, swamps and marshes, nor coastal or offshore hydrographic features. The network of streams represents the natural drainage features through which precipitation returns overland to the oceans. It is indicated by blue lines on topographic maps.

The portrayal of the blue lines on maps prepared by the Topographic Division is governed by several manuals and technical memoranda issued at various times since 1928. The earliest instruction, issued in 1928, were contained in Geological Survey Bulletin 788. This bulletin states in part (p. 244):

> "The field sheets should clearly classify all streams as perennial or intermittent....A perennial stream is one that flows throughout the year....An intermittent stream is one that is dry for a considerable time each year, say for three months or longer....In regions where both perennial and intermittent streams abound, the pencilling should be complete and clearly distinct as to each kind, but if the proportion or amount of intermittent drainage is so large that the field drafting of the dash and three dot symbol becomes burdensome the copy can be made clear for inking by means of an overtracing (information sheet) showing only the perennial streams with a statement that all other streams were intermittent."

Although providing for complete and detailed field mapping of drainage, Bulletin 788 also provides (p. 292-293) for extensive editing of the field compilation of the drainage before publication. The instruction for final drafting state:

> "In general all perennial streams (see p. 244) except very short stubs and insignificant rills should be inked on maps drawn for publication on a scale of 1:62,500. For maps on larger scales (1:31,680, 1:24,000, etc.) all perennial streams except the smallest rills may be inked, but rills also may be inked where, in the absence of contour lines defining their channels, they constitute features of topographic importance."
>
> On maps drawn for publication on a scale of 1:125,000 the amount of perennial drainage to be inked should be only slightly

less than for a scale of 1:62,500, the omitted streams being the shorter forks or tributaries whose inking would give a stubby expression to the drainage. For a scale of 1:250,000 much-less drainage should be inked than would be represented on a scale of 1:125,000.

The general rule should be to ink no intermittent stream that will be less than three-quarters of an inch long on the scale of publication. In the more arid districts a smaller proportion of the intermittent drainage should be inked, and the minimum length should be increased to 2 inches or more, according to scale, as may seem appropriate to the degree of aridity."

Thus blue lines as determined under instruction in Bulletin 788 represent an edited portrayal of drainage. The edited portrayal of drainage was continued in Technical Memorandum 62-1 of the Topographic Branch dated November 5, 1947. Although this memorandum superseded the instruction on hydrographic features in Bulletin 788, no major changes in instruction were made concerning classification or portrayal of streams.

A major change in instruction for drainage portrayal occurred, however, in July 1954. At this time, Chapter 3A6, Mapping of Hydrographic Features, was issued as part of the Geological Survey loose-leaf manual of Topographic Instructions. Chapter 3A6 provided for classification of streams as perennial or ephemeral in the same general concepts as previous instructions, but further stated that:

"When there is doubt as to the proper classification, streams in areas having an annual runof....of 10 inches or more shall be considered perennial...."

The Chapter then sets forth areas having 10 inches or more annual runoff. Except for small areas of Colorado, Montana and Wyoming, and the Pacific Coast, generally west of the Coast Range and Sierras, runoff of 10 inches or more is confined by definition in the chapter, to the humid region east of a line from Lake Michigan through southern Illinois and Missouri and then along the western boundary of Arkansas and Louisiana. Within these areas, stream classification as intermittent by field engineer required explanatory notes, and as a result, practically all streams in these areas were designated perennial on the final maps.

Editing of the drainage compiled under instruction in Chapter 3A6 were covered in Chapter 4C1 dated February 1955. Chapter 4C1 states that:

> "In order that treatment of drainage will be as consistent as possible on all published maps and that the drainage patterns on maps of a general area will appear uniform, the office completion engineer or editor usually prepares a transparent overlay indicating the streams to be inked and their classification, perennial or intermittent.
>
> Although the field completion engineer is responsible for providing complete drainage information, the editor must review and sometimes modify the representation of drainage to agree with the treatment used on adjoining quadrangles because field completion was done by different engineers or during different seasons of the year. The editor must reconcile these differences either by office research or, preferably, by consulting the engineers responsible for the field work."

A recent study of the hydrology of the Piedmont Province indicates that standard U.S.G.S. maps of this area generally contain less drainage portrayal than comparable maps by other agencies. Also, as would be expected, the amount of drainage portrayal is governed by both scale and contour interval. However, another factor is of prime interest here- U.S.G.S. maps compiled after the 1954 revision of standards for hydrographic portrayal contain considerably less drainage portrayal than those compiled prior to 1954.

For the comparison of maps, stream frequencies were determined and compared. Stream frequency is the number of first-order (headwater) streams within a given basin. On the topographic maps, first-order streams are those segments of the blue-line network above the first branching.

Analyses of data derived from 108 topographic maps of the Piedmont Province from Virginia to Alabama indicated a simple relationship between drainage area and number of first-order streams of the form

$$N_u = k\ A.$$

where N_u is the number of first-order streams in a basin, and A is the area of the basin in square miles.

Thus the constant k in the equation is a measure of the number of beginnings of streams per unit of area. Values of k derived in the study are shown in the following table.

Map source	Scale	k
USGS, pre - 1954	1:24,000	3.2
USGS, post - 1954	1:24,000	1.4
Other agencies	1:24,000	3.2
USGS, pre - 1954	1:62,500	1.25
USGS, post - 1954	1:62,500	.43
Other agencies	1:62,500	1.90

The decrease in drainage portrayal resulting from the 1954 standards for portrayal is evident. However, even prior to 1954, maps published by the U.S.G.S. at 1:62,500 scale portrayed about one-third less drainage than maps published by other governmental agencies.

Thus, in practice, it appears that the instruction, both prior to and after 1954, that permit the editing of drainage have been loosely interpreted to provide for balance and artistic appearance of blue line on topographic maps.

Vegetation.-

Bulletin 788 of the Geological Survey prescribed in 1928 for the mapping of vegetation. It defined woodland to be mapped as including "all timber, woods, or brush, whether alone or mixed, of sufficient stand and height to impede ordinary travel or affordcover for small detachments of troops. Logged over or burned areas, if covered by second growth or brush, should be shown as woodland." These standards, with only minor modification, are still used.

Modifications in the standard for mapping woodlands were stated in two technical memoranda, dated June 1, 1945, and December 15, 1947. These modifications are reflected in Chapter 3A9 of the Geological Survey Topographic Instructions, dated May 1953. This chapter is currently being used.

Vegetation is currently classified into five mapping types: woods, scrub, orchards, vineyards, and mangrove. Orchards, vineyards, and mangroves are defined in classic terms. Scrub, however, is defined as "a low or stunted vegetation such as cactus, mesquite, or sagebrush, found on the poor soil of arid regions." Woods are modified from earlier definition to include:

> "trees and brush. Trees must be at least 6 feet high and thick enough to afford cover for troops. Brush must be potential tree growth, at least 6 feet high, and thick enough to impede foot travel or give cover for troops. Logged or burnt areas are classified as woods when new growth is well established and of sufficient height."

Chapter 3A9 also provides for mapping of wooded areas exceeding approximately 200 feet by 200 feet. It also defines woodland as area in which trees cover about 35 percent of the ground. Areas of less than 20 percent tree cover are classed as open, and intermediate areas of 20 to 35 percent tree cover are classed as either open field or woodlot, depending on whether the area "seems to be gaining or losing woodlot."

GEORGIA PROJECT

The decision of the Interdivision Committee to study the representation of drainage on topographic maps resulted in the selection of two study areas in Georgia. The areas selected for study were the Tired Creek Basin, east of Thomasville, and the Yellow River Basin, northeast of Atlanta. Their locations are shown in figure 1. Several factors governed their selection.

Both basins typify larger physiographic areas. The Tired Creek basin, lying in the Coastal Plain, has gently rolling hills with broad, rounded summits. Local relief is generally less than 50 feet, and extremes of elevation in the basin range from about 160 feet at the stream gaging site near Cairo, Georgia, to about 350 feet along the crest of the escarpment forming the northwest boundary of the basin. The Yellow River basin, lying in the Piedmont Province, is moderately dissected by streams. Relief is also moderate, rarely exceeding 200 feet locally, and ranging in the basin from about 810 feet at the stream gaging site near Snellville, Georgia, to about 1200 feet along the ridge in the northeast corner of the basin.

Relatively extensive streamflow data also were available for both basins. Streamflow measurements made at many sites in each basin provided detailed knowledge of the hydrology of the basins. Each basin contains sub-areas which differ in the low-flow characteristics of the streams. These differences in low-flow characteristics provided a strong base for determining whether differences in amounts of drainage in various parts of each basin were significant hydrologically.

The general plan of study required a field check of special drainage maps to determine beginnings of perennial flow in both basins, and a study of areas in which flow became perennial. The two items--the origins of perennial flow and the characteristics of the associated area--were related so that the characteristics could be used as interpretive keys in the delineation of the perennial stream network.

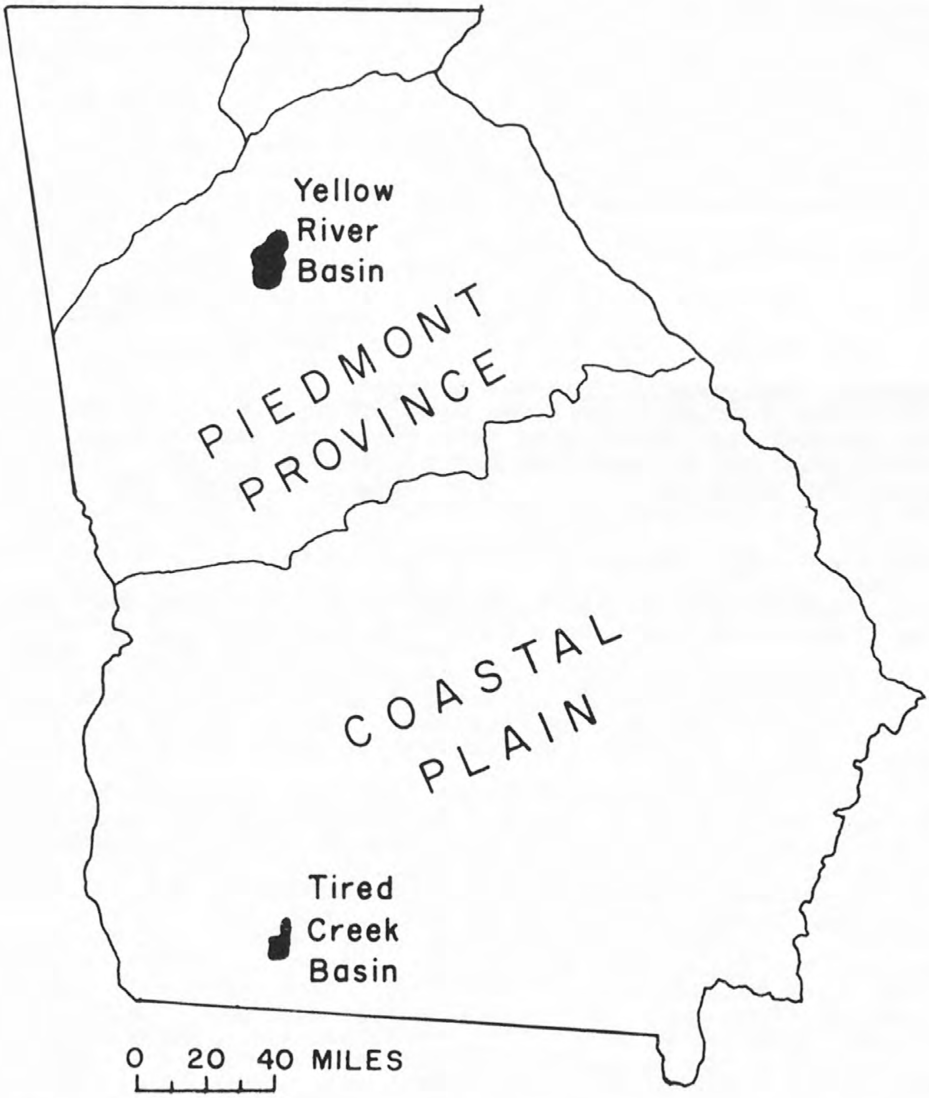

Figure 1.- Map of Georgia showing locations of Yellow River and Tired Creek basins.

Early in the study, several classification for portraying streams on topographic maps were considered. For the hydrologist, a measure of duration of flow is an excellent means of classification. Duration of flow is a non-chronological time concept, usually presented as a percent of time that a given amount of streamflow is equalled or exceeded. For the geomorphologist, stream order as proposed by Horton (1945) or as modified by Strahler (1957) is meaningful. However, as the study progressed, the uniqueness of the points of origin of perennial flow in both basins became apparent, and the dichotic classification of perennial and non-perennial (ephemeral) flow was adopted.

The special vegetation maps were field-checked as a part of the studies of the relations between vegetation and hydrology.

Tired Creek: description.-

The Tired Creek basin is part of the Tifton Upland which extends from the southwestern corner of Georgia northeastward as a belt about 30 to 50 miles wide, and 240 miles long (Fenneman, 1938). Soils are chiefly grey and with clay subsoil.

The soils are derived from the weathering of the Hawthorn formation. The Tifton soil contains small iron concretions up to a half-inch in diameter, and is found primarily in the upland areas.

Most of the land above the valley bottoms is under cultivation. Sugar cane, cotton, corn, and truck produce are the principal crops. However, in recent years shortages of farm labor have led to the introduction of cattle-raising, and acreage formerly cultivated is being converted to pasture. Open pine stands under intensive management also are found in many places. Pecan groves are prevalent on the hilltops, particularly near farm dwellings.

Streams in the Tired Creek basin flow sluggishly through rather broad valleys with low gradients, with velocities averaging well under 2 feet per second. Except in the upper headwaters, the streams meander across wide floodplains which flood at frequent intervals.

Tired Creek: preparation of special maps.-

The Topographic Division compiled special maps of the Tired Creek basin using existing data and aerial photography obtained specifically for this study. For this study, special infra-red photography was obtained in November, 1959 at flight heights of 6,000 and 11,800 feet. Also available were panchromatic aerial photographs obtained in February, 1952, at a flight height of 14,200 feet.

Most of the basin had been mapped previously. Standard 15-minute quardrangles compiled in 1955 and 1956 cover all of the basin except a small area of less than 5 square miles lying above latitude 31°00'. Planimetric bases for the existing maps were compiled at a scale of 1:12,000. Current mapping for this study was done on the planimetric bases available. The bases were reduced photographically to 1:24,000 and mosaiced to the four $7\frac{1}{2}$-minute projection sheets. The small area north of 31°00' latitude was mapped according to standard procedures. All compilation was done on the Kelsch Plotter.

Drainage was compiled on the projection sheets under the following classification: perennial channel drainage was shown as a solid line, ephemeral channel drainage as a dash and three dot combination, and indefinite drainage as short dashes. The indefinite category denoted both unchanneled drainage courses and courses where vegetation or other factors prevented the compiler from observing a channel. Two complete sets of drainage maps were compiled. One set was compiled from the 1952 panchromatic photography and the other from the 1959 infra-red photography flown at 11,800 feet. For comparison with these two sets, drainage of a small area covering several square miles was compiled from the infra-red photography flown at 6,000 feet, using eight stereo models.

Vegetation maps for the basin were compiled from the small-scale (11,800 feet) infra-red photography. Original plans called for use of the 1952 panchromatic photography for vegetation classification. The infra-red photography was substituted for two reasons. First, the panchromatic photography showed poor tonal contrast in the vegetation, and second, greater reliability could be placed on field checks of the classification because of the more current photography.

Vegetation mapping followed the classification proposed by R. S. Sigafoos (written communication, 1960). The vegetation was classified as open (non-timbered) area, orchard, or woodland, with the woodland further sub-divided into deciduous or conifer and shrub or forest. Open land consists of areas in which crown density of trees and shrubs is less than 10 percent. Two distinguishing factors separate forest from shrub. Shrubs consist of woody plants less than 15 feet high, and trees consist of woody plants taller than 15 feet. A second distinction between forest and shrub is the relative crown volume of each type of plant within the given area. Classification as shrub requires 90% shrubs by volume; forest 10 percent trees by volume. The division into deciduous or conifer classification is based on relative proportion of each type. A classification as undifferentiated forest or shrub covers those areas where distinction in type cannot be made from the photographs, or where the amounts of deciduous and coniferous vegetation in an area appear about equal.

Tired Creek: field studies and observations.-

Streams in the Tired Creek basin normally have their highest flows during March and April. In May, with the coming of the growing season, streamflow decreases rapidly because of both decreases in precipitation and increases in evapotranspiration. This decrease in streamflow generally continues through June. Heavy thunderstorm activity, however, usually reverses the downward trend in streamflow during July and August, with streamflow again receding during September and October. Reductions in evapo-transpirative water use again reverse the downward trend beginning in late October and November, and streamflow once more shows a general increase until its peak in March or April.

Because of this pattern of streamflow, field investigations in the Tired Creek basin were made during the months of June and September, 1961. These periods, covering both the early summer and fall recessions of streamflow, represented the most likely periods when the base flows of the streams would be at their minimums.

The major part of the field work was done in June, when precipitation measured at Cairo was below normal for the month. The first half of the month was exceptionally dry. This condition reflected in the runoff from the basin which was only 50 percent of normal. However, the 0.34 inch of runoff for the month is not exceptionally low; in 1955, only 0.03 inch of runoff was measured at the gaging site below Cairo. The streamflow was somewhat higher during the latter part of June, but daily flows were generally still below that which is exceeded about 90 percent of the time.

Streamflow continued well below average throughout July, August, and September, with flows during these months of 27 percent, 55 percent, and 23 percent of normal respectively. Thus streams which were flowing both during the latter part of June and in September could reasonably be considered perennial.

Field observations were first limited to a general reconnaissance of streams in the basin. Stream channels in the vicinity of road crossings were selected by means of aerial photographs and the special drainage maps, and were classified as flowing or dry at these points. Some of these streams were extremely small, flowing through narrow incised channels at rates of several gallons per minute. In some places, the area adjacent to the channel was swampy, with water filling minor depressions in the ground surface; in other, it consisted of a broad, sandy floodplain. Further investigation revealed that streamflow began at sharply defined heads of channels, which appeared as incisions in the form of semi-circular vertical faces. At these fluvial cirques streamflow issued from the base of the incision in spring-like manner at rates estimated from less than one to more than five gallons per minute.

Below the fluvial cirques, the stream continued flowing in well-defined channels; above them there was no channel and no streamflow. Thus, these unique beginnings of perennial channel provided a clear topographic feature for distinguishing between the flowing and dry reaches of a stream. The broad, sandy valley bottoms above the cirques are depositional features, probably formed as a result of recent erosion farther up the valley.

Although the reaches immediately above the cirques are not incised, gullies are common nearer the head of the valleys. These gullies generally were discontinuous, beginning as small incisions, gradually deepening and widening, and then becoming narrower and shallower until they gradually disappeared into the flat valley floor. The gullies observed in the Tired Creek basin ranged in cross-sectional area from 3 or 4 to perhaps more than 50 square feet. A typical example of the flood plain deposition and upstream gullying is shown in figure 2.

At one site, a soil pit dug into the sandy deposition showed about seven inches of light-colored soil above a darker, less sandy, but more organic soil. In some cases, depth of alluvium in the valleys may range up to more than 8 feet for drainage areas as small as 1 square mile.

Results of these field investigations indicated the feasibility of classifying streams by observation as either flowing or dry. Accordingly, two sub-basins were selected for complete study and classification. Selection of the sub-basins was necessary to keep the amount of field work within reasonable limits. Consequently, all points of origin of flow in the Upper Tired Creek sub-basin and the Wolf Creek sub-basin were determined in the field. Because these determinations of flow ere made in the latter part of June during a period of low base flow, it was assumed that the fluvial cirques represented the demarcation line between perennial and ephemeral channel. This assumption was verified by additional field checks later in the season.

Unlike most of the upland areas, the stream valleys are densely forested. Two major kinds of forest can be distinguished on the aerial photographs, and these differences are indicated on the special vegetation maps as evergreen and deciduous forest. Early in the course of the field investigations, a coincidence was noted between a distinctive vegetation pattern that appeared on the infra-red aerial photographs and the location of the channel heads. Forests adjacent to perennial channels showed a darker, somewhat smoother pattern on the photographs that could be delineated either monoscopically or stereoscopically. The upper end of this photographic pattern coincided closely with the spring-like beginnings of

A--Typical active gully in first order stream valley.

B--Recent sandy deposition in valley just downstream from discontinuous gully, and just upstream from beginning of perennial stream channel.

Figure 2.--Current erosion and deposition in Tired Creek basin.

perennial flow. Although most of these areas were designated on the special vegetation map as coniferous forest, field checks revealed forest (figure 3) consisting largely of blackgum or alder. However, this error of classification is not serious because the vegetation map clearly distinguishes between the two major kinds of forest growing in the valleys.

In both basins, the perennial channels which were determined in the field were identified on the infra-red photographs by the distinctive vegetation pattern presented by the gum and alder stands. (figure 4). In some places, however, isolated round or oval patches of the photographic pattern occurred above the determined point of origin of streamflow. These isolated patches represented sink-hole swamps which drained during periods of higher base flows, but were self-contained bodies with no surface drainage during low base flow periods. Consequently, because of the dry soil and lack of the distinctive vegetation along the valley between the sink and the perennial channel head, the ephemeral channel did not record on the photograph in the same dark tones as the sink and perennial channel.

Forest consisting largely of blackgum 1/ trees grew on most of the swampy flood plains. This forest contained a dense ground cover of ferns, vines, and herbaceous plants, and in many places a dense understory of evergreen magnolias was present. Some of the sink hole swamps contained cypress. The less swampy surfaces, many of which were covered by recently deposited sand, usually supported pure stand of speckled alder. These alder stands gradully gave way to blackgum stands within relatively short distances downstream from the head of the perennial channel as the ground became more swampy.

The sandy deposits supporting the alder stands probably were derived from erosion and gullying of the upland areas, which are heavily cultivated. Two superficial examinations of these sedimentary deposits indicated that the loose sandy soil overlays a less permeable clayey subsoil to a depth of about a foot at one site and about 2.5 feet at a second site. At both places, perennial flow began at the base of a semi-circular head of an

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1/ See table 5 for scientific names of plants mentioned in text by common name.

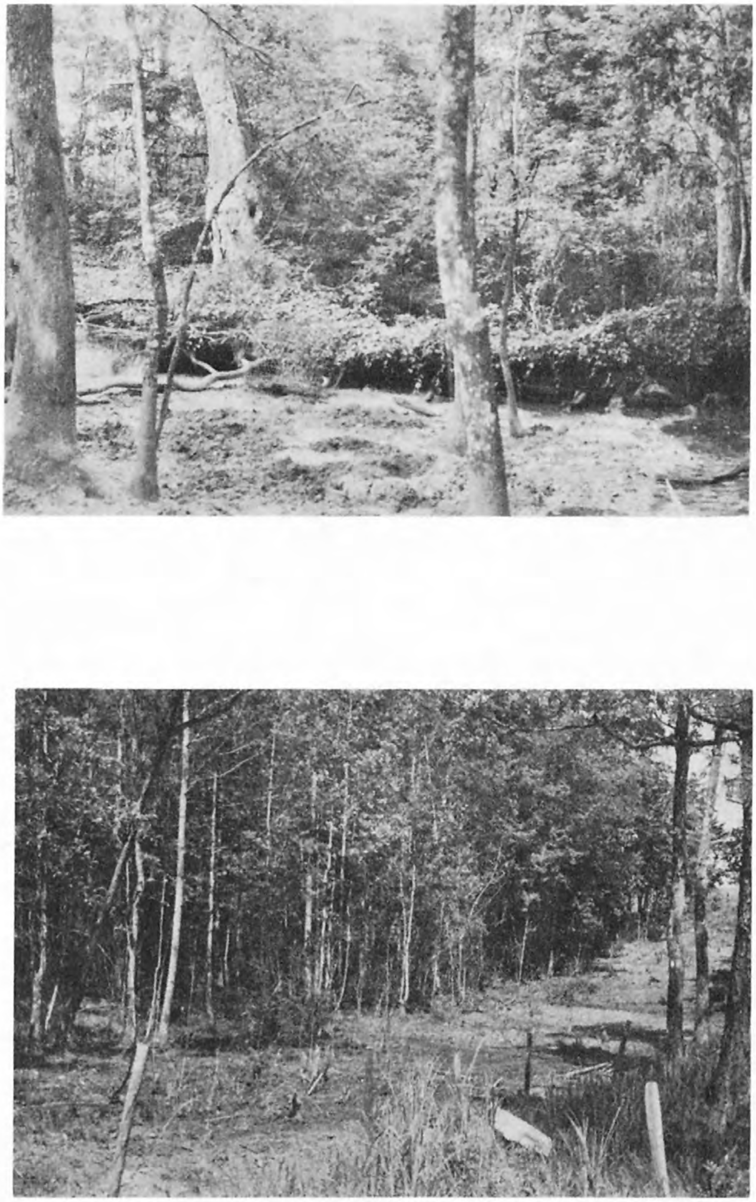


Figure 3.--Typical black gum forests in Tired Creek basin. These forests are associated with swampy areas in which streamflow becomes perennial.

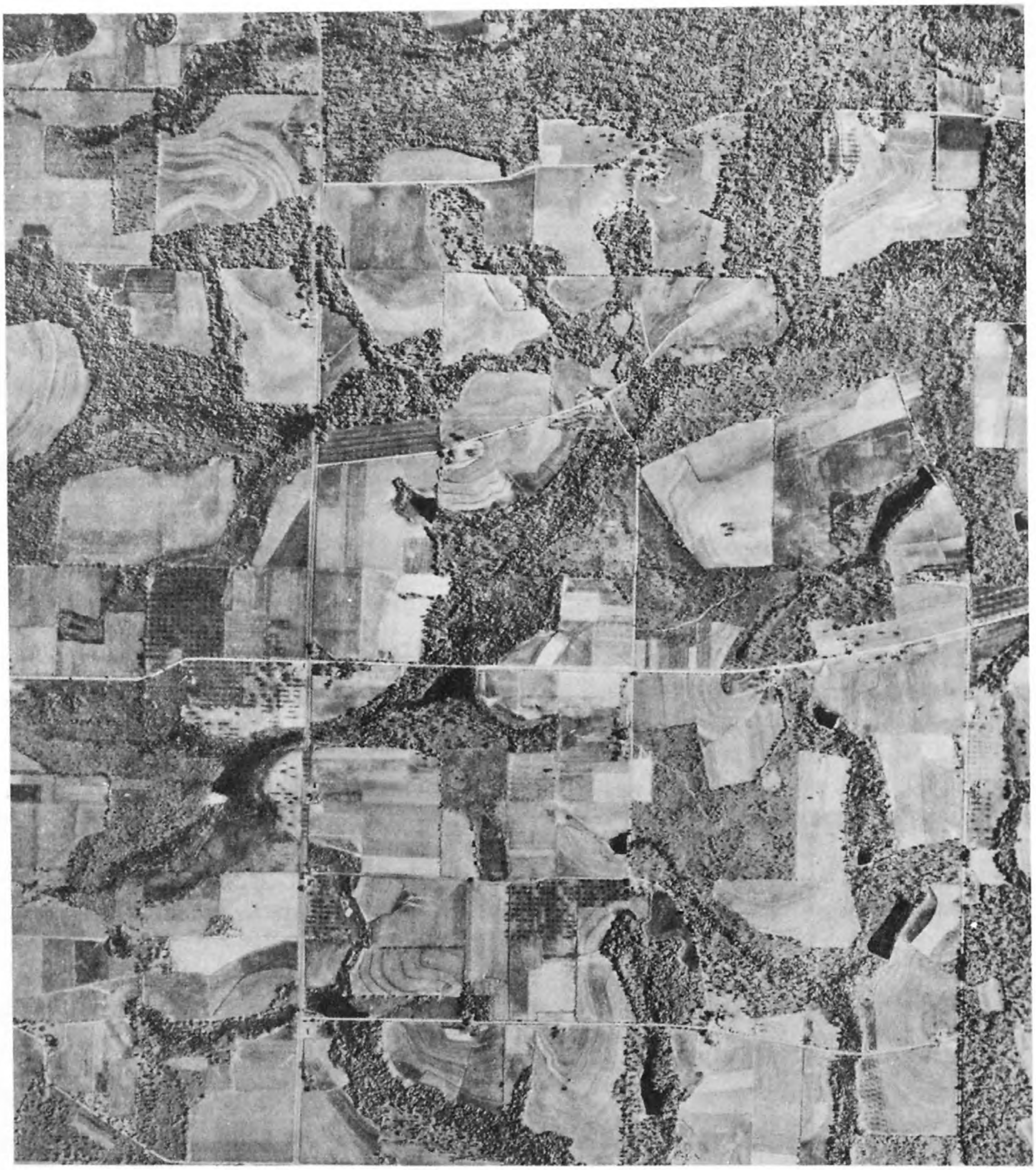


Figure 4.- Infra-red aerial photograph showing distinctive dark pattern associated with perennial channels in Tired Creek basin.

incised channel, cut into clayey subsoil.

The network of perennial streams in the Wolf Creek sub-basin, and its relation to the selected patterns of vegetation, is shown in figure 5. In figure 5, both the areas of distinctive pattern selected on the aerial photographs by the authors and the areas designated by Topographic Division as evergreen forest on the special vegetation maps of the basin are shown. Of particular note are the common areas designated by both and the close relation of these areas to the beginnings of the perennial stream network as shown in the figure.

Small impoundments, commonly called farm ponds, are prevalent in the Tired Creek basin. More than 320 ponds were mapped from the aerial photographs obtained in 1959. Most of these ponds are relatively small, with surface areas ranging from a fraction of an acre to perhaps five acres. The largest pond in the basin has a water surface of about 15 acres. Two typical ponds are shown in figure 6.

Almost all of the ponds are located in the upper headwater tributaries on either first or second order streams. They are located either at or just below the semi-circular heads of the perennial streams, and are therefore spring-fed. Flow from the spring, however, is usually inadequate to meet seepage and evaporation losses from the pond, and pond levels tend to decrease during the summer and fall period. Although pond levels were observed below outlet levels, streamflow remained perennial below the impoundment. This is probably the result of the incised channel intercepting a high ground water reservoir in the valley which is recharged by seepage from the pond. The relatively high ground water levels produce swampy conditions in the valley bottoms below the impoundments, and the typical blackgum vegetation usually predominates. In all cases observed, streamflow below the impoundments was perennial.

In addition to the field check conducted during the course of the hydrologic studies, the special vegetation maps were checked along some of the roads in the Tired Creek basin. The results of this examination are presented in table 1. At selected points the plant cover was

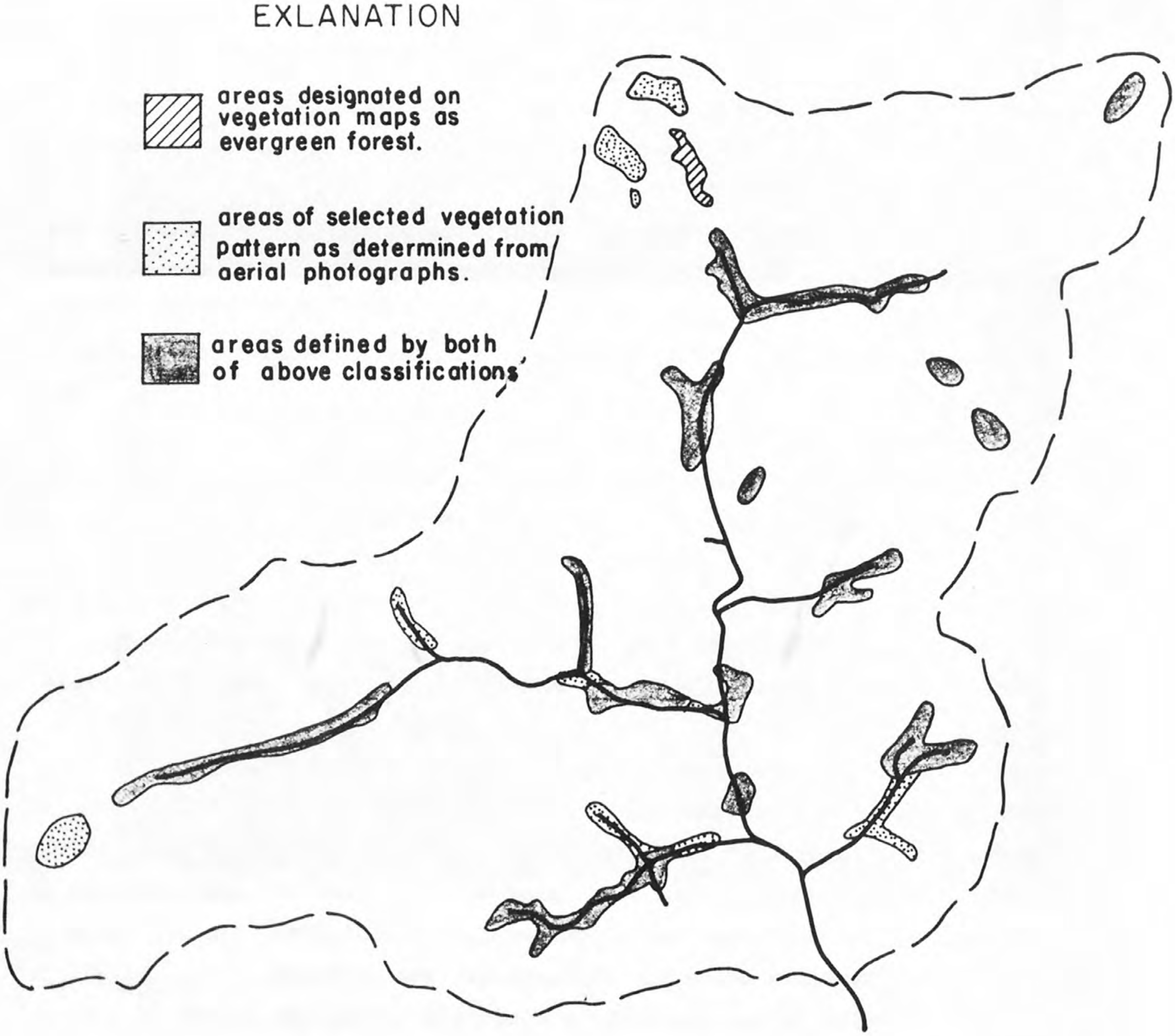


Figure 5.— Relation of selected patterns of vegetation to the network of perennial streams in Tired Creek basin.

Figure 6.--Typical farm ponds in Tired Creek basin. These ponds are generally located at or just below the spring-like sources of perennial flow.

Table 1.--Results of field check of special vegetation maps for Tired Creek basin.

Unit mapped	Number of observations	Number correct	Percentage accuracy	Number of errors	Remarks	Plates
Deciduous shrub..	10	6	60	4	2 evergreen forest, 1 mixed forest, and 1 deciduous forest mapped as "deciduous shrub".	1-A, 1-B
Deciduous forest.	75	18	24	57	55 evergreen forests and 2 mixed forests mapped as "deciduous forest".	1-E
Evergreen forest.	14	5	36	9	8 deciduous forests and 1 mixed forest mapped as "evergreen forest".	1-C, 1-D 1-G, 1-H
Orchard..........	12	11	92	1	1 long leaf pine plantation mapped as "orchard".	-

Photographed, and these photographs (plate 1) illustrate a number of the problems involved in the classification of vegetation from aerial photo graphs.

The boundaries drawn between the different types of vegetation on the maps almost always delineated differences that were clearly apparent on the ground. The vegetation at 94 of the check points was forest, and all but 5 of these stands were so designated on the maps, an accuracy of almost 95 percent. Four of the errors involved faulty estimation of the height of the vegetation. The fifth involved a uniformly spaced long-leaf pine plantation, which showed the geometric symmetry of an orchard on the aerial photographs and was so classified.

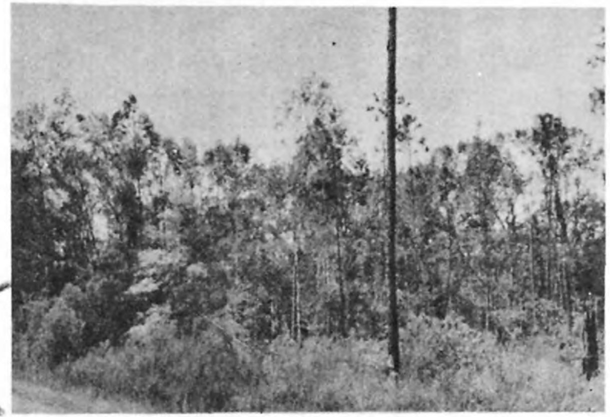
However, only 23 of the 89 forest stands checked in the field were correctly classified as deciduous or coniferous, an accuracy of about 25 percent. This faulty classification of forest was the outstanding error in the special vegetation maps, an error almost entirely due to faulty criteria proposed for the identification of the types. Deciduous vegetation was defined, in review, as vegetation through which more than 50 percent of the ground could be seen on the aerial photographs, which were made in November. Evergreen vegetation was defined as that through which less than 50 percent of the ground could be seen.

Throughout most of the forested regions of the United States, the deciduous, broad-leaved trees shed their leaves in early autumn. Aerial photographs of deciduous forest taken after leaf fall thus show a large percentage of the ground surface. However, many of the braod-leaved trees in the Tired Creek basin are either evergreen or tardily deciduous. Even those broad-leaved forests consisting predominantly of trees that shed their leaves in early fall often contain an understory layer of evergreen broad-leaved trees and shrubs. For an example an examination of the forests adjacent to the heads of the perennial streams in early September, 1961, showed that the blackgum trees constituting the canopy layer and shed almost all of their leaves. Some of these gum forests contained a dense understory of evergreen sweetbay and southern magnolia, or dense stands of cane. Study of aerial photographs taken in November would show almost no ground visible under the leafless blackgum trees,

E- Coniferous forest, consisting of long-leaf pines. Dense shrub layer is broad-leaved, consisting of southern red and water oaks, cherry, and pecan. Mapped as deciduous forest (FD).

F- Pine plantation; trees are about 50 feet tall and up to 9 in. in diameter. Mapped as unclassified forest (FUNCL).

G- Mixed broad-leaved and coniferous forest. Taller trees are almost all black gums, with a few overtopping long-leaf pines. The dense understory consists of sweet-bay (evergreen), black gum, and willow. Mapped as evergreen forest (FE).



H- Broad-leaved forest, consisting almost entirely of black gum trees. Note dense broad-leaved shrub layer consisting of southern magnolia, black titi (or he-huckleberry), buttonbush, and willow. Mapped as evergreen forest (FE).

Plate 1.- Plant cover in Tired Creek basin

A- Scattered loblolly and long-leaf pines in old field. Mapped as deciduous shrub (SD).

B- Coniferous forest, consisting of loblolly and long-leaf pines. Trees range from about 50 feet in height. Understory trees are mostly broad-leaved, consisting of southern red and water oaks, sweet gum, and persimmon. A few pine seedlings less than 10 feet tall are visible. Mapped as deciduous forest (FD).

C- Mixed broad-leaved and needle-leaved forest. Overstory trees are conifers (loblolly and long-leaf pines). Dense understory trees are broad-leaved (southern red and water oaks, sweet gum). Note the dense shrubby layer in foreground, less than 6 feet tall. Mapped as deciduous forest (FD).

D- Mixed broad leaved and needle-leaved forest. Overstory trees are coniferous (long-leaf pines) and deciduous (post oaks). Understory trees are broad-leaved, consisting of southern red oak, water oak, and sweet gum. Mapped as deciduous forest (FD).

Plate 1.- Plant cover in Tired Creek basin

and result in the classification of this kind of forest as coniferous.

The difficulty of classifying forest vegetation in the Tired Creek basin is compunded by the fact that the coniferous forest consist of longleaf or loblolly pines, which have widely-spaced, feathery crowns. In addition, intensive management in many of these stands has resulted' in removal of a broad-leaved understory, resulting in single-story. open-canopy forests through which the ground is readily visible. Most forests of this type were therefore classified as deciduous.

Although the criteria for classification of coniferous and deciduous vegetation were erroneous, they were consistently applied. Thus, if the criteria were reversed, 90 percent, instead of 25 percent, of the units that were field checked would have been correctly classified.

Yellow River basin: description

The Yellow River at the gaging station near Snellville, Georgia drains 134 square miles. Garner Creek, which enters the Yellow River about a mile below the gaging station, drains about 6 square miles. The two drainage areas were considered as one basin for the study.

The area lies in the Atlanta Province of the Piedmont Plateau, about 15 miles northeast of Atlanta. It is a rolling upland of moderate relief. Altitudes range generally from about 1,100 to 1,200 feet along the ridges to about 810 feet at the gaging station on the Yellow River. Local relief varies from about 100 to slightly over 200 feet in some parts of the basin.

The upland soils of the Yellow River basin are residual soils derived from the underlying rocks, and their properties vary with the composition of the rocks. Predominant are the Cecil and Appling soils derived from the granites, gneisses, and schists. They are generally well-drained, particularly on the slopes and ridges. Another prominant group of soils is the Lloyd group which are derived from schists and gneisses containing hornblende, and have a heavy subsoil.

The three groups are quite similar in properties. They are reddish-brown soils consisting mostly of clay loams and gravelly clay loams underlain by clay subsoils. The upper soil horizons are easily cultivated and have a moderately good water-absorbing capacity.

Much of the Yellow River basin was formerly cultivated. At present, however, only an estimated 10 percent is cultivated. Many former fields which were abandoned have returned to pine and hardwood forest. A few managed plantations of pines exist, but in general, the pines appear to have regenerated in the abandoned fields by natural seeding. Present cultivation yields mostly corn and cotton, along with some small grains, forage, and truck crops.

Erosion of upland surfaces is a serious problem. Gullying is prevalent in extreme headwater reaches (figure 7), with its subsequent downstream deposition of alluvium in the form of valley fans or plugs. In many parts of the basin gullies are forming at the present time, partly as the result of suburban development.

The Yellow River flows south through the study area. The axes of tributary sub-basins in the upper part of the area are also mostly south-oriented. The orientation rotates progressively in the downstream direction, until tributaries in the vicinity of the gaging station on the Yellow River are eastwest oriented. The gross effect is that of dendritic pattern in a somewhat circular basin.

Yellow River basin: preparation of special maps.-

Unlike the Tired Creek basin, less than one-fifth of the Yellow River basin was covered by recent maps. Most of this coverage was in the Snellville and Norcross quadrangles, with small areas extending into corners of Stone Mountain and Duluth quadrangles. All four quadrangles were compiled in 1956 and published at 1:24,000 scale.

Photography for the entire basin was obtained November, 1959. Both infra-red and panchromatic photography were obtained at flight heights of 7,200 ft and 14,500 feet. Also available are photography obtained at 14,500 feet in 1955, and at 15,000 feet in 1956. These flights, however, cover only small parts of the basin, and are the basis of compilation of the existing maps.

Figure 7.--Ephemeral gullies in Yellow River basin.

New sterocompilation using the panchromatic photography at 14,500 feet covered the previously-unmapped areas at a scale of 1:24,000. Two sets of drainage overlays for the entire basin were compiled, one set using the large-scale (7,200 feet) infra-red photography and the second using the large-scale (7,200 feet) panchromatic photography. Drainage was classified in the same manner prescribed for the Tired Creek mapping.

Vegetation maps also were prepared for the Yellow River basin using the same classifications proposed for the Tired Creek mapping. These maps were compiled from the 1959 panchromatic photography obtained at 14,500 feet.

Yellow River basin: field studies and observations.-

Streams in the Yellow River basin exhibit the typical seasonal pattern of recession during the growing season. The extent and duration of the recession depends upon the amount and distribution of precipitation during this period, but the recession usually continues into September or October when streamflow reaches its minimum.

Field investigations in the Yellow River basin were made primarily in September so that observations of streamflow would represent low-flow conditions. Reconnaissance studies of the area also were made at earlier times during the recession periods.

Reconnaissance studies in the Yellow River basin revealed that the demarcation between flowing and non-flowing reaches of a stream was similar to that found in the Tired Creek basin. Flow began at the base of a semi-circular head of an incised channel. Again, as in the Tired Creek basin, these fluvial cirques began abruptly, with no channel incision in the flood plains immediately upstream from them. Channel incisions at and below the cirques in the Yellow River basin generally were deeper than in Tired Creek basin, ranging in some cases to over eight feet deep. In all cases, both depth and width of channel incision increased in the downstream direction. Plate 2 shows several of the fluvial cirques in the Yellow River basin.

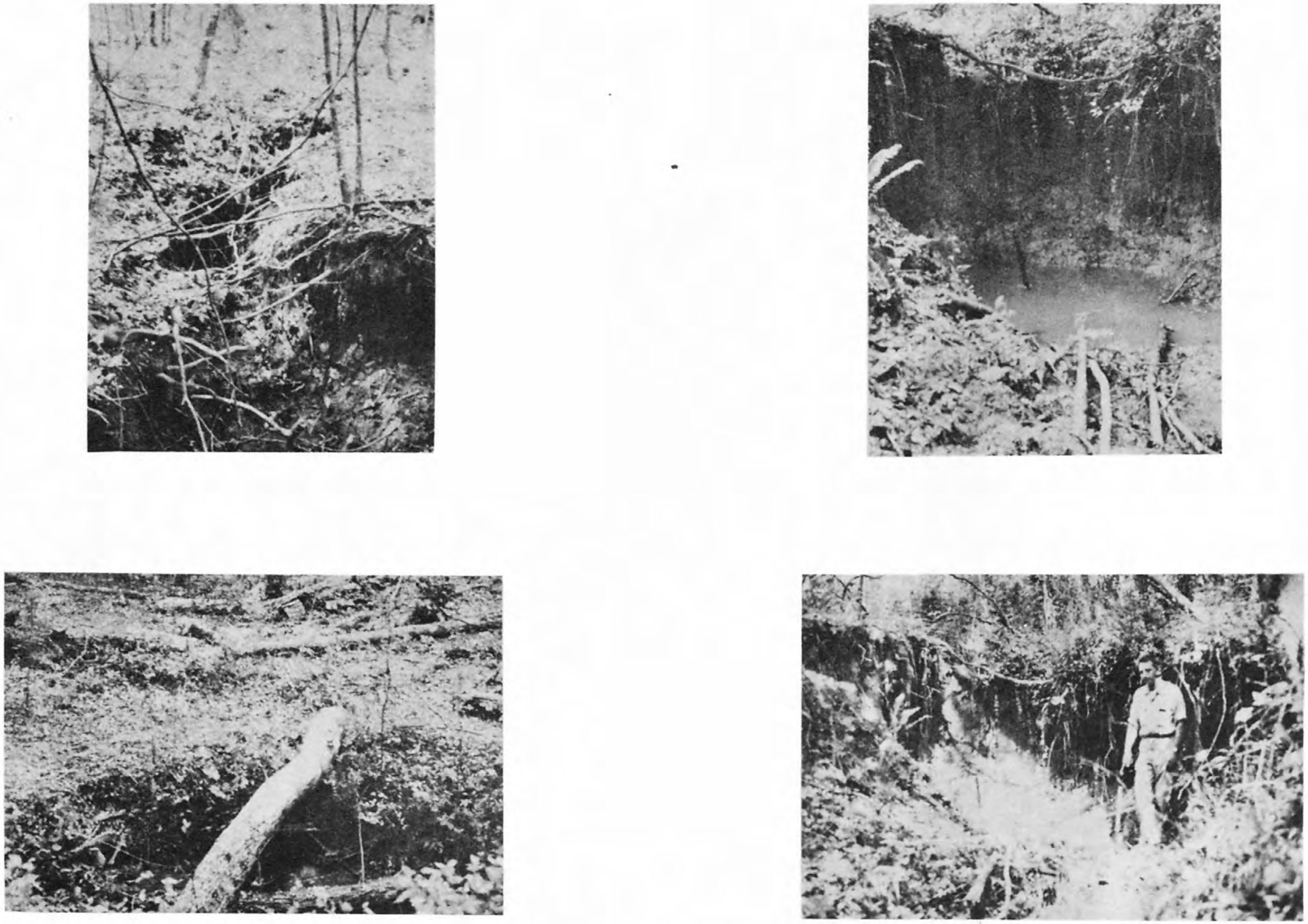


Plate 2.- Semi-circular heads of perennial stream channels in Yellow River Basin

Broad floodplains extended upstream along the valley floor just above the cirques. These floodplains were generally wooded, with deposits of the forest litter on the ground. In some areas, the forest floor was bare of undergrowth; in order cases, a dense undergrowth of vines, ferns and herbaceous plants was present. Evidence from debris indicated that direct runoff following heavy precipitation flows across a wide area of the valley bottom at shallow depths. Water-borne debris piled against the upstream face of trees rarely exceeded a foot high, but frequently occurred across widths exceeding 30 feet. Some of these valley bottoms were swampy, and supported a distinctive vegetation.

Field investigations included more than 500 small streams to determine the origins of flow. Each stream was traced in the field from the ridge to the origin of flow or to its junction with a larger perennial stream. Although in general these streams are distributed throughout the entire basin, about two-thirds of them are concentrated in two sub-basins which were completely field-mapped. The two sub-basins are the Garner Creek area of 5.5 square miles in the extreme southwest part of the basin, and the Little Suwanee Creek area of 3.1 square miles in the extreme northwest part of the area.

About 75 percent of these small streams were ephemeral throughout their length. Of the 121 streams field checked in the Little Suwanee Creek sub-basin, 31 sources of perennial flow were observed. In the Garner Creek sub-basin, 53 were observed. The remainder of streams in these basins contained no fluvial cirques which characterized the beginning of the perennial stream channel.

Although differences in plant cover exist in the Yellow River basin, they cannot be related to stream classification as clearly as in the Tired Creek basin. The differences in tree species above and below the cirques are too subtle to appear on aerial photographs. The marked tonal contrast on the photographs associated with the beginning perennial channel that provided the interpretive key to classifying stream channel as perennial or ephemeral in the Tired Creek is lacking.

In the Yellow River basin, a topographic key permitted identification of the channel as ephemeral or perennial. Fluvial cirques at which streamflow became perennial occurred in valleys which had concave-upward valley profiles above the cirques. Valley with ephemeral drainage had convex-upward profiles. Typical profiles are shown in figure 8. Although an accurate measurement of the shape of the valley profile can only be obtained by field measurement, stereoscopic viewing of aerial photographs gave a general impression of the concavity or convexity of the valley profile.

Accordingly, 42 valleys were randomly selected for stream classification from the aerial photographs. Reaches of perennial stream channels were delineated in 13 of the valleys, and the estimated locations of the beginnings of the perennial channels designated on the photographs. A subsequent field check of the 42 valleys indicated better than 80 percent accuracy. Of the 13 valleys delineated as having perennial streamflow, 10 were verified by field inspection. The other three were ephemeral throught their length to their junction with a larger stream. Of the 28 valleys classed as ephemeral, 23 were verified. Although the remianing five valleys had perennial channels below clearly defined spring-like sources of flow, in several of these cases the sources of the perennial flow were within several hundred feet of the junction with a larger stream.

During the preparation of the special drainage maps, the stereo-compilers were unable to determine the presence or absence of water in most of the smaller headwater streams. These streams, therefore, were designated as indefinite drainage because of the inability to determine perennial or ephemeral conditions. The determination of a recognition feature for the beginning of perennial flow, therefore, permitted reevaluation of the indefinite drainage through a photo-interpretive key and provided a test of the ability fo classify drainage from the anaglyphic model using shape of the valley profile.

This test was applied to two small sub-areas. The first area was selected in the Stone Mountain, NE quadrangle. It covered about 4½ square miles in three anaglyphic models. The area lay immediately northwest of

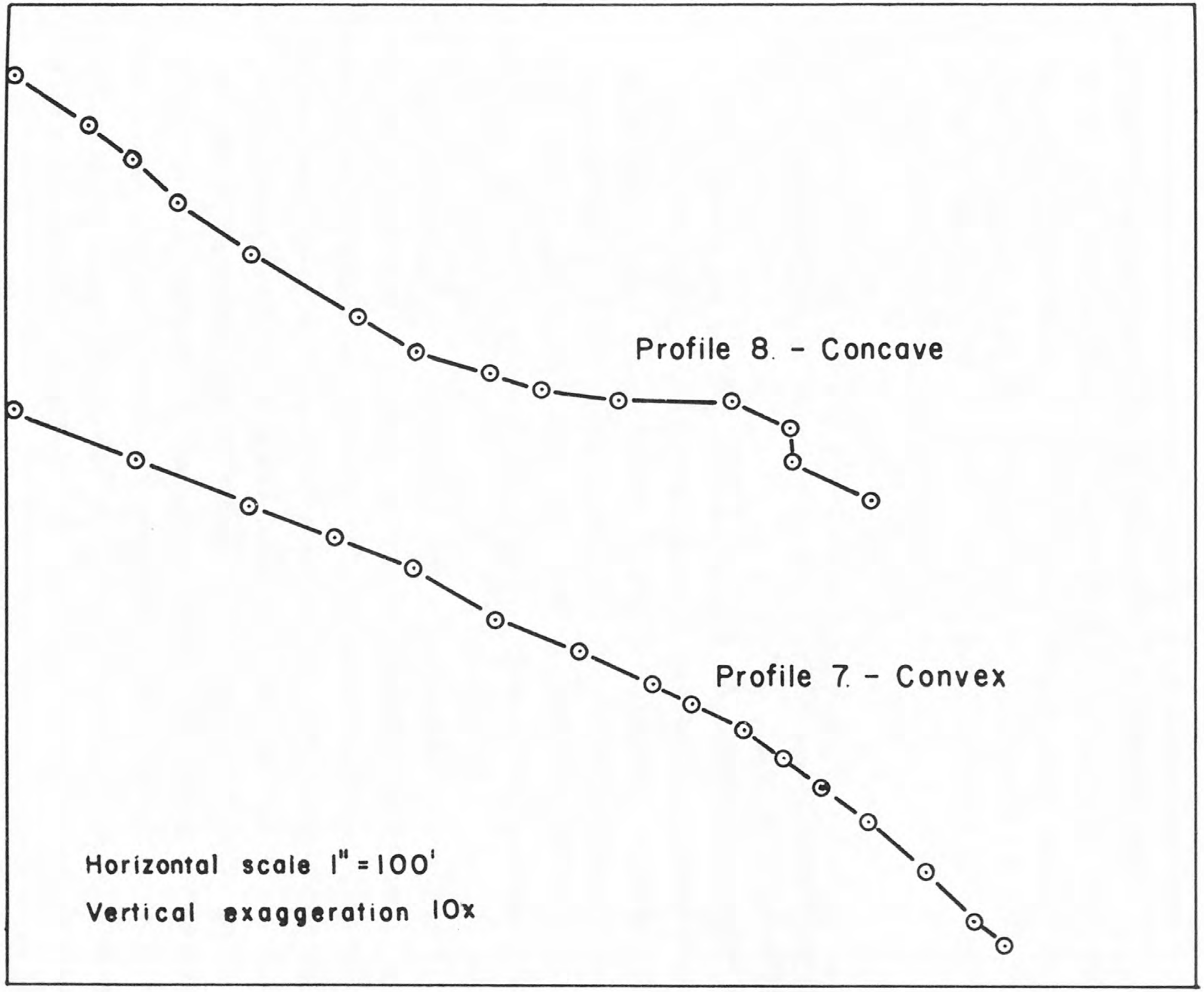


Figure 8 – Types of stream profiles in Yellow River Basin.

Lawrenceville. The second area was selected in the Norcross quadrangle about $2\frac{1}{2}$ miles east of Norcross. This area covered about 3 square miles in two anaglyphic models.

The stream classification presented no problem. Sixty-six beginnings of perennial channels were identified in the Lawrenceville area and 38 in the Norcross area. Random field checking of several valleys in each basin indicate slightly better accuracy than from the simple stereoscopic viewing. The increase in accuracy to almost 90 percent is probably due to better alignment of the photographs in the stereo-plotter and the magnification of the model.

The classification of the drainage network for the two sub-areas near Lawrenceville and Norcross, and for a portion of the Garner Creek area is shown in figure 9.

The special vegetation maps of the Yellow River basin were field checked along roads, as in the Tired Creek basin. The results of the field check are presented in table 2. Plate 3 illustrates some of the errors in classification. In addition, sample plots in 10 first order valleys provided quantitative data concerning forest composition. These data illustrated the range of variation included in the forest classifications.

A much greater percentage of the land surface in the Yellow River basin is mantled with vegetation than in the Tired Creek basin. This fact greatly increased the labor of delineating and classifying differences in the plant cover. The delineation of vegetation units was less precise in the maps of the Yellow River basin, which is reflected in a greater use of the mixed or undifferentiated unit to cover large blocks of heterogeneous vegetation. Thus, almost half (47 percent) of the points classified as forest or shrub that were field checked along roads were classified as mixed or undifferentiated. Nevertheless, in distinguishing between shrub and forest vegetation the compilers reached an accuracy level of 95 percent.

Of the 15 errors of classified noted, 3 involved faulty estimation of the height of the vegetation. Two of these involved fallow fields covered with dense stands of ragweed, which were mapped as evergreen shrub.

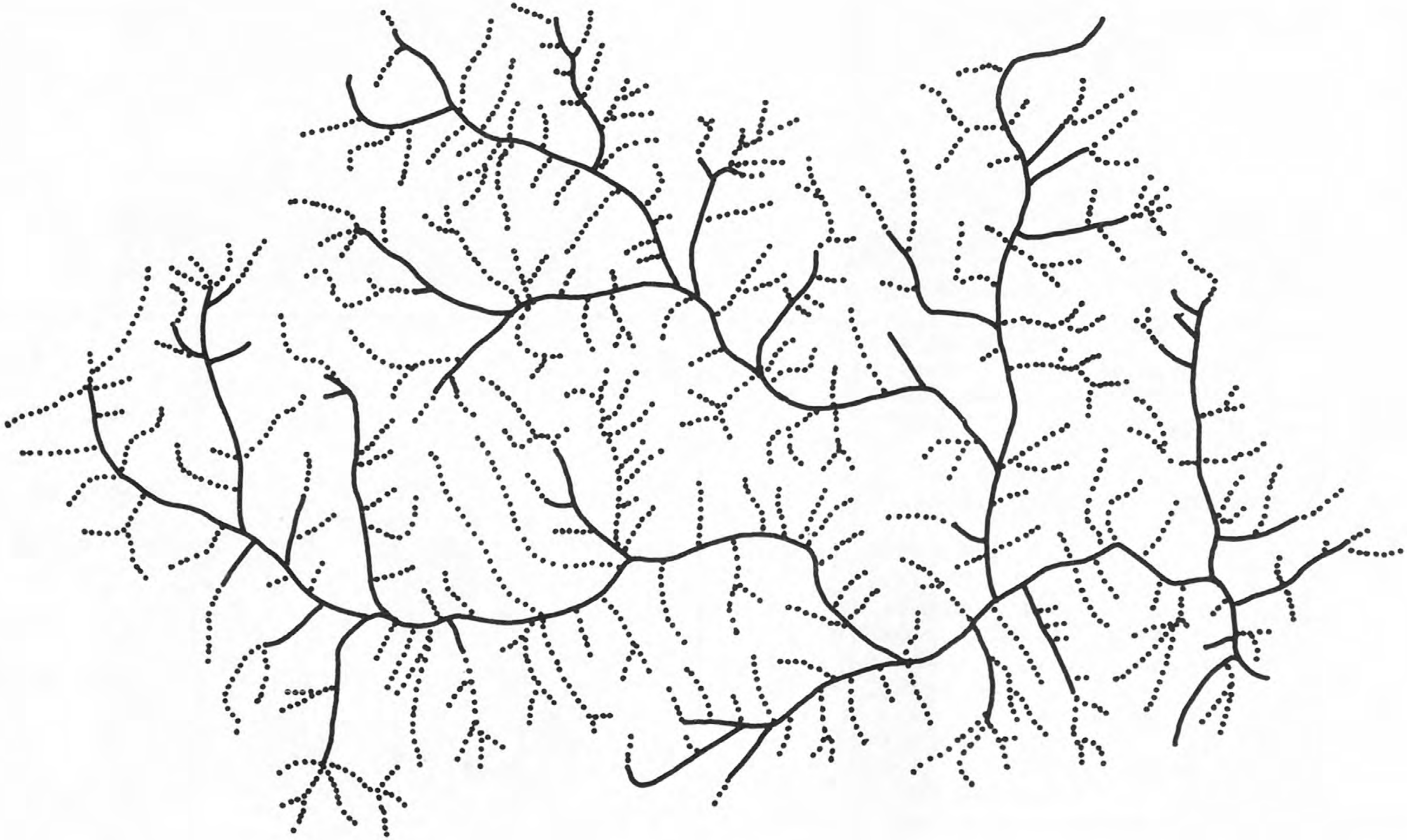


Figure 9.- Drainage network for the Garner Creek basin, showing classification of streams. Channels of perennial streams are shown by solid lines, ephemeral drainage courses by dotted lines.

Table 2.--Results of field check of special vegetation maps for Yellow River basin.

Unit mapped	Number of observations	Number correct	Percentage accuracy	Number of errors	Remarks	Plates
Open.............	12	12	100	0	-	-
Mixed shrub......	9	7	63	2	1 deciduous forest mapped as mixed shrub. 1 evergreen forest mapped as mixed shrub.	1-A, 1-B
Evergreen shrub..	8	5	70	3	2 open areas mapped as evergreen shrub. 1 evergreen forest mapped as evergreen shrub.	-
Mixed forest.....	25	25	100	0	-	-
Deciduous forest.	1	0	0	1	1 evergreen forest mapped as deciduous forest.	1-E
Evergreen forest.	30	21	70	9	7 mixed forest mapped as evergreen forest. 2 deciduous forest mapped as evergreen forest.	1-C, 1-D, 1-G, 1-H

A- Deciduous forest 40-60 feet tall forming field border that ranges in width from about 50 to 150 yards. The large trees are post oaks, scarlet oaks, and mockernut hickories. Behind the strip of forest is an open to somewhat shrubby field. Whole area mapped as mixed shrubs (2A).

B- Area immediately east of forest shown in A. Tall trees at left are the ragged margin of the forest shown in A. The narrow strip of open field is mapped "open" (1). The scattered trees behind the open field are loblolly and short-leaf pines, sweet gums, and various oaks. Except for the open field, everything visible across the road is mapped as mixed shrubs (2A). A and B show the variation in plant cover encompassed in a single area classified as mixed shrubs (2A).

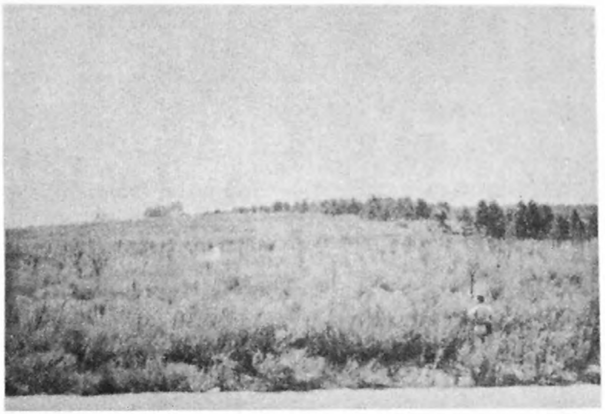
C- Coniferous forest. Overstory consists of loblolly and short-leaf pines, ranging in height from about 35 to about 60 feet tall. Understory trees are deciduous, consisting of southern red and willow oaks, flowering dogwood, pignut, black gum, tulip-poplar, persimmon, cherry, and princess-tree. Mapped as mixed trees (3A).

D- Old field loblolly pine trees, mostly less than 15 feet tall. Deciduous trees in foreground are sweet gums. Taller trees in mid-distance at right side of photo are tulip-poplars, growing down axis of small tributary stream. Area mapped as mixed shrubs (2A).

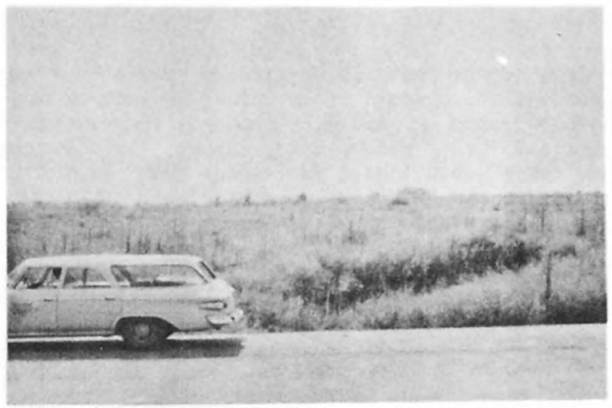
Plate 3.- Plant cover in Yellow River basin

E- Old field pine stand, kudzu-vine in foreground area mapped as mixed shrubs (2A).

F- Coniferous forest mapped as mixed trees (3A).



G- Field of pure ragweed mapped as evergreen shrubs (2C).



H- Field of ragweed, less dense than in area shown in G, mapped open (1).

Plate 3.- Plant cover in Yellow River basin

When the compilers applied the criteria for distinguishing between evergreen and deciduous vegetation, the results were much more successful than in the Tired Creek basin. Of 39 points examined, 27 were correctly classified, an accuracy of 70 percent. Three reasons appear to be responsible for this greater accuracy. Leaves of deciduous trees fall earlier and braod-leaved evergreen trees are less common in the Yellow River basin than in the Tired Creek basin. Short leaf pine, which has a dense crown, is abundant in the area, and long-leaf pine is almost completely absent. Intensive forest management is not practiced in most of the Yellow River area, and many of the pine stands have a dense understory of other kinds of plants.

Of the 21 plots in the 10 first order valleys, 3 were located in areas mapped as deciduous forest, 7 in areas mapped as evergreen forest, and 11 in areas mapped as mixed forest and one plot in an area mapped as evergreen forest completely lacked evergreen trees, but none of the plots in areas mapped as deciduous forest lacked evergreen trees (table 3). However, the percentage of evergreen trees in areas mapped as deciduous forest never exceeded 30 percent. No plot in areas mapped as evergreen forest contained as much as 50 percent of evergreen trees, but 2 plots in stands mapped as mixed forest contained more than 50 percent of evergreen trees. The plot data are summarized in tables 3 and 4. Note that the range of variation in composition of plots in areas mapped as mixed forest encompasses the entire range of variation of the other forest types.

These plots are too small to demonstrate the relative percentage of evergreen and deciduous trees in the different forest map units. Furthermore, crown diameter, not stem diameter, is the feature of the forest that is visible on aerial photographs, and the two are not perfectly correlated. Nevertheless, the plot data demonstrate two characteristics of the map units. First, the low percentages of evergreen trees in areas mapped as evergreen forest probably reflects the fact that pine trees are strikingly apparent on the aerial photographs, as well as on the ground. In mixed stands they rise above the level of the deciduous trees, and a few trees per acre present the appearance of relative abundance. Stated in another way, forests containing high percentages of deciduous trees may appear to be predominantly coniferous. Second, the extreme variability in the

Table 3.- Composition of forests in first order valleys in the Yellow River basin, expressed as precentages of basal area in 0.1 acre plots.

Species \ Plot No ‡	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
red maple			4	1	22		6	2	1	1		3						7	3		12
speckled alder												1									
American hornbeam										1											
pignut hickory	1		1		3	26					13		1		2				7	1	1
sand hickory											8		3		1						
mockernut hickory		5	6	4		2	1				18		1		4	4			16		
hickory spp.																	58				
flowering dogwood	2	2	6	2		3	1		5	4	1					4	1	1	1	1	4
common persimmon					2																
American beech																				6	
white ash						2	16			3											
eastern redcedar*									3												
sweetgum				13	14		50	8	6	37		40		1		6		7			
yellow-poplar	2	20	40	47	16	8	7	61		46		6						55	5	8	75
red mulberry			1																		
blackgum		2	1	2	13				2		5	12	7		4	8	10	2		6	
sourwood						2	2	1	6			2	2					3		4	2
shortleaf pine*	17		16			2		25	5		10		55	14	22	5	7	1			
loblolly pine*	4	27	13	17	14	11	12	3	40		1		1	44		2		22			
cherry			2	2		2	1		4	5	1				1	1					
white oak			1	12	16	18	4		7	1	1	23	5		32	12			18	65	
scarlet oak	11					2			15					30	8				40		5
southern red oak	38	41							4							43	1	2	9	4	
blackjack oak													2	11	2						
chestnut oak															1						
northern red or Shumard oak			1			22										2				5	
post oak	5	3	8								41		20		8		17				
black oak	20								2		1		3		12	11	5				1
black willow												12									
basswood										2											
other species												1			3	2	1		1		
Totals																					
evergreen	21	27	29	17	14	13	12	28	48	0	11	0	56	58	22	7	7	23	0	0	0
deciduous	79	73	71	83	86	87	88	72	52	100	89	100	44	42	78	93	93	77	100	100	100

* indicates evergreen species

‡ plots 1-3 shown on vegetation maps as deciduous forest, plots 4-10 as evergreen forest, and 11-21 as mixed forest.

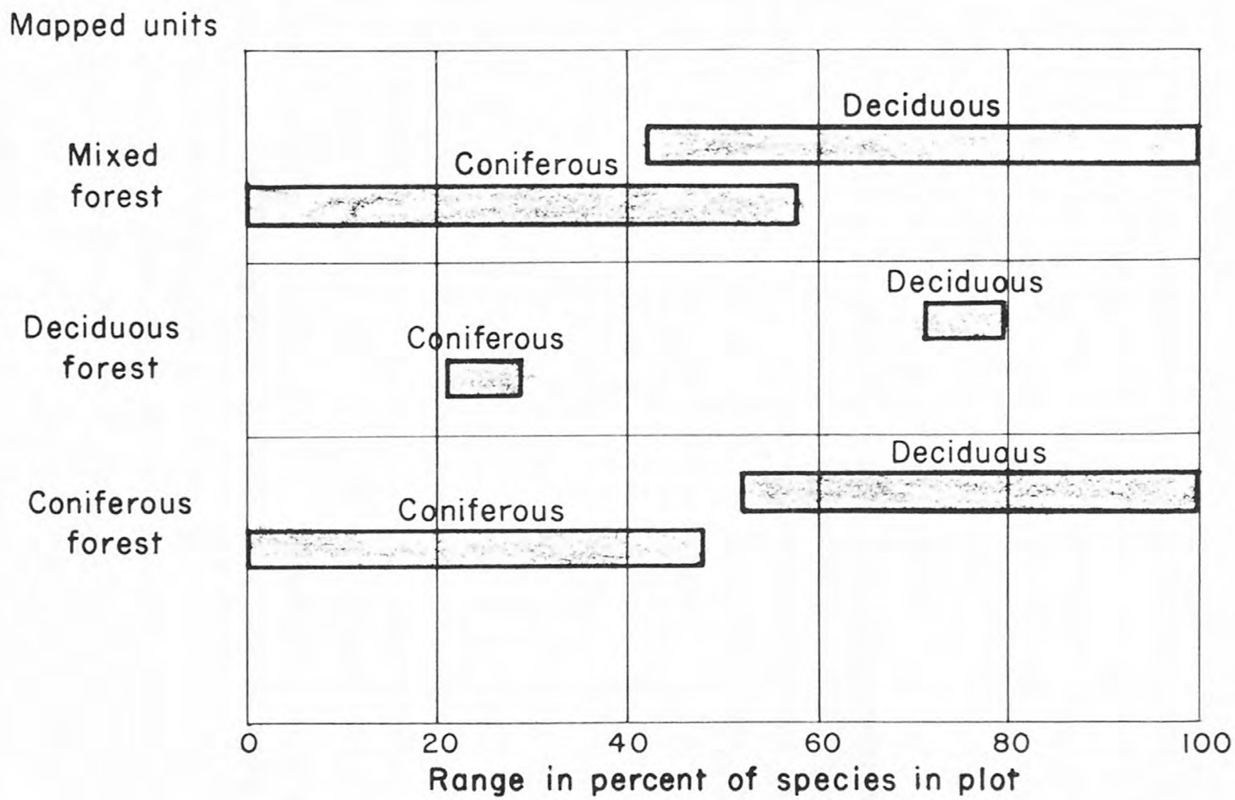


Table 4.— Range in the percentage of basal area of evergreen & deciduous species in the Yellow River basin.

mixed forest unit probably reflects a tendency to lump large areas of vegetation of similar height but variable composition into a noncommital unit in the densely forested Yellow River basin.

The sample plots in the first order valleys permitted the calculation of percentages of evergreen and deciduous trees, which could then be compared to the type as shown on the special vegetation maps. The diameters of individual stems of trees in 0.1 acre plots were measured and recorded by species. From these data, total cross-sectional area of the stems could be calculated. This quantity, expressed in square feet, is called basal area. Calculation of the percentage of the total basal area in a plot contributed by a species is a useful measure of the importance of that species in the stand sampled. A species that constitutes a large percentage of the total basal area is present either in large numbers or the individual trees are of large diameter, or both. Mean diameters can be calculated from the data to differentiate between these features. In this report, however, the basal area data are presented in percentages of total basal area only. Pine trees, which make up most of the evergreen trees in the Yellow River basin, tend to form an upper canopy in mixed stands of needle-leaved and broad-leaved forests. This means that they generally are of large diameter. Therefore, a high percentage of basal area contributed by pine trees usually indicates an abundance of large trees, which are readily seen on aerial photographs. Lower percentages of pine trees in mixed stands usually indicates a small number of large trees, two or three per acre, rather than a large number of small trees.

RESULTS AND CONCLUSIONS

Complete and accurate delineation of drainage from aerial photographs is feasible in the Yellow River and Tired Creek basins of Georgia. The springlike origins of base flow, beginning at abrupt channel head, provide clear demarcation features between ephemeral and perennial channel of a stream.

Studies in the Yellow River basin indicate that the density of drainage-ephemeral, perennial, or both-may vary considerably within relatively short distances. These differences in density can be attributed to various factors. Differences of perennial channels may be due to varying soils and lithologies. As shown by the differences in shapes of valley profiles in the Yellow River basin, the relation between the ephemeral and perennial network is influenced by topographic factors that may reflect the erosional history of the area. Thus land-use history even becomes a factor, for the flattening of the valley profile associated with the origins of perennial flow are largely alluvial deposits probably related to the erosion of the upland headwater areas.

The differences in density of drainage in the Yellow River basin are hydrologically significant. The variations in the density of the perennial channel are inversely related to the variations in low-flow yields for the three sub-basins, as shown in figure 10. This relation is based on the drainage densities for the three sub-areas of $2\frac{1}{2}$ square miles each and the minimum flow determined at a site in each area during the severe drought of 1954. The minimum flow, however does not necessarily represent the drainage of only the sub area; in fact, the minimum flow of 0.0032 cfs per square mile represents the measured flow from a drainage area of 1.5 square miles which lies about one mile northeast of the Upper Yellow Creek sub-area for which drainage density was determined. For this reason, figure 10 should be considered only as an indication of the potential value of accurate drainage classification rather than an absolute relationship for the Yellow River basin.

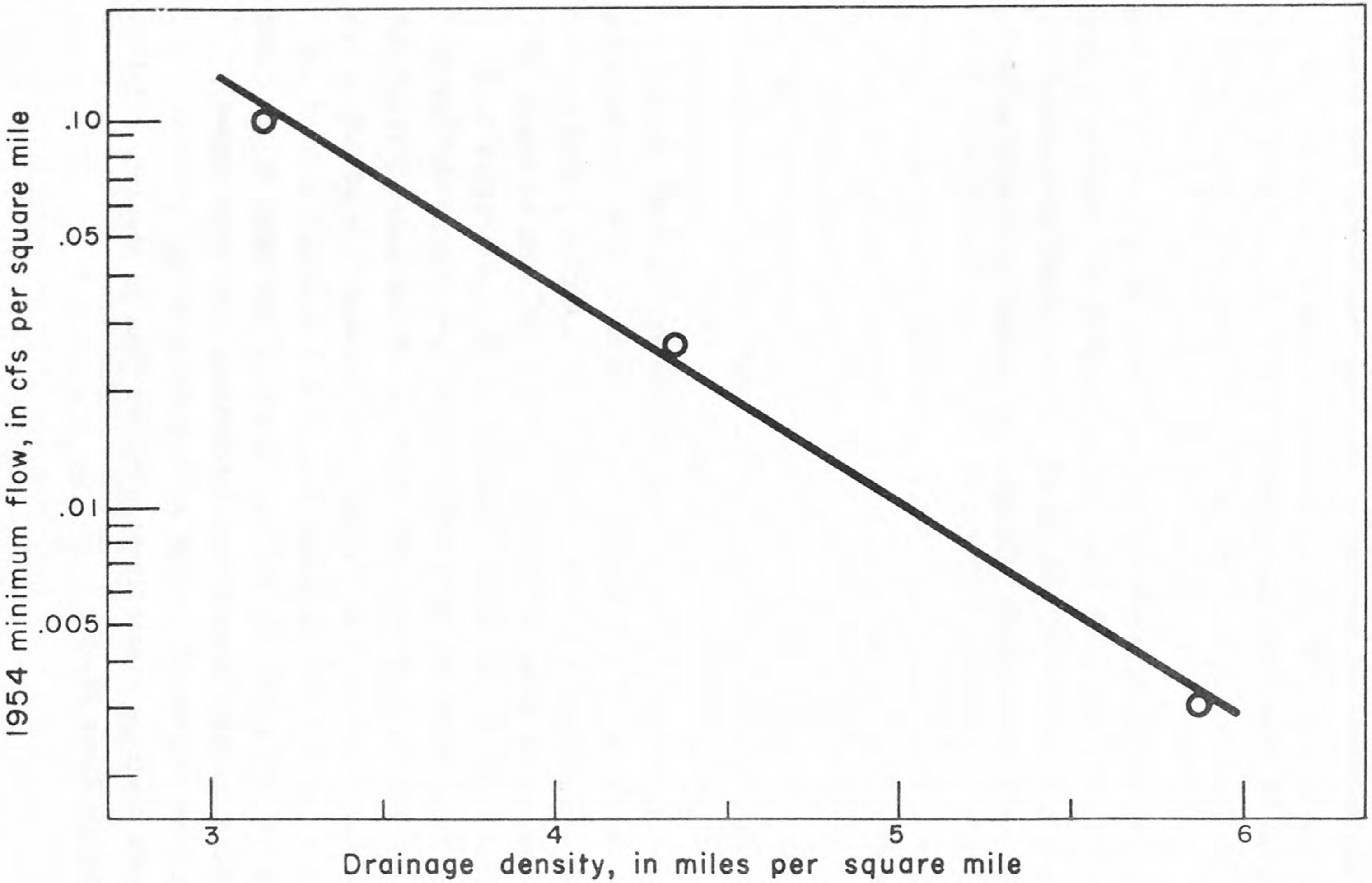


Figure 10.- Relation between density of perennial stream channels and 1954 minimum flows for 3 sub-areas in the Yellow River basin.

This speculative analyses for the Yellow River basin probably also hold for the Tired Creek basin. Although no quantitative comparisons were made, qualitative observations of low-flow yields and densities of stream channels indicate the same inverse type of relation as in the Yellow River sub-basin. Because vegetation provided a good interpretive key to the origin of perennial flows, no stream profiles were measured. However, field experiences indicated that similar to the Yellow River basin, perennial channels generally began in flat, alluvial deposits with little or no channel incision in the valley above the point of origin of perennial flow. To this extent, the valleys of Yellow River and Tired Creek are similar, and it is very probable that the relation between valley profiles and perennial channels heads also holds for the Tired Creek basin.

Several speculative factors are worth considering at this point. The first factor is a consideration of the perennial nature of the flow originating at the abrupt channel heads. Although all sites investigated during periods of low flow in two years were perennial, the possibility does exist that some of these cirques will cease to yield flow during extended or severe drought conditions. To this extent, the definition of perennial as applied to these origins of flow bears a concept of reasonable expectancy. That is, one can expect to find flowing water at the sites except for brief periods of prolonged or severe drought which occur at infrequent intervals. A frequency concept is extremely desirable; however, lack of hydrologic data precludes a once-in-ten year or once-in-twenty year type of frequency concept. The hydrologic data necessary for this type of concept can only be obtained from continued observations over many years.

Downstream losses in streamflow are a second factor to consider. Evaportranspiration demands-the consumptive use of water by vegetation and evaporation-are usually highest during periods of low stream flow. In some cases, these demands exceed the available water within a given stream reach, creating sufficient draft locally to cause intermittent reaches of flowing and non-flowing stream below the spring-like origin of perennial flow. Although the non-flowing reaches might be considered ephemeral, the classification of streams on topographic maps should consider the overall reach as perennial if a perennial source of flow as previously defined exists.

Although lying in different physiographic regions, the two study areas show marked similarity in the topographic characteristics which affect the origin of perennial flows. Because the similarity exists between such dissimilar regions, it is reasonable to assume that the similarity also exists between basins in each physiographic region. Thus under this assumption, accurate and complete drainage portrayal is possible for most of the Southeastern United States. Furthermore, the apparent success of the Georgia studies provides an optimistic atmosphere for the extension of precise drainage classification-either by the same or by entirely different recognition features-to other parts of the country.

Because the vegetation of the Tired Creek basin differs strikingly in appearance and in distribution from that of the Yellow River basin, attempts to map the vegetation from aerial photographs provided a rigorous test for the critera chosen to distinguish between vegetation types in the Georgia project. Field checks of the special vegetation maps revealed different sources of error in the two basins, a reflection of the differences in the vegetation.

About 70 different kinds of trees were noted in the two basins. Although many of these species are common to both basins, the proportions of species and the appearance of the forests are different. For example, most of the upland broad-leaved forests of both basins could be characterized as oak forests, but the oak forests of the Yellow River basin consist almost entirely of lobed-leaved oaks (white, scarlet, black, southern red, northern red, Shumard, and post oak), whereas the oak forests of the Tired Creek basin consist predominantly of entire-margined or unlobed-leaved oaks (water, live, laurel, and willow oak). In addition, a high percentage of broad-leaved evergreen or semi-deciduous trees are found in the forests of the Tired Creek basin, but are almost completely absent from the forests of the Yellow River basin. The coniferous forests of the two basins differ not only in species composition, which results in marked differences in crown form, texture of the canopy, and spacing of the individual trees, but also in the density and nature of the understory layers. To a considerable extent, the differences in the nature of the understory layers is a reflection of the relative amounts of intensive forest management practiced in the two basins.

Almost all of the valley floors in both basins are forested. Forests mantle most of the uplands in the Yellow River basin, but are almost completely lacking the the Tired Creek basin. Vegetation of the uplands in the Tired Creek basin consists mostly of intensively managed stands of long-leaf and loblolly pine and pecan orchards. Thus the mapping of vegetation in the Yellow River basin required much more labor than that of the Tired Creek basin.

Portrayal of the vegetation on the special vegetation maps required recognition of open areas, shrubs, and forest. Thus, the fundamental subdivision required the ability to recognize consistently differences in the height of the plant cover. This differentiation was performed with high degrees of accuracy in both basins.

The classification of differences within shrub and forest vegetation first of all required an ability to recognize and delineate distinctive patterns within these two categories. This delineation of differences was performed in detail and at high levels of accuracy in the Tired Creek basin, and permitted the rapid location on the ground of the fluvial cirques. However, in the Yellow River basin much of the vegetation was lumped into large areas of mixed or undifferentiated vegetation. In other words, a relatively small percentage of the variation in the vegetation was recognizable from the aerial photographs and delineated on the special vegetation maps. Consequently, field studies showed no relation between vegetation types and the points of perennial flow in the streams.

The specific classification of distinctive patterns of vegetation according to predominance of evergreen or deciduous plants was perhaps the most difficult part in the preparation of the special vegetation maps, and it was performed poorly in both basins. In the Tired Creek basin, the classification was erroneous for botanical reasons, and a reversal of the criteria for classification would result in a high degree of accuracy. In the Yellow River basin, the level of accuracy of classification was higher, but the results are of much less value. Large areas were classified as mixed or undifferentiated. Field checks indicated that mixed was often a misnomer, and suggested that the alternative, undifferentiated, actually meant unclassified. Thus, the level of accuracy of the classification in the Yellow River basin is high only if credit is given for no classification, which seemed to be the meaning of the mixed unit in most areas.

RECOMMENDATIONS

Water is becoming increasingly important as a natural resource. As demands for its use increase, planning for optimum utilization becomes a necessity. For hydrologic studies related to this utilization, as well as for other purposes, complete and accurate drainage portrayal is needed. We therefore recommend that as soon as administratively feasible, standard topographic maps produced by the Topographic Division show accurate classification of drainage. Several alternate plans as follows have been outlined to accomplish this goal.

Three plans are presented for the portrayal of drainage on topographic maps, in the order of increasing amounts of drainage to be delineated. Plan 1 requires that only perennial channels be shown by the standard solid blue line and that all ephemeral channels be deleted from the published map. Plan 2 permits the editing of a completely-compiled and accurately classified drainage network to delete ephemeral streams above their first branching. That is, all ephemeral streams are deleted from their beginning to the first point of juncture downstream, and the published map shows therefore all perennial streams plus those ephemeral streams below the first headwater branching. Plan 3 allows no editing. It requires that all drainage be compiled, classified as ephemeral or perennial, and included in the final edition of the map. The three plans are illustrated for parts of the Yellow River basin, and for an area in the Tired Creek basin in figures 11 to 14.

All three plans have several common factors. All require the accurate classification of streams as ephemeral or perennial. This classification is possible for the two study areas, and most likely also for the larger parts of the Piedmont and Southern Coastal Plain areas. The outlook is good for extending this ability for accurate classification beyond these areas. The three plans also require a complete compilation of all drainage although this is perhaps not mandatory for Plan 1. However, many stereo-compilers delineate drainage extensively as a guide to contouring land surface, and therefore do compile rather complete drainage portrayal early in the compilation procedure. Because of these similar factors, no particular plan has a decided advantage in the standard map-making procedures.

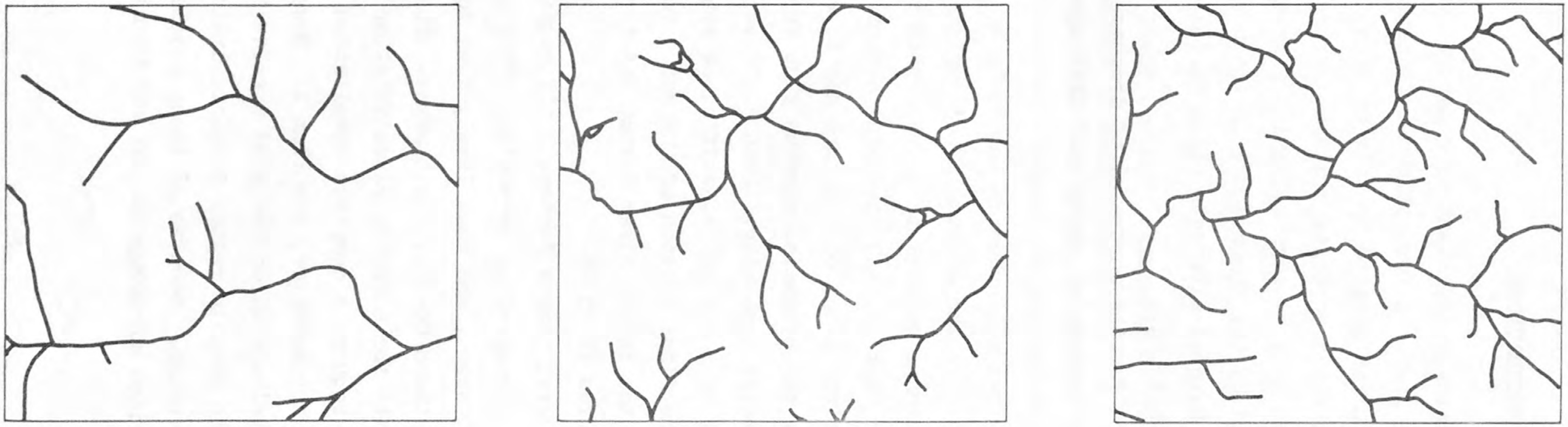
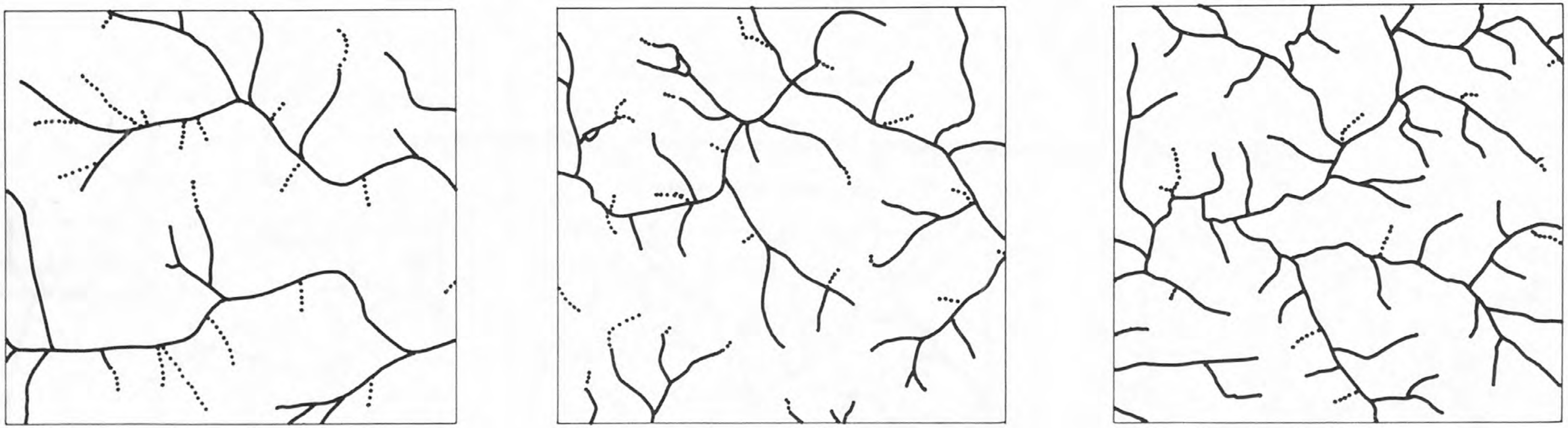


Figure 11 – Plan I for portrayal of drainage: only perennial channels are shown in 3 sub-areas of Yellow River basin.

Scale in miles

0 1/2 1

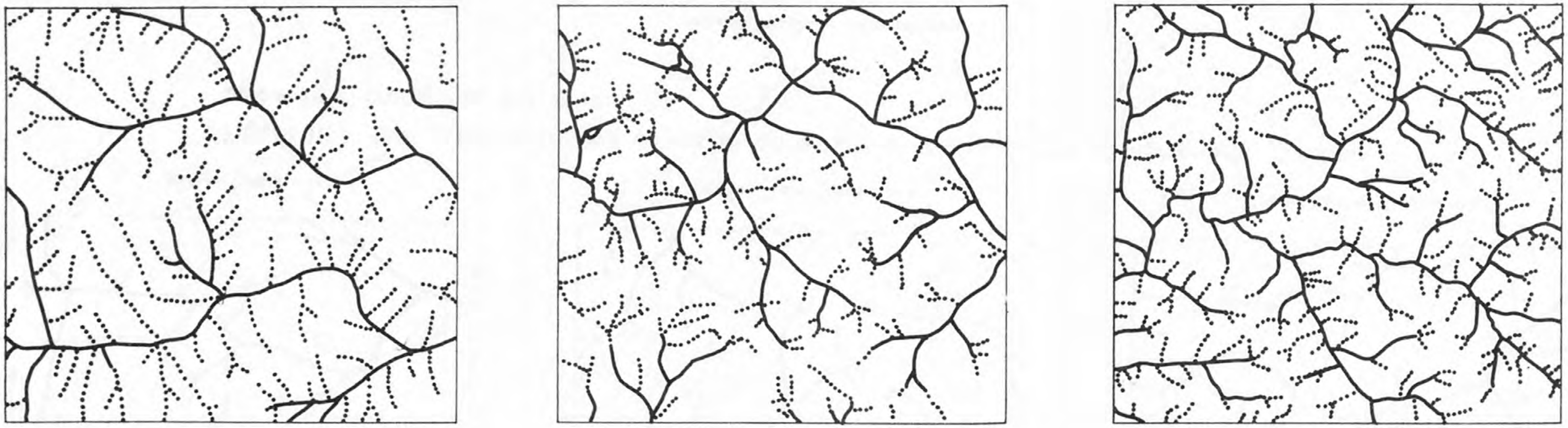


Garner Creek area　　Beaver Ruin Creek area　　Upper Yellow River area

Figure 12.- Plan 2 for portraying drainage: all perennial channels, and all ephemeral channels below first branching, are shown.

Scale in miles

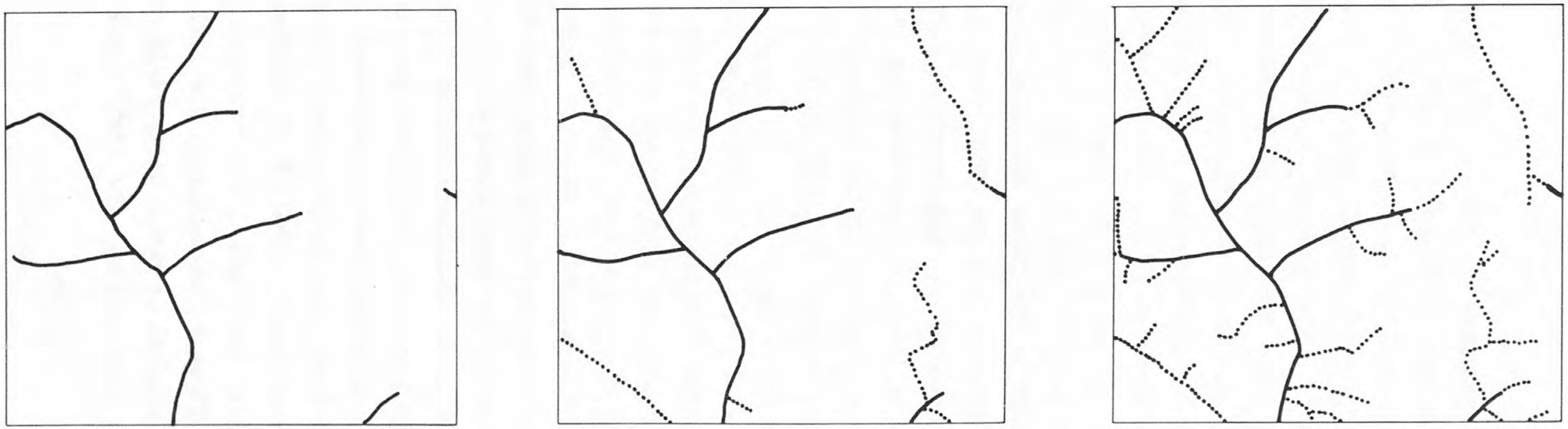
0　1/2　1



Garner Creek area   Beaver Ruin Creek area   Upper Yellow River area

Figure 13.- Plan 3 for portraying drainage: all drainage courses, designated either perennial or ephemeral, are shown.

Scale in miles
0   1/2   1

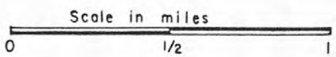


Plan 1: Perennial drainage only

Plan 2: All perennial drainage, plus ephemeral drainage below first branching

Plan 3: All drainage, perennial and ephemeral

Figure 14.- Drainage for a sub-area in Tired Creek basin,— illustrating portrayal for the 3 suggested plans.



We do however recommend adoption of Plan 2. This plan has both hydrologic and aesthetic advantages over the other plans. First, from the hydrologic aspect, the delineation of all drainage below first upstream branching permits accurate determinations of all second-order and higher-order streams. Established geomorphic relationships will permit the extension of these data for determination of various morphometric characteristics of the first-order streams not delineated. Thus, by extension, substantially complete and accurate measurements of stream parameters can be made for hydrologic studies. Aesthetically, Plan 2 represents a reasonable balance of drainage portrayal consistent with meaningful criteria for the portrayal. In heavily-dissected terrain, portrayal of all drainage on the final map could present an overpowering effect which might detract from the other equally-important map features. In other areas, portrayal of only perennial streams might be insufficient to show clearly by the blue lines even the basic pattern of the stream network. Plan 2 appears to offer a reasonable amount of drainage portrayal which will be consistent with the portrayal of other topographic and cultural map features.

The adoption of Plan 2 will require a modification of the proposed revision to Chapter 3A6, Mapping of Hydrographic Features. The proposed revision of Chapter 3A6 requires that headwater branches of streams need be shown only if over 2,000 feet long. We propose that the arbitrary length limitation be abandoned in favor of geomorphic criteria for showing all streams below first branching, regardless of length.

The adoption of Plan 2 as recommended, along with careful and accurate classification based on photo-interpretation should produce maps with unexcelled drainage portrayal. Such maps are vitally necessary to the proper management of our nation's water resources.

The following recommendations for the portrayal of vegetation on topographic maps are also presented in terms of alternatives, arranged in order in increasing detail. Presumably, they are also arranged in order of increasing costs. These recommendations are divided into two categories, on the basis of whether or not a hasty field check of the mapped area is made prior to compilation. The field check visualized is not an extensive one. A preliminary review of aerial photographs should show the principal features of the vegetation and the principal patterns of variation. A brief field reconnaissance should then permit the compilers to classify these patterns of variation. For example, a preliminary classification of a small area of vegetation in the Tired Creek basin followed by no more than half a day of field study in the basin, either by a botanist or a non-botanist, would have revealed that the criteria for differentiation of evergreen and deciduous vegetation were not applicable to that area. Such a field check would permit a greater amount of botanical detail to be presented, with much greater accuracy, and with only a moderate increase in cost.

These recommendations are possible only through the study of the special vegetation maps of the Yellow River and Tired Creek basins. The first three alternatives require no field check prior to compilation; the others do require a field check.

Plan 1: Treatment in use at the present time.

Plan 2: Separate classification of forest and shrub for all areas having over 10 percent crown density of woody shrubs and trees. Shrubs are defined as woody plants ranging from 6 to 25 feet high, trees as woody plants over 25 feet high. A mixture of trees and shrubs is classed as forest if more than 10 percent of the area consists of trees over 25 feet high.

Plan 3: Classification of forest and shrub, with further subdivision into units by means of solid lines to delineate distinctive patterns of vegetation recognizable on the aerial photographs. The units may be classed by a simple number code applicable only to maps compiled from a single set of photographs.

Plan 4: Same as plan 3, but with further designation of relatively pure stands of coniferous and deciduous trees. A forest having eighty percent or more crown density of either type would be considered a pure stand.

Plan 5: Classification as used in the special Yellow River and Tired Creek vegetation maps, with a field check to determine map units.

Plan 6: Same as plan 5, but with distinction between mixed stands of coniferous and deciduous trees and unclassified stands which cannot be recognized on the aerial photographs. Unclassified vegetation, however, is not intended as a catch-all unit to aggregate heterogeneous plant cover.

Plan 7: Same as plan 6, with classification as coniferous, deciduous, mixed or unclassified extended to shrubs.

Of the seven plans presented, we believe that plans 2, 3, and 4 represent desirable and increasingly useful systems for mapping vegetation. Plan 1 represents only a rough guide to the distribution of forests, and is therefore of limited use in botanical and other related studies. Plans 5, 6, and 7 represent maximum efforts which will require extensive and costly field-checking. Plans 2, 3, and 4 however, provide considerable botanical information. Designation of distinctive patterns of vegetation, as in plan 3, may reflect differences in the physical environment or differences in past use of the land. These differences, if mapped, can be valuable to workers in many scientific disciplines. Further classification of relatively pure forests of either coniferous or deciduous trees further reflects differences in geology or in man's treatment and use of the land. For example, in the eastern United States, many pure stands of conifers grow in areas of glaciofluvial deposits, in areas formerly cultivated, or in areas subjected to severe fires.

We therefore recommend that either plan 2, 3, or 4 be adopted for portrayal of vegetation on topographic maps. We further suggest that plan 3 offers the most promise of maximum value at moderate additional effort.

The treatments of drainage and vegetation are separate processes in the preparation of topographic maps. However, the features portrayed represent the interrelated disciplines of botany and hydrology. These disciplines in turn are also interrelated with other fields of the natural and earth sciences. The advancement of these sciences depends upon adequate data for the support of hypotheses. To this end, improvements in the portrayal of drainage and vegetation on topographic maps are both desirable and justifiable.

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Table 5. Scientific and common names of trees listed in report. Nomenclature follows that of Little, 1953

Acer rubrum L.	red maple
Alnus rugosa(DuRoi Spreng.	speckled alder
Ostrya virginiana(Mill.) K. Koch	American hornbeam
Carya glabra(Mill.) Sweet	pignut hickory
Carya pallida(Ashe) Engl. and Graebn.	sand hickory
Carva tomentosa Nutt.	mockernut hickory
Cornus florida L.	flowering dogwood
Diospyros virginiana L.	common persimmon
Fagus grandifolia Ehrh.	American beech
Fraxinus americana L.	white ash
Juniperus virginiana L.	eastern redcedar
Liquidambar styraciflua L.	sweetgum
Liriodendron tulipifera L.	yellow-poplar
Magnolia grandiflora L.	southern magnolia
Magnolia virginiana L.	sweetbay
Morus rubra L.	red mulberry
Nyssa sylvatica Marsh.	blackgum
Oxydendrum arboreum(L.) DC.	sourwood
Pinus echinata Mill.	shortleaf pine
Pinus palustris Mill.	longleaf pine
Pinus taeda L.	loblolly pine
Prunus spp.	cherry
Quercus alba L.	white oak
Quercus coccinea Muenchh.	scarlet oak
Quercus falcata Michx.	southern red oak
Quercus laurifolia Michx.	laurel oak
Quercus marilandica Muenchh.	blackjack oak
Quercus nigra L.	water oak
Quercus phellos L.	willow oak
Quercus prinus L.	chestnut oak
Quercus rubra L.	northern red oak
Quercus shumardii Buckl.	Shumard oak
Quercus stellata Wangenh.	post oak
Quercus velutina Lam.	black oak
Quercus virginiana Mill.	live oak
Salix nigra Marsh.	black willow
Taxodium ssp.	cypress
Tilia spp.	basswood

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