FLORIDA GEOLOGICAL SURVEY

SIXTH ANNUAL REPORT

FLORIDA STATE GEOLOGICAL SURVEY

E. H. SELLARDS, Ph. D., State Geologist

SIXTH ANNUAL REPORT

PUBLISHED FOR
THE STATE GEOLOGICAL SURVEY
TALLAHASSEE, 1914

THE E. O. PAINTER PRINTING CO., DE LAND, FLA.

LETTER OF TRANSMITTAL.

To His Excellency, Hon. Park Trammell, Governor of Florida.

SIR:—In accordance with the Survey law I submit herewith my Sixth Annual Report as State Geologist of Florida. This report contains the statement of expenditures by the Survey for the year ending June 30, 1913, together with those investigations by the Survey that have progressed far enough to be available for publication.

Permit me to express in this connection my appreciation of the interest you have shown in the work of the State Geological Survey.

Very respectfully,

E. H. SELLARDS,
STATE GEOLOGIST.

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ADMINISTRATIVE REPORT.

E. H. SELLARDS, STATE GEOLOGIST.

PUBLICATIONS ISSUED BY THE STATE GEOLOGICAL SURVEY.

The following is a list of the publications issued by the State Geological Survey since its organization:

First Annual Report, 1908, 114 pp., 6 pls.

This report contains: (1) a sketch of the geology of Florida; (2) a chapter on mineral industries, including phosphate, kaolin or ball clay, brick-making clays, fullers earth, peat, lime and cement and road-making materials; (3) a bibliography of publications on Florida geology, with a review of the more important papers published previous to the organization of the present Geological Survey.

Second Annual Report, 1909, 299 pp., 19 pls., 5 text figures, and one map.

This report contains: (1) a preliminary report on the geology of Florida, with special reference to stratigraphy, including a topographic and geologic map of Florida, prepared in co-operation with the United States Geological Survey; (2) mineral industries; (3) the fullers earth deposits of Gadsden County, with notes on similar deposits found elsewhere in the State.

Third Annual Report, 1910, 397 pp., 28 pls., 30 text figures.

This report contains: (1) a preliminary paper on the Florida phosphate deposits; (2) some Florida lakes and lake basins; (3) the artesian water supply of eastern Florida; (4) a preliminary report on the Florida peat deposits.

Fourth Annual Report, 1912, 175 pp., 16 pls., 15 text figures, one map.

This report contains: (1) the soils and other surface residual materials of Florida, their origin, character and the formations from which derived; (2) the water supply of west-central and west Florida; (3) the production of phosphate rock in Florida during 1910 and 1911.

Fifth Annual Report, 1913, 306 pp., 14 pls., 17 text figures, two maps.

This report contains: (1) Origin of the hard rock phosphates of Florida; (2) list of elevations in Florida; (3) artesian water supply of eastern and southern Florida; (4) production of phosphate in Florida during 1912; (5) statistics on public roads in Florida.

Sixth Annual Report, 1914.

Bulletin No. 1. The Underground Water Supply of Central Florida, 1908, 103 pp., 6 pls., 6 text figures.

This report contains: (1) Underground water; general discussion; (2) the underground water of central Florida, deep and shallow wells, spring and artesian prospects; (3) effects of underground solution, cavities, sink-holes, disappearing streams and solution basins; (4) drainage of lakes, ponds and swamp lands and disposal of sewage by bored wells; (5) water analyses and tables giving general water resources, public water supplies, spring and well records.

Bulletin No. 2. Roads and Road Materials of Florida, 1911, 31 pps., 4 pls.

This bulletin contains: (1) An account of the road building materials of Florida; (2) a statistical table showing the amount of improved roads built by the counties of the State to the close of 1910.

In addition to the regular reports of the Survey as listed above press Bulletins have been issued as follows:

No. 1. The Extinct Land Animals of Florida, February 6, 1913.

No. 2. Production of Phosphate Rock in Florida during 1912, March 12, 1913.

No. 3. Summary of Papers Presented by the State Geologist at the Atlanta Meeting of the American Association for the Advancement of Science, December 31, 1913.

No. 4. The Utility of Well Records, January 15, 1914.

No. 5. Production of Phosphate Rock in Florida during 1913, May 20, 1914.

Of the Press Bulletins Nos. 1 and 3 are available for distribution in the original form as issued. No. 2, the supply of which is exhausted, was included without change of text in the Fifth Annual Report, pp. 291 to 294. Nos. 4 and 5 are included in the present volume in connection with the report on mineral industries.

DISTRIBUTION OF REPORTS.

The reports issued by the State Geological Survey are distributed upon request, and may be obtained without cost by addressing the State Geologist, Tallahassee, Florida.

THE PURPOSE AND DUTIES OF THE STATE GEOLOGICAL SURVEY.

Among the specific objects for which the Survey exists, as stated in the enactment, is that of making known information regarding the minerals, water supply and other natural resources of the State, including the occurrence and location of minerals and other deposits of value, surface and subterranean water supply and power and mineral waters and the best and most economic methods of development, together with analysis of soils, minerals and mineral waters, with maps, charts, and drawings of the same.

A distinctly educational function of the Survey is indicated by Section 4 of the law, which makes it the duty of the State Geologist to make collections of specimens, illustrating the geological and mineral features of the State, duplicate sets of which shall be deposited with each of the State colleges. The publication of annual reports is provided for as a means of disseminating the information obtained in the progress of the Survey. The Survey is thus intended to serve on the one hand an economic, and on the other an educational purpose. In its economic relations a State Survey touches on very varied interests of the State's development. In its results it may be expected to contribute to an intelligent development of the State's natural resources. Its educational value is of no less immediate concern to the State, both to the citizens within the State and to prospective citizens without.

A knowledge of the soil and of the available water supply is very necessary to successful agriculture, and the Survey's investigations along these lines are of value to all land owners. A knowledge of the mineral deposits which may lie beneath the surface, is likewise necessary to a correct valuation of land.

RELATION OF THE STATE SURVEY TO THE OWNERSHIP OF MINERAL LANDS.

The relation of the State Geological Survey to the ownership of mineral lands is specifically defined. The Survey law provides that it shall be the duty of the State Geologist and his assistants, when they discover any mineral deposits or substances of value, to notify the owners of the land upon which such deposits occur before disclosing their location to any other person or persons Failure to do so is punishable by fine and imprisonment. It is not intended by the law, however, that the State Geologist's time shall be devoted to examinations and reports upon the value of private mineral lands. Reports of this character are properly the province of commercial geologists, who may be employed by the owners of land for that purpose. To accomplish the best results, the work of the Survey must be in accordance with definite plans by which the State's resources are investigated in an orderly manner. Only such examinations of private lands can be made as are incidental to the regularly planned investigations of the Survey.

SAMPLES SENT TO THE SURVEY FOR EXAMINATION.

Samples of rocks, minerals and fossils will be at all times gladly received, and reported upon. Attention to inquiries and general correspondence are a part of the duties of the office, and afford a means through which the Survey may in many ways be useful to the citizens of the State.

THE COLLECTION OF STATISTICAL INFORMATION.

For many purposes the collection and publication of statistical information is helpful, both to the industries concerned and to the general public. Such statistical information is desired from all the mineral industries of the State. Such information will be recognized as strictly confidential, in so far as it relates to the private business of any individual or company, and will be used only in making up State and county totals. The co-operation of the various industries of the State is invited in order that the best possible showing of the State's products may be made annually.

EXHIBITION OF GEOLOGICAL MATERIAL.

The space available for the exhibition of geological material is unfortunately as yet very limited. A part of one room is being used for this purpose. Three cases have been built, designed to serve the double purpose of storage and exhibition. The lower parts of the case contain drawers and are used for storage. In making the collections a definite plan has been followed to secure a representation of the rocks, minerals and fossils of each formation in the State. The collection will be added to as rapidly as space is provided for taking care of the material.

THE SURVEY LIBRARY.

A well equipped reference library is essential to the investigations of the Survey, and an effort has been and is being made to bring together those publications which are necessary to the immediate and future work of the department. The Survey library now contains more than 1,500 volumes. These include the reports of the several State Geological Surveys; the reports of the National Geological Survey; the reports of the Canadian and a few other foreign Geological Surveys; and many miscellaneous volumes and papers on geology and related subjects.

RECOMMENDATIONS.

MORE OFFICE SPACE NECESSARY.

The State Survey is at present housed in two small rooms. Of these one is used as store room, photo room and library, while the other serves as office and work room. These small rooms, including about 1,000 square feet of floor space are totally inadequate to the requirements of effective work. Fully 10,000 square feet of floor space is necessary to meet the immediate requirements of the Survey. The library shelves are full, and it is now and for some time has been quite impossible to care for the publications that are being received. Many of these new publications represent the results of investigations by the neighboring State Surveys or by the National Survey, and are very necessary for comparative purposes to the Florida Survey. Other publications being received from various sources are for reference purposes and are necessary to the determination of fossils or mineral specimens, or, of geological formations, or other matters in connection with the Survey work. The cases used in exhibiting and storing mineral specimens and fossils have been placed temporarily in one of the rooms formerly occupied by the Supreme Court library.

The Survey at present is practically without a work room. There is no table or desk room available to store or to handle the maps, charts, and drawings that are constantly being used in the Survey work. It is impossible from lack of space to properly open up and study the collection of mineral and fossil specimens that have been obtained by the Survey. The store room space is too small to accommodate even the current issues of the Survey's own publications which must be cared for temporarily awaiting their distribution.

In connection with the work of the Survey there is a constant accumulation of notes, records, photographs, manuscripts, plates and cuts, as well as the general correspondence of the office which must be cared for. The present limited office space affords no room for storing, filing or properly caring for these records.

I urgently recommend, if it meets with your approval, that the Legislature be asked to provide adequate rooms for the future work of the State Geological Survey.

A STATE MUSEUM.

The desirability of an adequate museum in which to properly exhibit the resources of the State is apparent. The State Survey law makes it the duty of the State Geologist to collect. determine and label specimens illustrating the geological and mineral features of the State and large collections have been made since the Survey was organized. The small room used for exhibition purposes has long since been filled and a large amount of material suitable for exhibition remains unopened in boxes as collected. It is important that the State provide for the proper preservation and exhibition of the Survey collections in a State Museum.

THE PREPARATION OF A DETAILED TOPOGRAPHIC MAP OF FLORIDA.

While a general topographic map of Florida with contour lines at 50 foot intervals of elevation has been issued, as already stated, there is a constant demand for detailed topographic maps on a scale of about one inch to the mile and with contour lines at 10 foot intervals of elevation. Topographic maps are usually made in atlas sheets covering unit areas bounded by parallels and meridians. The unit adopted by the United States Geological Survey in topographic mapping, designated as the quadrangle, includes when made on the scale of about one inch to the mile an area of 15 minutes of latitude by 15 minutes of longitude. A separate atlas sheet is issued for each unit area and when completed the maps so issued make up a complete map for the state as a whole. The maps thus made show the land area in relief by means of contour lines. In this way all hills, valleys, stream channels, sinks, depressions and all changes in elevation are indicated. The actual elevation above sea, based on exact levels, are also shown by means of figures printed on the contour lines. Each contour passes through points which have the same altitude. One who follows the contour on the ground will go neither up hill nor down hill but on a level. By the use of contours the maps of the plains, hills and valleys as well as their elevations are shown. The line of the sea coast itself is a contour line, the datum or zero of elevation being mean sea level. The contour line at, say, 20 feet above sea level is a line that would be the sea coast if the sea were to rise or the land to sink 20 feet. Such a line runs back up the valleys and forward around the points of hills and spurs. On a gentle slope this contour line is far from the present coast line, while on a steep slope it is near it. Thus a succession of these contour lines far apart on the map indicates a gentle slope; if close together a steep slope; and if the contours run together in one line, as if each were vertically under the one above it, they indicate a cliff. The heights of many definite points such as road corners, railroad crossings, railroad stations, summits, water surface, triangulation stations and bench marks are also given on the map. The figures in each case express the elevation to the nearest foot.

In addition to indicating relief and actual elevation above sea these maps show all the natural features, such as lakes, ponds, rivers, streams, canals, swamps, and all cultural features including public roads, railroads, towns, cities, county and state boundaries.

The topographic maps thus prepared find many uses. They are above all essential to the proper planning of drainage operations throughout all the interior of the state. It is a well known fact that we have in Florida, particularly in the flatwoods sections, large areas of land that, although not actually flooded, yet would be much improved by the more rapid removal of the heavy summer rains. The state contains also valuable muck lands in addition to those already being drained. The topographic maps such as are here contemplated are essential to a proper planning of drainage operations.

The topographic maps are of very great assistance in the preparation of detailed soil maps. They afford first of all an exact base map of the area to be surveyed, thereby reducing the cost of the average soil map in Florida about one-half. They also facilitate the study of the soils which bear well known relations to drainage and moisture conditions. In detailed geologic mapping and in the study of the mineral resources, topographic maps are practically necessary for the final reports.

Topographic maps find many additional uses. They are of very great assistance in laying out and developing a system of public roads, showing as they do the relief of the land including hills, depressions and valleys. In planning the location of railroads, canals, waterways, or other public improvements they are of great assistance. Finally they afford to the land owners, as well as to the citizens in general, the manifold conveniences of a well-made and accurate map.

CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY IN THE PREPARATION OF TOPOGRAPHIC MAPS.

Many of the States co-operate with the National Geological Survey through their respective State Survey organizations in the preparation of topographic maps. The usual basis of such co-operation is an equal contribution of funds on the part of the State and National Survey. The plan of mapping followed is that already developed and established by the National Survey. The men employed in the mapping are the expert topographic mappers already in the employ of the National Survey. The following States are either now co-operating or have in the past co-operated with the National Geological Survey in this work: Alabama, California, Connecticut, Illinois, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Tennessee, Texas, Virginia and West Virginia.

It is probable that such co-operation can be secured in the preparation of the topographic maps of Florida, thus practically doubling for the State any appropriation made by the Legislature for this purpose. The Director of the United States Geological Survey has repeatedly expressed his willingness to co-operate with the State Geological Survey in the preparation of topographic maps, meeting any appropriation made by the State with an equal amount so far as funds permit. An appropriation made for the preparation of topographic maps may be so framed as to admit of co-operation with the United States Geological Survey; or may be made if desired contingent upon such co-operation to be carried on in accordance with plans approved by the Governor.

SOIL MAPS.

Another very important line of investigation is the preparation of detailed soil maps. While a general report on the soils of the State has been issued by the Survey, there is a very great demand for specific information regarding local soils such as can be supplied only by detailed soil maps of the several counties. A limited amount of soil mapping has already been done by the United States Bureau of Soils. As in the case of topographic maps many of the States are co-operating with the National Bureaus in the preparation of soil maps, and it is probable that an appropriation made for this purpose would be doubled by the United States Bureau of Soils. I would urgently recommend an appropriation of $5,000 per annum for the preparation of topographic and soil maps. Such an appropriation may be made contingent upon co-operation with the national bureaus and would thus result in the expenditure of $10,000 per annum in the State for this purpose.

EXPENDITURES OF THE GEOLOGICAL SURVEY FOR THE YEAR ENDING JUNE 30, 1913.

The total appropriation for the State Geological Survey is $7,500 per annum. No part of this fund is handled direct by the State Geologist, as all Survey accounts are paid upon warrants issued by the Comptroller of the State as per itemized statements approved by the Governor. The original of all bills and the itemized statements of all expense accounts are on file in the office of the Comptroller. Duplicate copies of the same are on file in the office of the State Geologist.

LIST OF WARRANTS ISSUED DURING THE YEAR ENDING JUNE 30, 1913.

July, 1912.	
T. J. Appleyard, State Printer	$ 100.00
Southern Express Company	13.76
D. R. Cox Furniture Company, supplies	4.13
August, 1912.	
Alex. McDougall, postage	25.00
Southern Express Company	3.03

September, 1912.	
E. H. Sellards, State Geologist, salary for quarter ending September 30, 1912	625.00
Herman Gunter, Assistant, salary for quarter ending September 30, 1912	300.00
Southern Express Company	1.60
October, 1912.	
E. H. Sellards, State Geologist, expenses, October, 1912	62.80
Herman Gunter, Assistant, expenses, October, 1912	42.71
Arthur H. Thomas Company, supplies	19.55
November, 1912.	
E. H. Sellards, State Geologist, expenses, November, 1912	66.47
Herman Gunter, Assistant, expenses, November, 1912	29.10
H. R. Kaufman, repairing typewriter	5.00
Alex. McDougall, postage	25.00
Southern Express Company	3.13
December, 1912.	
E. H. Sellards, State Geologist, salary for quarter ending December 31, 1912	625.00
E. H. Sellards, State Geologist, expenses, December, 1912	72.85
Herman Gunter, Assistant, salary for quarter ending December 31, 1912	300.00
H. & W. B. Drew Company, supplies	1.79
W. & L. E. Gurley, supplies	3.70
Keuffel & Esser Company, supplies	39.90
Engineering and Mining Journal, subscription	5.00
Southern Express Company	8.02
January, 1913.	
E. H. Sellards, State Geologist, expenses, January, 1913	42.60
Alex. McDougall, postage	22.16
Alex. Walton, janitor services	10.00
American Journal of Science, subscription	6.00
Southern Express Company	7.02
February, 1913.	
E. H. Sellards, State Geologist, expenses, February, 1913	47.35
Herman Gunter, Assistant, expenses, February, 1913	47.62
Alex. Walton, janitor services	10.00
T. J. Appleyard, State Printer	132.30
Economic Geology Publishing Co., subscription	3.00
Southern Express Company	4.16
H. & W. B. Drew Co., supplies	6.94
American Museum Natural History, publications	27.97
Ware Bros. Company, subscription	2.00
Wrigley Engraving & Electrotype Co., engraving	4.60
Alex. McDougall, postage	57.15
March, 1913.	
E. H. Sellards, State Geologist, salary for quarter ending March 31, 1913	625.00
Herman Gunter, Assistant, salary for quarter ending March 31, 1913	300.00
Emil Gunter, services	20.00
Alex. Walton, janitor services	10.00
H. R. Kaufman, supplies	4.25

American Peat Society, subscription	3.00
E. O. Painter Printing Company	5.75
April, 1913.	
Alex. McDougall, postage	20.00
Alex. Walton, janitor services	10.00
H. & W. B. Drew Company, supplies	6.37
Justus Perthes, Geographical directory	2.11
Southern Express Company	4.25
May, 1913.	
Alex. McDougall, postage	70.00
Alex. Walton, janitor services	10.00
Wrigley Engraving Company, engravings	5.10
Laura Smith, stenographic services	12.00
Maurice Joyce Engraving Company, engravings	32.80
June, 1913.	
E. H. Sellards, State Geologist, salary for quarter ending June, 30, 1913	625.00
E. H. Sellards, State Geologist, expenses, June, 1913	33.60
Herman Gunter, Assistant, salary for quarter ending June 30, 1913	300.00
Alex. McDougall, postage	4.40
H. R. Kaufman, supplies	5.00
Alex. Walton, janitor services	10.00
Emil Gunter, services	15.00
Dan Allen, freight and drayage	13.00
Underwood Typewriter Company, supplies	53.03
University of Chicago Press, subscription	3.60
David S. Woodrow, subscription	6.00
T. J. Appleyard, supplies	53.65
Southern Express Company	3.86
D. R. Cox Furniture Company	50.90
S. A. L. Ry., freight	21.06
S. A. L. Ry., freight	38.01
Record Company, printing	1,004.25
Total	$6,194.40
Appropriation for fiscal year ending June 30, 1913	$7,500.00
Available from the preceding year	1,112.87
	$8,612.87
Total expenditures for the fiscal year ending June 30, 1913	6,194.40
Balance available	$2,418.47

MINERAL INDUSTRIES AND RESOURCES OF FLORIDA.

BY E. H. SELLARDS.

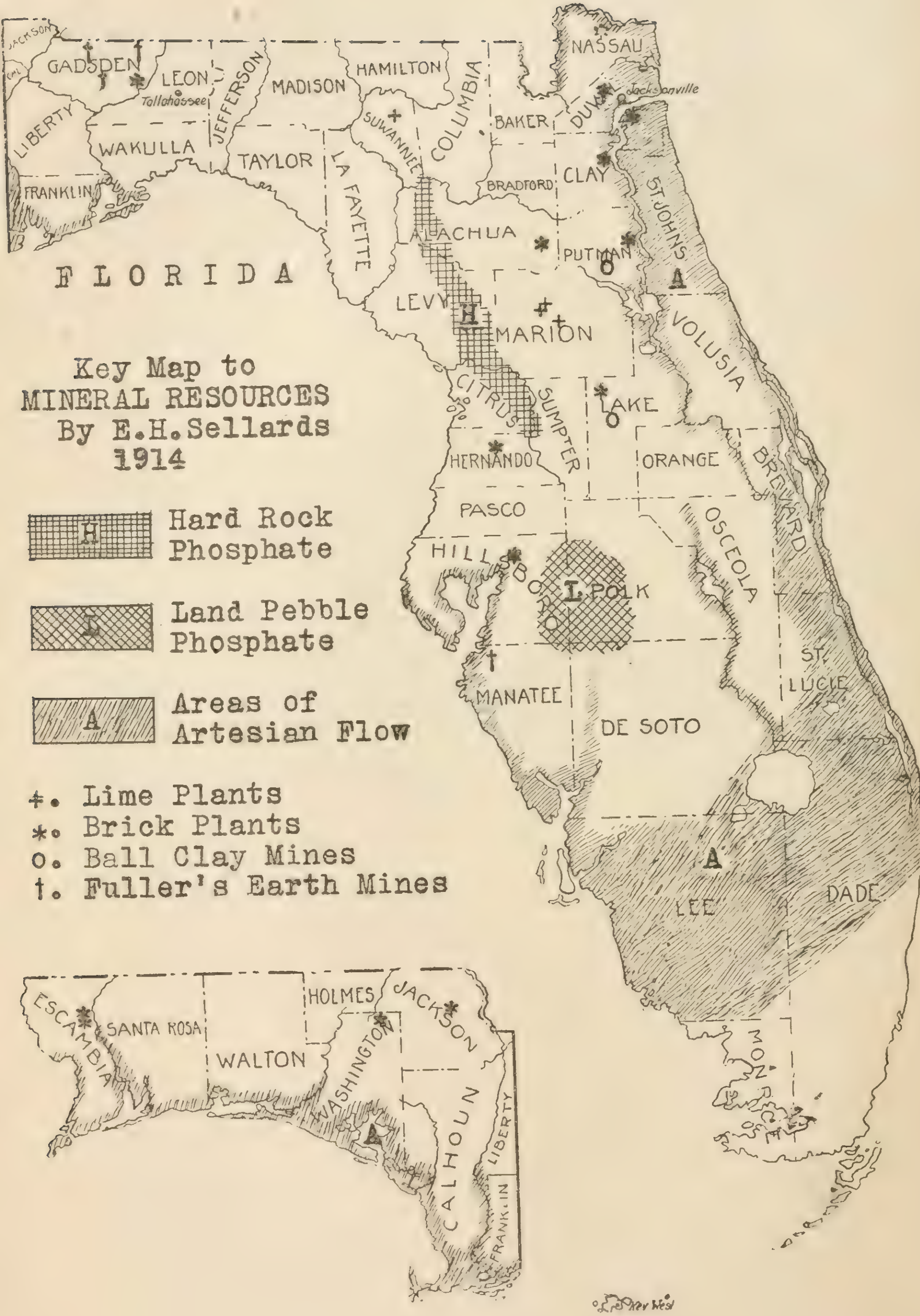
STATISTICS ON PRODUCTION COLLECTED IN CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

CONTENTS.

ERRATA.

Page 36, third line from the bottom of the page, for "18,917," read 16,845: and for "$100,335," read $89,973.

Page 114, second and third lines from top, same correction as for page 36; also twelfth line from the top of the page, for "73,415," read 13,371; and in last line on page, for "$10,646,628.00," read $10,636,266.00.


FLORIDA
Key Map to
MINERAL RESOURCES
By E.H. Sellards
1914
Hard Rock Phosphate
Land Pebble Phosphate
Areas of Artesian Flow
Lime Plants
Brick Plants
Ball Clay Mines
Fuller's Earth Mines
JACKSON
GADSDEN
LEON
Tallahassee
JEFFERSON
MADISON
HAMILTON
COLUMBIA
NASSAU
Jacksonville
DUVAL
BAKER
LIBERTY
WAKULLA
TAYLOR
SUWANNEE
LA FAYETTE
BRADFORD
CLAY
ST. JOHNS
FRANKLIN
ALACHUA
PUTMAN
LEVY
MARION
VOLUSIA
CITRUS
SUMPTER
LAKE
HERNANDO
ORANGE
BREVARD
PASCO
OSCEOLA
HILLSBORO
POLK
MANATEE
DE SOTO
ST. LUCIE
LEE
DADE
MONROE
ESCAMBIA
SANTA ROSA
WALTON
HOLMES
WASHINGTON
CALHOUN
LIBERTY
FRANKLIN

MINERAL INDUSTRIES AND RESOURCES OF FLORIDA.

E. H. SELLARDS.

STATISTICS ON PRODUCTION COLLECTED IN CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

CLAY AND CLAY PRODUCTS.

BALL CLAY OR PLASTIC KAOLIN.

The ball clays or plastic kaolins are among the most important clay products of the State. The Florida ball clays are white burning, highly refractionary and very plastic. These are used largely to mix with the less plastic clays to bring up the grade of plasticity. This clay as it occurs in Florida is intimately mixed with coarse sand. The presence of the sand in the clays necessitates washing, after which the clay is allowed to collect in the settling basins. It is then compressed into cakes by which excess of water is removed. The cakes are then broken up and either air-dried or artificially dried for shipment. The deposits at present known lie in the central peninsular section from Putnam to Polk Counties. The Putnam County deposits occur in and about Edgar and McMeekin. Deposits have been worked in Lake County along Palatlakaha Creek. Ball clays have also been reported from near Bartow Junction in Polk County, and probably extend into DeSoto County.

At Edgar, 4 to 10 feet of loose sand lies above the kaolin-bearing sand. This top sand is coarse, containing siliceous pebbles up to one-third of an inch across. The large pebbles are flattened and all are rounded. The kaolin-bearing sands beneath are gray in color, although the weathered surface is sometimes slightly iron-stained. They are said to have a total thickness of 30 feet or more. These sands are distinctly cross-bedded, especially the upper five feet as seen in the pit at Edgar. They are underlain by a sticky blue clay. It is reported that beneath the blue clay a fullers earth occurs, and that this in turn passes at the depth of about 70 feet into a scarcely indurated shell stratum.

A well put down by the Edgar Plastic Kaolin Company is reported to have passed through coarse superficial sand, 10 feet; kaolin-bearing sands, 30 or more feet; sticky blue clay with fullers earth beneath, about 40 feet; scarcely indurated shell stratum, 20 feet. The well terminated on a hard limestone rock at the depth of 90 feet.

Fig. 1.—Pit of the Edgar Plastic Kaolin Co., Edgar, Putnam County. Mining ball clay.

The kaolin in Lake County occurs under conditions similar to those found in Putnam County. The superficial sands here as at the Edgar mines are coarse and contain white siliceous pebbles. The kaolin-bearing sands are gray in color except where stained red with iron. At places a small amount of mica is found in the kaolin sands which is screened out in the process of washing. Sands of similar character but with a larger proportion of iron occur in the vicinity of Leesburg and Hawthorne and are used for road materials.

Two plants, under the management of the Edgar Plastic Kaolin Company, were engaged in mining ball clay during 1913. The value of the clay produced, although not separately given, is included in the total mineral products of the State.

BRICK AND TILE.

The surface formations of north and central Florida contain many clay beds, some of which are suitable for brick-making. The clay deposits, however, are often of local extent and variable in character. Such clay beds as occur in Florida suitable for brick making are confined to no particular geologic formation, and to no restricted section of the State, although the amount of brick clay is greater perhaps in the northern than in the southern part of the State. In extreme southern Florida in particular clay beds are but little developed.

The total number of common brick manufactured in Florida during 1913 was 42,450,000, valued at $240,126. The quantity of tile produced in the state is not separately given, but is included in making up the total mineral products of the state.

Fig. 2.—Brick kiln of the Florida Brick Company, Brooksville, Hernando County.

The following firms in Florida have reported production of brick or tile during 1913:

Barrineau Brothers, Quintette.
Campville Brick Company, Campville.
Clay County Steam Brick Company, Green Cove Springs.
Florida Brick Company, Brooksville.
Gamble and Stockton Company, 108 West Bay St., Jacksonville.
Jacksonville Brick Company, 315 West Forsyth St., Jacksonville.
Keystone Brick Company, Whitney.
McMillan Brick Company, Molino.
O. O. Mickler Brick Company, Callahan.
Ocala Lumber and Supply Company, Ocala.
Ocklocknee Brick Company, Ocklocknee.
Platt Brothers, South Jacksonville.
Tallahassee Pressed Brick Company, Havana.

DIATOMACEOUS EARTH.

The only abrasive material produced in Florida is that known as diatomaceous earth, the best known deposits of which are located near Eustis in Lake County. In addition to the Lake County deposits, however, a number of samples of a similar material have been received by the Survey from Polk County, and it is evident that it is widespread in its occurrence. The earth is found chiefly in fresh-water lakes, where it is intimately mixed with peat or muck, the material as taken from the bog having the appearance of peat of a grayish color. The method of treatment is to burn out the carbonaceous matter, the siliceous material remaining as a very fine powder. The diatomaceous earth mined near Eustis appears to consist largely of the spicules of fresh-water sponges, shells of diatoms and particles of amorphous silica.

Diatomaceous earth is used largely as a polishing powder for which its hardness and fineness render it particularly suitable. It is also used in some scouring soaps, and to some extent in the manufacture of dynamite as an absorbent for nitroglycerine. It is a good non-conductor of heat and hence is valuable for packing steam pipes, and to some extent for fireproof materials in general.

Diatomaceous earth was produced in Florida during 1913 to a limited extent by the Standard Diatomite Company of Eustis. There being only the one producer the output is not separately listed, but is included with the total mineral production of the State.

The following account of diatomaceous earth in the United States is taken from the report on the Production of Abrasive Materials in 1913, by Frank J. Katz*:

Diatomaceous earth, called also infusorial earth and *kieselguhr,* is a light, earthy material, which from some sources is loose and powdery and from others is more or less firmly coherent. It often resembles chalk or clay in its physical properties, but can be distinguished at once from chalk by the fact that it does not effervesce when treated with acids. It is generally white or gray in color, but may be brown or even black when mixed with much organic matter. Diatomaceous earth is made up of tests of minute aquatic plants composed of a variety of opal, which, chemically, is hydrous silica. Owing to its porosity it has great absorptive powers and high insulating

*Mineral Resources of the United States, Calendar Year 1913, Pt. II, p 268.

efficiency. The hardness, the minute size, and the shape of its grains make it an excellent metal-polishing agent.

Heretofore diatomaceous or infusorial earth has been largely used as an abrasive in the form of polishing powders and scouring soaps, but of late its uses have been considerably extended. Because of its porous nature it has been used in the manufacture of dynamite as a holder of nitroglycerine, but so far as known not in the United States. Its porosity also renders it a non-conductor of heat, and this quality in connection with its lightness has extended its use as an insulating packing material for safes, steam pipes, and boilers, and as a fireproof building material. In this country a new use of the material is reported in the manufacture of records for talking machines. For this purpose it is boiled with shellac, and the resulting product has the necessary hardness to give good results.

In Europe, especially in Germany, infusorial earth has lately found extended application. It has been used in preparing artificial fertilizers, especially in the absorption of liquid manures; in the manufacture of water glass, or various cements, of glazing for tiles, of artificial stone, of ultramarine and various pigments, of aniline and alizarine colors, of paper, sealing wax, fireworks, gutta-percha objects, Swedish matches, solidified bromine, scouring powders, papier-mache, and many other articles. There is a large and steadily growing demand for it.

Fig. 3.—Northwest shore of Lake Milton, about 5 miles south of Tavares.

Preliminary preparation of the crude material involves drying and roasting to destroy organic matter, if that is present.

Production of diatomaceous earth in the United States in 1913, by States, in short tons.

State.	Quantity.	Value.
California and Nevada	5,785	$51,556
Connecticut, New York, and Washington	378	9,565
Maryland, Virginia, and Florida	423	8,119
Total	6,586	$69,240

FULLERS EARTH.*

CONTENTS.

Fullers earth is a clay which has the property of absorbing basic colors and removing these from solution in animal, vegetable and mineral oils, as well as from water and certain other liquids. In commerce the earth finds its chief use in clarifying oils, although it has in addition a number of minor uses, among which are the removal of the excess of coloring from water in dyeing cloth; as an ingredient in talcum powders; as a detergent in fulling cloth; and to some extent for medicinal purposes, having been used in poultices for swellings, ulcers and sores. Fullers earth has also been used recently in the preparation of a new reagent, known as Lloyd's reagent for alkaloids. This reagent, used for the removal of alkaloids from the aqueous solution of their salts, is reported to be more efficient for that purpose than charcoal or freshly precipitated aluminum, heretofore chiefly used for that purpose. The action of the reagent is supposed to be due to the presence of hydrous aluminum silicate.†

Fullers earth, like other clays, is complex and consists not of a single mineral, but of a variety of minerals, the mineral particles being mixed in different earths in widely differing proportions, resulting in a varying chemical and mineralogical composition. The ultimate analysis does not differ materially from that of other clays, although fullers earth has as a rule a rather high percentage of combined water. The properties of the earth arise

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*The following paper on fullers earth is abridged from two papers prepared during the past year by the writer. The first of these, entitled Fullers Earth in the United States, was presented at the Atlanta Meeting of the American Association for the Advancement of Science; the second, entitled Fullers Earth Production, was prepared for Mineral Industry, 1913, Vol. xxii.

†Journal of the Amer. Pharmaceutical Association, May, 1914, pp. 625-630.

apparently from the physical condition of the clay and can be detected only by a filtering test by which its practical utility in clarifying oils is determined.

In testing an earth for clarifying a mineral oil the earth is dried, powdered and placed in a tube. The mineral oil is then passed through the tube and will be more or less perfectly clarified, depending upon the quality of the earth. A different test is necessary for a vegetable oil. In testing vegetable oils according to Wesson* a weighed amount of the oil and the fullers earth are stirred together for a regular period at a temperature of 100 degrees C. The oil is then filtered and compared with other known fullers earth treated under exactly the same conditions.

Various other properties are assigned to fullers earth, but all, aside from the actual bleaching tests, are so variable, or are common to such a variety of clays as to be of only secondary value as a means of identification. Non-plasticity is often given as a property of fullers earth, but it appears from the investigations of Porter† and others that some of the fullers earths are distinctly plastic when mixed with a large proportion of water. Some of the fullers earths will disintegrate in water, although others are little affected thereby. Most fullers earths on account of their porosity when dry will adhere firmly to the tongue, but some other clays will do the same. In color fullers earth is as variable as other clays, and while buff and blue clays predominate, others are brown, gray or almost white. As a rule fullers earths are light in weight owing to their porosity, although there are exceptions, and the specific gravity is much the same as that of other clays. These secondary properties, although of value in tracing any particular bed after this has been located, are not to be relied upon as a complete test.

MINING FULLERS EARTH.

All the sedimentary deposits of fullers earth are mined by the open pit method, the overburden being removed by steam shovel in the larger mines, and by team and scraper or by pick and shovel in the smaller mines. The depth of overburden that can profitably be removed is variable, depending as it does upon the

*Bleaching of Oils with Fullers Earth, by David Wesson, Trans. Amer. Inst. of Chemical Engineers, Vol. iii, 1910, pp. 327-332.

†Properties and Tests of Fullers Earth, by John T. Porter, U. S. Geol. Sur. Bull, 315, pp. 268-290, 1907.

thickness and quality of the fullers earth stratum beneath and upon the character of the overburden itself. In the Florida mines the maximum overburden removed is from 12 to 14 feet in thickness. This consists of sand, clay and in some cases marl. The fullers earth in these mines includes two strata each from six to ten feet thick, and separated by a thin stratum of sandy or calcareous material. As a rule the first stratum only is worked. The fullers earth itself is dug with pick and shovel, and is then loaded onto cars to be drawn to the plant.

Fig. 4.—Pit in fullers earth mine, Quincy, Florida.

In Arkansas where the earth is found following basaltic dikes, underground mining is resorted to. Vertical shafts are sunk from which laterals run to the vein of earth. The fullers earth is drawn to the surface in buckets and is hauled by wagon to the plant near by.

DRYING FULLERS EARTH.

At the plant the earth is broken up by passing through a crusher, thus facilitating both handling and drying. Although the earth is usually taken directly to the crusher, yet in some instances it is placed in storage bins and air dried before being crushed. Drying fullers earth is for the purpose of removing the excess of moisture.

The driers employed are for the most part rotary cylinders. Those in use in the Florida mines are from 40 to 60 feet in length and about 6 feet in diameter. When in operation they rotate slowly, the earth being moved along by means of flanges attached to the inside of the cylinder. These cylinders are heated to a moderate heat by petroleum burners, the heat being applied either at the end where the wet earth enters, or at the opposite end from which the dry earth escapes. Overheating is not feared in these plants, as the earth is used for filtering mineral oils. When the earth is to be used for edible oils precautions are taken to avoid overheating, as driving off the combined water is supposed to be injurious. To guard against overheating especially constructed rotary cylinders are used, or the earth is run into brick form and is dried in tunnel driers through which hot air is forced. Although the English fullers earth is injured by driving off the combined water, it has been found that some at least of the American earths bleach fully as well after the combined water is removed, and it is probable that these precautions against overheating the earth for edible oils are in some cases at least unnecessary.

GRINDING AND BOLTING.

In grinding the fullers earth a variety of mills are in use. After grinding, the earth is bolted. That intended for refining petroleum is bolted to a definite size and is placed on the market graded as 15 to 30 mesh, 30 to 60 mesh, 60 to 80 mesh. The coarser sizes are in most demand, there being as a rule no market for material passing 90 mesh, which is not infrequently a total loss, being thrown into the dump. For the edible oils it is said that the earth should be ground to pass 100 mesh, but that there should not be an excess of exceedingly fine material which if present will clog the pores of the coarser material and prevent successful filtering. It is apparent that the different fullers earths differ in the degree of fineness to which they can be successfully ground. While the English earths are ground to a 120 mesh without having an excess of very fine particles, many of the American earths cannot be ground finer than 100 mesh for edible oils. It is true also that the mill employed must be adapted to the particular earth for which it is used.

PROPERTIES OF FULLERS EARTH.

The action of fullers earth in clarifying oils, and the varying behavior of different fullers earths form an interesting study on which much yet remains to be done. Porter in 1907 reviewed the different explanations of the carifying action that had been given and advanced a new theory to explain this property. Porter believes that the clarifying action is due chiefly to colloidal silica present in the clay, and records a series of very interesting tests and analyses which are believed to support this view.* Porter's theory briefly stated is as follows: (1) Fullers earth has for its base a series of hydrous aluminum silicates. (2) These silicates differ in chemical composition. (3) They are, however, similar in that they all possess an amorphous colloidal structure. (4) The colloidal structure is of a rather persistent form and is not lost on drying at a temperature of 130 degrees Centigrade, or possibly higher. (5) These colloidal silicates possess the power of absorbing and retaining organic coloring matter, thus bleaching oils and fats.

Among other striking properties of fullers earth is the fact that some earths that serve particularly well in refining mineral oils have not been used successfully for vegetable oils and conversely those best suited for vegetable oils are not suitable for mineral oils. A recent study bearing on these problems has been issued by the U. S. Bureau of Mines.† At the present time the English fullers earths are being used largely in vegetable oils, while the American fullers earths are used almost entirely for mineral oils. It is stated in this report, however, that the Bureau of Mines believe that the United States has fullers earth far better suited for refining edible oils than any imported, and that to assure the almost universal use of this earth by American refiners there is required only a careful and intelligent control of the preparation of the output and its application to the bleaching of oils.

Most fullers earth gives more or less of a taste to the edible oils, and formerly the American earth was rejected by refiners of edible oils on this account, but at the present time methods are known for removing taste and odor from the oil. This is accom-

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*Properties and Tests of Fuller's Earth, by John T. Porter. Bull. 315, U. S. Geol. Survey, pp. 268-290, 1907.

†Fullers Earth, by Charles L. Parsons, Bureau of Mines, Bull. 71, 1913.

plished by blowing dry steam through the refined oil which is heated to a temperature above the boiling point of water. A serious difficulty in the use of this clay is the rapid oxidizing action which some fullers earths have on edible oils. In milling practice air is blown through the filter press to force out the oil remaining in the earth after treatment. With some of the earths the oxidizing action is so rapid that the oil remaining in the earth takes fire, or is liable to take fire at this time. It is to be hoped that this difficulty will be overcome.

DISTRIBUTION OF FULLERS EARTH IN THE UNITED STATES.

Clays having the properties of fullers earth more or less well developed are widely distributed in the United States and are confined to no particular geological horizon, although the largest known deposits are of Cenozoic age. By far the greater part of fullers earth is in the form of a sedimentary deposit which is distinctly stratified, and from which an overburden must be removed in mining. In Arkansas, however, fullers earth is known that is exceptional in that it is residual, having been formed *in situ* from the disintegration of basaltic dykes.* In the United States fullers earth is known from the following states: Alabama, Arizona, California, Colorado, Florida, Georgia, Massachusetts, Minnesota, Mississippi, New York, South Carolina, South Dakota, Texas and Utah. Of these states, however, only six were actively producing fullers earth during 1913, as follows: Florida, Georgia, Arkansas, California, Colorado and Massachusetts.

The fullers earth of southern Georgia, which is worked at Attapulgus near the Florida line, represents a northward extension of the Florida deposits. In central Georgia near Macon, however, is found a different type of earth, which according to the Georgia Geological Survey is found in the Claiborne formation of Eocene age. This earth differs in some important respects from that of Florida, being used chiefly for vegetable oils, while that from Florida finds its chief use at present in clarifying mineral oils. The fullers earth of Arkansas is used chiefly in clarifying vegetable oils. The fullers earth of Colorado is said to be used in bleach-

*Residual fullers earth is said to occur also in Saxony where it is found *in situ* derived from gabbro.

ing cottonseed oil, while that of Massachusetts is reported as being used in fulling woolen goods. The fullers earth of California is used according to the State Mineralogist principally as a clarifying agent in the refining of crude oils.

PRODUCTION OF FULLERS EARTH IN THE UNITED STATES.

Florida is the chief producer of fullers earth in the United States. The deposits being worked are those of Gadsden County in northern Florida, and of Manatee County in southern Florida, the earth being found at both localities in the Alum Bluff formation of Upper Oligocene age. The following companies reported production of fullers earth in Florida during 1913: The Atlantic Refining Company, Ellenton; the Floridin Company, Quincy; the Fullers Earth Company, Midway. In addition to these the Manatee Fullers Earth Company, Ellenton, is reported as expecting to operate during 1914.

The total production of fullers earth in the United States during 1913 was 38,594 short tons, valued at $369,750, being an increase both in quantity and value over that of the preceding year*. In addition to that produced, there was imported into the United States during the year ending June 30,1913,16,866.16 tons, of which 1,597 tons valued at $10,359 were unmanufactured or unground, while 15,269.16 tons valued at $135,229 were manufactured or ground. These importations were under the old rate of duty, which was $1.50 per ton for the unmanufactured earth, and $3.00 per ton for the manufactured product. During the last half of 1913, July 1 to December 31, under the new tariff rates, which are for unmanufactured earth 75 cents per ton, and for manufactured $1.50 per ton, there was imported 974 tons unmanufactured valued at $7,660 and 7,613 tons manufactured earth valued at $68,558. These valuations are based on the wholesale price of the product at the port of origin. The actual cost to the consumer includes freight and commission in addition. The exports of fullers earth from the United States cannot be determined owing to the fact that this product is not listed separate from other clays.

*The Production of Fullers Earth in 1913, by Jefferson Middleton. Mineral Resources of the United States, Calendar Year, 1913. Pt. II, p. 111, 1914.

The fullers earth used in clarifying mineral oils, which includes by far the greater part of that produced in America, is sold at the mine, ground, bolted and sacked for shipment at about $9.50 per ton. That used for refining vegetable oils brings a somewhat higher price, although more expense is incurred in handling, since the earth must be ground finer for vegetable than for mineral oil.

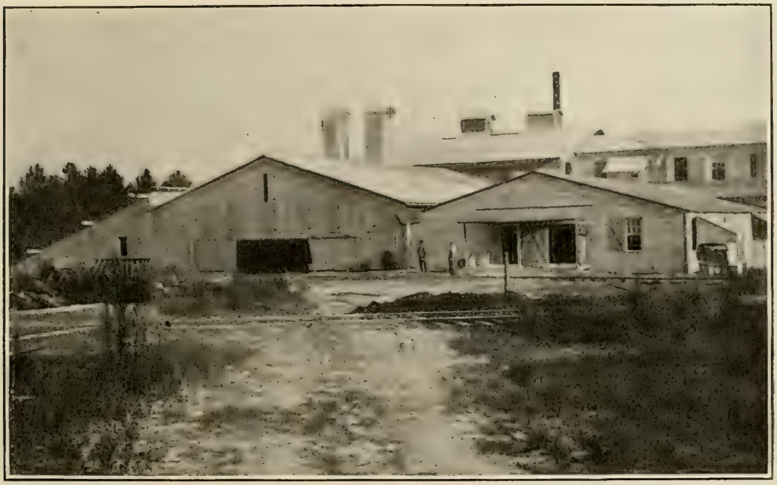

Fig. 5.—Fullers earth plant at Quincy, Gadsden County.

Fig. 6.—Fullers earth plant at Ellenton, Manatee County.

LIME.

Lime or "quick lime" is chemically an oxide of calcium or calcium and magnesium. It is formed ordinarily by burning limestone, although shells and other calcium carbonates may be used for the same purpose. Limestone when burned gives up carbon dioxide. The residue after burning forming a lime, consists of a calcium oxide, when a pure calcium carbonate limestone is used; or of calcium and magnesium oxide when a dolomitic limestone is used. The reaction in the case of a pure limestone is as follows: $CaCO_3$ when heated breaks up into $CaO+CO_2$. In the case of dolomitic limestone a magnesium oxide as well as calcium oxide is formed.

The character of the lime varies according to the amount of magnesium present in the limestone from which it is made. Peppel* offers the following classification of the ordinary or "white limes", including in that term limes containing not more than 5 per cent of sandy and clayey impurities:

(1) High-calcium, or "hot" or "quick" limes. Made from limestones containing not less than 85 per cent. of carbonate of calcium.

(2) Magnesium limes. Made from limestone containing between sixty-five and eighty-five per cent. carbonate of calcium and between ten and thirty per cent. of carbonate of magnesium.

(3) Dolomitic, or "cool" or "slow" limes. Made from limestones containing more than thirty per cent. of carbonate of magnesium.

These limes differ slightly among themselves. The high calcium or "hot" or "quick" limes set more quickly, while the magnesium and dolomitic limes set more slowly. Limes thus serve different purposes, the high calcium limes being used when a quick-setting lime is desired, while the other limes are used when slow-setting limes are desired. After calcination, the lime may be placed on the market as quick lime, or it may be slaked and placed on the market as hydrated lime. Hydrated lime is said to be desirable for certain purposes since the lime if properly slaked breaks up into exceedingly fine powder.

The total quantity of quick and hydrated lime made in Florida during 1913 amounted to 18,917 tons, valued at $100,335. The companies reporting production of lime in Florida during 1913 were as follows:

*Bulletin No. 4, 4th Series, Ohio Geol. Survey, p 254, 1906.

Florida Lime Company, Ocala, Florida.
Live Oak Limestone Company, Live Oak, Florida.
Marion Lime Company, Ocala, Florida.
Standard Lime Company, Kendrick, Florida.

In addition to these, the Virginia-Florida Lime Company, and the Blowers Lime and Phosphate Company, organized during 1913, were expected to begin operations during 1914.

The following account of the uses of lime, together with comments on hydrated lime, is taken from an article on Lime by Ernest F. Burchard in Mineral Industry for the Calendar year 1911, pt. II, pp. 649-652, 1912.

USES OF LIME.

Few mineral products have so wide a variety of uses as lime. Nearly half the lime manufactured in the United States is used as a structural material, and the remainder, amounting to about 1,750,000 tons, valued at about $5,500,000, is consumed in chemical uses. The principal uses which lime has in building operations are in lime mortars and plasters, in gaging Portland cement mortars, concrete, and gypsum plasters, and as a whitewash. Both quick and hydrated lime are used in building operations.

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The chemical uses of lime are much more varied than the uses of lime in building. A number of the industries that are large users of lime are listed below, together with the special purposes served by lime in each industry and the kind of lime most suitable to such purposes.

CHEMICAL USES OF LIME.*

Agricultural industries:
- As a soil amendment, c. m. †
- As an insecticide, c, m.
- As a fungicide, c, m.

Bleaching industry:
- Manufacture of bleaching powder, "Chloride of lime," c.
- Bleaching and renovating of rags, jute, ramine, and various paper stocks, c, m.

Caustic alkali industry:
- Manufacture of soda, potash, and ammonia, c.

Chemical industries:
- Manufacture of ammonia, c.
- Manufacture of calcium carbide, calcium cyanimid, and calcium nitrate, c.
- Manufacture of potassium dichromate and sodium dichromate, c.
- Manufacture of fertilizers, c, m.
- Manufacture of magnesia, m.
- Manufacture of acetate of lime, c.
- Manufacture of wood alcohol, c.
- Manufacture of bone ash, c, m.

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*Notes on the part played by lime in these industries are given in Circular No. 30 of the Bureau of Standards, 1911, pp. 13-21.

†. High calcium lime is indicated by "c," magnesium and dolomitic lime by "m".

Manufacture of calcium carbides, c.
Manufacture of calcium-light pencils, c.
In refining mercury, c.
In dehydrating alcohol, c.
In distillation of wood, c.

Gas manufacture:
Purification of coal gas and water gas, c, m.

Glass manufacture:
Most varieties of glass and glazes, c,

Milling industry:
Clarifying grain, c, m.

Miscellaneous manufactures:
Rubber, c, m.
Glue, c, m.
Pottery and porcelain, c,m.
Dyeing fabrics, c, m.
Polishing material, c, m.

Oil, fat, and soap manufacture:
Manufacture of soap, c.
Manufacture of glycerine, c.
Manufacture of candles, c.
Renovating fats, greases, tallow, butter, c, m.
Removing the acidity of oils and petroleum, c, m.
Lubricating greases, c, m.

Paint and varnish manufacture:
Cold-water paint, c, m.
Refining linseed oil, c, m.
Manufacture of linoleum, c, m.
Manufacture of varnish, c, m.

Paper industry:
Soda method, c.
Sulphite method, m.
For strawboard, c, m.
As a filler, c, m.

Preserving industry:
Preserving eggs, c.

Sanitation:
As a disinfectant and deodorizer, c.
Purification of water for cities, c
Purification of sewage, c.

Smelting industry:
Reduction of iron ores, c, m.

Sugar manufacture:
Beet root, c.
Molasses, c.

Tanning industry:
Tanning cowhides, c.
Tanning goat and kid hides, c, m.

Water softening and purifying, c.

HYDRATED LIME.

Definition.—When quicklime is slaked, by whatever process, whether in the simple mortar box by adding water by the bucketful and stirring with a hoe, or whether the lime and water are automatically weighed out in definite parts and the mass is stirred by machinery, the chemical principle involved is the same, viz., quicklime plus water becomes slaked lime, or hydrated lime—

$$CaO+H_2O=Ca(OH)_2.$$

or, if the limestone used for making quicklime contains magnesia, the following equation is appropriate: Magnesian quicklime plus water becomes slaked or hydrated magnesian lime—

$$CaO.MgO + H_2O = Ca(OH)_2.MgO.$$

Commercially the term "hydrated lime" is restricted to the dry powder prepared by treating quicklime with just enough water to combine with all the calcium oxide present. In the preparation of hydrated lime two materials only are used—fresh caustic lime and water. The general method of preparation is first to reduce the lumps of lime by crushing to about ½-inch size. In some plants this reduction is carried further by grinding the lime to about the fineness of granulated sugar. The crushed or granulated lime is then treated with sufficient water to combine chemically with the calcium oxide in the lime, care being taken that the quantity is neither too little to satisfy the chemical requirements nor so great as to leave the hydrated mass wet or even damp. In practice, an excess of water is used, but this excess is driven off by the heat generated in the slaking or hydrating of the lime. The object of crushing the product is to produce a larger surface for the action of the water, and, moreover, large lumps would be rather unwieldy in the hydrater. The lime comes from the hydrater as a fine, dry powder, which must be screened to remove any coarse or overburned lime that would not slake. From the screens it goes to the storage bin, where, if the capacity is available, it is at some plants allowed to age for 30 days. Finally, the product is fed into bags for shipment. The equipment of the hydrating plant generally includes two elevators, one to take the lime from the crusher to the bin over the hydrater and one to take the hydrated lime from the hydrater to the storage bin. Most mills include, also, a machine for grinding the oversize from the screens. This material consists of unburned stone, overburned lime, lime which is not fully hydrated, and even pieces of brick from the kilns, and coal ashes. When ground, the tailings may be sold for fertilizer. The methods of manufacture most extensively employed in this country are the batch process, the continuous process, and modifications of these two processes.

LIMESTONE.

In addition to that used in making lime, limestone is produced in Florida for other purposes as follows: Broken limestone used for railroad ballast, concrete and road material, and ground limestone for application to soils. A limited amount of limestone was probably also used in building, although not reported. The quantity of limestone produced for the various purposes mentioned are as follows: Railroad ballast, 93,750 tons, valued at $37,500; concrete, 123,506 tons, valued at $72,432; road material, rock valued at $156,589; ground for application to soils, 16,908 tons, the total production amounting to $156,589.00.

The following is a list of firms reporting the production of limestone in Florida during 1913:

Blowers Lime and Phosphate Company, Ocala, Florida.
Crystal River Rock Company, Crystal River, Florida.
Florida Lime Company, Ocala, Florida.
Marion Lime Company, Ocala, Florida.
E. P. Maule, Fort Lauderdale, Florida.
Palm Beach County, West Palm Beach, Florida.
Standard Lime Company, Kendrick, Florida.

BUILDING STONE.

The building stone of the State consists chiefly of limestones, of which several varieties occur.

Coquina:—The coquina rock of Anastasia Island near St. Augustine has been known as a building stone for more than three hundred years. This coquina was in fact the first stone used for building purposes in America, its use having begun with the settlement of St. Augustine about 1565. Coquina consists of a mass of shells of varying size or fragments of shells cemented together ordinarily by calcium carbonate. A small admixture of sand is in some instances included with the shells. When first exposed the mass of shells is imperfectly cemented and the rock is readily cut into blocks of the desired size. Upon exposure, however, the moisture contained in the interstices of the rock evaporates and in doing so deposits the calcium carbonate which it held in solution, thus firmly cementing the shell mass into a firm rock. Thus indurated the resisting qualities of the rock are good. The shells from this formation have been extensively used with concrete in the construction of modern buildings at St. Augustine. Aside from its occurrence on Anastasia Island coquina is found at many other points along both the east and the west side of the peninsula.

Vicksburg Limestone:—The Vicksburg limestone has been used to some extent for building purposes. This is true especially of that phase of the Vicksburg known as the "chimney rock" described in the preceding reports as the Marianna and the Peninsular limestones. The chimney rock when first taken from the ground is very soft and can be easily sawed into blocks. Upon exposure to the air it hardens, due, as in the case of the coquina, to the evaporation of moisture from the interstices of the rock. The chimney rock was early used both in Alabama and Florida for the construction of chimneys and to some extent for building purposes.

Locally the Vicksburg and some of the other limestones in Florida become very close grained and compact. In this condition the limestone is hard, approaching marble in appearance. Although little used this phase of the limestone formation is capable of producing a good building stone.

Miami Oolite:—The Miami oolitic limestone has been used successfully as a building stone at Miami. This formation extends for some distance along the eastern border of the Everglades north and south from Miami. As in the case of the other limestones when first taken from the quarry it is relatively soft and easily worked, but hardens upon exposure. The court-house, Halcyon Hall hotel and some other buildings at Miami are constructed of this rock.

The limestones of the Everglades of Florida constitute a resource that will become valuable as that section of the state is developed. In this connection may be included a brief paper on the geology of this interesting region, prepared originally for the State Drainage Commission, in which is included descriptions and analyses of the several limestones that are found underlying the Everglades. In making the examination of the exposures along the canals and in Lake Okeechobee, May 19 to 23, 1914, a small launch was used, placed at the writer's disposal through the courtesy of the Chief Engineer of the State Drainage Commission.

THE GEOLOGY OF THE EVERGLADES OF FLORIDA.

The developments that are now in progress, and particularly the extensive excavations that are being made in connection with drainage operations, are rapidly opening up new territory in southern Florida, affording the opportunity of making important additions to our knowledge of the geology of that part of the State. The canals from the Caloosahatchee River on the west, through Lake Okeechobee, and thence through the Everglades to New River and Miami on the east give almost complete exposures of the underlying formations across the Everglades, the geology of which was until recently practically unknown. In fact the geologic observations previously made were confined to the borders of the Everglades or to the banks of the streams leading out to the east, south and west.

Among these early observations were those of Buckingham

Smith, who in 1847 examined the oolitic limestone in the vicinity of Miami and along the Miami River. The locality was subsequently visited by Agassiz, Tuomey and others of the early geologists, and the age of the rocks correctly determined as Pleistocene. The limestones bordering the Everglades west of Palm Beach and at the extreme southern end of the peninsula were examined in 1908 by Samuel Sanford, supplementing similar investigations made in 1887 by Joseph Wilcox, and together with the rocks found west of Palm Beach, were described in the Second Annual Report of the Florida Geological Survey. The limestone west of Palm Beach was there designated as the Palm Beach Limestone, while that found bordering the Gulf coast at the southern end of the Everglades was named the Lostman's River Limestone.

On the west side of the Everglades along the Caloosahatchee River there is found a shell marl formation of Pliocene age first described in 1887 by Angelo Heilprin and known as the Caloosahatchee marl. This marl, remarkable for the number, size and excellent preservation of the fossil shells which it contains, disappears from view beneath later formations at Fort Thompson near the head of the Caloosahatchee River.

The formations lying above the Caloosahatchee marl at Fort Thompson consists of hard and soft limestones, shell and clay marls. The principal limestone seen at this locality is a hard almost flinty rock containing an abundance of the fresh-water snail, *Planorbis*. Both above and below this limestone stratum, are shell marls, some of which are of fresh-water and some of marine origin. The most persistent of these marls is a shell stratum resting directly upon the limestone and having a thickness of about two feet. The predominating fossil in this stratum, the small *Chione cancellata,* is a species which prefers shallow water, frequently living between low and high tide. Above this marine shell marl is a fresh-water clayey marl which contains an abundance of the remains of the pond snails. These deposits in which marine marls alternate with fresh-water marls and limestones indicate that at the time of their formation this part of Florida was being gradually elevated above sea. The elevation of the land area as is usual in such cases, progressed slowly with minor fluctuations, permitting the formation of fresh and brackish water lagoons, in which the fresh-water marls accumulated, then by a minor subsidence the ocean waters were allowed once more to come in, the marine shell marls being deposited during this time. The general upward movement, however, continued, the whole area being finally lifted to its present height of from 10 to 20 feet above sea level.

This exposure at Fort Thompson affords the key to the study of the formations extending to the east and underlying the Everglades, in which the limestones and marls of this type are widely distributed. In following up the canal from Fort Thompson these limestones and marls are seen in the canal banks for a mile or so where all except the upper freshwater marl drop below water level. That they are still present, however, is shown by the quantities of shells that have been thrown out by the dredge. At Coffee Mill Hammock, about 8 miles above Fort Thompson, a slight fold or anticline brings the rock to the surface, and for a few miles the limestone and marl are again seen in place in the banks of the canal. It is worthy of note also that at this locality the dredge cuts entirely through the overlying deposits and brings up the Caloosahatchee marl from beneath, showing the eastward extent of that formation beyond the locality at which it disappears from view in the river bank. Beyond the Coffee Mill Hammock cut, limestone and marls are occasionally reached by the dredge. A considerable mass of shells has been taken from the canal just above Citrus Center Landing, while within three miles of Lake Hicpochee a rather heavy limestone comes to the surface.

Within Lake Okeechobee there is a reef of rock extending in a general northwest-southeast direction between Observation and Rita islands. At a point about 5 miles southeast of Observation Island the rock of this reef now stands above water at intervals for a mile or so, the maximum exposure at the present low water stage being about two feet. At the surface this limestone is quite hard, or is streaked in a characteristic manner with alternate hard and soft layers. Beneath the surface, however, the rock is a rather soft oolitic marl or limestone of granular texture and light yellow color. The hard phase of this limestone is much like the limestone found in the canal three miles west of Lake Hicpochee, while a thin stratum of a similar limestone is found near the surface at Coffee Mill Hammock. A few pieces of the marl phase of this limestone seem also to have been brought up from the lake at the entrance of the north New River canal.

The following analysis of a composite sample of the hard and soft phases of this limestone, as well as the other analyses given in this paper, was made by the State Chemist from samples taken for the purpose by the writer. The rock in Lake Okeechobee, as is seen from this analysis, is slightly phosphatic, this being the only phosphatic limestone as yet reported from the Everglades.

Analysis of Limestone from Lake Okeechobee.

	Per cent
Calcium Oxide, 42.76%, equivalent to Calcium Carbonate	76.37
Magnesium Oxide, 0.35%, equivalent to Magnesium Carbonate	0.70
Phosphoric Acid, 0.85%, equivalent to Tricalcium Phosphate	1.85
Insoluble matter, silica, etc.	21.14

From the canals leading out of Lake Okeechobee to the south and southeast for a distance of about 25 miles very little rock has as yet been removed. Such fragments as are seen along the canals, however, represent very hard compact fresh-water limestones. On the North New River canal dredging of the heavy limestone begins about 26 miles from Lake Okeechobee. The rock cut through on this part of the canal consists of a very hard, compact, close-grained limestone which breaks with a sharp fracture and will evidently make valuable concrete material. The same limestone is cut into on the South Canal at 24 miles from the lake. The very hard phase of this rock is a fresh-water limestone. As found on the banks of the canal, however, marine and fresh-water limestones and marls are intermixed, indicating that here as elsewhere the formation includes alternating fresh-water and marine deposits. While the shallow-water shell, *Chione cancellata,* occurs here as at Coffee Mill Hammock, the predominating fossil in the Everglades is the estuarine and shallow-water form, *Rangia cuneata,* together with corals and other forms that inhabit shallow marine water. Pieces of this hard limestone are found on the North New River canal as far as 42 miles from the Lake, although for the last three or four miles of this distance the heavy limestone stratum gives place largely to marls.

The following is an analysis of a sample of this rock from the South New River canal, 25 miles south of Lake Okeechobee.

Analysis of limestone from 25 miles south of Lake Okeechobee.

	Per cent.
Calcium oxide, 44.68%, equivalent to calcium carbonate	79.80
Magnesium oxide, 0.38%, equivalent to magnesium carbonate	0.76
Phosphoric acid	trace
Insoluble, silica, etc.	17.90

Another limestone, seen on the North New River canal, is cut into by the dredge at a distance of about 42 to 52 miles from Lake Okeechobee. This limestone is granular and more or less distinctly oolitic in structure and is not so hard as that seen nearer the Lake. The surface of this rock becomes very rough on exposure, presenting a characteristic matted appearance. This rock is seen in the canal to within 9 miles of Fort Lauderdale (52 miles from Lake Okeechobee).

The following is an analysis of a sample of this rock from the North New River canal, 13 miles from Fort Lauderdale.

Analysis of limestone from the North New River Canal.

	Per cent.
Calcium oxide, 39.88%, equivalent to calcium carbonate	71.23
Magnesium oxide, 0.20%, equivalent to magnesium carbonate	0.40
Phosphoric acid	trace
Insoluble, silica, etc	26.56

Lying upon this limestone is a stratum of sand which was cut across in this canal for about 3 miles, or from 52 to 55 miles from Lake Okeechobee (9 to 6 miles from Fort Lauderdale), where it passes beneath the Miami oolitic limestone. This latter formation, the Miami oolite, coming in on this canal just above the dock extends east to the Atlantic Ocean. The following analysis was made from a sample of this rock from the North New River canal, 4 miles from Fort Lauderdale.

Analysis of Miami Oolitic Limestone.

	Per cent.
Calcium oxide, 42.40%, equivalent to magnesium carbonate	75.73
Magnesium oxide, 0.09%, equivalent to magnesium carbonate	0.18
Phosphoric acid	trace
Insoluble, silica, etc	23.00

A word as to the substructure of the Everglades is of importance in this connection since from the underlying formations must be obtained the water supply so necessary to the development of the country. As already indicated the Pliocene deposits seen on the Caloosahatchee River probably extend beneath the Everglades to the east. The next older deposits, the Miocene, since they are found exposed along the eastern flank of northern Florida and are believed to have been recognized in deep well drillings on the Atlantic coast, are likewise to be expected underlying southern Florida. The Oligocene deposits, which are yet older than the Miocene, and are extensively exposed to the north and west, may confidently be expected underlying the Everglades, although at a considerable depth. The older of the Oligocene formations, the Vicksburg limestone, has in fact been recognized in well drillings west, east and south of the Everglades. At Fort Meade, about 100 miles northwest of Lake Okeechobee, the Vicksburg limestone lies at a depth of 410 feet; at Palm Beach on the east, it is found at about 900 feet from the surface, while at Key West, about 100 miles southwest of the Everglades, this formation is buried to a depth of 700 feet. The Vicksburg limestone in particular is mentioned as it is the great water reservoir of the State, from which most of the large wells of peninsular Florida draw their supply. While its depth within the Everglades has not yet been determined, it is sure to be found there, and when drilled into it may confidently be expected to supply the abundant flow of water that is obtained from it elsewhere in the State.

From the account that has been given it will be seen that the formations of the Everglades consist of limestones, marls and sand strata, which in general dip to the east. It will also be seen that the surface limestones present considerable variation among themselves and are well suited to the general uses of a rapidly developing country, while from the deeper formations will be obtained an abundant water supply for domestic and industrial purposes.

MATERIALS FOR MORTAR AND CONCRETE.

MORTAR.

Sands, either siliceous or calcareous, suitable for mortar, occur in practically all parts of Florida. The size of the sand grains has a bearing on its qualities as a mortar sand. Coarse sand has a smaller surface area in proportion to volume than has fine sand. In order to obtain the best results each grain of sand in a mortar should be thoroughly coated with cement, and it appears probable that the coarse sand owing to its smaller proportion of sur-

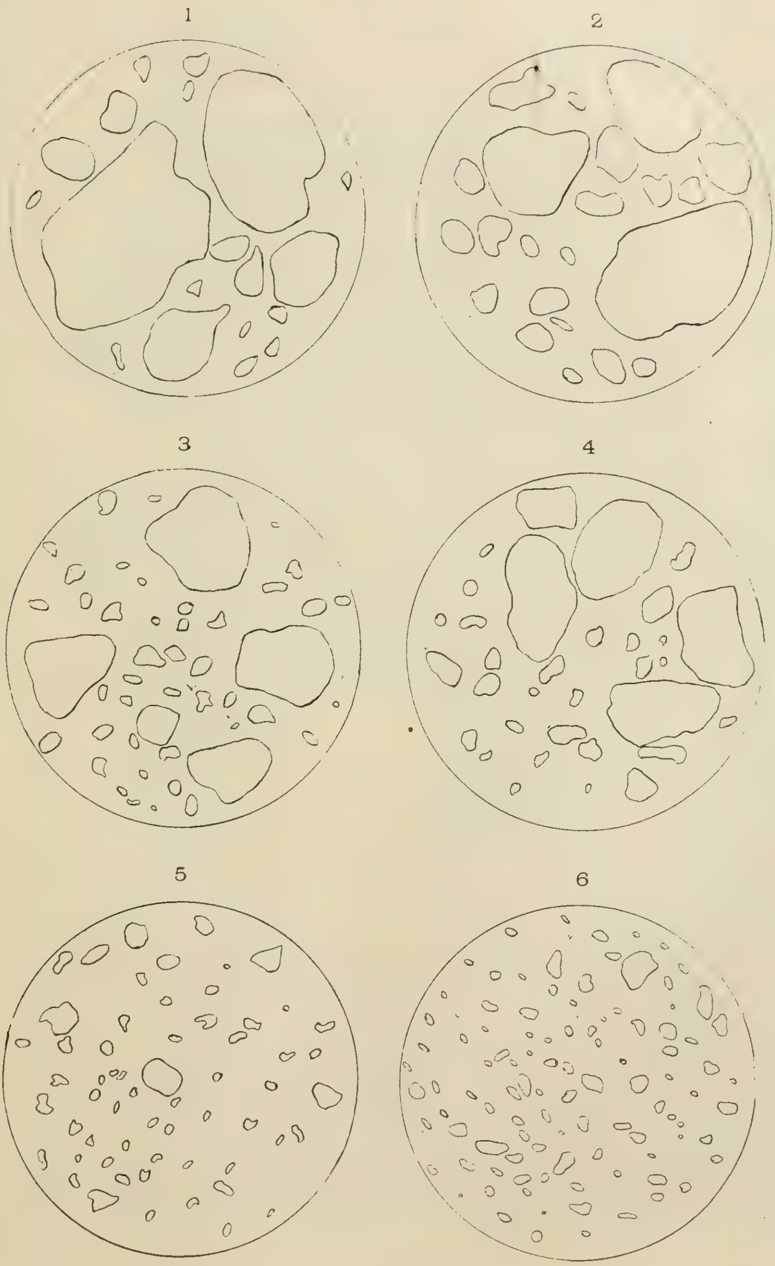


Fig. 7.—Florida Sands. No. 1, Alapaha River, Hamilton County; 2, Lake Weir, Marion County; 3, Glendale, Lake County; 4, Suwannee River, Suwannee County; 5, Cedar Keys, Levy County; 6, Crystal River, Citrus County. All figures 4 1-3 times natural size.

face area becomes better coated than a fine sand. While a coarse sand is preferable to a fine sand, for certain purposes it may be desirable to have a mixture of coarse and fine grains. The cement used in the mortar must be sufficient to completely fill all voids existing in the sand. The relative proportion of voids may be reduced by the use of a mixture of coarse and fine sands. Such a mixture of sands permits the use of a relatively smaller amount of cement, and is apparently without detriment to the resulting mortar. Sand is used along with lime in the manufacture of sand-lime brick; and with cement in the preparation of artificial stone or building blocks.

The sands most frequently used for mortar are siliceous. It appears, however, from various tests that calcareous sands are in no way inferior.* In addition to the natural sands ground rock may also be used. A small amount of clay, not exceeding eight per cent, is said not to weaken the cement. The presence of humus or peaty matter, or an excess of clay as well as mineral particles of any kind subject to decay, must be guarded against.

The accompanying illustrations show the prevailing shape of the sand grains from a number of localities in Florida. The relative size of the sand grains is also indicated, all of the illustrations having been drawn to the same scale.

CONCRETE.

The materials in Florida suitable for concrete consist chiefly of shell deposits and some compact limestones and of flint rock which may be crushed for the purpose.

Shell deposits, both recent and fossil, are numerous in the State. The use of shell from the coquina rock for building purposes has already been mentioned. Among notable buildings from these shells may be mentioned the Ponce de Leon hotel at St. Augustine. The calcareous shell mass as found at this locality may contain a small admixture of siliceous sand blown in by the winds. Recent shell deposits occur at many places along both the Atlantic and the Gulf coasts. Shell mounds piled up by the Indians are likewise numerous on and near the coast. Some occur inland also, those of the St. Johns River from Jacksonville to Sanford being notable examples.

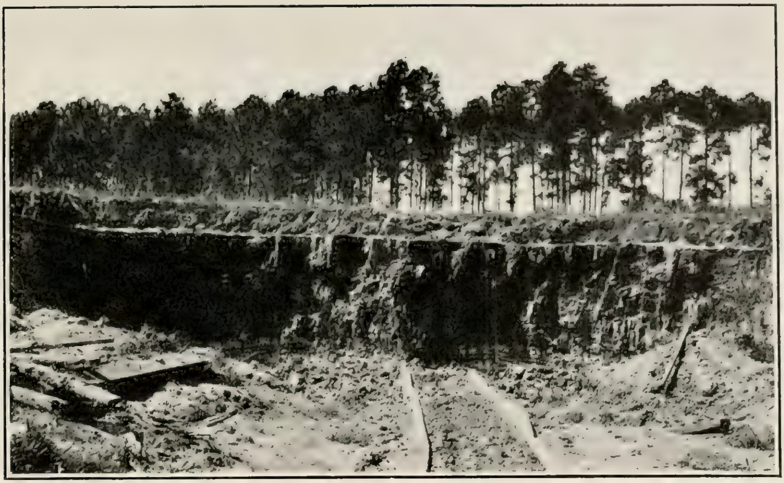
*Sabin, Cement and Concrete, p. 170, 1907.

Fig. 8.—Vicksburg Limestone, Ocala phase. in lime pit at Ocala.

Fig. 9.—View in the pit of the Keystone Brick Company, Whitney, Lake County.

Fig. 10.—View in the pit of the Clay County Steam Brick Company, Green Cove Springs.

Fig. 11.—Plant of the McMillan Brick Company, Molino, Escambia County.



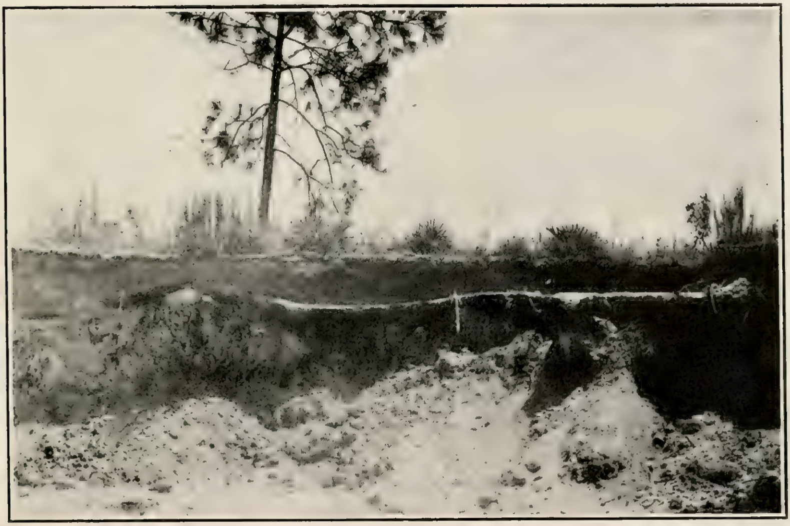


Fig. 12.—Vicksburg limestone, Marianna phase, Jackson County.

Fig. 13.—Miami oolitic limestone, Miami, Dade County.

Fig. 14.—Limestone exposure showing a mild fold in the strata, at Ft. Thompson, Lee County.

Fig. 15.—Limestone in Lake Okeechobee between Observation and Rita Islands. Exposed at low water. Concretionary phase.

Fig. 16.—Limestone in the Everglades. On North New River Canal 30½ miles from Lake Okeechobee.

Fig. 17.—Exposure of the Chattahoochee formation in cut of the Atlantic Coast Line Railroad near River Junction.

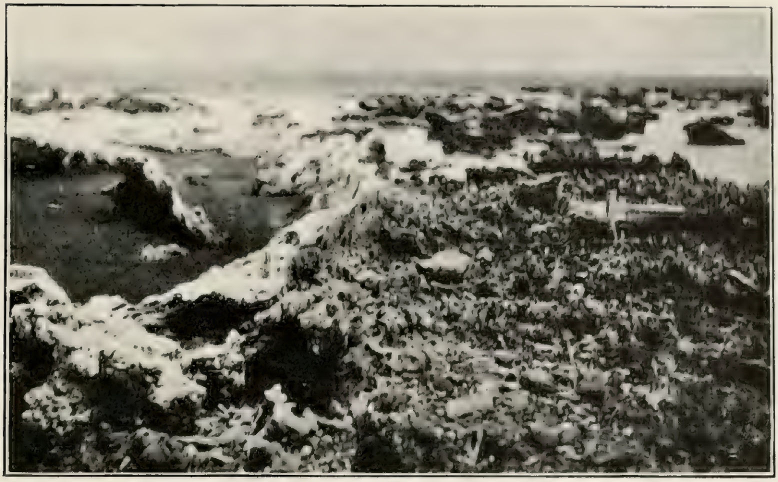


Fig. 18.—Exposure of fresh-water limestone at Ft. Thompson.

Deposits of fossil shells are likewise numerous, although as a rule less free from impurities than are the accumulations of recent shells.

Compact and hard limestones are found at many localities in the state, which when crushed afford desirable material for concrete. As stated under "Building Stone" local areas of compact and partly crystallized rock are found within the Vicksburg limestone formation which lies near the surface over much of central Florida. The Chattahoochee formation likewise has compact limestone strata, and the rock of this formation is being mined at Live Oak. The limestones of the Everglades which include strata that will serve excellently for concrete have already been described.

Flint is chemically an oxide of silicon (SiO_2), with more or less accompanying impurities. It is a variety of the mineral quartz, occurring massive and non-crystallized or more accurately very imperfectly crystallized (cryptocrystalline). The term chert is often used interchangeably with flint. Properly chert is an impure flint or flinty rock. Flint and chert are lacking in cleavage. They break, as do the other varieties of quartz, with conchoidal fracture. A flint rock when crushed breaks into sharp-cornered pieces of varying size.

Properties:—The mineral quartz, of which flint is a variety, has a hardness of seven on a scale in which the hardest mineral, diamond, is ten. The varieties of quartz vary in hardness slightly according to the impurities that they contain. Silica is one of the relatively insoluble minerals and is very resistant to decay.

Occurrence of Flint and Chert in Florida:—Flint and chert occur mostly as masses or "horsebacks" in the limestone formations. A good illustration of the manner of occurrence may be seen in phosphate pits or in some of the pits of the Florida Lime Co., at Ocala. In some of the sinks on Thompson's farm two miles east of Sumterville can be seen flint masses exposed by the natural decay of the limestone. The flint masses appear to conform to no rule as to size and extent. They may form ridges running through the limestone; or again they may occur as rounded or elongate masses. Occasionally the flint forms as a thin stratum lying horizontally. This flint-bearing limestone lies at no great distance from the surface throughout all of the central peninsular section of the State from Columbia County on the north to Sumter County on the south and from the Suwanee River and the Gulf coast to eastern Alachua and Marion Counties. Much of the hard rock phosphate rests upon and in this flint-bearing limestone, and from the phosphate pits great quantities of the flint may be obtained. Occasional flint hills such as that near Evinston and Micanopy stand out as evidence of the resistance of flint to the weathering agencies, the surrounding limestone having disappeared through erosion. This flint lies chiefly within the Vicksburg limestones. It is not to be inferred, however, that no other Florida formations contain silica. On the contrary, many of the formations are highly siliceous. The Vicksburg limestones are, however, the chief flint-bearing formations of Florida.

Fig. 19.—Exposure of Caloosahatchee marl.

The production of both sand and concrete is necessarily inadequately reported owing to the large number of small and occasional operators.

The following is a list of the companies in Florida that have reported the production of sand for building purposes or crushed rock for concrete during 1913:

Blowers Lime and Phosphate Company, Ocala.
Crystal River Rock Company, Crystal River.
Florida Crushed Rock Company, Montbrook.
Lake Wier Sand Company, Lake Wier.
E. P. Maule, Fort Lauderdale.
Woodman & Company, Ocala.

PEAT.

The investigations of the peat deposits of the State made during 1908, 1909 and 1910, by the State Geological Survey in co-operation with the United States Geological Survey, not only demonstrated that extensive peat deposits are widely distributed throughout the State, but also showed that the fuel value of the Florida peat is well up to the average of that of other countries. The original report on the peat deposits of the State was published in the Third Annual Report of the State Geological Survey,* from which is taken the following table of analyses of Florida peats together with the explanation of the samples and comments on the analyses. The only plant mining peat in Florida at present is that of the Ranson Humus Company, Pablo Beach.

Fig. 20.—Peat prairie covering several hundred acres (locality No. 41), about a mile northwest of Haines City, Polk County.

ANALYSES OF FLORIDA PEAT SAMPLES.

The subjoined table shows the percentage of water, mineral matter, volatile combustible matter, fixed carbon, sulphur, and (in a few cases) nitrogen, and the fuel value, of the samples of Florida peat collected by the writer in 1908-1910 and analyzed in the peat laboratory of the U. S. Geological Survey at Pittsburgh, Pa., mostly under the direction of Dr. F. M. Stanton.

In the number assigned to each sample the figures before the decimal point indicate the consecutive number of the locality, the first figure after the decimal point the number of the hole from which the sample was taken, and the last figure the number of the sample from that hole. In most cases

*A Preliminary Report on the Peat Deposits of Florida, by Roland M. Harper.

No.	COUNTY	LOCALITY	Depth of sample	Maximum depth
2.12	Leon	Gum swamp 5 miles W.N.W. of Tallahassee	1	6
2.21	"	Gum swamp 5 miles W.N.W. of Tallahassee	1	6
4.11	Lake	Peat prairie 3 miles east of Tavares	15	(35)
4.12	"	Do. ("infusorial earth" bog)	1	-----
6.11	Duval	Confluence of Davis and Julington Creeks	12	(30)
6.21	"	Do. Dry lump from bank of canal	?	-----
7.11	Santa Rosa	Blackwater River swamp near Milton	8	(20)
7.12	"	Blackwater River swamp near Milton	4	-----
8.11	Putnam	River swamp 1 m. S. of Palatka, near water	8	20
8.21	"	Same, about half-way back to dry land	4	10?
11.11	Osceola	Drained prairie bordering lake near Ashton	1	10
12.11	Polk	Small lake near Florence Villa	1	2
13.11	"	Bog or peat prairie bordering Lake Marianna	8	20+
13.12	"	Bog or peat prairie bordering Lake Marianna	1	-----
14.11	"	Slash-pine bog 2 miles west of Auburndale	6	10
15.11	"	Prairie bordering Lake Bony, E. of Lakeland	6	20+
16.11	Hernando	Withlacoochee River swamp near Istachatta	1¼	6
17.11	Citrus	Margin of L. Tsala Apopka, near Inverness	1	5
18.11	Lake	Saw-grass marsh on L. Harris, near Eldorado	6	10
18.12	"	Saw-grass marsh on L. Harris, near Eldorado	1	-----
19.11	"	Saw-grass marsh on L. Griffin, near Leesburg	10	12
19.12	"	Saw-grass marsh on L. Griffin, near Leesburg	1	-----
19.21	"	Do. Dry lump from bank of canal	?	-----
20.11	Hernando	Shallow basin in Choocochattee Prairie	1	3?
21.11	DeSoto	Non-alluvial swamp near Nocatee	1	3
22.11	Lake	Small grassy lake near West Apopka	1	2+
23.11	"	Marshes at west end of Lake Dora	2	4
23.21	"	Marshes at west end of Lake Dora	2	3
24.11	Dade	Gator-hole in Everglades, near Paradise Key	1	3?
25.11	"	Marly Everglades soil, near same place	1	-----
26.11	"	Everglades, near head of Miami River	2	5
27.11	"	Marshes of Miami R. about 2 m. from its mouth	2	4
28.11	"	Everglades 9 or 10 m. N.W. of Ft. Lauderdale	1	(15)
29.11	Lake	Small peat prairie near Clermont	6	10
29.12	"	Small peat prairie near Clermont	1	-----
30.11	Manatee	Peaty prairie 2 miles S. of Manatee Sta.	2	4
31.11	Sumter	Lake marshes near Panasoffkee	10	20
31.12	"	Lake marshes near Panasoffkee	4	-----
32.11	"	Bayou in cypress swamp near same place	6	12?
34.11	Lake	Marshes of Lake Apopka, near Montverde	8	10+
34.12	"	Do. (cultivated in corn)	1	-----
35.11	"	Along Helena Run, west of Lake Harris	1	3
36.11	Franklin	Tyty bay about 2 miles N.E. of Lanark	1	4
37.11	"	Deep tyty bay about 1 m. N. of Carrabelle	4	10+
38.11	"	Large tyty bay about ½ m. N. of Carrabelle	4	12+
39.11	Walton	Dense tyty swamp just N.W. of DeFuniak Sprs.	1	10
41.11	Polk	Large peat prairie 1 m. N.W. of Haines City	4	8
42.11	Madison	Large marshy prairie 5 m. E. of Greenville	1½	5

No.	Moisture in air-dry peat	ABSOLUTELY DRY PEAT: Ash	Fixed carbon	Volatile matter	Sulphur	Nitrogen	Fuel value (B. T. U.)	CHARACTER OF PEAT.
2.12	6.7	4.3	30.4	65.3	.48	2.30	9743	Full of roots and logs, reddish brown
2.21	5.7	7.5	29.4	63.1	.24	2.61	9439	and rather coarse.
4.11	5.5	18.7	27.2	54.1	.75	1.95	9025	
4.12	6.5	21.9	24.5	53.6	.68	2.53	4889	
6.11	8.6	13.8	31.8	54.4	2.77	1.89	9095	Decided sulphurous odor.
6.21	9.5	11.4	32.4	56.2	3.13	2.59	9056	Exposed to air 4 or 5 months.
7.11	3.4	79.7	6.8	13.5	.84	---	2597	Has sandy streaks.
7.12	3.5	67.7	11.9	20.4	2.12	---	2898	Has sandy streaks.
8.11	6.2	16.5	32.9	50.6	2.08	---	8644	
8.21	4.2	8.9	38.3	52.8	.94	---	9423	
11.11	4.6	19.9	33.9	46.2	.38	---	8456	Rather sandy.
12.11	7.1	36.9	24.8	38.3	.28	---	6361	Shallow and sandy.
13.11	7.0	4.2	34.8	61.0	.30	---	10424	
13.12	7.8	10.7	32.0	57.3	.40	---	9364	
14.11	8.0	7.9	36.2	55.9	.41	---	9580	
15.11	7.5	3.1	33.4	63.6	.39	---	10539	
16.11	8.4	15.5	28.1	56.4	.65	---	10561	Very coarse and incoherent.
17.11	8.2	12.4	27.5	60.2	1.00	---	9331	
18.11	4.1	39.3	17.5	43.2	.59	---	6352	Coarse, odorless.
18.12	5.3	5.1	28.6	66.3	.29	---	9502	Very coarse, little decomposed.
19.11	5.4	34.8	16.5	48.7	1.21	2.62	6768	Very coarse, little decomposed.
19.12	4.9	8.2	25.8	66.0	.37	---	9290	Very coarse, light colored.
19.21	7.2	8.2	32.8	59.0	.60	---	9391	Long exposed to air.
20.11	3.5	63.5	13.0	23.5	.14	---	3366	Black and sticky, but impure.
21.11	7.5	9.7	30.5	59.8	.30	---	9414	Coarse and full of roots, etc.
22.11	5.4	5.7	28.0	66.3	.40	---	10181	Brown, moderately coarse.
23.11	6.9	20.4	31.2	48.4	2.7	---	8500	
23.21	6.8	16.2	31.8	52.0	.41	---	8935	
24.11	6.2	51.4	13.4	35.2	.24	---	4325	Blackish, but very impure.
25.11	1.7	50.1	38.5	11.4	.09	---	1202	More like marl than peat.
26.11	8.2	9.2	84.5	56.3	.63	---	9691	Light brown above, blackish below.
27.11	5.6	39.5	26.0	34.5	2.66	---	-----	Contains streaks of silt or marl.
28.11	9.3	15.9	31.2	52.9	.42	---	8269	Rather coarse.
29.11	7.5	1.5	30.7	67.8	.39	---	10865	Very coarse and pale for peat prairie.
29.12	7.8	2.3	32.0	65.7	.28	---	10548	Very coarse and pale for peat prairie.
30.11	4.2	59.4	16.9	23.7	1.51	---	4237	
31.11	11.8	13.5	27.1	59.4	2.50	---	9000	Brown, moderately coarse, with
31.12	11.1	10.7	30.2	59.1	2.55	---	9216	slight sulphurous odor.
32.11	6.5	39.3	30.5	30.2	2.08	---	4111	Full of logs and shells.
34.11	11.3	14.2	32.0	53.8	.57	---	8635	
34.12	13.3	7.1	37.2	55.7	.29	---	8388	
35.11	12.0	12.4	29.0	58.6	.40	---	8109	Full of logs.
36.11	9.4	8.8	35.6	55.7	.17	---	10429	Black, plastic, retentive of water.
37.11	10.4	3.4	35.4	61.2	.78	---	10737	Brown, moderately coarse.
38.11	10.3	6.6	32.2	61.2	1.10	---	10512	Brown, moderately coarse.
39.11	5.9	24.6	31.2	44.2	.15	---	8384	Dark reddish brown, plastic.
41.11	10.1	3.9	39.0	57.1	.53	---	10402	Brown, fibrous, watery.
42.11	9.0	3.9	32.5	63.6	2.87	---	10048	Coarse, fibrous, little decomposed.

only one sample from each swamp or bog was taken, on account of the limited time available. For the same reason nearly half the samples were dug out by hand from a depth of about a foot. The deeper ones were taken with a sampling instrument devised by Dr. Chas. A. Davis, consisting of a number of sections of half-inch iron pipe which could be screwed together, one of them with a short transverse handle at one end, and a brass cylinder nearly an inch in diameter and about nine inches long, which could be screwed to the pipes and pushed down to any desired depth, and then filled with peat from that depth by an ingenious mechanism. This cylinder had to be filled a good many times to obtain a sufficient quantity of peat for analysis, and in practice each sample was made up from several taken from the same depth within a few feet of each other.

The next column after the name of the locality gives the depth from which the sample was taken, and the last column on the first page the maximum depth of peat found in each deposit. In a few cases where this depth was given me by other persons the figures are put in parentheses.

The moisture percentage is taken from air-dry samples, and the other determinations were made after the water was eliminated by heating slightly above the boiling point (not enough to decompose or volatilize the peat.). The ash was not analyzed, but it is probably chiefly silica in most cases, though in the samples from Panasoffkee, Helena Run, and the south end of the Everglades it must be mostly lime. The reason for determining the sulphur (which is done more generally for coal than for peat) is that an excess of it would have a corrosive effect on the iron parts of fire-boxes, and might also be objectionable if the peat was made into illuminating gas. The percentage of nitrogen gives some indication of the value of the peat for agricultural purposes.

The ash, fixed carbon and volatile matter (other than water) together add up to 100% in each case. The sulphur and nitrogen are part of the volatile matter determined separately. The percentages of ash and fixed carbon added together give the amount of coke which may be obtained from each sample, for in the process of coking enough heat is used to drive off all the other ingredients.

The fuel value is given in "British thermal units" per pound. A British thermal unit is the quantity of heat required to raise the temperature of a pound of water one degree Fahrenheit, or, to be more precise, from 50° to 51° F. If the fuel value is given as 10,000 B. T. U., for instance, this means that a pound of the material if burned under the most favorable conditions could be made to raise the temperature of 5 tons of water 1°, or 1 ton 5°, etc.

MISCELLANEOUS ANALYSES.

A few analyses of Florida peat have been obtained from other sources, as follows:

1. Small peat prairie about two miles northwest of Orlando, Orange County. The peat here seems to be at least 15 feet deep, and a few years ago a good deal of it was excavated to a depth of about 8 feet, put through a briquetting machine on the spot, and when dry taken to town and used for fuel in the light, water and ice plant. Analyses taken from U. S. Geol. Surv. Mineral Resources for 1905, p. 1321, and Bulletin 290, p. 77. In these publications the fixed carbon and volatile matter were given only for air-dry peat, but I have re-computed these two factors on a water-free basis, so that they can be compared with the table above.

2 to 5. Marsh at confluence of Davis and Julington Creeks, Duval County, already described. Samples collected by Robert Ranson in May, 1908, from various depths (of which the records are not now available), analyzed by the U. S. Geological Survey, and results communicated to the writer by Dr. Chas. A. Davis.

6. Average of 26 samples from various points in the vicinity of the St. John's River, analyzed for Robert Ranson, and communicated by him. His figures were for air-dry peat, but I have re-computed them on a water-free basis, except the fuel value.

7. Mangrove peat from along east side of Snake Creek, which is the channel between Windly's Island and Plantation Key (or Long Island), Monroe County, near 437 mile-post on Florida East Coast Ry. Taken from about 3 feet below the surface, in mangrove swamp, whose vegetation is mostly *Rhizophora Mangle* (red mangrove). Peat reddish brown, very coarse and fibrous. Collected in September, 1910, under direction of W. J. Krome, Constructing Engineer of the F. E. C. Ry. Extension, at our request. Analysis by E. Peck Greene, assistant state chemist.

No.	Moisture in air-dry peat	ABSOLUTELY DRY PEAT					
		Ash	Fixed Carbon	Volatile matter	Sulphur	Nitrogen	Fuel value (B. T. U.)
1	17.2	8.3	30.1	61.6	.59	2.89	10082
2	---------	14.7	30.7	54.6	4.08	1.93	8816
3	---------	18.0	29.9	52.0	3.94	1.97	8586
4	---------	25.7	25.9	48.4	3.64	1.66	7783
5	---------	16.6	30.8	52.6	4.13	1.94	8705
6	10.0	11.0	26.1	62.8	.39	2.74	(9877)
7	16.0	15.2	---------	---------	---------	2.36	--------

NOTES ON THE SIGNIFICANCE OF SOME OF THE ANALYSES.

It would seem from the figures given that most of our peat contains only about half as much water when air-dry as does the better known material from the glaciated region of Europe and the northern parts of this continent. Too much stress should not be laid on this, however, for the water-content shown probably depends nearly as much on the condition of the air at Pittsburgh at the time the analyses were being made as it does on the nature of the peat itself. (All the samples which show more than 10% of water were collected in April, May or June, and analyzed a month or two later, when the air of the room in which the tests were made was presumably more humid than in winter, on account of artificial heat not being used.) Nevertheless, it is probably safe to say that the Florida peat dries out as well as that from any other part of the world, if not better.

The purest peat is No. 29.11, which has only 1.5% of ash. Other samples with less than 5% are Nos. 13.11, 15.11, 29.12, 37.11, 41.11, 42.11, all of which are from peat prairies or similar situations. (Locality No. 37 I have called a tyty bay, but it is treeless in the middle, and, therefore, has the character of a peat prairie.)

The proportion of volatile matter to fixed carbon is nearly 3 to 1 in No. 19.11, a coarse saw-grass peat. In nearly every case where it is over 2 to 1 the peat is coarse and imperfectly decomposed. It runs below 1½ to 1 both in good black plastic peat and in some very impure samples, which might be better designated as muck.

The sulphur runs highest in estuarine peat, especially in that from Julington Creek (No. 6.21 and miscellaneous Nos. 2-5), and is pretty high in calcareous peat and that from Madison County. There is probably not enough of it to be objectionable in any of our samples, however. It is lowest in the samples from small filled lakes, bays. etc. No. 36.11 contains the least sulphur in proportion to other volatile matter, and No. 39.11 is a close second in that respect. (Both of these happen to be from tyty bays.)

The nitrogen determinations unfortunately are too few to warrant much generalization, but in other parts of the world the nitrogen content of peat is rarely less than 1% or more than 3%, and the same seems to hold true in Florida, as far as our information goes.

In fuel value our peat compares very well with that in other parts of the world. According to Davis, 5,760 B. T. U. per pound is a good average for wood, 8,500 for pressed peat, and 14,000 for anthracite coal. The average of the 53 determinations given in the above tables is 8,341; but if Mr. Ranson's 26 samples combined (miscellaneous No. 6) had been counted separately the average would have been 8,833. Most of our samples (counting miscellaneous No. 6 as only one again) exceed 9,050 B. T. U., two-thirds of them exceed 8,500 (Davis's average), and three-fourths of them exceed 8,341 (our average).

The highest fuel value is as a rule in the purest peat. No. 29.11 (the purest) is best in that respect, though No. 16.11, with 15.5% of ash, and no plasticity (and therefore not adapted to be made into briquettes), stands very high in the list. It should be borne in mind that the fuel value given in these tables is on a water-free basis, which is never realized in practice, for peat as used always contains some water, which reduces its fuel value. But the analyses are usually expressed in this way to eliminate differences due to variations in atmospheric humidity.

PHOSPHATE

CONTENTS.

INTRODUCTION.

The present paper on Phosphate is largely based on the following papers prepared during the year: (1) The Impurities That Affect the Market Value of Phosphate Rock, Their Origin, Character, and the Methods of Their Elimination in Mining; (2) Conservation as Applied to Methods of Mining Phosphate; (3) The Phosphate Deposits of the Southern States. Of these, the first-mentioned, prepared for the American Institute of Mining Engineers, was given in abstract at the Pittsburgh meeting, October, 1914, and published under the title, "The Origin, Mining, and Preparation of Phosphate Rock" in the September issue of the Bulletin of the Institute, pp. 2379-2395, 1914. The second paper was presented at a meeting of Geologists held at Knoxville, Tennessee, September 19, 1913, in connection with the National Conservation Exposition. The third paper was prepared for the Atlanta meeting of the American Association for the Advancement of Science.* Although based chiefly on these papers, the present report does not include the exact reproduction of any one of them except the one on the Impurities of Phosphate Rock, which is included here with only minor changes from the original manuscript.

*Abstract in Science n. s., Vol. 39, p. 401, March 13, 1914.

THE IMPURITIES THAT AFFECT THE MARKET VALUE OF PHOSPHATE ROCK, THEIR ORIGIN, CHARACTER AND THE METHODS OF THEIR ELIMINATION IN MINING.

Phosphate rock, like most other mineral substances, is found in nature in varying degrees of purity. Of the impurities that are present some are constituents of the rock itself; others are inclusions of a foreign substance within the rock; while still others represent merely associated materials or minerals, either clinging to the rock or found in cavities and natural depressions, and hence largely removed in mining. Some of these impurities are distinctly deleterious to the processes of manufacture for which the phosphate is mined, while others, although neutral in action or nearly so, yet by their presence reduce the average grade of the rock and thus add useless bulk to the shipment.

It is the object of refined processes of mining to bring the product, as delivered from the mine, to the highest possible grade consistent with the market requirements and demands. This, however, is not accomplished without actual loss in the form of discarded phosphate. It is evident, therefore, that the devising of methods for reducing this loss in mining, and yet maintaining the grade of the rock which the market requires is an improvement in mining methods greatly to be desired by the producers and toward which all are working.

THE MINERALS OF PHOSPHATE ROCK.

The minerals included under the term "phosphate rock" are the calcium phosphates. Of these, apatite is perhaps the most definite and constant in composition, although of this mineral two varieties are recognized, namely, fluorapatite, $Ca_5(PO_4)_3F$, and chlorapatite, $Ca_5(PO_4)_3Cl$. Moreover, the calcium of this mineral may be partly replaced by manganese, forming yet another mineral, manganapatite; or the mineral may become hydrated, forming hydroapatite, which is found as mammillary deposits often not unlike chalcedony in appearance. The term "phosphorite" has been applied to the massive amorphous deposits of phosphate which may be compact, earthy or concretionary. Among other varieties of apatite may be mentioned, staffelite, which contains a small percentage of both iron and aluminum. It is of interest to note also that this variety is believed to result from the action of carbonated waters on phosphorite, and hence is likely to occur incrusting ordinary phosphate rock acted upon by carbonated waters. Another variety, pseudoapatite, contains both sulphur and carbon dioxide.* Of the many other calcium phosphate minerals some closely approximate apatite while others grade into compounds so variable and indefinite in composition as scarcely to be classed as minerals. The deposits of phosphate found in nature evidently contain a number of calcium phosphate minerals, the constituent impurities of which affect the market value of the rock. The aluminum phosphate, wavellite, should also be mentioned since it is mined to some extent as a source of phosphorus.

ASSOCIATED MINERALS.

Various other minerals are found associated in nature with the calcium phosphates. This association is sometimes due to actual relationship between the minerals. On the other hand the association of minerals may be purely accidental, or incidental to the manner of formation of the deposits. With regard to the related minerals, it is apparent that where the calcium phosphates are abundant, other phosphates are likely also to occur. In fact it is scarcely to be expected that extensive calcium phosphate deposits will be found without the presence of at least a limited amount of other phosphate minerals. This is particularly true of iron and aluminum phosphates. These two bases are widely disseminated in nature and, moreover, they combine readily with phosphoric acid to form phosphates. Of the iron phosphates the mineral vivianite, although occurring in relatively small quantities, is widely distributed in nature, and may occur in limited quantities in phosphate

*Dr. Austin F. Rogers, who is investigating phosphate minerals, states that phosphorite, or phosphate rock, seems to be a mixture of two minerals, amorphous collophanite, largely a solid solution of calcium carbonate in calcium phosphate, and crystalline dahllite, a calcium carbonophosphate with the formula $3Ca_3(PO_4)_2$. $CaCO_3$ analagous to fluorite. The amorphous collophanite gradually changes to the crystalline dahllite. (Personal letter of May 23, 1914.)

deposits, usually as an incrustation, or as an alteration product of other minerals. The iron minerals frequently form in bogs, and it is an observed fact that the phosphate deposits in such localities not infrequently contain more iron than do the same deposits when found on the uplands. In such cases the iron is doubtless a comparatively recent infiltration, and may include phosphates of iron as well as oxides and other iron minerals. Of the aluminum phosphates a large number are known, one of which, wavellite, as already stated, is mined as a source of phosphate. This mineral and others of the aluminum phosphates are likely to occur in association with calcium phosphate.

Some of the large phosphate deposits have been formed by the replacement of an original rock by calcium phosphate. In this process parts of the original rock not infrequently remain unchanged or incompletely phosphatized. Since the phosphatizing processes proceed from the surface, the imperfectly phosphatized remnant is likely to lie within the rock, thus giving rise to included impurities that are difficult to eliminate. Moreover, small amounts of clay and silica are usually found in the limestone and as these substances do not readily phosphatize, if not worked out, they remain as impurities in the rock.

Aside from these related minerals, the materials associated with the phosphate rock are varied in character. They include clay, fragments of limestone, flints, gravel, silica in the form of sand, and other resistant materials, the character of which is determined by the manner of formation of the deposits. The associated materials of this nature make up the matrix in which the phosphate rock is imbedded. It is scarcely possible in mining to remove entirely all associated minerals, and the purity of the rock as delivered to the market, is affected, without doubt, by the presence of more or less of these minerals, as well as by the constituent impurities of the rock.

OBJECTIONABLE IMPURITIES.

Of the impurities contained in or associated with phosphate rock. the most objectionable in the processes of manufacture of acid phosphate for fertilizers, for which purpose the phosphate rock is almost wholly used, are iron and aluminum. For this reason practically all phosphate mined is sold under a guarantee that the combined iron and aluminum expressed as oxides, do not exceed a given small percentage of the whole, from 2 to 4 per cent being allowable. Iron when present in excess of about 2 per cent brings about reactions which result in the formation of a gelatinous substance injurious to the mechanical condition of the mixture, occasioning also a loss of soluble phosphoric acid. A first step in the reaction with the iron is probably as follows: $2FePO_4+3H_2SO_4=2H_3PO_4+Fe_2(SO_4)_3$. Of the sulphate of iron thus formed, a part according to Fritsch*, reacts on acid phosphate of lime, thus forming the objectionable gelatinous precipitate. Owing to the demand of calcium sulphate for water, hydrated iron phosphate, which is a product of these reactions, may subsequently become dehydrated and insoluble, thus causing the loss of available phosphoric acid.

Aluminum, existing as a silicate in phosphate rock, is likely to be injurious, since, according to Fritsch, if not decomposed by the acid, it may cause a part of the phosphoric acid to retrograde. However, when existing in the rock in small amounts as a phosphate, the aluminum is not supposed to occasion a loss of phosphoric acid, both the hydrated and non-hydrated phosphate being soluble in the precipitated condition in phosphoric acid.

Carbonates of calcium, when existing in small quantities in phosphate rock, are beneficial rather than injurious. When the ground rock is treated with acid the carbonate is the first of the ingredients to be attacked, and the heat thus engendered promotes subsequent reaction among the other constituents. Moreover, the carbon dioxide gas, given off from the carbonate, lightens the mixture and facilitates drying. Phosphate rock low in, or lacking, carbonate develops little heat in mixing, and reacts slowly. In such cases this constituent must be added. It is true that the presence of the carbonate necessitates the use of an increased amount of acid, which in turn results in the formation of an increased amount of calcium sulphate or gypsum.

The amount of carbonate that is desirable is sometimes given as 5 per cent, but the limits are not strict, and manufacturers do not as a rule find it necessary to specify directly the amount of the carbonate that the rock must or must not contain. Indirectly, however, an excess of the carbonate is guarded against by other

*J. Fritsch, The Manufacture of Chemical Manures, p. 79, 1911.

requirements as to the grade of rock. If it is true, as elsewhere stated in this paper, that the principal mineral of the massive phosphate deposits is a calcium carbono-phosphate, this fact will afford an explanation of the presence of the desired amount of carbonate in all phosphate deposits of this class.

The fluorine found in phosphate rock, upon being attacked by the acid, forms hydrofluoric acid gas which passes into the atmosphere, it being estimated that as much as from 50 to 66 2-3 per cent of the fluorine present is eliminated in this way. Although a small amount of acid is used up in this reaction and a proportionate amount of calcium sulphate formed, yet it is seldom, if ever, necessary to specify against the fluorine content of the rock, the amount present being negligible.

Among the numerous other impurities that may be present in phosphate rock, silica and clay are perhaps the most common. Here also should be mentioned moisture, which when present not only adds bulk to the shipment but also interferes with the processes of manufacture. The excess of moisture must, therefore, be removed by drying, not more than 3 or 4 per cent being allowable in the rock as shipped.

THE ORIGIN OF PHOSPHATE DEPOSITS.

The origin of phosphate deposits is such that the presence of associated minerals as well as constituent impurities is almost invariable. The original source of phosphorus, the constituent for which phosphate rock is mined, is in the igneous and crystalline rocks, where it exists in combination with other elements forming phosphate minerals. These minerals, as indeed is true of all minerals, are soluble in water, the degree of solubility, however, varying with the different minerals, and with the diverse conditions to which they are subjected. Indeed, some very interesting and suggestive observations have been made on the relative solubility of phosphates under varying conditions. Thus it has been shown that the solubility of the phosphate minerals is increased by the presence of decaying organic matter in water. They have also been found to be appreciably soluble in carbonated waters. In this connection Reese* has made the very important observation

*Chas. L. Reese, Amer. Jour. Sci., 3rd Ser., Vol. 43, p. 402, 1892.

that while the phosphate dissolves freely in waters containing decaying organic matter and in carbonated waters, yet when allowed to stand over calcium carbonate, the phosphate is redeposited. In summing up his observations Reese says: "This experiment shows that phosphates may be transported in hard waters, but on standing on calcareous beds would tend to be given up." In speaking of hard waters the author evidently has in mind waters containing, among other things, carbon dioxide in solution, and his conclusion is that such waters will or may drop the calcium phosphate from solution when they stand over limestone. These observations, if true, have two important corollaries, one of which has been noted by Clarke, (U. S. Geol. Surv. Bull. 330, p. 443, 1908) namely, that in the presence of the carbonate, the phosphate would probably not be dissolved, while the carbonate could pass into solution, thus leaving the enriched residue of phosphate. The second corollary is that calcium phosphate taken into solution by the soil waters at and near the surface may be thrown out of solution in case the water stands for a time at a lower level in the earth on or over limestones. That this process may have been and probably was a factor in the formation of large phosphate deposits resting upon limestone will be shown in the subsequent pages of this paper.

The rain water, in passing through the soil and surface materials, receives organic acids from the decay of vegetable and animal matter. It also receives carbonic acid which is held in solution, the water thus becoming carbonated, and hence more efficient as a solvent. The original rocks and the soils derived from them contain particles of the phosphate minerals, which when acted upon by the ground waters pass slowly into solution. It is through the solution of the mineral, its removal and subsequent redeposition that workable phosphate deposits are formed. When it is remembered that the phosphorus in the igneous rocks amounts to merely a fractional part of one per cent of the whole,* and was without doubt originally widely disseminated, the importance of the processes of concentration of the mineral by ground water and the extent to which they have operated becomes evident.

The removal of the mineral from the original rocks and its concentration in later rocks is by no means a simple process. There

*According to Clarke, Bulletin 330, U. S. Geological Survey, p. 32, 1908, the phosphorus in the lithosphere amounts to only .11 per cent.

are as a rule many intermediate stages, the load being taken up, dropped again for a time, only to be once more started on its journey. Among the primary results of concentration and enrichment may be mentioned the phosphate deposits of the crystalline rocks, where the mineral is found in veins, being more or less perfectly crystallized as the mineral apatite. Of deposits of this class some, including those of Canada, are of economic importance, and would be more extensively worked were it not that other and more cheaply mined phosphate deposits are available.

Of the phosphate taken into solution by the ground water a part is taken up from the soils through the roots of plants, and thus becomes a constituent of the plant life of the earth. From the plants the phosphorus passes to herbivorous animals, and through them to carnivorous animals. Phosphorus thus becomes a constituent of the organic life of the earth. The bones of the vertebrate animals in particular contain an appreciable amount of calcium phosphate. It seems well established also that certain of the important phosphate deposits, as well as the guano deposits are derived from excrement and remains of gregarious animals, particularly birds. It is also true that a part of the phosphate taken into solution by the ground waters is again thrown out owing to changed chemical conditions, and in this way important phosphate deposits are formed. In any case, however, the phosphate may be regarded as only temporarily delayed in its round of circulation. Ultimately phosphate is carried in solution in the ground waters through springs and rivers to the ocean. While the amount in solution at any one time is relatively small, yet, through the continued operation of this agency over long periods of time, a large amount has been carried into the ocean.

The phosphate carried into the ocean is again removed from solution through the agency of organic life, or owing to changed chemical conditions, is precipitated. Of the animals that utilize phosphorus taken from the sea water in the construction of a shell covering or skeleton, the best known perhaps is the brachiopod, *Lingula,* the shell of a recent species of which has been found to contain 85.79 per cent of calcium phosphate. The tests of the crustacea, although less distinctly phosphatic than the shell of *Lingula,* contain an appreciable amount of phosphate. Thus the shell of a recent lobster was found to contain 3.26 per cent of calcium phosphate, while the lobster as a whole contained .76 per cent.* The aquatic plants also utilize some of the phosphorus in solution in the water and through them the phosphorus passes to the skeleton of vegetable feeding aquatic animals, and through them in turn to the carniverous animals.

The phosphorus taken from solution by chemical action is evidently considerable, since nodules of chemical origin, high in phosphates are found somewhat abundantly in the bed of the ocean. Some of these nodules, reported by Clarke,† contain 19.96 to 23.54 per cent of phosphoric acid.

The amount of phosphate that finds its way into the sedimentary formations through organic and chemical agencies is thus undoubtedly considerable resulting in the enrichment of certain deposits which, if not themselves workable, at least serve as an important source of phosphate from which by further concentration workable phosphate deposits are formed.

In this respect the deposition of calcium phosphate is analogous to that of the related mineral calcium carbonate, although of the carbonate much more extensive deposits accumulate than of the phosphate. The carbonate, as is well known, is not only a much more abundant constituent of the superficial formations of the earth than is the phosphate, but, under the conditions that normally exist on and near the surface of the earth, is also a much more soluble mineral. Moreover it would seem from some of the experiments that have been recorded that when the two minerals occur together the carbonate is taken up by preference, leaving the phosphate, thus giving in effect a degree of selective solubility favoring the carbonate. The carbonate, therefore, is carried in solution by the surface and ground waters in much larger quantities than is the phosphate, and is also apparently readily available as a skeleton-building material. Accordingly the aquatic life of the earth has utilized the carbonate largely in building protective skeletons. This is true not only of the corals and of the mollusks of marine and fresh waters, but also of many other organisms, important among which by reason of their abundance are the unicellular foraminifera. Indeed in such abundance have the organisms with calcareous skeletons flourished, under the favorable con-

*Bull. 330, U. S. Geol. Surv., p. 448, 1908.

†Bull. 330, U. S. Geol. Surv., p. 105, 1908.

ditions that are found in marine waters, that their remains have often accumulated to form extensive and nearly pure limestones. Fresh-water limestones of organic origin are also not uncommon, although of lesser extent and thickness than are the marine formations. Moreover, not only is the carbonate taken from the water through the action of organic life, but owing to changed conditions in both fresh and marine waters it may be thrown out of solution, forming limestone by chemical action. Thus by organic and chemical processes extensive marine and fresh water limestones are formed.

Silica (SiO_2) in its round of circulation in the earth presents some interesting analogies and yet strong contrasts to both calcium phosphate and calcium carbonate. In point of abundance silica exceeds both the carbonate and the phosphate, being by far the most abundant constituent of the earth's crust, making up, according to the estimate of Clarke, 59.79 per cent of the lithosphere.* In point of solubility, on the other hand, silica is much less soluble than calcium phosphate, and under the conditions that ordinarily prevail on and near the surface of the earth, many times less soluble than calcium carbonate. However, by reason of its abundance and the fact that in the form of sand it is ever present in the soil and surface residual materials, it is found in solution in all ground waters, and is present in the waters of the ocean in small although recognizable amounts. Silica is also used to some extent by plants and animals as skeleton-building material, the largest users of silica for this purpose being, among plants, the diatoms, and among animals, the unicellular radiolarians and certain of the sponges. From the skeletons of these organisms a limited amount of silica of organic origin has been included in sedimentary rocks. Silica, however, as a skeleton-building material has not been so extensively used as to result in the formation of large deposits, and aside from diatomaceous earth, usually of local extent, large deposits of silica of organic origin are unusual. The massive accumulations of flint, not infrequently found in sedimentary rocks, are formed by the replacement of the original rock by silica in solution in the ground waters, presenting in this respect an analogy to a similar process which has operated in the formation of certain calcium phosphate deposits.

*U. S. Geol. Surv. Bull. 330, p. 31, 1908.

While the round of circulation of phosphate minerals is thus capable of demonstration as a normal process comparable to that of other common minerals, yet the actual processes of the accumulation of large workable deposits of phosphate rock are in many ways complicated.

THE FLORIDA PHOSPHATE DEPOSITS.

The complexity of origin of the phosphate rock, and the manner in which impurities are included in the formation, is well illustrated by the Florida phosphate deposits. Of these there are two distinct types known respectively as the hard rock and the land pebble phosphates. These differ materially in their location, origin and manner of occurrence. The hard rock phosphates lie in a belt along the Gulf side of the peninsula, extending in a general north and south direction roughly paralleling the Gulf coast for a distance of about 100 miles. The land pebble phosphate deposits are found farther south, lying chiefly in Polk and Hillsboro counties.

The hard rock phosphate deposits rest upon a thick and very pure, light-colored, porous and cavernous limestone known as the Vicksburg formation, which is of Lower Oligocene age. At the present time, in that section of the State in which the hard rock phosphate occurs, no formation other than the phosphate itself lies on top of this limestone. It has, however, been demonstrated by the combined observations of several geologists that certain formations, of which only a residue remains, formerly extended across the area that now holds the hard rock phosphate deposits. The formations referred to are the Chattahoochee Limestone and Alum Bluff sands, both of which are of Upper Oligocene age. These formations are now found bordering the hard rock phosphate area. The proof of their former extent has been given elsewhere and need not be repeated at this time.* The hard rock phosphate deposits are made up largely of the residue of these formations which have disintegrated *in situ* and accordingly consist of a mixture of materials of the most diverse character including sands, clays, limestone fragments, pebbles and water worn flints, vertebrate, invertebrate and plant fossils; in fact a heterogeneous mixture of

*Origin of the Hard Rock Phosphate Deposits of Florida, by E. H. Sellards, Fifth Annual Report, Florida State Geological Survey, pp. 23-80, 1913.

the relatively insoluble and resistant elements of the earlier formations.

The phosphate itself is derived from the Alum Bluff sands, the later and thicker of the two formations that have disintegrated. This formation, the Alum Bluff, in some places reaches a thickness of several hundred feet, and has a large areal extent reaching from west Florida, through northern and central Florida, into southern Florida. Throughout its entire thickness, and throughout its whole areal extent this formation is distinctly phosphatic, although in no instance is the phosphate in this formation sufficiently concentrated to form workable deposits.

While these formations, the Chattahoochee and the Alum Bluff, were disintegrating in the area that is now the hard rock phosphate region, the calcium phosphate from the Alum Bluff formation was gradually being taken into solution by ground water and was being redeposited at a lower level in the earth, thus forming the workable hard rock phosphate deposits. In this process the replacement of the original limestone by calcium phosphate was an important factor, and these deposits afford excellent illustration of the formation of phosphate rock by the replacement process, the shells of the original limestone in many instances retaining their form, although changed chemically to calcium phosphate. In addition to replacement, other processes are observed, prominent among which is the formation of the phosphate by precipitation from solution in a manner similar to the formation of calcium carbonate deposits in caves. This process is evidently secondary, and, being now operative, is to be observed in the phosphate boulders themselves, in which all existing cavities are being gradually filled by the accumulation of calcium phosphate. By this process pinnacles are formed hanging from the roof of the cavities, while successive layers of phosphate are spread out over the floor of the cavities. This method of formation of phosphate deposits has given rise to very high grade phosphate rock, the Florida hard rock grading, under present methods of mining, 77 to 80 per cent tricalcium phosphate, while individual specimens contain 84 to 85 per cent.

While the origin of the hard rock phosphate in its present form is thus clearly evident, there yet remains a large field of investigation to determine the chemical processes by which the phosphate is first taken into solution, and is subsequently redeposited. Some of these processes, however, are well understood. That normal phosphate is to some extent soluble in soil waters is well established and fully recognized. In the hard rock phosphate section of Florida there is practically no surface drainage, the rain water passing directly into the earth. At a lower level the circulation of the water is interfered with and the water may become stationary or nearly so. The check in circulation is due in some instances to masses and beds of clay which are residual from the disintegrating formations. In any case the movement of the water is checked upon reaching the water line. The relation of the phosphate deposits to the ground water level, and also the evident and probable changes of the water level during geologic time have been discussed in the writer's paper on these deposits previously referred to. It is thus apparent that there are important changes in the chemical conditions in the earth. Among these may be mentioned the check to the free movement of the water, and the evident mingling of different waters. In this connection the observations of Reese, previously referred to, in which it is shown that calcium phosphate in solution in carbonated waters is precipitated when the water stands over limestone, are particularly suggestive. As shown in my earlier papers the hard rock phosphates of Florida are invariably formed directly upon limestone, and need not be sought for elsewhere. Moreover they are thrown out of solution from carbonated waters which pass over and through these limestones, the manner of their formation apparently being entirely in accord with Reese's experiments.

The land pebble phosphate deposits of Florida are probably derived, like the hard rock deposits, from the Alum Bluff formation. The processes by which they have accumulated in their present form are, however, strikingly different. While the hard rock phosphates, as has been stated, represent chemical precipitates or replacement deposits, the phosphate having been transported to its present location in solution, the land pebble deposits appear to represent materials which are residual from erosion of the parent formation. The hard rock phosphates occur in sections where the parent formation has entirely disintegrated over limestones; the land pebble deposits, on the contrary, are found as a blanket deposit resting upon, and representing a concentration from the parent formation. It thus follows that the matrix of the land pebble deposits is not necessarily strikingly different from that of the hard rock deposits, except as chemical action has modified the residue, particularly by the formation in many instances of siliceous boulders in the hard rock deposits.

The grade of rock produced from the land pebble deposits under the present methods of mining varies from 66 to 74 per cent tricalcium phosphate, while individual samples contain from 77 to 78 per cent.

THE TENNESSEE PHOSPHATE DEPOSITS.

As further evidence of the complexity of the origin of workable beds of phosphate, and of the diversity of ways in which the deposits may accumulate, may be mentioned the phosphates of Tennessee.

The brown phosphates of Tennessee are very evidently formed *in situ* from phosphatic limestone. Hayes and Ulrich* find that at least four limestone horizons have given rise to brown phosphates in Tennessee. The calcium carbonate from the limestone is more or less completely leached out, and is replaced in part at least by calcium phosphate.† The rock is thus enriched and becomes a workable phosphate. The leaching of the rock usually begins along jointing planes and for this reason unchanged masses of the original limestone in this type of deposit frequently remain as "horses." Two types of deposits are recognized, which are known as "blanket" and "collar" deposits. The blanket deposits are those which extend over a considerable area; the collar deposits are formed where the phosphatic limestone comes to the surface around the slope of a hill. The collar deposits are necessarily limited in extent, while the blanket deposits may cover considerable areas. The brown phosphates, from their manner of origin, have necessarily accumulated in comparatively recent times.

The blue phosphates, on the other hand, are much older than the brown, having accumulated in their present form during Devonian time. It is believed by Hayes and Ulrich that the blue phosphates were originally formed as residual material from, and

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*Columbia Folio, U. S. Geol. Surv., p. 5, 1903.

†Some of the brown phosphate of Tennessee is formed, according to Dr. A. F. Rogers, by replacement of crinoidal limestone by calcium phosphate (Personal letter, April 1, 1914.)

resting upon the Ordovician phosphatic limestones, much as the brown phosphates of the present time are formed. After this residual material accumulated the area was depressed, allowing the sea to cover the limestone. By the action of the waves in shallow water the residual mass was thoroughly washed, the soil and clay material being sifted out and carried away, while the phosphatic material was left to form the phosphate rock as found at present. The sea subsequently deepened, so that shales and other formations were deposited upon the phosphate.

The richest of the blue rock deposits is believed to have been formed from the Ordovician limestone, known as the Leipers formation. This formation is full of the same minute spiral and other shells that occur abundantly in the immediately overlying phosphate rock. Phosphates were formed from Ordovician limestone other than the Leipers formation, but they are of a lower grade and at present not workable.

It would thus seem that the blue rock of Tennessee was formed during the interval between the Ordovician and the Devonian, washed during the Devonian, and in this condition was preserved for modern mining operations.

PHOSPHATES OF THE WESTERN UNITED STATES.

The extensive phosphate deposits of the western United States are interbedded with sedimentary formations, and to this extent resemble the blue rock phosphates of Tennessee. The rock in these deposits is described as prevailingly oolitic, although an exceptional occurrence is recorded by Richards and Mansfield* in which high grade rock was found to consist of shell fragments regarded by Girty as broken shells of pelecypods. The source of the phosphoric acid and the history of its accumulation in the form in which it is now found in these deposits, if at present obscure, will perhaps upon further investigation become apparent.

PHOSPHATE DEPOSITS FROM GUANO.

The phosphate deposits of Navassa, a small island in the West Indies, may be mentioned as an illustration of those which are believed to have been formed from guano. In the case of phosphate

*Bull. 470, U. S. Geol. Surv., p. 376, 1911.

deposits formed from guano, the phosphate is taken in solution by rain water, and after being carried to a lower level is redeposited, replacing the carbonate of the limestone. The rapidity with which this process may be carried on is illustrated by an instance cited by Dr. Albert R. Ledoux* in which limestone on one of the South Pacific islands was observed to have been changed to phosphate to a depth of several feet within a period of twenty years, the phosphoric acid in this instance being leached by rain water from recently deposited guano.

MINING.

Phosphate rock is mined either by open pit or by underground mining. Those deposits having a removable overburden are mined by the open pit method, underground mining being resorted to only for deposits interstratified with other formations, so that the overburden cannot be removed.

UNDERGROUND MINING.

The deposits worked in America by underground mining include the blue rock of Tennessee, the Arkansas deposits, and for the most part the extensive deposits of the western United States, which are as yet but little developed. In underground mining, ordinarily, operations begin at the surface outcrop of the phosphate stratum, the first rock being uncovered by stripping off the overburden. When the overburden can no longer be removed economically, drifts are run into the bank and the phosphate rock removed, support being given to the roof, when necessary, after the phosphate is taken out. This method of mining is similar to that used in mining coal seams. In the Arkansas and Tennessee mines the phosphate rock is first drilled and blasted. It is then broken up by pick and loaded into tram-cars to be drawn from the mine.

OPEN PIT MINING.

By far the greater part of the phosphate rock produced in America is obtained at present by open pit mining, in which the overburden is first removed from the rock. The purity of the rock,

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*Trans. N. Y. Acad. Sci., Vol. 9, p. 85, 1890.

however, is not materially affected by the methods employed in removing the overburden, and hence it is not necessary to describe these methods in detail. It may be noted, however, that diverse methods prevail, depending upon the thickness and character of the overburden, the magnitude of the operations and the facilities available. Examples may still be found of removal of overburden by pick and shovel, team and scraper, or team and dump cart. It is, however, only a shallow overburden that can be so removed profitably. In the larger mining operations the overburden is removed by steam shovel, by means of which the material is loaded into cars, which are then drawn to the overburden dump; or the overburden is removed by the hydraulic method, the material being pumped through pipe lines to the overburden dump. Whatever method is employed a limited amount of overburden remains with the phosphate rock and must be separated in subsequent treatment.

Removal of Phosphate from the Pit.—It is not necessary in this connection to describe in detail the methods of removing phosphate rock from the pit, since the purity of the rock is but incidentally affected thereby. It may be said, however, that the phosphate rock is either loaded by pick and shovel on wagons or tram cars to be drawn from the pit, or it is taken up by dredge or by hydraulicking. If taken by the hydraulic method the rock is forced through pipe lines to the washer plant. The character of the deposit determines the methods of removal that may be employed. Where the phosphate is loaded by pick and shovel, such objectionable impurities as siliceous boulders, limestone rock and clay balls are rejected at the pit, and in some mines only the coarse rock is taken, leaving the finer phosphate, clay and sand. As a rule, however, there is no attempt to separate the phosphate from the matrix before removal from the pit.

PREPARATION OF THE PHOSPHATE FOR THE MARKET.

The phosphate rock mined by the open pit method must be washed and dried. The methods of treatment described in this paper are those followed in America and particularly in the Florida mines.

WASHING.

The hard rock phosphate of Florida when brought from the pit is dumped onto a grating of iron bars with 2 or 2½ inch openings. The fine materials of the matrix pass through while the coarse materials, including phosphate, flint, limestone boulders, and clay balls, are lodged on the grating. The phosphate boulders are then thrown by hand into a rock crusher near by, while the flint and limestone boulders and clay balls are discarded. That part of the matrix which passes the grating together with the rock from the crusher is dropped into a log washer beneath. The practice in the land pebble mines is somewhat different from that followed in the hard rock section, the matrix, as pumped from the pit, being thrown as a rule onto a large revolving tube, known as a separator, punched "hit and miss" with holes one or two inches in diameter. As the separator revolves, the phosphate pebbles, as well as the finer materials of the matrix, fall through the openings and lodge on a screen beneath, while the coarser materials, including sand, rock and clay balls, remain in the separator from which they are carried to the waste dump. From the screen beneath the separator the phosphate rock passes into the log washer. While this is the usual arrangement in the land pebble phosphate mines, yet in some of the newer plants it has been found practicable to omit the separator altogether, the rock from the dump being allowed to enter the log washer after passing over a screen of about 1-16 inch mesh. When the separator is omitted, practically all the matrix from the pit passes through the log washers, and it has usually been found necessary in these plants to install a crusher, which is then placed between the two logs. The larger pieces of bone and phosphate rock, as well as the clay balls, if not disintegrated by the washer, are broken up in the crusher, and the phosphate which they contain is saved.

The log washer, through which the phosphate rock is passed, consists of two cylinders or logs placed side by side in a box or trough. A series of blades arranged in a spiral is fastened to each cylinder. The trough is inclined, the phosphate being run in at the lower end, and as the logs are made to revolve in opposite directions, the phosphate rock is pushed forward by the blades, meeting as it goes a constant stream of water. By this means the rock is fairly well washed, the water, carrying all the finer materials of the matrix, escaping at the lower end or in the newer washers through an opening at the side of the trough. Frequently the phosphate rock is passed through a second log of the same type as the first, and in all cases receives a final rinsing while passing over screens.

In the hard rock phosphate mines of Florida the coarse phosphate after leaving the rinser is made to pass over a picker belt, which is usually made in the form of a large revolving table. The phosphate rock remains on the picker belt during one complete revolution of the table, being carefully inspected by men and boys stationed around the table. The inferior rock, clay balls, flint and limestone fragments, so far as recognized, are picked out and discarded at this time, thus bringing up the grade of the shipment. In the land pebble mines the phosphate rock from the last washer falls on jig screens, the finer of which are 3-64 or 1-32 inch mesh. From these screens the rock is elevated by endless cup chains to the loading bin.

DRYING.

After being taken from the pit the phosphate rock must be dried before being marketed. Two methods of drying are in use. The first of these, which is adapted to drying coarse rock, consists in piling the phosphate rock on ricks of wood. The wood is then burned, thus drying the rock. This method assists somewhat in cleaning, since clay and sand, adhering to the rock, tend after drying to loosen and fall away in subsequent handling.

The second method of drying, which is now largely employed, is by the use of heated rotary cylinders through which the rock is passed. The rock is introduced usually at the cool end of the cylinder, and by means of various devices is made to pass through, escaping at the furnace or heated end. Although well adapted to drying small pebble rock, the coarser rock when dried by this method must first be crushed.

IMPROVEMENTS IN MINING METHODS.

An important factor in the cost of producing phosphate rock is the necessity of discarding the low grade rock, as well as that which cannot be properly cleaned or separated from the minerals with which it is associated. It is encouraging, however, to find that through improved methods of mining the amount of phosphate thus discarded is being gradually reduced, while the grade of rock produced is maintained or advanced. In the modern phosphate mining plants of Florida, practically no phosphate rock reaches the dump except that which will pass a 1-16, 3-64 or 1-32 inch mesh screen, or is carried out with the overflow from the side opening in the log washer. In Tennessee, where a very considerable part of the brown rock phosphate is in the form of minute pebbles, settling tanks for saving the small pebble have been introduced in late years. From the log washer the fine material passes through these tanks, and much phosphate that was originally thrown into the dump is thus cleaned and saved, and in fact some of the abandoned dumps in Tennessee are now being rewashed by this method.

However, notwithstanding these improvements in mining methods a very considerable amount of phosphoric acid in the form of very fine pebble and soft phosphate still finds its way into the waste dump. It is true that a large part of the phosphate that is thus lost is too high in iron and aluminum to be used in the manufacture of fertilizers under existing processes. It is, however, none the less desirable that the phosphoric acid be saved. To this end it is to be hoped that devices for recovering the very fine pebble phosphate may be further perfected, and that new process of manufacture may be developed in which the grade of rock that can be used is not so strictly limited.

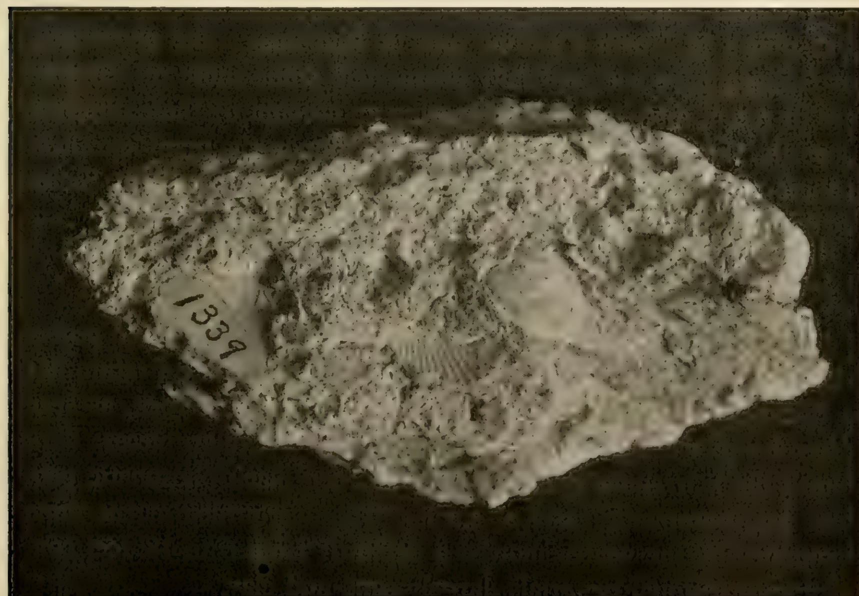

Fig. 21.—Sample of phosphate illustrating the formation of phosphate by the replacement process. The rock was clearly originally limestone of the Vicksburg formation, the form of the shells being well preserved. The carbonate has been replaced by phosphate, and the rock as shown by analysis is now a high grade phosphate. Natural size. Specimen contributed by H. R. Keyster, of the Dunnellon Phosphate Company, Rockwell, Florida.

THE PHOSPHATE DEPOSITS OF THE SOUTHERN STATES.

The Southern States at the present time are pre-eminently the source of phosphate rock in the United States, the total rock mined elsewhere in America being not more than 10,000 or 11,000 tons per annum. In fact this section contributes fully one-half of the phosphate rock of the world. The production from the United States in 1913 was 3,111,221 long tons, all of which, with the exception of 5,053 tons, was from the southern states.*

DESCRIPTION OF DEPOSITS BY STATES.

The phosphate deposits of the Southern States are widely distributed. Those states that are actively producing rock are: Arkansas, Tennessee, South Carolina and Florida. At least five other states, namely, Kentucky, Virginia, North Carolina, Georgia and Alabama are known to have phosphates or phosphatic marls of value to agriculture. The Kentucky deposits are being worked to a limited extent, and in former years a limited amount of rock was mined in North Carolina and in Alabama. The phosphates of Georgia have been partially prospected, while those of Virginia are of recent discovery. In preparing an account of these different deposits, the writer has necessarily drawn upon the many excellent papers relating to the phosphate deposits of the Southern States by various writers, to whom he acknowledges his indebtedness.

SOUTH CAROLINA.

The phosphates of South Carolina occur as a nodular and pebbly stratum lying upon a phosphatic marl. The phosphate stratum has a thickness of from 6 to 14 inches. The phosphate rock, as seen after being washed, includes light colored irregular pieces, dark bluish black irregular pieces, small flattened black phosphatic pebbles, and phosphatic casts of shells. The overburden at the mine examined by the writer showed a depth of from 6 to 18 feet consisting of residual materials, largely sand and clay.

The South Carolina deposits are of much interest as having been the first phosphates mined in America. In fact, the begin-

*The Production of Phosphate Rock in 1913, By W. C. Phalen. Mineral Resources of the United States, Pt. II, p. 273, 1914.

ning of mining in these deposits dates almost to the beginning of the use of mineral fertilizers. The first mineral phosphate to be used by the modern methods of treating with sulphuric acid were made in England in 1841, while plans for using the South Carolina phosphates were made as early as 1860, and actual mining began in 1867.

The grade of rock produced in the South Carolina fields, for rock properly washed and dried, permits a guarantee of about 60 per cent tricalcium phosphate. The age of the South Carolina phosphates, as is often the case with this class of deposits, is hard to determine, owing to the mixed character of the beds, for, while the phosphates rest upon the Eocene marl, they are themselves of later date.

ARKANSAS.

The Arkansas phosphates that are being worked are found as bedded deposits within shales lying between limestones. The overlying formation, the St. Clair limestone, according to Purdue,* is of Silurian age, while the underlying formation, the Polk Bayou Limestone, is of Ordovician age. The shales, within which the phosphate occurs, are believed to be the top member of the Ordovician. The phosphate beds are variable in character, ranging from those that are brown and sandy and of low grade to those that on the fresh surface are blue gray, apparently without sand, and of uniform texture and color. Two beds are usually present. The upper bed, the only one being worked, is described by Purdue as a compact, homogeneous, light gray rock. The color is said to be due to small white particles resembling fragments of bone that are thoroughly mixed with a grayish dark material. The gray material is made up of particles of varying size, some so small that they can be seen only with the lens, while others are as large as one-fourth inch in diameter. These particles are more or less angular, some of them distinctly so, making the stone conglomeratic in character. Near the surface exposure of the rock, the lime has been leached out by surface waters and the rock appears black in color. This rock is richer in phosphate than unweathered material.

The lower bed of phosphate, which is not being worked, is similar in character to the upper, though darker in color, more com-

*U. S. Geol. Survey, Bull. 215, pp. 463-483, 1907.

pact, and, so far as observed, not conglomeratic. The dark color is believed to be due to the smaller amount of white material and possibly to a larger amount of iron and manganese. The two beds are separated by a thin layer of manganese iron ore. In addition to the developed locality more or less phosphatic material occurs as nodules and pebbles in the Devonian shales and sandstones.*

The phosphate rock that has been produced in Arkansas is said to average about 65 per cent tricalcium phosphate. No phosphate rock was produced in Arkansas during the year 1913.†

TENNESSEE.

In Tennessee several more or less distinct types of phosphate occur, only two of which, however, blue rock and brown rock, are being mined at present. The blue phosphate occurs as a bedded deposit within, but forming the lowest member of the Chattanooga formation of Devonian age, and resting directly upon Ordovician limestone. The blue phosphates are said to vary in grade from about 30 to 85 per cent tricalcium phosphate. Iron and aluminum in the better grade of rock aggregate less than three per cent. The beds vary in thickness from zero to 50 inches, although the bed furnishing high grade rock rarely exceeds 20 inches in thickness.

The brown rock of Tennessee is at the present time of greater commercial importance than the blue rock. This rock occurs in irregular deposits lying near the surface and resting on limestone. The overburden consists usually of residual material including clay, some phosphate and a limited amount of sand. Its thickness is extremely variable, although averaging 8 or 10 feet. The phosphate consists of a shelly rock, breaking up into pieces of varying size, and of small variegated pebbles which in mass have a dark brown color. Locally the small pebble rock predominates, forming a scarcely coherent mass having a brownish color. A phase of the material, known locally as "muck" deposit, consists of a mass of small pebbles, often not exceeding a pin head in size. The underlying limestone has an irregular top surface, and not infrequently projects into the phosphate stratum. The limestone is dense and

*The Phosphate Deposits of Arkansas, by John C. Branner, Amer. Inst. Min. Eng. Trans. xxvi, pp. 580-598, 1896.

†Mineral Resources of the United States, Calendar year 1913,—part 2, p. 285, 1914.

has a bluish cast, and is more or less phosphatic. The age of this underlying limestone is Ordovician.

FLORIDA.

The phosphate produced in Florida includes, as previously stated, two kinds, namely, hard rock and land pebble phosphates.

The matrix in which the hard rock phosphate is imbedded is extremely variable. The formation includes a mixture of materials from various sources and of the most diverse character, further complicated by pronounced chemical activity within the formation itself. The prevailing phase of the formation is feebly coherent, more or less phosphatic, light gray sand. Aside from these sands the principal materials of the formation are clays, phosphate rock, flint boulders, limestone inclusions, pebble conglomerate, erratic and occasional waterworn flint pebbles, vertebrate and invertebrate fossils, and occasional pieces of silicified tree trunks.

The gray sands may be observed in every pit that has been excavated in this section. Moreover, from drill and prospect holes it is known that these sands occur very generally over the intervening or barren area. The sands are of medium coarse texture, the grains being roughly angular. The amount of phosphate associated with these sands is variable. When affected by slow decay and by water, carrying more or less iron in solution, they become reddish or ochre yellow in color. Lithologically these sands resemble closely the gray phosphatic sands of the Alum Bluff formation as seen at the type locality at Alum Bluff, on the Apalachicola River.

The clays in this formation occur locally as clay lenses imbedded in the sand, or separating the sand from the phosphate rock, or overlying the phosphate rock. The clays are often of a light buff or blue color. When lying near the surface, however, they often oxidize to varying shades of red. The relative amount of clay in the phosphate-bearing formation increases in a general way in passing to the south. The exposures in the southern part of the area show as a rule more clay than do similar exposures in the northern part of the area. The phosphate boulders seem to have a tendency to group around and to be associated with local clay lenses. Frequently the productive pit gives place laterally to barren gray sands.

Flint boulders occur locally in this formation in some abundance, and occasionally phosphate pits that are otherwise workable are abandoned on account of the number of flint boulders encountered. The flint boulders are usually oval or somewhat flattened in shape and are of varying size, some weighing several tons. Some of the boulders are hollow and occasionally the cavity is filled with water; other boulders are solid, compact and of a bluish color throughout. Limestone inclusions are frequent in this formation.

Phosphate rock, although the constituent of special economic interest, nevertheless makes up a relatively small part of the formation. The phosphate in these deposits occurs as fragmentary rock, boulder rock, plate rock or pebble. The boulders are often of large size, in some instances weighing several tons, and must be broken up by blasting before being removed from the pit. It is also necessary to operate a rock crusher in connection with all hard rock phosphate mines to reduce the larger pieces of rock to a size suitable for shipping. The relative amount of material that it is necessary to handle to obtain a definite amount of phosphate is always variable with each pit and with the different parts of any one pit. The workable deposits of phosphate lying within this formation occur very irregularly. While at one locality the phosphate may lie at the surface, elsewhere it may be so deeply buried as not to be economically worked; while a deposit once located may cover more or less continuously a tract of land some acres in extent, elsewhere a deposit, appearing equally promising on the surface, may in reality be found to be of very limited extent. As to location, depth from surface, extent into the ground, lateral extent, quantity and quality, the hard rock phosphate deposits conform to no rule. The desired information is to be obtained only by extensive and expensive prospecting and sampling.

The materials above the phosphate deposits include pale yellow incoherent sand and in some localities clayey sand. The incoherent sands are variable, an average thickness being from 5 to 15 feet, although as much as 30 feet have been observed.

In practically all published literature the hard rock phosphates of Florida are referred to as of Vicksburg, Lower Oligocene age, Although resting upon the Vicksburg limestone, the formation is apparently of Pliocene age, for, although fossils older than the Pliocene are present, yet these are derived from the formations that have disintegrated.

The land pebble phosphate deposits of southern Florida are much more uniform in their manner of occurrence than are the hard rock deposits. The phosphate is in the form of pebble rock imbedded in a matrix of clay, sand and soft phosphate. Although variable from place to place the phosphate bed has an average thickness of from 8 to 10 feet, its maximum thickness being from 18 to 20 feet. The overburden, which consists largely of sand and sandy clays, with local indurated or calcareous ledges, has an average thickness of from 10 to 14 feet.

The best grade of land pebble rock when properly washed, dried and selected permits a guarantee of 75 or 76 per cent tricalcium phosphate. Other grades on the market range from 62 to 75 per cent. The hard rock phosphates average from 79 to 83 per cent, although selected samples run as high as 84 or 85 per cent tricalcium phosphate.

Practically all of the hard rock phosphate mined in Florida is exported, that used in America amounting to not more than 15 or 18 thousand tons per annum. Of the land pebble phosphate produced a little more than one-third is now being exported.

KENTUCKY.

The phosphate deposits in Kentucky resemble in a general way the brown rock of Tennessee. According to Gardner* the phosphate is in the form of loose rock, consisting of thin plates and finely comminuted material mixed with some clay, the whole being of a dark brown color. The hard rock plates vary from light gray to dark brown and are usually rather dense. These plates vary in size from the granular form up to pieces that weigh several pounds. The deposits as a whole occur in blanket form on limestone and are covered by clay and soil. As in the case of the brown rock phosphate of Tennessee the deposits are extremely irregular both as to thickness and extent. Gardner states that the deposits originate from secondary concentration from the process of weathering of phosphatic limestone. The surface of the underlying rock is irregular and naturally the bottom of the phosphate conforms with it; at some places it suddenly deepens and at others rock horses rise in the phosphate beds. The cover of clay and soil varies from about 2 to more than 10 feet, being thicker on the tops than on the sides of hills and ridges.

*Rock Phosphate in Kentucky: Mines and Minerals, Nov., 1912, pp. 207-209.

VIRGINIA.

The recently discovered phosphate deposits of southwestern Virginia, if not of sufficient grade and quantity to be of economic value, are nevertheless of much scientific interest. The beds, which contain the phosphate nodules and grains, lie near the base of the Devonian, and are a little less than a foot thick. The highest grade rock at this locality was found to contain 54.97 per cent tricalcium phosphate, although the average of the rock is of somewhat lower grade. While the phosphate was found at only two localities, the strata with which it is associated were traced for a distance of twenty miles, and it is probable that additional phosphate localities will be discovered.*

NORTH CAROLINA.

The phosphate deposits of North Carolina lie in a belt extending from the South Carolina line northwestward to the Neuse River. The area is from 15 to 20 miles wide and lies from 20 to 25 miles from the coast. The layer of phosphate rock is said to be from 6 to 20 inches thick. The rock occurs in lumps, shading from a light gray to dark green, and varying in size from rocks weighing half a pound to half a ton or more. Analysis of a considerable number of samples indicated that deposits could be selected that would run from 28 to 57 per cent tricalcium phosphate.

Another type of deposits found in North Carolina is that known as conglomerate rock, which was worked to a limited extent from about 1885 to 1899, the rock being ground and applied as raw phosphate to the soil.† This deposit, consisting of coprolites and fish bones has a thickness of from 3 to 5 feet, and in places underlies a limestone or marl. A sample of the conglomerate as a whole was found to contain only 11.16 per cent tricalcium phosphate, the balance being chiefly calcium carbonate, silica, iron and aluminum. A number of the coprolites from the conglomerate ground up and mixed, analyzed about 30 per cent tricalcium phosphate.

ALABAMA.

A small amount of phosphate was mined in Alabama in 1887, although operations were afterwards discontinued. The phos-

*Phosphate Deposits in Southwestern Virginia, by George W. Stose, U. S. Geol. Sur. Bull. 540-L, 1913.

†U. S. Geol. Survey, Mineral Resources, 1883 and 1884, pp. 788-793.

phates of this state are found in both the Cretaceous and the Tertiary formations. The Cretaceous strata, extending into Mississippi, contain more or less phosphatic material.*

GEORGIA.

The phosphates of Georgia are found in the Coastal Plain deposits and, although of low grade, are widely distributed.†

Fig. 22.—Removing overburden from phosphate rock in Florida by hydraulicking. The overburden as seen in this view, presents the usual condition, consisting of three or four feet of loose light colored sand beneath which is found several feet of clayey and sandy material. The bank is knocked to pieces by the stream of water and after being washed into the sump hole, is pumped to the waste dump. The phosphate stratum which lies beneath is subsequently removed in the same way, being pumped through pipe lines to the washer plant. The phosphate washer and also the waste dump are seen in the background. From this view may be seen also type of country in which the land pebble phosphates of Florida are found. The land is level, or but slightly rolling. The native timber growth, chiefly long-leaf pine, is now largely removed.

*The Phosphates and Marls of Alabama, by Eugene A. Smith, Geological Survey of Alabama. Report on the Coastal Plain of Alabama, pp. 449-525, 1895; and Amer. Inst. Min. Engrs. Trans. xxv, pp. 811-822, 1896.

†A Preliminary Report on a Part of the Phosphates and Marls of Georgia, by S. W. McCallie, Geol. Surv. of Georgia, Bulletin No. 5-A, 1896.

WORLD PRODUCTION OF PHOSPHATE ROCK.

In the production of phosphate, the United States is easily the leading country of the world, contributing from the well known fields of Florida, Tennessee, South Carolina, Arkansas and the new fields in the western United States approximately 3,000,000 tons of a total world production of between 6,000,000 and 7,000,000 tons. Florida alone, at the present time, contributes over 2,500,000 tons per annum. The statistics for 1911, the latest date of which approximately complete returns are available, show the world production of phosphate to be approximately 6,145,413 metric tons, of which the United States produced 3,102,131 metric tons, or slightly more than one-half.*

Aside from the United States, the principal phosphate countries of the world are Northern Africa, including Tunis, Algeria and Egypt; Continental Europe, including France, Belgium and Russia, the latter at present producing but little rock; the South Sea Islands, including Ocean, Naura, Anguar, Makatea and other islands of lesser importance in the Pacific Ocean, and Christmas Island in the Indian Ocean; the Dutch West Indies, including Aruba, Curacao and Lesser Curacao Islands in the Caribbean Sea. In addition a small amount of phosphate rock is produced in Canada, Australia and South Africa, while from a number of other localities, both on the continents and on the Islands of the Sea, discoveries of phosphate rock are reported, some of which, without doubt, will be found to be of commercial importance.

NORTHERN AFRICA.

TUNIS.

Tunis, a small province in northern Africa bordering the Mediterranean Sea, owned by France, leads among foreign countries in the production of phosphate rock. The companies operating in these fields during 1912 were as follows: Compagnie des Phosphates et du Chemin de Fer d Gafsa; Societe des Phosphates Tunisiens; Compagnie des Phosphates du Dyr; Societe anonyme des Manufactures des Glaces et Produits chimiques de St. Gobain; Societe Franc. d'Etudes et d'Exploitation des Phosphates en Tu-

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*The Production of Phosphate Rock in 1913, by W. C. Phalen, Mineral Resources of the United States, Calendar year 1913—Part II, p. 279, 1914.

nisie; Societe de Phosphates de Maknassy; Societe Franc. des Phosphates de Gouraya; La Floridienne, J. Buttgenbach & Co. Of these companies, the first named, Compagnie des Phosphates de Gafsa, is by far the largest, having produced during 1912, 1,312,378 tons. This company at the present time is without doubt, in point of production, the largest phosphate company in the world. The other seven companies named produced 578,359 tons, making a total of 1,890,737 tons exported from Tunis during 1912, almost all of which is shipped to the European countries.

ALGERIA.

Algeria is also a French province in northern Africa bordering the Mediterranean Sea immediately west of Tunis. The phosphates of Algeria are found in the vicinity of Setif and Tebessa. The deposits of Kouif at Tebessa near the Tunis border include five beds from 60 centimeters to 3 meters thick (approximately 2 to 10 feet), separated by lime strata. Of these beds three are worked, the mining being done in part by open pit and in part by drift mining. The phosphate rock from these beds grades 63 to 70 per cent tricalcium phosphate, iron and aluminum 1 per cent. Among the companies operating in Algeria during 1913 are the following: Compagnie des Phosphates de Constantine; Compagnie des Phosphates du M'Zaita; Compagnie Centrale des Phosphates; Compagnie Algerienne des Phosphate de Tocqueville. The total shipments of phosphate from Algeria during 1913 amounted to 461,030 tons, all of which, aside from a small amount sent to Japan, were consigned to European countries.

EGYPT.

Phosphate is known in a number of localities in Egypt, although actual mining is being carried on at present in only two districts, namely, the Safaga and the Sibaia Deserts. The phosphates are found in sedimentary strata belonging to the uppermost part of the Cretaceous system. The total shipments from Egypt during 1913 amounted to 96,958 tons, all of which was exported, going chiefly to China and Japan.* The exports for 1913 were 64,160 tons.

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*A brief note on The Phosphate Deposits of Egypt, by John Ball, D. Sc. F. G. S. Survey Department Paper No. 30, Government Press, Cairo, Egypt, 1913.

The grade of rock produced in the Safaga mines by the Egyptian Phosphate Company admits a guarantee of from 65 to 72 per cent of tricalcium phosphate; calcium carbonate 8 to 12 per cent; iron and aluminum 2 per cent.

CONTINENTAL EUROPE.

FRANCE.

France has long been a phosphate producing country and, although the production has never been large as compared with some other countries, yet deposits are known and worked at many and widely separated localities. One of the principal centers of production is that of Pas de Calais, where the phosphate occurs as mamillary masses and nodules in the Cretaceous strata, varying in grade, but averaging about 50 per cent tribasic phosphate of lime. The phosphates at Beauval in the Somme are exceptional in their manner of occurrence, being found as sand pockets in the surface of the rock. Originally this sand, analyzing upon drying 75 to 80 per cent tricalcium phosphate, was used in mortar, its phosphatic nature not then being known. The production of phosphate and phosphatic chalk in France during 1911, the latest date for which statistics are available, amounted to about 380,000 tons.

BELGIUM.

Belgium has extensive deposits of phosphate rocks, which, however, are of rather low grade. The rock found around Liege and Mons, near the French border, contains about 50 per cent tricalcium phosphate. In the vicinity of Vaudour somewhat richer phosphates are found grading about 60 per cent tricalcium phosphate. The production from Belgium in 1911 was 196,780 tons.

RUSSIA.

Phosphates are known to exist over a wide extent of territory in Russia, deposits of commercial value being found in southern central and northern European Russia. The deposits of southern Russia are found near the Austrian frontier in Bessarabia and Podolia. These phosphates lie in schists and are mined chiefly by underground mining. The Podolia phosphate grades about 75.3 per cent tricalcium phosphate. Extensive phosphate deposits, as yet but little developed, are found in central Russia. Mining has been carried on only to a very limited extent in the northern and central regions, and that by the open pit method. The total production of phosphate in Russia during 1911 was 10,200 tons, of which Podolia produced 9,899 tons, Bessarabia 154 tons, and Kurtz in the central region 147 tons.

ISLANDS OF THE PACIFIC OCEAN.

Phosphate rock is obtained from a number of islands of the Pacific Ocean, the largest producers at present being Ocean, Naura, Anguar and Makatea islands. The shipments from these islands go chiefly to Japan, Australia, New Zealand, and China, although, owing to the high grade of the rock, a considerable demand is found in European countries.

Ocean Island—Ocean Island, an English possession in the Gilbert group in the Pacific Ocean (Lat. 0 degrees, 52 minutes south; Long. 169 degrees, 35 minutes east), although less than 1,500 acres in extent, contains important phosphate deposits. The phosphate on this island, a surface deposit, is mined by open pit mining, and is dried in cylinder dryers. The water around the island being shallow, the rock is necessarily transported by small boats to the steamers.

Naura—Naura, a German possession belonging to the Marshall Islands, lies 160 miles northwest of Ocean Island. The phosphate of this island is found resting upon and filling up irregularities in the top surface of a dolomitic limestone, and grades 86 to 87 per cent tricalcium phosphate. In mining, the rock is shoveled into buckets, which, when filled, are lifted and carried by cable to the railroad track. The deposits of these two islands are worked by the Pacific Phosphate Company, Ltd. The output, amounting to about 250,000 tons a year, is shipped to Japan, Australia, and New Zealand, as well as to the European countries.

Anguar—Anguar, one of the Pelew Islands of the Carolina Group in the Pacific Ocean east of Japan, produced in 1911, 41,000 tons of phosphate which grades about 80 per cent. The deposits of this island are worked by a German company, The Deutsche Sudsee Phosphat-Gesellschaft. This company is said to have exported 90,000 tons of phosphate, chiefly from this island, during 1913.

Makatea—From Makatea, one of the Paumotu Islands of the

Society Group and a French possession, there were shipped during 1912, 17,207 tons. This rock is mined by a French Company, Compagnie Francaise des Phosphates de L'Oceanie, and grades as high as 81 per cent tricalcium phosphate, iron and aluminum one-half per cent.

ISLANDS OF THE INDIAN OCEAN.

Christmas Island—Christmas Island, which lies south of Java, in the Indian Ocean, has in recent years become an important phosphate producer. The rock is of high grade with low content of iron. The deposits are worked by an English company, the Christmas Island Phosphate Company. The amount shipped during 1913 was 150,005 tons.

ISLANDS OF THE CARIBBEAN SEA.

The islands of Curacao and Aruba and Little Curacao, belonging to the Netherlands, lying in the Caribbean Sea, off the coast of Venezuela, contain phosphate deposits. The amount of rock shipped by the Aruba Phosphate Company during 1912 was 20,262 tons. This rock grades 70 to 75 per cent tricalcium phosphate; iron and aluminum 3½ to 4½ per cent. The phosphate on this island is obtained mostly from subterranean caves. The phosphates of Santa Barbara in the southern part of Curacao, the mining of which has been recently renewed, grade 80 to 86 per cent tricalcium phosphate. The grant to exploit the deposits on Little Curacao is held by an American Company. During 1911 about 2,000 tons, grading 50 per cent tricalcium phosphate, was shipped from this island.

Exact figures as to the production of phosphate rock for many of the foreign countries are not yet available. However, from the data that have been given, it is evident that the world production of phosphate during 1913 approximates six and one-half million tons.

PRODUCTION OF PHOSPHATE ROCK IN FLORIDA DURING 1913.*

STATISTICS ON PRODUCTION COLLECTED IN CO-OPERATION WITH THE U. S. GEOLOGICAL SURVEY.

The production of land pebble phosphate in Florida, which has steadily increased during the past several years, showed a further gain during 1913, the output having for the first time exceeded two million tons. The production of hard rock phosphate, on the contrary, showed a slight decrease, having fallen slightly below one-half million tons. However, notwithstanding the decline in hard rock mining, the total production for the State during 1913 was greater than that for any preceding year, having exceeded two and one-half million tons, with a valuation in excess of nine and one-half million dollars.

The total shipments of phosphate rock during 1913 as reported by the producers was 2,545,276 long tons, of which 2,055,482 tons were land pebble, including a small consignment of river pebble, and 489,794 tons were hard rock phosphate. The river pebble included with these shipments represents rock on hand from previous years, as no river pebble is being produced at present. The exports of phosphate rock from Florida to foreign countries during 1913 as shown by returns from the various shipping points, amounted to 1,364,296 tons, from which it appears that slightly less than one-half of the phosphate mined in Florida during 1913 was consigned for use within the United States. The rock consigned for domestic use is almost wholly land pebble phosphate, practically all of the hard rock being exported. The record of the export shipment is from the American Fertilizer of January 24, 1914.

Pebble phosphate from Florida sold at the mines during 1913 at $2.75 to $4.00 per ton according to grade, while the hard rock phosphate sold at $4.00 to $5.00 per ton. The actual value of the phosphate shipped from Florida during 1913 approximates $9,563,-084.

*Press Bulletin No. 5, Florida State Geol. Survey. Production of Phosphate Rock in Florida During 1913, by E. H. Sellards, Issued May 20, 1914.

Thirty companies in all were engaged in mining phosphate in Florida during 1913. Of these sixteen companies were mining pebble phosphate, while fourteen were mining hard rock phosphate. The accompanying list is complete for all phosphate companies that operated in Florida during 1913:

PHOSPHATE COMPANIES OPERATING IN FLORIDA DURING 1913.

Amalgamated Phosphate Co.	25 S. Calvert St., Baltimore, Md., and Chicora, Fla.
Armour Fertilizer Works	Bartow, Fla.
P. Bassett (Successor to Central Phosphate Co.)	Newberry, Fla.
Peter B. and Robert S. Bradley	92 State St., Boston, Mass., and Floral City, Fla.
J. Buttgenbach & Co.	Holder, Fla.
Camp Phosphate Co.	Ocala and Dunnellon, Fla.
Charleston, S. C., Mining and Manufacturing Co.	Charleston, S. C., and Ft. Meade, Fla.
Compagnie Generale des Phosphates de la Floride	Paris, France, and Pembroke, Fla.
Coronet Phosphate Co.	Lakeland, Fla., and 99 John St., New York.
Cummer Lumber Co.	Jacksonville and Newberry, Fla.
The Dominion Phosphate Co.	Bartow, Fla.
The Dunnellon Phosphate Co.	Rockwell, Fla.
Dutton Phosphate Co.	Gainesville, Fla.
Florida Mining Co.	165 Broadway, New York, and Mulberry, Fla.
Florida Phosphate Mining Corporation	Norfolk, Va., and Bartow, Fla.
Franklin Phosphate Co.	Newberry, Fla.
Holder Phosphate Co.	Ocala and Inverness, Fla.
International Phosphate Co.	27 State St., Boston, Mass., and Ft. Meade, Fla.
Interstate Chemical Corporation	Charleston, S. C., and Bowling Green, Fla.
Istachatta Phosphate Co.	Istachatta, Fla.
Mutual Mining Co.	Savannah, Ga., and Newberry, Fla.
Palmetto Phosphate Co.	Baltimore, Md., and Tiger Bay, Fla.
The Phosphate Mining Co.	55 Johns St., New York, and Nichols, Fla.
Pierce Phosphate Co.	2 Rector St., New York, and Pierce, Fla.
Prairie Pebble Phosphate Co.	165 Broadway, New York, and Mulberry, Fla.
Schilmann & Bene	Ocala, Fla.
Societe Franco-Americaine des Phosphates de Medulla (Successor to Standard Phosphate Co.)	Christina, Fla.

The Southern Phosphate Development Co. ....Ocala and Inverness, Fla.
State Phosphate Co....................Bartow, Fla.
T. A. Thompson........................Neals, Fla.

In addition, The Export Phosphate Co., Mulberry, Fla., The Lakeland Phosphate Co., Lakeland, Fla., and The Acme Phosphate Co., Morriston, Fla., have organized and are expecting to mine during 1914.

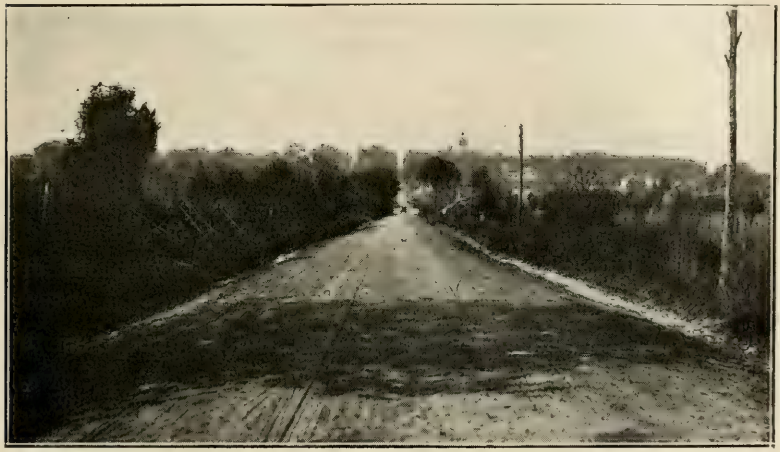

Fig. 23.—Sand-clay road, Tallahassee, Bellair road leading into Tallahassee from the south.

ROAD MATERIALS.

The road materials of the State include chiefly the limestone, marl, and shell deposits, the flint, chert and gravel, and the sandy or road-making clays. The production of road materials can scarcely be estimated. The sandy clays in particular are used locally, no record being kept of the amount handled. The calcareous and siliceous materials find more general usage, the production and value being frequently reported. The value of this class of road-making material is recorded, so far as obtained under the headings "Limestone" and "Gravel."

At the close of 1912 the total mileage of improved roads in Florida was approximately 2,848 miles. Of this number 857.8 miles are surfaced with marl or crushed stone; 1,408.75 are surfaced with sand-clay; 218 miles are surfaced with shell; 5.2 miles with cement; 26.5 miles with gravel; .4 mile with asphalt, and 8.5 miles with brick. These statistics are for the year 1912, the reports for the succeeding years not being sufficiently complete to justify publication. It is known, however, that the total mileage of improved roads in Florida was materially increased during 1912 and 1913. This applies particularly to the brick roads, several counties, among which are Duval, Hillsboro, Orange, St. Johns and Seminole counties, being now actively engaged in building paved brick roads along the important highways of travel.

In addition to the funds available from regular and special taxes, the following counties have issued bonds for road improvement: Alachua, $40,000; Columbia, $40,000; Dade, $250,000; DeSoto, Punta Gorda, special district, $200,000; Duval, $1,000,000; Hernando, $300,000; Hillsboro, $400,000; Jackson, $300,000; Manatee, $250,000; Nassau, $60,000 and $180,000; Palm Beach, $200,-000; Palm Beach special district No. 1, $85,000, special district No. 2, $60,000; Pasco, special district No. 1, $150,000, special district No. 2, $65,000, special district No. 3, $30,000; Pinellas, $370,000; Putnam, $155,000; St. Johns, $30,000 and $650,000; Seminole, special district No. 1, $200,000; St. Lucie, $200,000; Suwannee, coupon warrants, $20,000; Walton, $70,000. In addition to the regular and special annual road taxes, Florida has thus issued during the past few years road bonds to the value of over five million dollars.

SAND AND GRAVEL.

The sand produced in Florida is used chiefly for building purposes, although a limited amount is used as moulding sand. The gravel produced finds its chief use for road-making and road ballast. The total production of sand and gravel for 1913 was 87,061 tons, valued at $21,194.00. Of this amount 66,835 short tons, valued at $11,104.00, was gravel, the balance being sand of the grades mentioned.

The companies reporting the production of sand and gravel in Florida during 1913 are the following:

Atlantic Coast Line Railroad Company.
Interlachen Gravel Company, Interlachen, Fla.
Lake Wier Sand Company, Lake Wier, Fla.
Logan Coal and Supply Company, 866 East Bay St., Jacksonville, Fla.
W. E. Long, Orlando, Fla.
Walter L Wescott, Orlando, Fla.
Woodman and Company, Ocala, Fla.

SAND-LIME BRICK.

The materials used in the manufacture of sand-lime brick are sand and lime. The bonding power of the brick is due to the chemical reaction between these ingredients. The chemical changes

Fig. 24.—Ponce de Leon Springs, Holmes County.

occur in the presence of heat, pressure and moisture, and result in the formation of hydro-silicates of calcium and magnesium.

The sand used in the manufacture of sand-lime brick should be comparatively pure and perferably with some variation in the size of the grains. The mixture of lime, sand, and water, is cut in the form of bricks and conveyed to a hardening cylinder. Necessary heat and pressure are obtained in the hardening cylinder adapted for the purpose. The sand-lime bricks are placed in this cylinder and subjected to a pressure and temperature which vary according to the method of treatment.

Four companies were actively engaged in the manufacture of sand-lime brick in Florida, during 1913, as follows: The Bond Sandstone Brick Company, Lake Helen, Fla.; The Composite Brick Company, 3027 Hubbard St., Jacksonville, Fla.; Roux Composite Brick Company, Plant City, Fla.; and the Seminole Press Brick Company, Turners Road, Jacksonville, Fla.

The total production of sand-lime brick in Florida during 1913 was valued at $79,679.00.

WATER.

The springs of Florida are famous for their large volume of flow as well as for the clearness and beauty of their waters. Many of these springs are used as health resorts, while from others the water is sold for medicinal or table use. The total sales of spring waters in Florida during 1913 as shown by the returns from the owners of springs and wells amount to 343,123 gallons, valued at $37,474. The average price thus approximates eleven cents per gallon. The total sales are divided as follows: Medicinal waters, $20,290; table waters, $17,184.

The following is a list of those who report having sold spring or well water during 1913, together with the name of the spring or well from which taken.

Chumuckla Mineral Springs Company, Chumuckla Spring, McDavid, Florida.
Kissengen Wells Company, Stomawa Well, Tampa, Florida.
Lackawanna Water Company, Cedar and Lackawanna Springs, Jacksonville, Florida.
L. H. McKee, Quisisana Spring, Green Cove Springs, Florida.
Magnolia Springs Hotel Company, Magnolia Spring, Magnolia Springs, Fla.
Panacea Springs Company, Panacea Springs, Panacea, Florida.
Nathaniel Brewer, Jr., Newport Spring, Newport, Florida.
Orange City Water Works Company, Orange City Mineral Springs, Orange City, Florida.
E. J. Osborne, Wekiwa Springs, Apopka, Florida.
Ponce de Leon Springs Corp., Ponce de Leon Spring, Glenwood, Florida.
Purity Springs, Tampa, Florida.
James F. Tucker, Espiritu Santo Spring, Espiritu Santo Springs, Florida.
Welaka Mineral Water Company, Welaka Mineral Spring, Jacksonville, Florida.

The production of mineral waters as shown by these statistics is, however, insignificant, when compared to the vastly more extensive use of the spring and well waters for municipal, agricultural, industrial, domestic and other purposes for which statistics can scarcely be collected. As bearing on the general value of underground water may be included here the following press bulletin by the writer, issued by the Survey during the year.

THE UTILITY OF WELL RECORDS.*

The water supply stored in the earth is a resource the value of which can not be expressed in figures, since upon the water supply

Fig. 25.—Flowing artesian well at Palatka.

is dependent both plant and animal life as well as human existence and comfort. Without water, soil fertility would fail, all vegetation would quickly die, all activities of man would cease and the earth would become a barren waste. Water is the one

*Press Bulletin No. 4, issued by the Florida State Geological Survey, January 15, 1914.

resource common to all and in which all are directly interested regardless of occupation or position in life.

Water is a mineral and in fact differs from other minerals chiefly in that at the average moderate temperature it is in liquid form, while most other minerals, mercury excepted, at the same temperature are in solid form. At 0 degrees Centigrade, however, (32 degrees F.), water solidifies, and in doing so assumes as in the case of most other minerals a definite crystal form. Like other minerals also water must be sought for in the earth, and it is in fact more extensively prospected for, produced and utilized the world over, and affects the life and welfare of more people than any other mineral. The money expended annually in securing, distributing and utilizing water is almost incredible. It is probable that in this State alone as much as one hundred thousand dollars is spent annually in well drilling. This expenditure is to be classed under the head of prospecting, although the drill hole once made becomes the opening through which the water, if the well is successful, is brought to the surface. To the cost of prospecting it would be necessary to add in order to estimate the approximate expenditure on water supplies, the additional annual cost of pumping, piping, and distributing the water, as well as the general upkeep of the plant which involves a large annual expenditure. The water supply is, therefore, both an important and an extensive industry.

Like other minerals water obeys definite laws in its manner of occurrence in the earth and yet for no other mineral has the prospecting been carried on in so haphazard a manner. This is doubtless due to the fact that the water supply does not admit of concentration in development, nor beyond a limited extent of private ownership. The phosphate deposits of this state which are almost wholly under private ownership have been studied by expert geologists, and have been developed in accordance with carefully laid plans drawn by skilled engineers. Both in prospecting and in mining the phosphate, the most exact records have been kept and the data thus secured utilized in subsequent developments. The same is true of the fullers earth industry, and in fact of successful mining operations the world over. As regards the water supply, however. while the general geological studies have been or are being made. the acutal prospecting is being carried on by very unscientific methods. Notwithstanding the large amount of deep well drilling that is being done in Florida annually, the work is not in any way co-ordinated, and records are seldom preserved with sufficient care to meet scientific requirements.

The failure to keep an adequate record of a well when drilled is clearly due to the lack on the part of the owner of the well, of an appreciation of the value and utility of such a record, both to those who are having the well drilled and to others who subsequently may wish to drill wells in or near the same locality. It is to indicate some of the ways in which well records are of value and to urge more complete preservation of records, and more definite correlation of results of prospecting that this bulletin is issued.

Accurate data from wells can be obtained only by the personal attention on the part of the well driller or of some one who directly interests himself in the well, and involves more or less loss of time and delay in the drilling operations. As a rule no provision is made by the well-owner for preserving the record of the well, and it is left to the driller to preserve the record if preserved at all. While it is not reasonable to expect the driller to assume this extra expense, as a matter of fact nearly all the records that are now available have been secured in this way and it speaks well for the drillers that they are willing to thus make public the data that they have obtained at their own expense. To secure full and complete records the owner of the well should assume the expense of collecting the data since it is to himself and the community in which he lives that the record has the largest value. The owner of the well, frequently expecting to drill no well other than the one already undertaken, assumes that there is no further need so far as he is personally concerned for exact data. This, however, is a mistake. The instances are numerous in which valuable mineral deposits have been drilled through without being detected merely because the samples of drillings from the well were not preserved and examined by some one competent to judge of their character. In any case to drill a deep well involves considerable expense, and it is a waste of money not to make the most of the prospect hole while it is being made. Aside from the individual interest, there is the welfare of the community which is inseparably linked with that of each individual, and the success or failure of one well, or the difficulties encountered in drilling it, or the materials penetrated, may point the way to success or reduction of expense on the part of another.

The drilling of practically all deep wells is let by contract to the lowest responsible bidder, and it is obvious that if the party letting the contract has no idea of the underground conditions he is not in a position either to draw proper specifications or to judge of the reasonableness of the bid when made. In many cases the contract for wells fails to specify requirements that should be made for that particular locality, and on the other hand includes conditions that involve additional expense and yet for that particular well are useless. It is very much to the advantage of the owner of the prospective well to have full information as to the conditions of the underlying strata through which the well is to be drilled, the probable depth that it will be necessary to go and the depth to which the casing should be carried, as well as some idea of the ease with which the well can be drilled or the difficulties that must be expected, and to place this data as fully as possible before the prospective bidder, without, however, assuming responsibility as to the nature of the strata which are always variable within limits. If the driller must make his bid totally in the dark as to what to expect in the drill hole, naturally he must allow liberally for unexpected difficulties and for unknown conditions. On the other hand if the data available to him is approximately complete he can afford to submit a close bid. The more completely the element of uncertainty is eliminated the smaller the margin of unexpected expenses necessary to allow for in making a bid.

Not only do well records have an immediate practical utility for the community in which the well is located, but they have in addition a broader application. Owing to the prevailingly level surface of Florida there is not as good an opportunity to examine the substructure from surface exposures as in some other states, and a correspondingly greater reliance must be made on records from drill holes. A knowledge of the substructure of the country has in turn both educational and economic value. It is well known that oil and gas within the earth are more or less definitely associated with the structure of the rock, being found on or near the tops of the anticlines or folds or in dome structures. Reliable advice as to where best to drill prospect holes for oil and gas must necessarily be based on a knowledge of the structure of the underlying formations and to this knowledge the well records if properly kept will largely contribute. Moreover, a knowledge of the substructure is an important element in formulating the geologic history of the land area and hence has the same broad and general application as other geologic studies, having both an economic and educational value.

As an instance of a well from which an approximately complete record has been obtained may be mentioned the City well at Jacksonville in Duval County drilled in 1910, the record in this case being supplied through the courtesy of the drillers, the Hughes Specialty Well Drilling Company. This well reached a total depth of 980 feet, and samples of the drillings were kept at occasional intervals, a total of 46 samples having been preserved

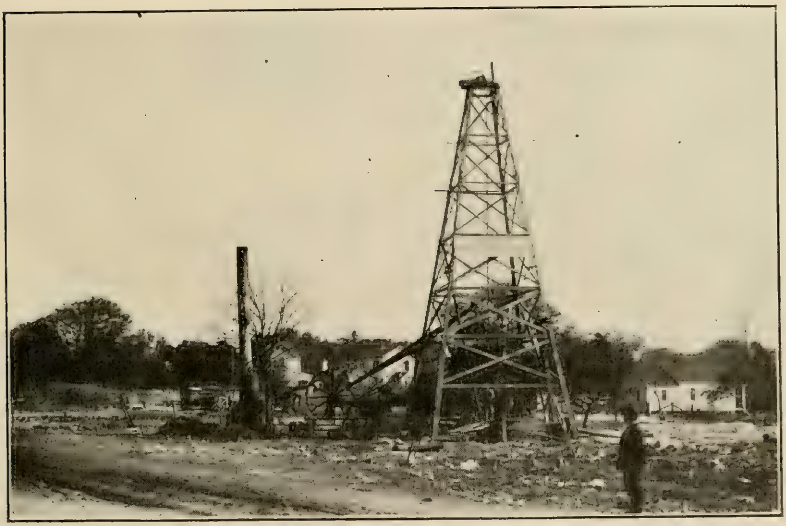

Fig. 26.—Well drilling machinery used in Florida.

and submitted to the State Survey. The detailed log of the well based on an examination of the samples supplemented by the notes made by the driller has been published in the Fifth Annual Report of the Survey, and need not be repeated here. The principal water supply in this well is obtained from the Vicksburg limestone, a formation well known to the drillers as it is the chief water bearing formation of the peninsular section of the State.

The first flow of water amounting to only about 5 gallons per minute was obtained in this well at a depth of 270 feet. At the depth of 493 feet the flow was increased to 112 gallons per minute, the water having as it flowed from the pipe a temperature of 71 degrees F. Upon entering the Vicksburg limestone which was reached in this well at 510 feet the flow was increased to 200 gallons per minute. The inner casing was rested upon this limestone, the drill hole being continued into this formation 470 feet or to a total depth of 980 feet. As the deeper strata of the Vicksburg limestone were penetrated the amount of flow, the pressure and the temperature increased. At 625 feet the flow amounted to 500 gallons per minute, having a temperature of 74 degrees F. At 680 feet the artesian pressure at the surface was 12 pounds per square inch, indicating a head above the surface of 27.7 feet. At 780 feet the flow from the well was about 900 gallons per minute, and the pressure 15 pounds per square inch indicating a head above the surface of 34.6 feet. The flow in the completed well at a depth of 980 feet was between 1500 and 2000 gallons per minute.

Through the records kept by the Superintendent of the City Water Works, something is known also of the flow of several wells at Jacksonville through a period of twenty years. These records were also included in the Fifth Annual Report of the Survey. Wells, the flow of which was measured, show a reduction in flow in a period of ten years to about one-fourth of their original efficiency.

Another well of which a very satisfactory record has been obtained is one drilled recently by F. S. Gilbert at Tiger Bay in Polk County, the samples and records being supplied through the courtesy of the owners of the well, the Palmetto Phosphate Company. This well has a depth of 838 feet, and samples were taken with some exceptions at ten foot intervals, a total of 67 samples having been preserved. These were forwarded to the State Geological Survey, and the detailed log made from the samples, supplemented by the notes of the driller, will be published in the subsequent reports of the Survey. After passing through the surface materials at this locality the drill penetrated sandy phosphatic marls to the depth of 360 feet. The material throughout this whole thickness, while by no means uniform apparently represents a single geologic formation which is locally variable. The phosphatic pebbles which occur throughout the whole thickness are black, brown or white in color and are rounded smooth and shiny, the larger pebbles being often pitted. The pebbles are imbedded in marl, the prevailing color of which is light buff or grayish. The marl is throughout more or less sandy, so much so that in some of the samples it becomes almost a calcareous sandstone. Within the formation are found two strata of calcareous and phosphatic clays, the first of which is found at a depth of 195 feet, and has a thickness of 9 ft. 6 inches while the second is found at a depth of 260 feet and has a thickness of 10 feet. Locally the materials of the formation have become compact and close grained, probably in the form of rounded boulders which are broken up in drilling. Such boulders frequently form within the earth owing to the action of underground water and may be either calcareous or flinty. This record is of special interest as showing the great thickness of phosphatic materials underlying the land pebble phosphate beds, these marls being with little doubt the parent formation from which the land pebble phosphate deposits have been formed.

Local hard ledges sufficient to rest the outer casing are found within this formation, the first, or 18 inch casing having been rested at the depth of 65 feet, while the second or 14 inch casing was rested at the depth of 139 feet and 11 inches.

The formation next underlying this marl is a light colored limestone made up of a mass of broken fragments and having a thickness of 50 feet, extending from 360 to 410 feet. This limestone is slightly if at all phosphatic, the few phosphate pebbles seen in the samples having probably fallen in from the strata above.

Next beneath this limestone is the light colored limestone of the Vicksburg formation which is first encountered in this well at a depth of 410 feet and continues with some variation to the bottom of the well 838 feet. This formation here as elsewhere while fairly uniform shows more or less variation in character. The prevailing phase is a light colored or nearly white limestone consisting of a mass of shells and broken shells or of soft granular limestone with few fossils. Occasional strata are found, especially deep within the formation, which are hard and compact, these being usually of a brownish color and finely powdered by the drill. Locally also flint masses occur. These flints represent silicified limestone and may or may not be encountered in any particular well. Locally the limestone is found to be partially crystallized, this phase being due to the solution and redeposition of calcium carbonate by underground water. This well terminated in a seven-foot cavity from which an ample water supply was obtained. These cavities, which are not infrequent in this limestone, act as feeders to a well and afford as a rule an inexhaustible supply of water.

The inner, 12-inch, casing in this well was rested at 414 feet or just within the Vicksburg limestone. A limited amount of water was found in the well at the depth of 150 feet having a head of 33 feet, 3 inches below the surface. This head was reduced upon striking a second small supply of water at 155 feet, to 38 feet below the surface. This shallow water was shut off by the casing, and no large supply such as would serve the purpose for which the well was being drilled was obtained until the large cavity was reached at the bottom of the well. The water in the well after striking the cavity stood 37 feet from the surface and was not appreciably lowered upon pumping 500 gallons per minute, and machinery will be installed to pump the supply desired amounting to about 2500 gallons per minute. While the samples obtained from this well were sufficient to show the lithologic character of the formations, the fossils were not sufficiently abundant to determine satisfactorily the age of those formations lying above the Vicksburg limestone, and in order to obtain better representation of the fossils, the company is now undertaking to preserve larger samples from a second well that is to be drilled at this locality. In obtaining these larger samples screens will be used through which the drillings from the well will be passed and from which the samples will be collected.

Two wells drilled by the Florida East Coast Railway on Key Vaca, one reaching a depth of 435 feet, the other 700 feet, carefully recorded by Mr. Samuel Sanford, who was in charge of the drilling operations, have contributed largely to our knowledge of the sub-structure of the Florida Keys. The data obtained from these two wells has been supplemented by wells drilled at Key West, the first of which reached a depth of 2000 feet, the second, a depth of 1010 feet. At Palm Beach and at St. Augustine are deep wells, records from which have been of much value in the study of the geology and water supply of the State, the records of which are included in the published reports of the Survey which are available to those interested.

The well records which have been given will serve to indicate on the one hand the utility and value of exact data from deep wells, and on the other hand will serve to emphasize the fact that equally or more complete records are to be desired from the many other localities in the State from which at present only partial records are available. Moreover, a single record from a locality does not supply all the information desired, since the degree of variability within the formation is of much practical value in well-drilling, and on this point information approaches completeness only as successive well holes are drilled through the same formation.

The investigation of the water supply as a mineral resource as well as the general study of the geology of the state is made by law a part of the duties of the State Geological Survey, and in accordance with this requirement the services of the State Survey are at the disposal of individuals and communities in the study of water supply problems except, however, those concerning sanitary conditions, which are more properly the work of the State Board of Health. In accordance with this requirement the State Geologist will assist in preserving well records, will examine and report upon samples from drillings, and after correlating the data from numerous wells will make the information available through the published reports of the Survey to all those who may be interested. It would seem that municipalities in particular should be interested in thus preserving data of this character, and it is recommended that each municipality, as well as individual owners, include in their specification for wells a provision for the preservation of careful records and samples of the drillings to be forwarded to the State Geological Survey. By so doing the preservation of the record will be provided for. In many instances, particularly as data in each locality accumulates, the State Geologist will be able to supply information, based upon an examination of samples from wells previously drilled, that will be of service in drawing up specifications for wells, as well as to advise as to the depth that it is advisable to drill and the character of water that may be expected, this data being given as in the case of all other services rendered by the Survey as a part of its usual duties which involves neither obligation nor expense to those to whom the service is rendered.

SUMMARY STATEMENT OF MINERAL PRODUCTION IN FLORIDA DURING 1913.

COLLECTED IN CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

Common or building brick, 42,450 M., valued at ___$	240,126.00
Lime, including quick and hydrated lime, 18,917 short tons, valued at ______________________	100,335.00
Limestone, including ground limestone for agricultural use and crushed rock for railroad ballast, concrete and road material _________________	156,589.00
Mineral waters, 343,123 gallons, valued at _______	37,474.00
Phosphate rock, 2,545,276 long tons, valued at____	9,563,084.00
Sand and gravel, including building and moulding sand and gravel, 87,061 short tons, valued at __	21,194.00
Sand-lime brick, including common and front brick, 73,415 thousand, valued at _________________	79,679.00
Mineral products not separately listed, including ball clay, drain tile, diatomaceous earth, fullers earth and other miscellaneous materials, valued at __	448,147.00
Total mineral products in Florida during 1913, valued at ________________________________	$10,646,628.00

SOME FLORIDA LAKES AND LAKE BASINS

BY E. H. SELLARDS

SECOND EDITION.

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ILLUSTRATIONS.

SOME FLORIDA LAKES AND LAKE BASINS.

BY E. H. SELLARDS

INTRODUCTION.

Florida is justly celebrated for the number and beauty of its lakes. These lakes vary in size from the small ponds which scarcely exceed a few rods in circumference to the great Okeechobee, the surface area of which exceeds 700 square miles. Okeechobee is in fact noteworthy as being, with the exception of Lake Michigan, the largest fresh water lake lying wholly within the United States. In depth the Florida lakes are likewise variable, and in fact the depth is frequently in inverse ratio to the size. Many of the large lakes are comparatively shallow, while some of the small lakes are deep. This is particularly true of the small sink-hole lakes, some of which, while not exceeding a few rods in circumference have a depth of one to two hundred or more feet. In origin and history of development the Florida lakes are as variable as in other characteristics.

The lakes described in this paper include only a few of the many Florida lakes and represent a type peculiar in character and in manner of development. They are fresh water lakes, often of considerable size, although usually relatively shallow as compared to their areal extent. Moreover they are variable in character. Under normal conditions they are clear water lakes abounding in fish and the favorite haunt of the wild duck. They have as a rule no surface outlet, yet from many of them the water has at times disappeared in a manner seemingly inexplicable. In most instances the lakes thus disappearing have refilled slowly. Some of them, however, have remained dry a number of years. A correct understanding of these lakes together with the origin and development of the basins which they occupy is necessarily based on a study of the geologic formations which underlie them.

The fall of 1909 offered an exceptionally favorable time for investigating lakes of this character. The prolonged dry weather of the past few years had reduced these lakes to a low stage offering an opportunity of examining the soil and vegetation as well as the geologic structure of their basins. At the Tallahassee station in Leon County, near which several of these lakes are located, the rainfall at the close of 1909 had been below normal as shown by the weather bureau records for two years in succession. At the Gainesville station in Alachua County, the rainfall had been be-

*Second Edition. The first edition of this paper, the supply of which is now exhausted, was published in the Third Annual Report. pp. 43-76, 1910.

low normal during the preceding four years and at the Lake City station the rainfall had been below normal for at least three years in succession and apparently, from some imperfect records, had not reached normal during the preceding seven years.

Under these circumstances it was deemed advisable to make use of the favorable opportunity during the fall of 1909 for investigating the geology of these lake basins.

Attempts have been made to drain some of these lakes as the land is more or less valuable for agricultural purposes. In some instances drainage operations have been delayed owing to legal difficulties arising from the variable character of the lakes. The lake basins claimed by the State under the title of swamp and overflowed lands were likewise claimed by abutting property owners under the privilege of riparian rights. A decision of the State Supreme Court, rendered in 1909, vests the title of the lands in question with the State, not, however, as swamp and overflowed land, but as navigable water.

LOCATION OF LAKES.

The lakes described in this paper occur in the upland section of the interior of Florida. In general they may be said to occur in a belt extending with interruptions from the Ocklocknee River east and south paralleling the Gulf of Mexico to Hernando and Pasco Counties. The largest and best known examples are found in Leon, Jefferson, Columbia and Alachua Counties. Smaller but no less typical lakes of this type occur in Madison, Suwannee, Marion, Levy, Orange, Hernando and probably some other counties adjacent to those mentioned. West of the Apalachicola River small lakes of similar character occur in Jackson County and possibly also in Holmes County. The lakes selected for description as illustrating this type include Lakes Iamonia, Jackson, and Lafayette, in Leon County; Lake Miccosukee in Jefferson County; Alligator Lake in Columbia County; Alachua Lake in Alachua County; and Ocheesee Lake in Jackson County. The belt of country through which these lakes occur, although now broken up through natural processes of erosion into several more or less well defined sub-divisions, was probably at one time continuous.

CHARACTERISTICS.

The leading characteristics of these lakes have been mentioned. They do not occur along the coast nor in the level low lying parts of the state. On the contrary they are on the uplands, and occur in sections having a hilly or rolling topography. Sinks or openings occur through which the water escapes into the underlying formations. These sinks are located ordinarily at the foot of a steep bluff bordering the lake. Around the main sink one finds ordinarily other sinks of more recent formation indicating the manner and direction of enlargement of the basin. The sinks through which the water escapes are variable in depth but reach in all cases to underlying limestones. A channel as a rule leads back from this sink across the lake bottom representing the main channel of flow of water to the sink. Aside from this channel the bottom of the lake is relatively flat and level, although slight local depressions occur involving in some instances differences of level, of ten to fifteen feet. The soil in the lake basins varies considerably. In some of the lakes—those which seldom go dry—there is an accumulation of muck or peat formed largely from pond lilies and other aquatic vegetation. Local depressions in the lake often have an accumulation of this material amounting to several feet. Some of the other lakes which frequently go dry have little or no muck except in depressions which hold water even in dry seasons. Beneath the muck is usually found light colored sand washed and blown from the neighboring highlands. This sand may be several feet deep in places, elsewhere it is largely absent. Ordinarily a sandy clay occurs beneath the sand.

When these lakes dry up the water is commonly reported as running out very suddenly. This, however, is usually not the case. As long as the lake has sufficient water to cover the entire basin the lowering of the water surface proceeds very slowly. Subsequently when the total surface area of the lake becomes much restricted the lowering of the water surface proceeds much more rapidly. This leads to the statement that the water of the lake disappeared suddenly while as a matter of fact in many cases the water escapes through the sink no faster and indeed hardly so fast during the dry season as it had been escaping when the lake was full during the season of normal rainfall. It is true, however, that new sinks occasionaly form in the bottom of the lake. In the case of the formation of new sinks the rate of escape of the water is increased.

ORIGIN AND HISTORY OF DEVELOPMENT.

The origin of these lake basins is a part of the history of development of the general topography of the region. In this development both mechanical erosion and erosion by solution have had a part. The land surface when first elevated above sea was evidently much more nearly level than at present. Upon being lifted above sea level irregularities in topography rapidly develop.

A first step in the process of erosion is the development of stream channels and valleys, largely through mechanical erosion. In addition to mechanical erosion, erosion by solution due to underground water is likewise in process especially in sections underlaid by limestones.

As illustrating the efficiency of underground water as an eroding agent, the writer in a previous report computed the rate of erosion by solution in the sections of the state underlaid by limestones.* The estimate of the rate of solution given below is taken from that report.

Solution is the most apparent, and geologically the most important result of underground water circulation. Rain water, while passing through the air, takes into solution a small amount of CO_2 gas. To this is added organic and mineral acids taken up while passing through the soil. Increased pressure, as the water descends into the earth, enables the water to hold in solution greater quantities of gases, acids and salts, all of which greatly increase the dissolving power of the water.

That underground water is efficient as a solvent is evident from the analyses of well and spring waters. Rain water entering the earth with almost no solids in solution, returns to the surface through springs and wells with a load of mineral solids in solution determined by the length of time it has been in the ground, the distance traveled, and the character of the rocks and minerals with which it comes in contact.

The mineral matter thus taken into solution is carried along with water, and, while some of it is re-deposited, a large amount is removed annually.

An estimate of the total mineral solids thus removed is difficult. A conception of the largeness of the amount removed is obtained from a consideration of some of the individual springs.

The water of Silver Springs contains, as shown by analysis, 274 parts solids per million parts water. Otherwise expressed, each million pounds of water is carrying with it 274 pounds of solids in solution. Silver Spring is estimated to flow a little more than three million pounds of water per minute (368,913 gallons). The interior of Florida is thus being carried into the ocean through Silver Springs at the rate of more than 890 pounds per minute, or about six hundred tons per day.

*Fla. Geol. Survey Bulletin No. 1, pp. 46, 47, 48, 1908.

The total solids removed in solution through six other springs of central Florida, expressed in tabular form, gives the following results:

Name of Spring.	County.	Total solids (parts per million*)	Est. flow (gals. per min.)	Solids removed lbs. per day.
Blue	Marion	112.1	349,166	469,698
Blue	Levy	196.8	25,000	59,040
Ichetucknee	Columbia	211.6	180,000	457,056
Newland	Suwannee	233.5	75,000	210,150
Weekiwachee	Hernando	227.8	100,000	273,360
White Sulphur	Hamilton	166.6	32,400	64,774
Suwannee	Suwannee	332.7	19,747	78,816

As the basis of an estimate of the total solids removed annually from the interior, let it be assumed, (1) that the average total solids in spring water amount to as much as 219 parts per million, this average being obtained from eight of the typical large springs of central Florida; (2) that the annual escape of the underground water approximates the annual in-take, amounting, as previously estimated to 460,536,689 gallons per square mile. Upon these estimates the mineral solids removed amount to a little more than four hundred tons annually per square mile.

Of the minerals thus removed, calcium carbonate or limestone greatly predominates, exceeding the combined weight of all other minerals. From the analyses it appears that magnesium carbonate, magnesium and calcium sulphates are present in variable, although usually limited, quantities. Chlorides are normally present in small amount, although occasionally, as in the case of Perrian Spring, they are exceptionally high. Silica is present in amounts varying from 5 to 25.5 parts per million. Traces of phosphoric acid and of iron and alumina are usually present.

The several undetermined factors which enter into the above estimates of mineral solids removed make it difficult to formulate a concrete statement of the rate of lowering of the general surface level. Nevertheless, such statements are desired and have a comparative value. Assuming for the rock removed, most of which is

*Organic matter is deducted from the total solids as given for Suwannee Sulphur and White Sulphur Springs. The organic matter occurring in the other springs is of small amounts and was not separately determined. Analyses of the water of these springs were given in Bulletin No. 1, pp. 72-75, 1908.

limestone, an average specific gravity of 2.5, a layer one foot thick over one square mile should weigh about two and one-sixth million tons. The calculated rate of removal of this rock is about four hundred tons per square mile per year. From these estimates it would appear that the surface level of the central peninsular section of Florida is being lowered by solution at the rate of a foot in five or six thousand years.

With due allowance for a wide margin of error in the above estimates it is still evident that a very great amount of mineral solids is being removed annually in solution. The first effect of solution in limestone is to develop cavities through the rock along the line of ready flow of underground water. These cavities gradually enlarge until the overlying material, no longer able to support its own weight, caves in, forming a sink.

The formation of a sink is a first step in the development of the many basins large and small occupied by these temporary lakes. A sink usually retains connection with the underlying limestone for some time after its formation and water entering the sink escapes into the limestone. Under these circumstances more or less of the material lying immediately around the sink is carried by surface wash through the sink. Moreover the large amount of water entering through the sink results in rapid solution in the limestone of that immediate vicinity. The result is frequently the formation of other sinks in close proximity to the first. As old sinks become clogged or partly filled, new sinks form by this process continually enlarging the basin.

Not infrequently a sink forms in or near the bed of a stream. When this occurs the lower course of the stream, or a part of it, may be reversed. Where many sinks form in succession or through a long period of time the valley of the stream is thereby enlarged and is frequently carried to a level lower than the original outlet. Lakes Iamonia and Lafayette in Leon County and Alachua Lake in Alachua County are illustrations of basins of this type.

RELATION OF THE LAKE BASINS TO THE LEVEL OF PERMANENT UNDERGROUND WATER.

It is important to note the relation of these lake basins to the permanent underground water level of the formation into which they drain. It is a well established fact that solution by underground water goes on more rapidly above the level of permanent underground water than below this level. The term "belt of weathering" is commonly applied to that part of the earth's crust lying above the underground water level; while the term "belt of cementation" is applied to that part lying immediately below this level. According to Van Hise "the most characteristic reaction of the belt of weathering is solution. In contrast with this the most characteristic reaction in the belt of cementation is deposited in the openings of the rocks."* The rapid solution in the belt of weathering is due to a number of causes. First of all the water in this part of the earth's crust moves freely, while in the belt of cementation the water often moves very slowly. Moreover water is capable under given conditions of carrying a definite amount of mineral solids in solution and as the water from the surface enters the earth with little or no load, until it becomes saturated it takes materials into solution readily.

In accordance with this principle it is found that the largest of these basins are, as a rule, reduced practically to the level of underground water. Many of the smaller basins, it is true, have not reached the permanent water level, and stand at varying heights above that level. The relation of the basins to the underground water has a practical bearing and will be referred to again in connection with methods of drainage of the lakes.

DESCRIPTIONS OF TYPICAL LAKES.

LAKE IAMONIA.

Lake Iamonia lies near the north line of Leon County. The lake basin is irregular in outline, but has an average width of from one to one and one-half miles. The total length of the lake is from twelve to thirteen miles. At its west end the lake basin connects with the swamp of the Ocklocknee River. During flood seasons the river overflows into the lake. Similarly a high stage in the lake results in an overflow into the river. Small tributary streams enter the lake from both the north and the south side as well as from the east end. The tributaries are small flat-bottomed streams which are dry, except during the rainy season. The lake fluctuates much according to the rainfall. The lake basin when full covers an area of about 6,500 acres. Except at the west end, where it joins the Ocklocknee River, the lake is largely surrounded by the

*Treatise on Metamorphism Mon. U. S. Geol. Survey, XLVII, p. 165, 1904.

red clay hills characteristic of this part of the State. These hills rise to an elevation of from 50 to 75 feet above the level of the lake.

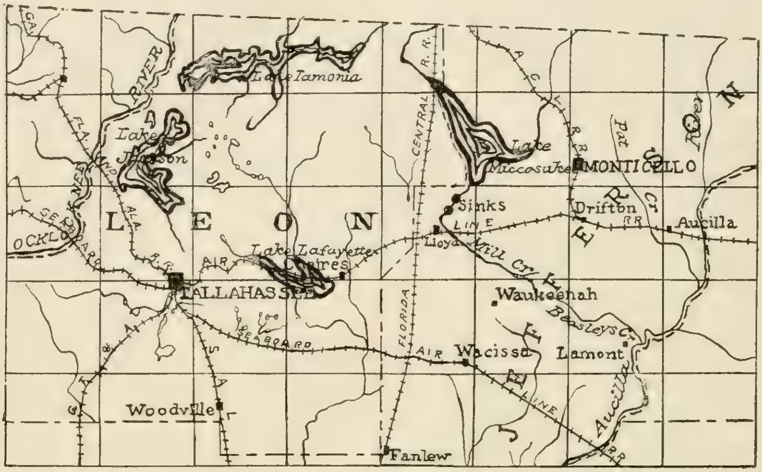

Fig. 27.—Sketch map showing the location of lakes Iamonia, Jackson, Lafayette and Miccosukee in Leon and Jefferson Counties.

The sink through which the water escapes from this lake is found on the north border. When visited May 7, 1910, the sink was practically dry, having only a small amount of water in the bottom. Limestone rock, probably of Upper Oligocene age, is exposed near the bottom of the sink, the water escaping through or under these rocks. Above the limestone partly decayed sandy clays occur. These contain few fossils, although oyster shells were found in abundance at one locality. The total depth of the sink below the general level of the lake is not less than 50 feet. The sink occurs, as is usual in this type of lake, facing an abrupt bluff 30 feet or more in height. A considerable number of sinks occur around the border of the lake especially in the vicinity of the one large sink which receives the drainage of the lake. The formation of these sinks is doubtless due, as previously stated, to the fact that the water entering the drainage sink spreads laterally in the underlying limestone and dissolves the rock rapidly. The result is the formation by subsidence of numerous sinks adjacent to the drainage sink. The presence of these sinks also indicates the manner of enlargement of the lake basin, and indicates in each case the direction of most rapid enlargement at the present time. At other times the enlargement by solution and subsidence may have been most active in some other locality or direction or part of the lake basin.

This lake only occasionally goes entirely dry and as a result a covering of muck or peat occurs over the greater part of the bottom of the lake. This deposit of muck reaches a considerable thickness in such natural depressions as occur over the lake bottom. Beneath the muck is usually found a deposit of light colored sand and beneath this is the red sandy clay.

The fact that the Ocklocknee River at flood stage flows into this lake makes any attempt at drainage doubtful of success. An effort which proved unsuccessful was made at one time to prevent the river water from entering the lake by means of a dam. It seemed to be the views of the party constructing the dam that if the water of the Ocklocknee River could be kept out the sink would carry off the water from the lake. This, however, is not probable, since in the several other lakes to be described the sinks have not proved sufficient to carry off the water except in times of greatly reduced rainfall. Lake Iamonia basin represents apparently a stream valley lowered by solution and enlarged laterally by subsidence through the formation of sinks. Originally a small stream tributary to the Ocklocknee River flowed through this section. In this part of the country soluble limestones occur at no great distance from the surface, and in the course of the natural processes of erosion the stream approached sufficiently near this limestone to permit of the formation of sinks and the escape of the water of the stream through the sinks. The enlargement of the valley to its present size has proceeded through the formation and partial filling of successive sinks. As each sink forms, it carries down to or below the lake level, a certain small area of land. Moreover the water passing through the bottom of the sink carries with it more or less detrital material so that the surrounding area is somewhat lowered by wash through the sink. In the course of time other sinks form, while the older sinks become clogged and usually partly fill up. The direction of active enlargement of each lake can be determined from the location of the recent sinks. As previously remarked this rapid enlargement is usually around the sink which is at present actively receiving the drainage.

LAKE JACKSON.

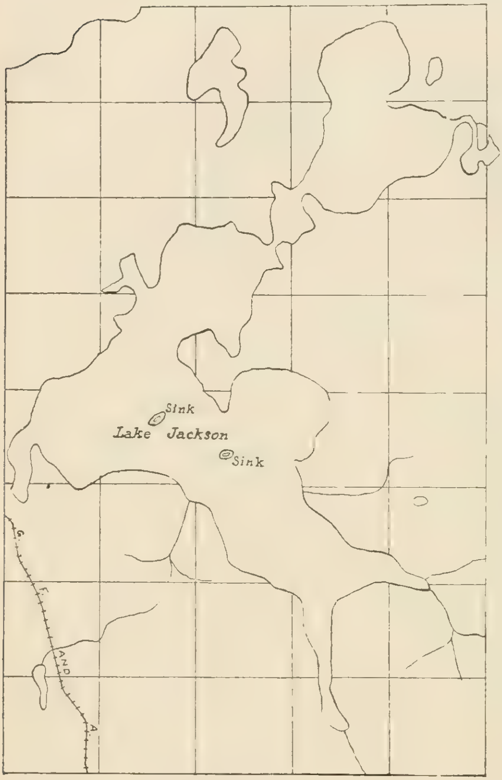

Fig. 28.—Lake Jackson.

Lake Jackson lies near the western border of Leon County within one and a half or two miles of the Ocklocknee River. This lake is irregular in shape, and has a total area of about 4,500 acres. The boundaries of the basin are sharply marked by the surrounding highlands which rise 75 to 100 feet above the level of the lake. Several sinks occur in the southern half of the lake. The largest of these, known locally as the "lime sink," is located well out in the basin and in the angle between the north and east arms. (See map). An opening in the bottom of this sink in May, 1907, permitted the water to run out, leaving the sink dry, and also draining the lake or such part of it as was connected with the sinks. An indefinitely defined broad depression or slough extends to the southeast from the lime sink. Several water holes representing old sinks occur along the line of this depression. A new sink occurred along the bottom of the depression about one mile southeast of the lime sink in June, 1907. A compact limestone showed in the bottom of this sink at a depth of about 25 feet from the surface. At the time this sink formed the lake was low, a part of the water having been carried off through the opening which had formed in the lime sink a month earlier. All the water that could reach the new sink was carried off in the course of two or three days, leaving the lake dry except for occasional water holes. When examined in September, 1909, a small open sink was found in the slough which carried away all of the water that reached it from the surrounding parts of the lake.

The surface soil in the basin is quite generally a gray sand darkened by admixture of organic matter. In the lower parts of the lake, quite generally covered by water, more or less muck or peat occurs formed from the accumulation of aquatic vegetation. Sand lighter in color and lacking the organic matter occurs at a depth of 1 1-2 or 2 feet to 3 or 4 feet. Beneath this sand is the usual red sandy clay.

This lake as already mentioned became dry, or nearly so, in the early spring of 1907. It was partly filled by the summer rains of the same year, but became dry or nearly so again during the summer of 1909. The accompanying photograph of this lake was taken July 5, 1909 and shows an unusually low water stage of the lake for that season of the year. (Fig. 32).

LAKE LAFAYETTE.

Lafayette Basin or Lake Lafayette lies in the eastern part of Leon County between Tallahassee and Chaires. The basin begins three and one-half miles east of Tallahassee, and extends to within one mile of Chaires, having a total length of about five and one-half miles, and a width of one-half to one mile. An arm of the lake extends north from near the east end of the lake. The bottom of the basin is nearly level with the exception of occasional slight depressions. The tributaries to the lake are flat-bottomed streams with relatively broad valleys and no well defined channel. The soil in these stream valleys is a sandy loam, and the streams are ordinarily dry, carrying water only during the rainy season.

A drainage sink in this basin occurs near the west end of the lake along the northern border (See Fig. 29). The sink when measured in September, 1909, was found to have a total depth of 75 feet. The sink is found, as is usual in this type of lake basin, near a prominent bluff. A second sink is formed beyond the lake border, thus indicating the enlargement of the lake basin in that direction by subsidence, due to underground solution. This new sink is one hundred yards or more in circumference, and when formed carried down to the lake level, land which stood fifty feet or more above the lake and was being used previous to the subsidence as a cemetery.

That part of the lake basin which surrounds the sink lies at a slightly lower level than the more remote parts of the basin and is the first to be submerged at the approach of the rainy season. This area is entirely devoid of trees, and during the dry season becomes a prairie. The greater part of the basin lying to the south of the railroad is thickly set with small cypress trees.

The soil in the basin is prevailingly a gray sand usually darkened by the presence of organic matter. At a depth of from one to two feet the amount of organic matter is reduced, the sand being lighter in color. Sandy clays are reached as a rule at a depth of from two and a half to three feet.

During a season of normal rainfall this basin is occupied by a lake having a total area of approximately two thousand acres. Following a period of prolonged drought the basin becomes entirely dry, water remaining only at the sink. In times of excessive rainfall the lake overflows at the east end, the water discharged reaching streams tributary to the St. Marks River.

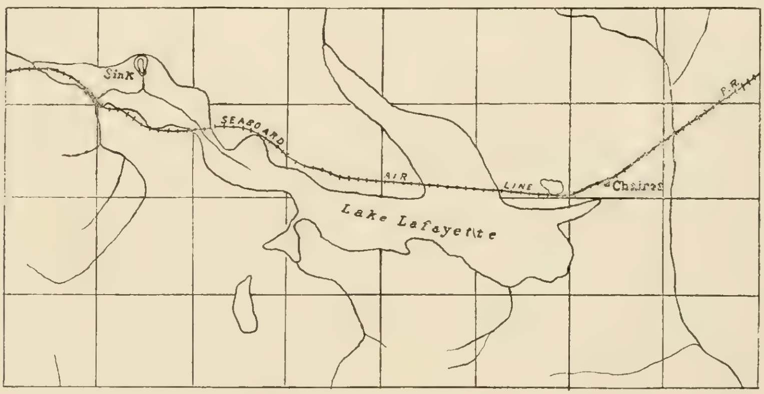

Fig. 29.—Lake Lafayette.

This basin has much the character of an elongated valley. The general course of the streams of this part of the county, the shape of the basin and particularly the topography of the surrounding country indicate that the drainage of this section was originally through these streams into the St. Marks River. The formation of sinks diverted the drainage to a subterranean course, the west end of the basin having been reduced to a level somewhat lower than the east end. The further enlargement of the basin is being carried on through the formation of sinks along the border. The largest of the newly formed sinks is found near the present drainage sink.

LAKE MICCOSUKEE.

Miccosukee Basin or Lake Miccosukee lies between Leon and Jefferson Counties, the west border of the lake forming the county line. A small arm of the lake, however, near the north end reaches into Leon County.

Miccosukee Basin has a total area of about 5,000 acres. In its northern part the basin is bordered by sharply defined bluffs, which rise from 50 to 75 or 100 feet above the lake bottom. Farther south these bluffs fall back and give place to a gradual rise of elevation from the lake border. At the south end bluffs are lacking. A drain known as Miccosukee drain enters from the east side. This drain consists of a low, swampy area from one-fourth to three-fourths mile in width. This swamp land supports a thick growth of hardwood trees.

When full, Miccosukee Basin is covered with water to a depth of from 2 to 5 feet. Toward the south end around the border of the lake grass and button bushes project above the water even when the lake is full.

The sink of Lake Miccosukee is located near the northwest corner of the basin, and is bordered by a bluff having an elevation of from 75 to 100 feet. Landslides along the border of the sink show recent enlargements of the basin. Numerous sinks occur along the border of the lake at this locality, showing enlargement of the lake basin through subsidence. The greatest depth of water found in the sink when examined September 7, 1909, was 38 feet. A channel leads back from this sink across the prairie in a southeasterly direction. This channel has cut to a depth of from twenty to twenty-five feet. Followed back from the sink the channel is of gradually reduced depth finally at a distance of about two miles merging into the general level of the lake bottom. When examined September 8, 1909, this stream was carrying water into the sink at a rate estimated to be 200 gallons per minute. Notwithstanding the inflow from the stream the water in the sink was being gradually lowered. Heavy rains occurred in this vicinity on September 21, 1909, and this stream when seen two days later was carrying approximately 7,000 gallons of water per minute. At this time the sink was being rapidly filled, having filled several feet during the two preceding days. From these observations it appears that the opening at the bottom of this sink permits the escape of water at a rate in excess of 200 gallons per minute, but much less than 7,000 gallons per minute. From the behavior of the sink it is probable that not more than 1,000 gallons of water are escaping per minute, and the rate of escape may be much less.

The principal escape of water from Lake Miccosukee when the lake is full is through a drain which leads out from the south end of the lake and enters a sink about two and one-fourth miles from the south end of the lake. This sink is formed in a light colored limestone of Upper Oligocene age, probably representing the Chat-

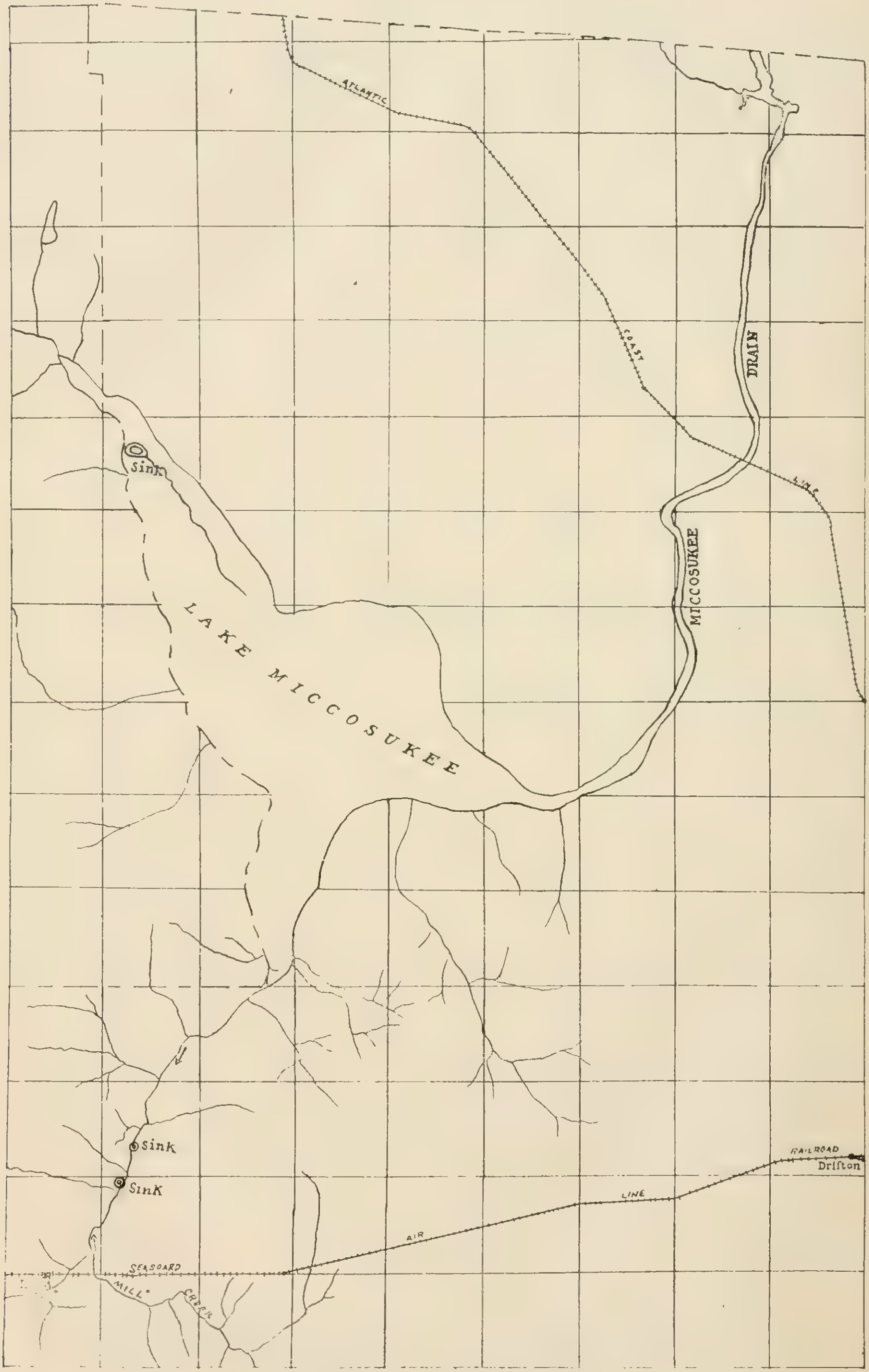

Fig. 30.—Lake Miccosukee.

tahoochee formation. The drain from the lake as it approaches the sink passes through a narrow gorge cut in this limestone.

About one-half mile farther south (Sec. 14) another sink is found. This third sink receives the flow from Mill Creek, a small stream draining considerable territory lying south of the Seaboard Air Line Railway and east of Lloyds.

During a season of excessive rains these sinks are unable to carry away the water. Under these conditions the overflow from Lake Miccosukee as well as from Mill Creek ultimately finds its escape by flowing to the southwest past Lloyds to the St. Marks River.

The surface in Miccosukee Basin is covered with muck to a varying depth. Borings put down near the north end of the basin, out from the margin of the drain, indicated the presence of muck for a depth of from six inches to one foot. Beneath the muck in this part of the basin was found a gray sand. This sand is underlaid, at a variable depth, by the usual red sandy clay. At the south end of the lake the sand is largely absent, the muck which is from one to three or more feet deep resting, so far as observed, directly upon the red clay.

Lake Miccosukee probably represents a basin developed by solution near the headwaters of streams originally tributary to the St. Marks River. Previous to the formation of Miccosukee Basin the drainage of this part of the country doubtless passed through small streams, to the south past the present village of Lloyds, thence to the Gulf through the St. Marks River. The lake basin since its formation has enlarged to the northwest, the lowest part of the basin now being found near the sink in the northwest corner.

Mill Creek which now enters from the south and disappears through a sink a few miles north of Lloyds illustrates the reversal of flow of a stream due to the formation of a sink. This stream, previous to the formation of the sink, flowed southwest to the St. Marks River. At the present time it flows north and enters the sink. At times of excessive rainfall the sink is unable to carry off the water and the stream under these conditions flows in its earlier course to the St. Marks River.

ALLIGATOR LAKE.

Alligator Lake lies in the central part of Columbia County, from one and a half to two miles southeast of Lake City. The lake basin has a total area of about 1,000 acres. Numerous smaller lakes occur to the west and north of this large lake. The surrounding country is in general level or rolling and lies at an elevation aproximating 200 feet above sea. The basin along its western side is bordered by a bluff which rises to an elevation of from 50 to 75 feet above the level of the lake. Along the eastern and southeastern side the basin passes gradually into low lying swampy hammock land, or cypress swamp. The sink of Alligator Lake occurs along the southwestern border. The escape of water at the present time is through this sink. In the country bordering the lake around this sink numerous other sinks occur. The lake is said to overflow at high water stage to the south through a small stream known as Clay Hole Branch.

A soil boring put down fifty yards from the edge of the basin along its southwest border gave the following section:

Black muck with admixture of clay	1 ft.
Yellow sand loam	½ ft.
Fine light gray sand	1½ ft.

A pit made by Mr. Greer in his garden near the border of the lake gave the following section:

Brownish colored imperfectly decayed vegetable matter (peat)	1 ft.
Black muck with admixture of sand and clay	2 ft.
Red very sandy clay	1 ft.

It is reported that at the time of the early settlements in Columbia County, 1835 or thereabouts, Alligator Basin was a prairie or savanna and was used at that time by the Indians as pasture land. The lake was dry in the fall of 1891, and again in the fall of 1899 or 1900. It was dry again during the winter and spring of 1909, but was partly filled by rains during the following summer.

Approximately complete records of rainfall are available at the Lake City station for the year 1897 and succeeding years. The rainfall for the year 1899, at which time the lake became dry, was much below normal, amounting for the year to only 30.49 inches. The next period of unusually low rainfall was the year 1908. During this year the rainfall amounted to only 29.83. The rainfall during the year 1909 was likewise slightly below normal, amounting at Lake City to 49.68 inches.

ALACHUA LAKE.

Alachua Lake or Payne's Prairie is the central and largest of the several lake basins of southeastern Alachua County. This basin is about eight miles long and varies in width from one and a half to four miles, and contains about twelve thousand acres. Low divides scarcely exceeding ten feet in elevation separate this basin from Kanapaha and other prairies on the west and from Levy, Ledwith, and numerous smaller lakes on the south, and from Newnans Lake on the northeast. The total area embraced within these various basins is not less than fifty square miles. For a map of this section the reader may consult the Arredondo topographic sheet of the U. S. Geological Survey.

When dry or nearly so, this basin supports a dense growth of grasses and weeds. On the more elevated and dryer parts dog-fennel prevails, growing to a height of eight or ten feet, while on the lower and wetter parts of the basin maiden cane abounds.

The principal stream entering this basin is a creek flowing from Newnan's Lake. This creek enters at the east side of the basin and flows west and northwest to the sinks, of which there are two located on the northeast border, the water from the lake enters the Vicksburg Limestone. The sinks are partly surrounded by bluffs rising to an elevation of thirty or forty feet above the general level of the basin. Numerous sinks also occur along the border of the lake showing enlargement of the lake basin in this direction. The stream entering the more westerly of the two sinks was carrying water when examined in October, 1907, at an estimated rate of 20,000 gallons per minute. At this time the water level in the sink was only 2.01 feet above the general level of water in the Vicksburg Limestone as shown by the Gainesville city well,* from which it is evident that the opening at the bottom of the sink permits the escape of water approximately at the rate of 20,000 gallons per minute. It is probable, however, that the capacity of the sink is little, if any, greater than this, as indicated by the fact that the water in the sink stood two feet above the water level in the limestone.

In November, 1909, the water in the sink stood approximately one and one-half feet above the level of the water in the surrounding limestone.

During seasons of heavy rainfall the stream draining from Newnan's Lake and other smaller streams carry water so rapidly that the water is unable to escape through the sink as rapidly as it flows in. Under these conditions the basin fills, becoming temporarily a lake. It is probable also that the drainage sink becomes more or less completely clogged at times, retarding the escape of water, and in this case the prairie may continue as a lake through a succession of years.

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*Bull. No. 1, Fla. Geol. Survey, p. 60, 1908.

Variation in this lake has been more or less perfectly recorded since the time of the earliest settlements in this section. When visited by Bartram in 1776 this basin was known as "Alachua savannah" and served as grazing ground for stock belonging to the Indians.* The basin was visited by James Pierce in 1824 and was dry at that time. The water in the basin is said by W. W. Cameron who lives near its margin, to have been very low in 1861. When visited by Dr. E. A. Smith in 1880, the basin was comparatively full, forming a lake. The basin in fact is reported to have continued as a lake from 1871 or 1873 to 1891. In the fall of 1891 the basin became dry, and, with the exception of temporary overflows, has been dry much of time since that date. It is possible that the higher water stage in the basin during the years from 1871 to 1891 was due to partial clogging of the sink. The records of rainfall during these years for this section is unfortunately lacking.

The following account of the disappearance of Alachua Lake appeared in the Providence Journal for September 14, 1891. The account is given with some omissions as quoted by Dr. W. H. Dall in Bul. 84, U. S. Geol. Survey, p. 94, 1892.

"A curious spectacle was to be seen on the outskirts of Gainesville, Florida, recently. Alachua Lake * * * is no more. On its banks were lying thousands of dead fish * * * and the atmosphere was heavy with noxious gases. Men and boys were there in throngs with hoes and rakes, dragging to shore hundreds of fish which had sought the pools for refuge. The waters were fairly alive with their struggles for existence. Except for a small stream known as Payne's Creek flowing from Newnan's Lake into the Sink, the two main basins of the Sink, and a few stagnant pools, no water is now to be seen where a few years ago steamers were ploughing their way. This is the second time since 1823, that a similar occurrence has taken place. At that time the bed of the lake was a large prairie—Payne's Prairie—having in it a body of water called the Sink and a small creek. In 1868 heavy rains filled up the prairie, but the water disappeared after a short time and the prairie was again dry land. In 1873, after a series of heavy rains, the Sink overflowed and the creek swelled to the dimensions of a lake. During several years the waters increased till a larger lake was formed, and for fully fifteen years sufficient depth of water stood over the prairie to allow of small steamers. During the last two years, however, the waters have been gradually lowering, and about four weeks ago they commenced going down with surprising rapidity, the lake falling about eight feet in ten days, until now nothing is left of Alachua Lake but the memory of it. The Sink is considered the cause of this change. There is evidently an underground passage connected, and for some reason not understood, this underground passage has been acting as a drain until all the water in the lake has been drawn off."

In this account the fact is noted as is usually the case that after the lake becomes somewhat restricted the water seemed to escape

*Bartram's Travels, First Edition, page 203, 1791. Philadelphia.

Fig. 31.—Miccosukee basin, low water stage, 1909. This view is taken at the sink near the northwestern side of the lake.

Fig. 32.—Lake Jackson. View taken from the north end of the lake. Photograph by R. M. Harper.

Fig. 33.—Alligator Lake. View taken from the bluff overlooking the lake. Photograph by A. M. Henry.

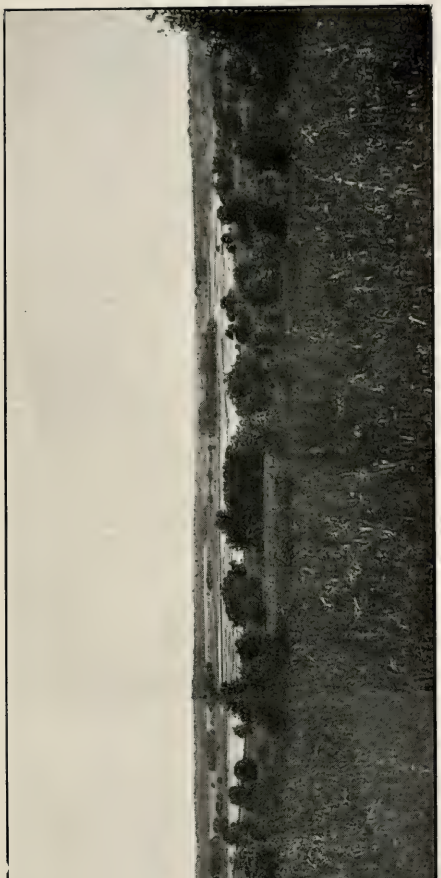

Fig. 34.—The sink of Lake Lafayette.

Fig. 35.—Payne's Prairie at low water stage. View from the sink. Photograph by E. Peck Greene.

Fig. 36.—Payne's Prairie at low water stage. Photograph by R. M. Harper.

Fig. 37.—Spouting well near Orlando. Photograph by T. P. Robinson.

with great rapidity. The rapid lowering of the surface is usually due, however, as previously stated, not to greater rapidity in the escape of the water, but to the fact that as the total surface area of the lake became greatly restricted the escape of a given amount of water lowers the surface much more rapidly.

The following remarks regarding the lake appeared in the Washington Evening Star of September 19, 1891. This quotation is also from Dr. Dall's report:

"The Star recently printed an account of the disappearance of Alachua Lake in Florida, a lake that was so well established that a steamboat line was maintained on it. A U. S. Geological Survey party has been engaged at work in that region. A member of this party, Mr. Hersey Munroe, who is now in the city, gave an interesting account of the lake, or rather the ex-lake, to a Star reporter. "Alachua Lake," said Mr. Munroe, "is situated in north latitude 29 degrees 35 minutes and west longitude 82 degrees 20 minutes, in Alachua County, Fla., and 2 miles south of Gainesville, the county seat. The lake was formerly a prairie, known as Alachua prairie before the Seminole War during 1835-37. It has since been named Payne's Prairie, after King Payne, an old Seminole chief of an early day. The prairie was a great grazing spot for the Indians' cattle and later was used for a like purpose and for tillage by the whites, some fine crops of corn and cotton being grown. The prairie lands are immense meadows, covered by the finest grass, interspersed with clumps of beautiful oak trees and palmettoes. These lands are subject to inundation during the summer season. Hatchet Creek rises 3 miles north of Gainesville and flows in every direction of the compass for a distance of 10 miles, emptying into Newnan's Lake, a beautiful sheet of water covering 10 square miles.

"HOW THE LAKE WAS FORMED.

"The overflow from Newnans Lake forms a large creek named Prairie Creek, which wended its way through Payne's Prairie to Alachua Sink, one of the curiosities of the State. There the waters found their way into a subterranean passage. Visitors, to have their curiosity gratified by seeing what the effect would be to have logs thrown into the sink, were the probable cause of the overflow of Payne's Prairie. The logs would float out to the center of the sink, whirl around in a circle and suddenly disappear. This choking of the outlet to the waters of Prairie Creek caused the overflow and made a sheet of water sufficient to float small steamers and other crafts.

"One steamer in particular had a splendid freight traffic, during the vegetable season carrying shipments of vegetables from its wharf on Chacala pond across Alachua Lake to the mouth of Sweetwater branch, the nearest point to Gainesville, the principal place for shipment north. After the overflow and the forming of a lake it was christened Alachua Lake. This name has been decided upon by the United States Board on Geographic Names. Alachua Lake is 8 miles long, east and west, and in one place 4 miles in width, north and south, covers 16,000 acres, and the average depth is from 2 to 14 feet.

"LOWERING FOR SEVERAL YEARS.

"For several years the lake has been gradually lowering. The elevation of the water above sea level as given by the Savannah, Florida and Western Railroad some years ago is 64 feet. By accurate levels run by one of the topographical parties of the Geological Survey working in this section during the winter of 1890-91 the elevation of the water was found to be 58 feet, thus showing that the lake had been changing elevation; and about two weeks ago I was informed that Alachua Lake had disappeared entirely, that only small pools remained and the usual amount immediately around the sink."

The early geological history of that section of Alachua County now occupied by these larger basins and lakes was apparently as follows: Originally the surface runoff from southeastern Alachua County made its way through Orange Creek and the Ocklawaha River into the St. Johns River. These streams were then heading

Fig. 38.—Sketch map of Hogtown Prairie and surroundings, illustrating a stage in the development of a solution basin. From the Arredondo topographic sheet, U. S. Geol. Survey. The 60-foot contour line borders the prairie.

back in the plateau region of Alachua County, and were fed both by the surface runoff and by the numerous small springs issuing from the clays and sands of the Apalachicola group underlying the plateau. In the course of time the streams cut down to or nearly to the underlying Vicksburg Limestone. The result of the close approach to this limestone was the formation of sinks due to solution in the limestone. After the formation of the sinks it became possible for the water to pass through the sinks and find its escape by subterranean drainage. This process of solution and subsidence continued through long intervals of time has resulted in the formation of these numerous basins. Some of these basins have been carried to a level equal to or below their original outlet through Orange Creek.

Basins may be seen at the present time in varying stages of development. In the plateau itself no basins are found. Even here, however, are found occasional sinks, the first evident effect of the reduction by solution. An illustration of a partially developed basin may be found in Sanchez Prairie near Hague. The country surrounding this small basin stands at a level of about 180 feet. The basin itself occupying an area of a few hundred acres is reduced to an elevation of about 100 feet above sea. Hogtown Prairie near Gainesville (Text figure 38) represents a more advanced basin. Hogtown Creek probably originally flowed through Alachua Basin, thence to the St. Johns River through Orange Creek. The formation of the sink, however, permitted a subterranean escape and around this sink is formed Hogtown Prairie, now separated from Payne's Prairie by elevations amounting to twenty or thirty feet.

OCHEESEE LAKE.

Of the few lakes occurring in Jackson County, Ocheesee Lake is perhaps the largest. This lake lies in the southeastern part of the county extending from near Grand Ridge in a southeasterly direction to within three or four miles of the Apalachicola River. The total length of the lake is six or seven miles. In breadth it varies from a few rods to possibly three-fourths of a mile. At the northwest end the surrounding country rises very gradually. The southwest part of the lake, however, is surrounded by red sandy hills which rise from 75 to 100 feet above the bottom of the lake. The lake is perhaps best described in this instance as a swamp, the greater part of the lake bottom being occupied by a growth of cypress, although near the east end open water occurs over an area of about 100 acres. The water from the lake sinks into the Chattahoochee Limestone at the southeast end of the basin.

The history of the development of this lake is very clear. Originally the drainage from this part of the county passed by a surface stream to the Apalachicola River. At a distance of three or four miles from the river, this stream, after cutting its channel some depth, reached the Chattahoochee Limestone. When this formation was reached the water passed into the earth, the drainage becoming subterranean. Subsequent erosion carried the basin to its present level.

METHODS OF DRAINAGE.

Two methods of draining basins of this type may be considered. (1) drainage by surface ditching to some stream or other outlet lying at a lower level; or (2) drainage into the underlying water bearing formation.

DRAINAGE BY SURFACE DITCHING.

Surface ditching usually suggests itself as the more natural method of drainage, and it is often inferred in the absence of definite information that the lakes lie at a higher level than near-by streams. This frequently is not the case, and such an assumption may lead to a very costly error. A lake or prairie of this type a few miles southeast of Citra was connected many years ago by canal at considerable expense with a tributary of the Ocklawaha River. Upon completion of the canal it was found that the lake basin was at a lower level than the stream bed, the water from the stream actually flowing into the lake. The peculiar method of formation of these lake basins by solution, as previously explained, carries them frequently to a lower level than the stream which served in earlier stages as an outlet. Lake Iamonia as previously stated lies practically on a level with the Ocklocknee River, and receives the overflow of that river during high water stages. Alachua Lake basin lies, as shown by the topographic map, at practically the same level as Orange Lake and the headwaters of Orange Creek which served formerly as the outlet.

DRAINAGE INTO THE UNDERLYING FORMATIONS BY WELLS.

Drainage into the underlying formations takes place naturally through the sinks already existing. Artificial drainage either by enlarging the sinks, or wells dug or drilled through to the water bearing formation is frequently resorted to. In either case the principle is the same. The underlying limestone is porous and cavernous, and is filled with water to a definite although slightly variable line or level known as the permanent underground water level.

Solution in the limestone occurs both above and below the water line, but chiefly above. As solution continues the overlying material is no longer able to support its own weight and caves in, forming a sink or natural opening from the surface to the limestone. As long as this sink remains open, water passes through and escapes readily into the limestone. Drilled or dug wells serve as artificial openings to the same formation. Wells drilled into this limestone will serve either as supply wells from which water may be pumped or as drainage wells into which water may be conducted. It is generally the case that a well entering this formation that can not be appreciably affected by pumping, will also conduct water readily. If the openings into the well are sufficiently free to permit ready flow to the well when being pumped, they are, conversely, sufficiently open to allow the water to spread rapidly from the well when used as a drainage well. The amount of water held in the pores and cavities of the limestone is so great that the water level is not appreciably affected either by the water removed when a well is being pumped, or by the water added when a well or sink is used for drainage purposes.

Attempts to enlarge existing sinks or to re-open sinks that have become clogged have usually proved futile. It is doubtless true that the opening through sinks is a more or less winding channel and to re-open this when clogged with debris is difficult.

Better success has been obtained by dug or drilled wells. Where the underlying porous formation into which the well is to be drained lies near the surface, dug wells can be used to advantage and may be preferable. Dr. H. Bjystra has used this method in draining a small lake or "prairie" on his farm near Brooksville, Florida. At this locality the cavernous limestone lies near the surface and is reached by relatively shallow wells. The one difficulty experienced as reported by Dr. Bjystra is the fact that during the summer rainy season in one or two instances the rainfall has been so heavy within a short space of time that the wells were unable to carry away the water as fast as it fell, the result being temporary overflow of the farm and serious injury to growing crops. When used as pasture land the temporary or partial overflows are, of course, less serious.

Drilled or bored wells have been in some instances notably successful. An advantage in the drilled well is that it can be put down to any required depth, and when properly cased and screened is permanent. The effectiveness of the well is dependent upon the structure of the formation penetrated. If the water-conducting power of the formation reached by the well is slight a limit is thereby placed on the effectiveness of the well. Unless the flow of water at the bottom of the well is free the in-take of water is necessarily limited.

Assuming free movement of the water at the bottom of the well, the rapidity of in-take and hence the efficiency of the well is influenced by (a) size of well; (b) construction of well; (c) depth of water above the mouth of the pipe; (d) distance from the top of the pipe to the underground water level.*

(a) The capacity of a drain pipe increases rapidly with increased diameter. The area of the section of the pipe is proportionate to the square of the diameter. Thus the area of the cross section of a 12-inch well is nine times that of a 4-inch well. Moreover, for a given velocity the friction of movement is less in a large than in a small pipe.

(b) The construction of a well also affects its rapidity of in-take. When the pipe is cut off squarely at the top according to the usual custom, the full capacity of the well is not realized. The rapidity of in-take may be appreciably increased by the use of a flared or bell-shaped mouth at the top of the pipe.

(c) If the underground water level lies some distance from the surface and if there is free discharge at the bottom of the well, siphonage or draft-tube action increases the rate of flow. When the distance from the top of the pipe to the underground water level is 33 feet or over, the maximum possible draft-tube head of 32.8 feet may be available.

(d) The influence of the depth of water above the mouth of the pipe is as follows: Assuming that the water flows into the pipe as through an orifice, the in-take at the mouth of the pipe will be proportionate to the square root of the depth of the water above the mouth of the pipe.

The velocity of flow in the drainage well may be measured by means of Pitot's tube. This is a bent tube one arm of which is graduated, used to determine the velocity of running water. To make the measurement insert the tube vertically in the top of the pipe, the short end projecting upward and having its mouth a few inches below the top of the drain pipe. The velocity of flow in the pipe is expressed within close limits by the following formula in which h is the height in inches to which the water rises in the long arm above the surface of the lake.*

$$V = \sqrt{\frac{64\ 32h}{12}} = 2.32\ \sqrt{h}$$

*U. S. Geol. Surv. Water Supply Paper, 145, p. 36, 1905. R. E. Horton.

The flow in cubic feet per second into the well will be

$$Q = 0.0055\, d^2 V = \frac{d^2 \sqrt{h}}{80} \text{ nearly}$$

In this formula Q represents the flow in cubic feet per second; d is the inside diameter of the pipe in inches, and h the height in inches to which the water rises in the long arm above the surface of the lake. V is the velocity of flow.

A notably successful instance of drainage by wells where the interests of a municipality were involved occurred at Orlando, Florida, and was given in Bulletin No. 1, as follows:

"A very considerable land area south and east of Orlando, embracing possibly fourteen square miles, lies in an irregualr basin with many lakes, marshes, and ponds. The overflow from this area originally drained to and disappeared through a natural sink about one mile east of the city. This sink became clogged in April, 1904. Unsuccessful efforts were made to re-open this sink, first by removing hyacinths accumulated around the opening, and later by the use of dynamite. In the meantime, heavy and continued rains formed a lake around the sink, overflowing the surrounding lands. In August, 1904, efforts were made to dispose of the water through drainage wells. The first well put down was a two-inch test well. The well reached a porous stratum and was thought to justify the expense of a larger and deeper well. Difficulty and delay were experienced in the drilling, but by August, 1905, two wells, one eight-inch and one twelve-inch, put down at the side and near the original sink, had been completed. Two other wells were started and abandoned owing to the difficulties in drilling. The two successful wells were running at full capacity. It was thought probable that the two wells already put down would prove sufficient. Heavy rains followed, and by January, 1906, a considerable area, including some cultivated ground, was flooded, practically all county roads leading into Orlando from the east were partly under water and impassible. The colored settlement known as Jonestown in the suburb of Orlando was partly under water and uninhabitable; the water was approaching the city of Orlando itself and the situation was becoming alarming. Levels taken by the county authorities indicated that drainage through surface canals was impossible or impracticable. Two additional twelve-inch wells were bored in November and December of 1906. The effect of these was evident at once, the lake beginning to fall. By February a third twelve-inch well had been completed making in all one eight-inch well and four twelve-inch wells running at this time. By the end of March the water had returned practically to its normal level and has since been kept under control.

"Four of these drainage wells are located near the original sink and have a uniform depth of 140 feet, a cavity several feet in diameter having been reached at that depth. The fifth well is located one-half mile west of the sink, and terminates in a porous stratum at a depth of 340 feet."

Since the completion of these wells by the city a number of other drainage wells have been put down by individuals, used largely to reclaim trucking and farming lands.

One of these drainage wells near Orlando developed recently the unusual phenomenon of spouting. The well is located three miles north of Orlando on land belonging to Charles T. Myers. It was drilled in 1907 jointly by Mr. Myers and Messrs. McNeal and Davis, the latter gentlemen having the property leased for farming purposes. The well is twelve inches in diameter and has a total depth of 260 feet, is cased 60 feet, and it is located at the edge of a small lake. The level of permanent underground water at this locality is 33 feet from the surface. Trucking is carried on around the border of the lake and the well is intended, by carrying off the surplus water, to prevent the lake from rising above a given level, since to do so would flood the farming land. The well is similar in character to the other drainage wells of this locality and as in the case of most of the other wells, terminates in a cavity in the limestone.

The well was first seen by the writer October 4, 1910. At this time the water of the lake stood a few inches above the level of the pipe and the well was receiving water at much less than its full carrying capacity. At intervals of a few minutes the well would reverse itself and spout, throwing a column of water into the air. The spouting comes on gradually. First the well ceases to receive water and begins bubbling; the column of water follows, rising with considerable force to a height of twenty feet or more above the surface, the spout occurred with tolerable regularity at intervals of four minutes. Mr. R. D. Unis, who has charge of the farm, states, however, that the intervals between spouts vary from two to fifteen minutes, being probably influenced by varying conditions under which the water enters the well. (Fig. 37).

Although drilled about three years ago and receiving water more or less constantly since that time the phenomenon of spouting developed for the first time on September 26, 1910, the first spouting having occurred about eight o'clock on the morning of that day. The well continued spouting without interruption for a little more than a week and until shut off by the owner.

Various fanciful theories have been advanced to account for the spouting, including supposed occurrence of gas and oil, and the supposed influence of recently formed sinks in the interior of the State. The true explanation is evidently much more simple. At the present stage of the lake the well is receiving water at less than its full carrying capacity and as the water enters the vertical pipe it forms a suction carrying a large amount of air into the well, which doubtless collects in a chamber or cavity along the side or at the bottom of the well. As the well continues receiving water the air accumulates under pressure in the earth until ultimately the pressure under which the air is confined is sufficient to overcome the weight of the overlying water and hence rushes out with considerable force carrying the column of water with it.

The fact that the well when first drilled did not spout, and afterwards began spouting, doubtless indicates that the essential conditions were subsequently developed either by caving or by other changes in the underground conditions.

The spouting of the well is therefore on the principle of the air-lift pump in which air under pressure is conveyed into the well through a special tube for that purpose and being liberated in the well lifts a column of water to the surface. In this spouting well, however, the air pressure is developed within the well. This well may, therefore, be classed as a self pumping well.

When partly shut off so that only a limited amount of water enters, the air taken into the well is able to return to the surface freely. Under these conditions spouting ceases. It is probable that if an elbow is placed on the well, allowing the water to enter laterally instead of vertically, the amount of air taken into the well will be so far reduced that the spouting will cease. Likewise when the lake rises so that the water stands several feet above the top of the pipe entering the well it is to be expected that the spouting will cease, since the pipe will then be carrying water at its full capacity, and little or no air under these conditions entering the well.*

The drainage wells are themselves remarkable and found in such perfection only under geological conditions similar to those existing in Florida. Of the many peculiarities of these wells,

*Since the above was written very heavy rains attending the storm of October 17, 1910, caused the lake to rise 18 to 20 inches, and Mr. Unis writes that when the water rose in the lake the well ceased spouting.

however, that of spouting is certainly the most striking and remarkable. It is of interest to note that a similar spouting well has been reported by Professor McCallie at Albany, Georgia.*

In considering the use of wells for drainage purposes the relation of the lake basin to the underground water level should first be definitely determined. The effectiveness of the well is reduced as the water level is approached, and it is of course obvious that the water in the lake can in no case be carried below the underground water level. Many of the larger lake basins are known to lie very close to the water level. If the lake basin lies as low as the permanent water level it is obvious that the water in the lake can not be drained by wells, moreover since the effectiveness of the well is affected by the near approach to the water level, it is hardly practicable to reduce the water in the lake quite to the permanent underground water level. It must also be borne in mind that while the underground water is a permanent supply the water level or water line is not stationary, but varies with the seasons. The amount of variation for the locality concerned should be determined.

The fact that a lake basin stands somewhat above the water line at the close of a long dry season is not proof that it will be found to stand above the water line after a season of heavy rainfall. In some sections of the state the range of variation of the water line has been found to be as much as ten feet, and may in some instances exceed that amount.

The relation between the level of the lake basin and the underground water has been determined for a few of the lakes. Measurements of Alachua Lake were made in 1907 and again in 1909. When measured in October, 1907, the water level in Alachua Lake was found to be 2.01 feet above the level of the underground water of the Vicksburg Limestone formation as determined from the Gainesville City well.* When measured in November, 1909, the water in the sink stood approximately 1.4 feet above the water level in the limestone as indicated by the city well. At the time these measurements were made the lake was at a low water stage. The underground water level was likewise at a low stage. From these measurements it appears that Alachua Lake during the dry seasons at least is lowered by natural drainage through the sink to or practically to the underground water level. During the rainy season the water in the lake doubtless rises above this level, although it must be borne in mind that the water line also rises during the rainy season, a fact that should be borne in mind when planning drainage.

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*Science, Vol. 24, p. 694, 1906.

*For a record of this well, see Bul. No. 1, pp. 30 and 88-89, 1908.

Approximate measurements of the water level in Alligator Lake near Lake City have also been made. This is one of the smaller basins and the measurements indicate that the level of the water in the lake stands appreciably above the underground water level. In this instance the measurements of the water level and the lake level were made at different seasons of the year and the results can be only approximately compared. The data on this lake are as follows: Levels made by Professor N. H. Cox, on June 19, 1903, showed that the water in Alligator Lake stood 94.22 feet below the Union Depot at Lake City.

The lake at the time the levels were made was at medium full stage. The water of the Lake City public well, located near, and on about the same level as the depot was found at the time the well was completed in 1907 to stand 134 feet from the surface. Allowing for any correction that it might be necessary to make owing to the fact that the measurements of lake level and ground water level were not made at the same time it would still seem that the lake basin in this instance stands somewhat above the water level.

RELATION OF THE GROUND WATER LEVEL TO THE FORMATION OF SINKS.

It is of interest in this connection to note the influence of the ground water level on the formation of sinks. Sinks do not form in Florida in that part of the State in which the water first encountered as permanent water in the limestone is under sufficient pressure to flow at the surface. The reason for this seems obvious. In areas of artesian flow, such cavities as exist in the limestone are filled with water under pressure, which, together with the resistance of the strata to breakage, is sufficient to prevent the overlying materials from subsiding and thus forming sinks. Along the border line between the flowing and non-flowing area the artesian water frequently breaks out forming springs. On the other hand the areas of most rapid formation of sinks are those in which (1), the limestone is rather near the surface; (2), the underground water level is below, although comparatively near the surface, and (3), the materials lying above the water bearing limestones are so far disintegrated that they permit the surface water, rainfall, to pass readily through them into the limestones beneath. Under these conditions the fluctuation of the water level has a pronounced effect. When the water level is high, as following the rainy season, the materials are water soaked almost to the surface. When the water level is low, following a prolonged drought, the support is withdrawn, and the already partially disintegrated strata break and subside into such cavities as have been formed by solution in the limestone.

Where the strata lying above the limestones reach a considerable thickness their resistance to breakage is of itself sufficient to prevent the formation of sinks. No specified thickness of strata can be given through which sinks will not break, since this depends both upon the character of the strata and the size of the cavities in the underlying limestone. In the plateau section of Florida sinks have broken through as much as 100 feet of materials, a large part of which, however, are themselves more or less calcareous and phosphatic, and hence may have been removed in part by solution before breaking.

Fig. 39.—Sketch indicating the relation between ground water level, surface level, sinks and lake basins in central Florida from near Gainesville, passing through Payne's Prairie and Orange lake and following the Ocklawaha river to the St. Johns river. The surface level is represented by the line "a"; the artesian water level by "b"; the top surface of the principal water bearing limestones, chiefly, if not entirely the Vicksburg formation, by "c." The vertical scale of the drawing is 1 in. equals approximately 100 ft.; horizontal scale, 1 in. equals 5 miles. The materials lying above the water-bearing limestones include, in the vicinity of Gainesville chiefly the Alum Bluff formation, while east of Orange Lake, later formation overlie the Alum Bluff. All of these formations dip toward the east, although in this sketch the dip appears exaggerated, owing to the differences between the vertical and horizontal scales.

The surface level on the plateau, on the edge of which the city of Gainesville stands, is about 180 feet above sea. Upon going down this escarpment to Payne's Prairie, the surface level falls to from 60 to 80 feet above sea, this elevation being maintained with little variation while crossing the group of basins which include Payne's Prairie, Orange and other lakes. Beyond Orange lake the slope is gradual to the St. Johns river, which is within a few feet of the sea level.

The artesian water level, "b", in the vicinity of Gainesville on the plateau, is 125 to 130 feet below the surface (50 to 55 ft. above sea level). In passing to the coast, this line shows a gradient and at the St. Johns river is probably about 50 feet above sea level. In the section represented by this sketch, the artesian water line crosses the surface somewhat east of Orange Lake, this being the border line between the flowing and the non-flowing artesian areas.

In the area of artesian flow, that is east of the point in this sketch, at which the line representing the water level crosses the surface, sinks do not occur and are not to be expected. Along the border line of the escarpment sink formation is most active. In the plateau where the limestones are covered with a thickness of 100 feet or more of stratified materials, sinks form less frequently. The escarpment shown in the sketch has been formed and is being carried inland by surface erosion and underground solution, the formation of sinks being one of the results of solution.

VARIATION IN THE GROUND WATER LEVEL.

The ground water level is first of all subject to change owing to the annual wet and dry seasons. Almost one-half of the annual rainfall in Florida occurs during the summer months, and following this season the ground water level rises for a time, reaching its maximum some weeks after the rainy season ends. It then gradually falls until the next following rainy season begins. This may be regarded as the normal variation on the ground water level, which amounts in places where it has been measured to from eight to ten feet or more. This variation in water level affects as a rule not materially the amount of water that a well will supply upon pumping, but merely the level at which the water stands in the well. In the case of flowing artesian wells, however, it is indicated by a change in the pressure, and those wells located near the border line between the flowing and the non-flowing area may cease to flow during the dry season.

A second and more marked variation in the ground water level arises from those periods including often a succession of years, of reduced rainfall, or a similar period of excessive rainfall. The variation of the ground water level during such time, although not accurately determined, is evidently much greater than the normal annual variation.

Not only does the underground water level fluctuate according to seasonal and periodic rainfall, but it is also being gradually lowered by the lowering of its outlet. The underground water finds its natural outlet through springs which enter the streams or emerge into the ocean. Since the streams are constantly deepening their channels it follows that the outlet for the underground water is being lowered and hence the water line itself is necessarily being gradually lowered. This gradual change in the water line in geologic time affects the life history of the lake basins, but does not of course affect the observed behavior of the lakes.

SUMMARY.

The basins of the temporary lakes have their origin in erosion by solution and by mechanical wash. Some of them appear to represent the enlarged valleys of what was originally a small stream. Sinks form along these streams diverting the course of the water into the underlying limestones. Other basins originate from sinks in no way connected with stream valleys. The origin of the sink was due primarily to solution in the limestone. After the sink is formed the general level of the surrounding area is lowered somewhat by mechanical wash, the material being carried into the sink. Subsequently other sinks form in the immediate vicinity, due also to solution. The large amount of water which entered the limestone from the sinks already formed facilitates solution and results in the formation of additional sinks. The continuance of this process through a long period of time results in the development of the large basins occupied by these lakes. From their manner of development it follows that the steepest bluffs as a rule are those immediately facing the active sinks. Likewise for reasons already given new sinks occur most frequently in the area immediately surrounding the active sink. The lakes occupy basins that have worked their way through the surface deposits, chiefly the Alum Bluff formation, down to or nearly to the underlying limestones of either the Chattahoochee or the Vicksburg formations. In any case, however, the lake basins can scarcely be lowered below ground water level, since for a stream entering a sink, the permanent ground water level is base level.

The behavior of the lakes is largely explained by the seasonal and periodic variation in the rainfall which affects the ground water level. The lakes appear to go dry suddenly. This, however, is often more apparent than real. So long as the entire basin is submerged, the water line recedes so slowly as scarcely to be noticed. Afterwards, however, when only a part of the basin is covered, or when there is water only in the small basin immediately around the sink, the water lowers very rapidly and the lake seems to be suddenly running dry. It is true, however, that the escape of the water is not infrequently facilitated by the formation at low water stages of new sinks.

It is doubtless true that some of the lakes, especially the smaller ones, could be drained by surface ditching. Any attempt at drainage should be preceded, however, by the preparation of a carefully made topographic map of the region, or at least sufficient exact leveling should be made to determine definitely the relation of the lake basin to the proposed outlet, and to the intervening country.

While some of these lakes can be drained by bored wells it is not to be assumed that all can be so drained. As has been shown some of these lake basins, especially the larger ones, have been lowered by solution practically to the permanent underground water level. Before attempting drainage by wells definite data should be obtained as to the relation between the level of the lake basin and the underground water level of that locality. This information can often be obtained by running a line of levels from the lake to a near by deep well and comparing the level of water in the lake with the level at which the water stands in the well. If necessary, test wells may be drilled before undertaking large wells. Such lakes as have been lowered by natural drainage actually to the underground water level can of course be lowered no further by wells.

THE RELATION BETWEEN THE DUNNELLON FORMATION AND THE ALACHUA CLAYS OF FLORIDA.

E. H. SELLARDS.

The term "Alachua Clays" was proposed by Dr. W. H. Dall in 1885 for the clay beds in the vicinity of Archer from which at that time extensive collections of vertebrate fossils were being made. The first published account in which this term was used, however, is found in Bulletin 84 of the United States Geological Survey, page 127, 1892. The formation is there described as occurring in sinks, gullies and other depressions in the Upper and Lower Oligocene (then regarded as Miocene and Eocene respectively). The clays were considered by Dall as representing a remnant of a previously more extensive formation. Although in his original description, Dall mentions a number of localities, including those on Peace Creek, Caloosa River and rock crevices at Ocala, now known to be of later date, yet the deposits are sufficiently characterized by the description of the exposures in the vicinity of Archer which are regarded as the typical localities.

The term "Dunnellon formation" was first used by the writer in 1910 to designate the extensive deposits which hold the hard rock phosphates of Florida. While the prevailing phase of the Dunnellon formation is light gray phosphatic sands, the deposits include also local beds, lenses, or masses of clay, as well as phosphate rock, flint boulders, pebble conglomerate and limestone fragments.

A recent examination of typical localities has convinced the writer that the Alachua Clays and the Dunnellon formation are not separable, the former representing, in fact, a local phase of the latter. The Dunnellon formation, as I have elsewhere shown, has accumulated from the residue of the formations that have disintegrated *in situ,* the material having been reworked to a considerable extent, through the agency of the sinks, sink hole ponds, small lakes and local streams that existed in this area during the earlier stages of its physiographic development.*

*Fla. Geol. Surv. Third Ann. Report, p. 32, 1910; and Fifth Ann. Report, pp. 53-56, 1913.

The Alachua Clays, with little doubt, represent the location of such sinks, ponds or lakes. This view is supported by the local extent of the clay beds, the manner in which the fossils are imbedded, as well as by the species that are found in the clay. Sinks very possibly began to form in central Florida as early as the late Miocene. Sink formation must certainly have been active during the Pliocene, and has continued in fact through the Pleistocene to the present. It would seem, however, that the Pliocene was the time in which sink hole ponds, small lakes, and local surface streams reached their abundant and typical development in this part of the State. An analagous stage of development may be observed in adjacent sections of the State at the present time.

The vertebrate fauna of the Dunnellon formation and the Alachua Clays is practically the same, including the mastodon, rhinoceros, camel and early horse.* With these late Miocene or early Pliocene forms is found *Odocoileus, Tapirus, Megatherium* and other late Pliocene or Pleistocene types. The mixing of fossils results unavoidably from the manner of accumulation of the deposits, for while the formation is believed to have accumulated chiefly during the Pliocene, yet sink formation having continued later forms were carried into the deposits and mixed with the earlier.

The term "Alachua Clays," although descriptive of the localities to which it was applied, yet is not applicable to the formation as a whole. Since, however, this term has precedence in time, and is also well established in literature, it seems advisable to drop the term "Dunnellon formation," and to designate the deposits as a whole as the Alachua formation.

*The mastodon found in these deposits is *M. floridanus*. The horse is *Neohipparion*, of which at least two species are present. The camel found in the Alachua clay deposits, of which three species have been described, was identified by Leidy and Lucas as *Procamelus*. Two species of rhinoceros are also recognized, namely *Teleoceras fossiger* and *Aphelops malachorinus*.

GEOGRAPHY AND VEGETATION OF NORTHERN FLORIDA

ROLAND M. HARPER

INTRODUCTION

In connection with the preparation of the report on the peat deposits of Florida, issued by the State Geological Survey in 1910 in co-operation with the United States Geological Survey, Dr. R. M. Harper, the author, collected during the years 1908, 1909 and 1910, a large number of notes relating to the natural geographic divisions and the native vegetation of the State. The data thus obtained formed the basis of the division of the State into geographic provinces as given in the peat report. Since the publication of that report, however, Dr. Harper has materially added to these notes, and to the bibliographic references bearing on this subject. He has taken also a large number of photographs, most of those used in this report having been contributed by him.

The division of the State into its geographic provinces as given in the earlier report having proved useful and suggestive, and the edition of that report being now practically exhausted, it has seemed advisable, utilizing the large amount of data already available, to issue a detailed report relating specifically to the geography and vegetation of the State. For this purpose the data on hand are being supplemented. and have been brought up to date for northern Florida by additional field work by Dr. Harper during the year 1914. For southern Florida additional data are necessary. The present report is therefore limited to northern and western Florida, including about two-fifths of the area and three-fifths of the present population of the State.

The problem of determining the agricultural capabilities of virgin soils by means of the native vegetation is one that has engaged many investigators, and there is perhaps no place in the eastern United States where this question can be studied to greater advantage or profit than in Florida where the original vegetation still remains over approximately nine-tenths of the whole area. Moreover, since the agricultural lands of Florida are being rapidly settled and cleared it is important to preserve at this time a record of the original distribution of the native vegetation together with its relation to the geographic divisions of the State, and to make this record available in subsequent more detailed soil studies.

This report preserves these valuable records and is moreover a contribution toward a better understanding of the complex relationship which exists between native vegetation, topographic and drainage conditions and soils.

E. H. SELLARDS,

State Geologist.

CONTENTS.

ADDITIONS AND CORRECTIONS.

PAGE.

209. Second paragraph. About two-thirds of the inhabitants of region 2 are white.
225. Last line of table. For 33.5 read 3.9.
236. Line 2. After Fraxinus Caroliniana insert *.
240. Line 8 begins a new sentence.
247. The soils of region 9 seem to be more silty than those of other flatwoods regions.
254. Add to references, U. S. Bureau of Soils Circular 72, on Payne's Prairie.
265. Line 8. Insert pears between peaches and English peas.
270. Middle paragraph. Gophers are said to occur near Bradfordville.
272. Near middle. Strike out one of the + marks before Quercus stellata.
276. Near middle. Move Goldenrod up one line.
277. Line 13. For Euphorbia heterophylla read E. dentata.
277. Line 17. After Cenchrus tribuloides insert (X)
279. Second paragraph. There are gates across the roads at the edges of this region in several places, to keep out cattle from neighboring free-range regions.
323. Line 2. Insert + before **Serenoa serrulata.**
338. Add to references, Harshberger (64, 69, 71).
342. Line 13 of first paragraph, for "and" read "or."

The names of the following evergreens, printed in ordinary type, should have been in bold-face:

PAGE

197. Line 21. **Persea Borbonia.**
198. Line 22. **Sebastiana ligustrina.**
199. Line 2. **Polystichum acrostichoides.**
220. Line 41. **Epidendrum conopseum.**
220. Line 45. **Asarum arifolium.**
234. Line 16. **Quercus laurifolia.**
260. Line 8. **Osmanthus Americana.**
263. Line 4. **Eriogonum tomentosum.**
405. Line 40. Batodendron **arboreum** (semi-evergreen).

(There are doubtless other errors of this kind due to insufficient observation of some of the smaller shrubs and herbs in winter.)

Typographical errors which are self-evident are not mentioned here.

GEOGRAPHY AND VEGETATION OF NORTHERN FLORIDA.

SCOPE OF THE REPORT.

The territory covered by this report is that part of Florida north of the southern boundaries of Lafayette, Alachua, Putnam and St. Johns Counties, an area of about 22,600 square miles. Within this area there is so much diversity of geographical conditions that any attempt to treat it as a unit, as is commonly done with whole states or countries in encyclopedias and school geographies, would be very unsatisfactory as well as unscientific. The wants of some readers would be best served by describing each county separately, but that would be equally unscientific, and would involve too much repetition. But the area can be divided into natural geographical divisions, which are almost as numerous as counties, and therefore average but little larger; and as each division is essentially homogeneous throughout, speaking in a general way, a description of the country by regions has decided advantages over any other plan.

A classification of geographical divisions for the whole state was given in the Third Annual Report of the State Geological Survey four years ago. The northern part is now subdivided somewhat more minutely and probably more accurately than was done at that time, and the salient characters of each region are described separately, with special emphasis on the vegetation, for reasons explained elsewhere. Although the writer has been in every county and traversed nearly every mile of railroad in northern Florida more than once, and has re-visited every division herein described during the present year, it has of course been out of the question to explore every township in the few years available; and previous publications contain very little information about the sections not yet visited, which are mostly remote from railroads. For this and other obvious reasons the regional descriptions are necessarily very generalized; and it has not been possible to make allowance for many exceptions, such as hills in some of the flattest regions, fertile spots in some of the poorest regions, etc. Likewise features which have been fully described in other easily accessible publications are not dwelt on at length.*

This report discusses not only the more striking natural features of each region, but also certain economic features, in order to illustrate the manner in which and the extent to which the natural resources (other than minerals and underground waters, which have been treated in considerable detail in previous publications of the Survey) have been utilized. This sort of information really belongs more to the domain of a census or statistical bureau, but it is given here because it seems appropriate, and because such data have heretofore been given only for counties and other political divisions, instead of natural divisions. In this way some very interesting differences between neighboring regions in density of population, status of the lumber industry, leading crops, etc., are brought out, and many geographical corrections can be made between these features and soil, topography and vegetation.

As in all scientific reports, the use of some technical terms is unavoidable, but these are explained as far as possible, and most of the matter which, although necessary to the proper exposition of the subject, will interest scientists more than any other class of readers is printed in smaller type, which the average reader can avoid if he desires. The writer will always be grateful for having his attention called to errors and serious omissions, or statements which could be improved upon without unduly increasing the length of the report; and all such criticisms will be taken advantage of in future publications.

*In many ways the best description of the natural and agricultural features of Florida ever published is the report on cotton production by Dr. Eugene A. Smith in the sixth volume of the Tenth Census, covering about 80 quarto pages, with three maps. Its accuracy is remarkable, considering the fact that the author spent only about six weeks in Florida, and that in the rainy season (summer) and at a time (1880) when there were no railroads in the State south of latitude 28° and only a few north of there. In preparing this report he had the advantage of long experience in an adjoining state, and he was unusually successful in extracting reliable information from the writings of some of his predecessors in Florida. He also brought out many new facts, especially in relation to the geology. The descriptive matter in Dr. Smith's report, as in most of the other state descriptions in the same series, is arranged both by natural divisions and by counties.

Geographical Significance of Vegetation.

Native vegetation is probably the most sensitive indicator of geographical conditions that can be found; for every variation in soil or climate is reflected in some way in the vegetation, so that if we understood the matter perfectly we could tell by inspection of the vegetation of an uninhabited region, without examining the soil at all, just what its agricultural possibilities would be. There is no better place in the eastern United States to apply this sort of knowledge than Florida, for in most parts of the state not more than 10 per cent of the land is under cultivation as yet, and the relations between soil and vegetation are often very marked.*

The fundamental facts about the vegetation set forth in the following pages ought to become more and more valuable in the future when the farms have encroached upon the forests to such an extent as to make the opportunities for this sort of investigation much more limited than they are at present. In most of the other eastern states some types of vegetation have disappeared entirely, and others have been mutilated so that it is no longer possible to form an adequate idea of their original condition.

In an area as small as that under consideration the diversity of vegetation seems to be due almost entirely to soil and topography, and the climatic belts or "life-zones" into which the whole continent is sometimes divided cannot be used. Many attempts have been made in other parts of the world to correlate vegetation with soil, but few general principles of world-wide application have been deduced as yet, apparently because the vegetation has nearly always been studied qualitatively and taxonomically instead of quantitatively and morphologically. In other words, investigators have usually tried to connect environmental conditions with the presence or

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*In fact most of the attempted classifications of Florida soils that were published up to very recently have been classifications of vegetation primarily, for they make use of such terms as "high pine land," "hammock," "swamp," "scrub" and "prairie," which are vegetation types rather than soil types. And maps of Florida and parts thereof on a large scale show many vegetation features, such as San Pedro Bay, Payne's Prairie, the Gulf Hammock (Levy Co.), "Swamp with dense growth of cypress and red cedar" (Hernando Co.), Annuttalagga Hammock (Hernando Co.), Grass Slough (DeSoto Co.), the Big Sawgrass (DeSoto and Lee Cos.), the Big Cypress (Lee Co.), and the Everglades. (See also 3d Annual Report, plates 11-13; 5th, plates 10-12).

absence of certain species, regardless of their relative abundance and structural adaptations.

In a certain neighborhood a certain plant may be common and apparently confined to a particular geological formation or type of soil, so as to lead to the belief that it is a good indicator of that type of soil*; but if a few specimens of the same plant are afterwards found on a very different soil in another part of the country that hypothesis is usually abandoned. But again the plant on the other soil, at first supposed to be the same species, may upon closer investigation be found to be a little different, and thus the original correlation may be re-established. In such cases everything depends on correct identification, an art in which very few botanists are proficient in this day and time.

A much better way of correlating vegetation with soil is to determine first the relative abundance of the different species in a given area, and then group together all those that have some character in common, such as trees, vines, evergreens, grasses, or plants belonging to some particular family, and see what proportion they make of the total. Some significant correlations can then often be made between these statistics and certain soil characters, such as texture or moisture or the percentage of some particular element or combination of elements. This kind of work could be carried on after a fashion by a botanist in a strange land where he did not know the name of a single plant; though of course it would be desirable to know the family to which each one belonged.

The usual way of studying the plant population of a state, county, or other area, is merely to make a list of the species of plants, noting their local distribution, habitats, etc.; which is a study of the *flora* rather than of the *vegetation*. The flora of Florida is now pretty well known, but this knowledge has been of comparatively little use to geographers. The inadequacy of qualitative studies may be illustrated by some analogies from other lines of investigation. A census report does not simply state that the population of a certain city, county or state is composed of natives and of immigrants from England, France, Germany, etc., but tells exact-

*For references to several studies of this kind see Ann. N. Y. Acad. Sci. 17:8-9 (footnote), 1906. See also Hilgard, Tenth Census U. S. 5:68—69, 76, 229. 1884; Soils. 487-526. 1906.

ly how many of each class. In describing the agricultural output of Florida we do not merely say that corn, cotton, oranges, vegetables, etc., are raised in the state, but we give the quantity of each in bushels, bales, or crates, as the case may be. A chemist in analyzing a mineral or soil or water or other substance does not content himself with making a list of the elements which it contains, but weighs each component carefully and expresses the results in percentages or in some other appropriate manner.*

In this report the vegetation is discussed quantitatively throughout. In each regional description the names of all the plants observed (except the rarer ones, which are omitted) are brought together in a single list, without separating the different habitats. A detailed study of habitats or vegetation types would require much more repetition of plant names and take up more space in other ways, and would be far too great an undertaking for a preliminary report like this. At some time in the near future it may be desirable to take up one region at a time and classify its plants by habitat; but the present study is essentially geographical, and the geographer

*Some illustrations of the advantages of quantitative studies in correlating vegetation with soil may appropriately be inserted here.

Two neighboring townships might both contain exactly the same species of pine and oak, say two or three of the former and a dozen of the latter, so that qualitative lists would show no difference between them. But if a forester should find that the virgin forests of one township averaged ten pines and a hundred oaks to the acre, while in the other the proportions were reversed, he would be justified in concluding that there was a considerable difference in soil, for it is well known that most oaks grow in richer soil than do most pines. Some valuable observations of this character were made by Coville and Branner in Arkansas a quarter of a century ago, long before most botanists had ever thought of studying vegetation quantitatively. (See Rep. Geol. Surv. Ark. for 1888, vol. 4, pp. 246-247.)

It is a matter of common observation in the southeastern United States, if not in other parts of the world, that deciduous trees are most abundant, not only in species but in individuals, on clayey and silty soils, and evergreens on sandy and peaty soils. But the differences between these soils are not merely physical. From all the available analyses of soils in which deciduous trees predominate it appears that they are all high in potassium (having usually at least 0.2 per cent soluble in hydrochloric acid), however much they may differ in calcium, phosphorus, nitrogen, and other essential constituents. And all soils with less than .05 per cent of acid-soluble potassium (or .06 per cent of potash, as it is usually expressed in analyses) which have come to the writer's knowledge are characterized by vegetation that is mostly evergreen. (The converse of these statements is not always true, however, for some soils well supplied with potassium support many evergreens. But in such is not specially concerned with plant associations, which are more the province of the plant sociologist and ecologist.

This method of lumping together all the plants of each region is analogous to that of the chemist who in analyzing a rock containing a mixture of several minerals grinds it all up and determines the composition of the whole, regardless of the separate minerals. The work of the plant sociologist is analogous to that of the mineralogist who might take the same rock and identify the minerals in it, and then analyze each mineral separately. The present paper seems to be the first attempt that has been made to analyze quantitatively the vegetation (including shrubs and herbs as well as trees) of so large an area, and no doubt there is considerable room for improvement in the methods used.

The methods here employed in making quantitative analyses of vegetation are described below, for the benefit of persons who may wish to test them in the same area, or to do similar work in other parts of the country.

cases it appears that the availability of the potassium compounds is restricted by some unfavorable condition, such as cold in the far north, aridity in some of the western states, and perpetual saturation of the soil in estuarine swamps.)

The soils of the "Yazoo Delta" of Mississippi contain from 0.25 to 0.91 per cent of potassium, according to Hilgard, and in that whole area of over 7,000 square miles there are practically no evergreens. Somewhat similar conditions exist in Indiana, Illinois, the western parts of Kentucky and Tennessee, and a good deal of contiguous territory. On the other hand, all the available analyses indicate that potassium is less abundant in the Atlantic coastal plain than in the regions of older formations, and evergreens are more abundant there than in any other part of the eastern United States.

Potassium is said to be notably deficient in peat, the world over, and rather scarce in tropical soils; and the abundance of evergreens in peat bogs and in the tropics is well known. Epiphytes (air-plants) have access to no potassium, or other mineral substances, except in the form of dust, and they are all evergreen. It seems, therefore, that the proportion of evergreen and deciduous trees in a given region or forest is a pretty good indication of the amount of available potassium compounds (commonly spoken of as potash) in the soil; and of course it is the number and size of the individuals rather than the number of species that counts.

There is a widespread belief that calcium (commonly expressed in terms of lime) is the most important factor in soil fertility; but however that may be, it does not seem to bear any definite relation to evergreens. This belief originated long before the days of chemical analyses, because calcareous soils are usually recognizable at sight, while the presence of potassium can be demonstrated only by a rather laborious analysis. The average Florida soil seems to

METHODS OF QUANTITATIVE ANALYSIS OF VEGETATION.

Up to ten or twelve years ago nearly all descriptions of vegetation were qualitative, and usually very incomplete besides. Toward the close of the last century, when the importance of quantitative studies was becoming apparent, botanists in the neighborhood of the Great Plains, where the vegetation is mostly prairie, devised the scheme (commonly known as the quadrat method) of counting all the plants on a measured area of ground (usually a meter square in grass-land, or ten meters in forests), repeating the process at several different places in the area studied, and then consolidating the returns. But where plants grow in tufts or colonies, like most grasses, it is practically impossible to count them; and after all it is not the number of individuals that is significant so much as their size. (For the productivity of a forest, orchard or field is not expressed in number of trees, stalks of corn or cotton, or hills of potatoes, but in cords of wood, feet of lumber, gallons of turpentine, boxes of oranges, bushels of corn, bales of cotton, etc.) This objection to the quadrat method could of course be met by pulling the plants up and weighing them, but even in its present form it would take an enormous amount of time to apply it to a whole state or even a county.

For many years foresters have been estimating timber by counting *and measuring* all the trees on selected typical areas, of an acre or so, and repeating the process at intervals over the whole tract that is being investigated. This method is ideal in its way, and has already been applied to small areas in Florida, but it is entirely too slow for present purposes.

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be better supplied with calcium than that of some of the interior states where deciduous trees are most prevalent, and limestone is particularly abundant in extreme southern Florida; but in that part of the state the potassium content of the soil is below the state average, and the vegetation is nearly all evergreen.

For further information on the subject of the relation of potassium to vegetation the interested reader should consult an article by Dr. H. W. Wiley on "Potash and its function in agriculture" in the Year-book of the U. S. Department of Agriculture for 1896, pp. 107-136, and a short note by the same author in Science (II. 17:794-795) for May 15, 1903. The writer has published some observations on this point in Geol. Surv. Ala. Monog. 8:28-29. 1913; Torreya 13:140-141. 1913; Bull. Torrey Bot. Club 40:398. 1913; 41:218, 1914; Rep. Mich. Acad. Sci. 15:197. 1914.

Plants of the heath family (Ericaceae) seem to bear much the same relation to potassium that evergreen trees do, but may be influenced also by calcium; while the majority of leguminous plants (Leguminosae), as well as those belonging to the large families Euphorbiaceae and Compositae, seem to prefer dry soils poor in nitrogen, but well supplied with mineral plant food. Grasses evidently prefer richer soils than sedges, but just what elements are significant in these cases has not yet been determined. In all investigations of this character it is essential to have quantitative data, for in the families named there are many species that are exceptional in their soil preferences, so that the mere presence or absence of several species belonging to one of these families might not have much significance; but by consolidating the figures for each family in a given area a number is derived which ought to be fairly constant for all places where conditions are essentially the same.

The writer has gradually evolved a method of quantitative analysis of vegetation which, though necessarily less accurate than those just mentioned, is much better adapted to rapid reconnoissance work. A description of it follows:

In traveling through Florida or any other part of the country where natural vegetation is abundant, I try to jot down the name of every wild plant observed, with some indication of whether it is abundant, common or rare, repeating the notes at convenient intervals, usually at every milepost when on a train, or at every stream or other topographic feature when walking. In this way the largest and most abundant plants are likely to be noted oftenest, which is just what is wanted in a quantitative study. Then at some subsequent time I go through the field notes for each region (or even for each habitat separately if desired) and count the number of times each species is mentioned, making allowance for relative abundance as follows. Where a species has been noted as abundant I count it three times, where common I count it twice, and where rare I do not count it at all.

Even this does not do justice to the great abundance of the longleaf pine and some other conifers, so I then usually multiply the figures for *Pinus palustris* by 4 and those for *P. Elliottii, P. Taeda, P. serotina, P. echinata, P. clausa, Taxodium imbricarium,* and *Chamaecyparis* by 2, and sometimes adjust the figures a little arbitrarily besides, if the results are obviously inconsistent with known facts. (It would probably be well to treat grasses in a similar manner, but that has not been undertaken). The resulting figures can then be added together and the percentages calculated.

Allowance has been made for the difference in size between trees, shrubs, herbs, etc., by the following device. Before calculating the percentages I take the size of the average forest tree as unity, divide the figures for small trees by 10, those for shrubs and woody vines by 100, and for herbs by 1000. If the smaller flowerless plants were included, the mosses, lichens, and larger fungi might be divided by 10,000, and so on "*ad infinitum.*" This decimal system is of course very arbitrary, but it has been adopted for convenience in dividing, and it is probably about as accurate as any other system of equal simplicity that could be selected.

Sources of error. Of course it cannot be claimed that the percentages obtained by this method are very accurate, but with all its imperfections it is far superior to anything used for such a large area before, and future investigations perhaps will not materially alter my main conclusions. The principal possible sources of error in the present enumeration, and the checks on them, are as follows:

1. A great deal of the long-leaf pine, and some of the other trees, especially cypress, has been removed by lumbermen, so that these trees are relatively less abundant now that they were originally. If it were desired to re-construct the original condition of the forests, perhaps the use of 6 or 8 instead of 4 as a multiplier for long-leaf pine would give a pretty close approximation to the truth.

2. The farmer in clearing land usually attacks the uplands first, making most of the swamp plants relatively more abundant. But there are not many parts of Florida where the proportion of cleared land makes much difference yet, and this report seeks to represent present conditions, anyway.

3. The boundaries of the regions may not have been accurately located in every case, and thus species may be included in some of the lists which do not properly belong there; just as in analyzing a mineral or ore, fragments of other minerals associated with it may be included. Errors of this kind are least in the largest regions, and those in which many notes have been taken near their centers, well away from neighboring regions.

4. For some of the regions, especially the smaller ones, my observations have been too few to make the plant lists reasonably complete and the percentages sufficiently accurate. In such cases the percentage figures are omitted entirely, but the approximate relative abundance is indicated by the sequence, as in all other cases.

5. My practice of taking notes from the car-window and on hurried journeys on foot tends to show relative frequency rather than relative abundance; for if I saw ten specimens of a certain tree in every mile for ten miles and a thousand specimens of another in one mile and no more for ten miles the former would figure more largely in the returns. But such extreme cases are unusual and likely to counterbalance each other to a considerable extent in the long run; and besides the discrepancies are not so objectionable when bulk is taken into consideration, as is attempted here.

6. Some of the herbs are quite conspicuous when in bloom and very inconspicuous or practically invisible at other times, so that notes made in the same region at different seasons may differ considerably. But at the beginning of every list the months in which the observations were made are given, so that the reader, especially if he is familiar with the flora, may form some idea of its completeness. Of course the herbs that are recognizable any day in the year, such as Spanish moss and wire-grass, will figure more largely in the returns than those that disappear in summer or winter, and there seems to be no obvious remedy for this. Shrubs and vines are affected less by this seasonal error than herbs, and trees, especially evergreens, very little.

7. Some of the herbs are so small that they cannot be seen at all from a moving train. But every region has been explored on foot more or less, so that few species of flowering plants have been overlooked entirely merely on account of their size; and where bulk is the primary consideration, as it is here, it is right and proper that the smallest plants should have the lowest percentages.

8. Some species are difficult to identify at sight, especially when one is traveling thirty miles an hour, and some of my identifications may be wholly erroneous, for this and other reasons. Some errors of this sort, however, can be checked up afterwards by what is known of the distribution, habitat, time of flowering, etc., of the species in question; and even where they are not corrected they do not affect the statistics of the proportions of evergreens, grasses, Leguminosae, etc., for it is not likely that I have mistaken the family of plants in any case. Of course to be sure of the identity of every plant, specimens should be collected for study and comparison, but that sort of work consumes much more time than it is usually worth. Those parts of the country where botanists are most particular about the correct identification of plants are generally those where the least progress has been made along phytogeographical lines.*

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*In this connection see Bull. Am. Geog. Soc. 45:41 (middle paragraph). 1913.

9. At any time what has been regarded as a single species may be divided into two or more by some taxonomist. When that is done the components will often be found to be confined to different regions, but even if both (or all, as the case may be) grow in the same region, thus giving them smaller percentages and lower places in the list than the composite species had, it does not make any appreciable difference in summing up the percentages for each family or other category of plants.

PLAN OF REGIONAL DESCRIPTIONS.

The description of each region follows as nearly as possible the following plan:

References to previous literature and illustrations.
Location and area. Extent of similar country elsewhere (if any).
Geology and Soils—Soil analyses (if any). Soil fauna or subterranean animals.
Topography and Hydrography.—Maximum and minimum altitudes. Springs and streams, lakes and ponds. Character and fluctuation of water.
(Climate. See page 182.)
Vegetation Types.—Frequency of fire in each.
Field work of the writer, by months.
List of plants—
- Trees.
- Small trees or large shrubs.
- Woody vines.
- Shrubs.
- Herbs.

Noteworthy features of the list.
- Characteristic species, etc.
- Percentage of evergreens, Ericaceae, Leguminosae, etc.

Economic features.
- Utilization of native plants.
- Proportion of improved land.
- Density of population. Rate of increase. Proportion of white and colored. Principal crops.

Illustrations.

The amount of space devoted to each topic varies with the character of the region, and the order is not always exactly as given above. Some of the items in the foregoing outline seem to call for a little more explanation, which follows.

Bibliographic references. A list of books and papers relating to the geography of northern Florida will be found near the end of this volume. (See table of contents.) At the beginning of each regional description there are references to the more important or easily accessible works in the list from which additional information about that particular region can be obtained. For the sake of brevity these references do not give the complete citations, but only the author's name, the number of his paper (as given in the bibliography), and the page numbers if any particular pages can be designated as bearing on the region under consideration.* In most cases there are also references to illustrations which have been published in previous annual reports of this Survey.

Geology and soils. The geology of the whole state and various parts thereof has been discussed in several easily accessible state and government publications, some of which are referred to herein. Consequently little more needs to be said about the geology here, except in a few cases where previous accounts seem to be inadequate. (It might be remarked in passing that geological investigation in Florida, as in many other parts of the coastal plain, is attended with peculiar difficulties, owing largely to the prevailing blanket of sand, and our knowledge of some of the problems is still far from satisfactory.) Mineral resources and underground waters are here referred to only incidentally, for they have been discussed at considerable length in previous publications of the State Geological Survey.

Soils are described only in a superficial way. Detailed descriptions of the soils of some of the counties, without chemical analyses, are included in the reports of the U. S. Bureau of Soils for about ten years past. (See bibliography for list of areas surveyed by that Bureau in northern Florida). Some mechanical (i. e. physical) analyses of soils have been copied from these government reports.

Very few chemical analyses for northern Florida are available, unfortunately, but four or five essentially complete ones have been taken from the sixth volume of the Tenth Census (Smith 2 in bibliography), and several showing the amounts of certain essential elements have recently been made for us in the laboratory of the State Chemist.

Under the head of soils are included some desultory notes on the soil fauna, or subterranean animals, which have a very important influence on soils and therefore on vegetation. As in most other parts of the country, ants are found nearly everywhere except in the wettest places. Earthworms, which are perhaps the most

*Some of the older books cited in the bibliography have been seen only in New York libraries, and cannot be referred to by page at this time.

important soil renovators in clayey soils, especially in climates a little cooler than ours, are rather scarce in Florida. Our two largest burrowing animals, which are confined to the coastal plain, or nearly so, and seem to be more abundant in Florida than in any other state, are the "salamander" (a rodent, *Geomys Tuza*)* and the "gopher" (a turtle, *Testudo* or *Gopherus Polyphemus*). These, especially the former, are common in dry sandy pine lands, and together they must move almost every particle of soil in considerable areas every few years, and thus counteract to a considerable extent the leaching effect of the rain. In places not accessible to these animals, such as islands, the soils are often perceptibly poorer than the average. Other common soil animals are moles, crawfish (in wet places), crabs (in and near salt marshes), and many insects and crustacea which have not been identified.

Climate. As the climate does not vary much from one point to another within the area studied (which extends over less than two degrees of latitude), it is not discussed for each region separately. The following table gives certain climatic data which appear to be significant, for all stations in northern Florida for which the records have been kept long enough to make the averages reasonably accurate. Most of them are taken from Section 83 of Bulletin W of the U. S. Weather Bureau, which brings the records down to the end of 1908.

The data selected are the average temperature for January, July, and the whole year, in degrees Fahrenheit, the average length of the growing season (period between last killing frost in spring and first killing frost in fall), in days, the average annual rainfall, in inches, and the percentage of it that comes in the four warmest months (June to September) and in the six warmest months (May to October, inclusive).

*For notes on the distribution and habitats of this animal in Florida and elsewhere see Science II. 35:115-119. Jan. 19, 1912.

STATIONS	Temperature			Growing season	Rainfall		
	Jan.	July	Annual		Annual	Per cent June-Sept.	Per cent May-Oct.
Flomaton*	-------	-------	66.2	260	57.80	37.9	49.9
Pensacola	52.3	81.4	67.9	285	56.07	44.5	56.1
DeFuniak Springs	51.6	80.5	-------	-------	65.49	44.3	55.8
St. Andrew's	52.1	81.8	-------	-------	58.69	47.8	61.1
Marianna	50.6	81.0	66.8	265	--------	-------	-----
Carrabelle	53.5	81.7	69.3	302	52.69	50.1	60.5
Tallahassee	52.1	80.4	67.2	277	57.12	46.9	59.0
Stephensville†	51.4	80.7	67.2	281	55.40	59.1	66.6
Archer	55.4	81.0	69.0	-------	54.90	52.7	64.5
Gainesville	54.9	81.4	69.3	294	51.34	54.1	66.5
Lake City	55.6	81.1	69.2	273	54.19	48.2	59.1
Macclenny	54.6	81.9	68.9	268	51.63	49.8	63.9
Jacksonville	53.9	80.9	68.2	293	52.53	51.0	67.2
St. Augustine	56.2	81.8	69.4	318	48.05	48.1	66.1
Huntington‡	56.4	81.8	70.2	317	49.99	55.1	69.6

*Mostly in Escambia Co., Ala., but partly in Escambia Co., Fla.
†Near the southern corner of Taylor Co.
‡In the southeastern part of Putnam Co.

It will be noticed that the differences in temperature between different stations are not very marked, particularly in the case of the July temperatures. There is more difference in the growing season, and this probably has some significance, though in an area as diversified as northern Florida it is difficult to separate its effects from the more obvious ones of soil and topography. The total rainfall ranges from 48.05 inches at St. Augustine to 65.49 inches at DeFuniak Springs, apparently without any definite relation to latitude or altitude, except that the high elevation of DeFuniak (256 feet) may have something to do with the heavy precipitation there, and the difference between Tallahassee and Carrabelle might be explained in a similar manner.

The wetness of the summers varies somewhat too, being least in the extreme northwest and generally greatest southeastward. Although the above figures do not bring it out very well, the rainy season usually begins and ends a little earlier in the western parts of the state than in the eastern. The percentages for both four and six months are given to facilitate comparison with figures that have been published by the writer elsewhere for other parts of the coastal plain. The wettest four-month period seems to be at Stephensville (which reports over ten inches of rain for both July and August), but the wettest six-month period is at Huntington. At Flomaton the rainfall is almost equally balanced between the two halves of the year, but the four warmest months get a little more than their share.

Taking the area as a whole, the salient features of its climate, as compared with that of Georgia and Alabama, are the mild dry winters and wet summers. The copious summer rains, while they make droughts rare, seem to be largely responsible for the prevalence of sandy soils and evergreen trees in Florida, for the rain tends to leach out the clay, lime, potash, etc.,* and leave the sand, and evergreens seem to be especially characteristic of soils poor in clay and potash, as already noted.†

Vegetation types. No systematic study of vegetation types is attempted here, as explained on page 175, but under each region a few of the leading types are mentioned. Special reference is made to the frequency of fire, which varies greatly in different regions and in different types of vegetation. Outside of the long-leaf pine regions of the South (and somewhat similar forests in a few other parts of the world), forest fires are comparatively infrequent, and have been commonly regarded as regrettable accidents. But in Florida it is evident that fire is a part of Nature's program. The pine forests which cover the greater part of the state everywhere bear the marks of fire, which visits any one spot perhaps once in two years, on the average. In pre-historic times the fires must have been started mostly by lightning, but now they are mostly of human origin. Although fires are more numerous at the present time than they were originally, the area over which each one can spread is limited by roads, clearings, and other artificial barriers, so that the frequency of fire at any one point may not have changed much. Long-leaf pine is injured less by fire than almost any other tree, so that the effect of repeated fires is to give this tree the advantage over all its associates.

It is reasonably certain that if fire were kept out of a long-leaf

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*Cherrapongee, in Assam, is the wettest known place in the world, having an annual rainfall of over 600 inches;[1] and travelers who have been there report the surrounding country as practically barren. No doubt if the soil is not all washed away it must be pretty thoroughly leached of plant food.

†Some of the probable relations of seasonal distribution of rainfall to the character of the soil have been discussed briefly by the writer in Bull. Torrey Bot. Club 37:415-416. 1910; 40:395-396. 1913; Torreya 13:141. 1913; Geol. Surv. Ala., Monog. 8-19, 24, 36. 1913. For notes on the relation of evergreens to soils see footnote on pages 175-177 of this report.

pine forest long enough hardwood trees of various kinds would come in and choke out the pine (which does not thrive in shade), and thus convert the pine forest into a hammock.* Most of our hammocks are in situations protected from fire by the topography, as on slopes down which fire would not travel readily, or in places partly surrounded by water.

Besides the native vegetation every region has areas greatly modified by civilization, such as cultivated fields, old fields, roadsides, railroad rights-of-way, etc. Some of the plants in such places are native species which have survived the changed conditions, but most of them have been brought in unintentionally by man or domestic animals from other parts of the country or from foreign countries. Most of the foreign weeds in Florida seem to be of tropical origin, but we also have quite a number from Europe and Asia.† The great majority of them are herbs.

Plants which exist only in cultivation are not here regarded as vegetation.

Plant lists. Each list aims to include all the wild plants, both native and introduced, seen by the writer in the region under consideration, except the rarer ones. Trees and shrubs seen only once or twice in a given region are usually omitted, except in the case of some of the smallest regions. A much larger proportion of the herbs is omitted, partly to save space, and partly because the names of the rarer herbs would be meaningless to the average reader. For some of the larger regions no herb is mentioned which has been seen less than five or six times, which involves the omission of over a hundred species from such a list. (For there are everywhere more rare species than common ones.) Such omissions however have little effect on the conclusions drawn from the quantitative analyses, for the percentages of the omitted species are very small fractions.

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*This was pointed out a quarter of a century ago by the late Mrs. Ellen Call Long, of Tallahassee, but her views never gained much credence in the North, where forest conditions are very different. The matter has been further discussed by the writer in Bull. Torrey Bot. Club 38:515-525. 1911; 41:217. 1914; Geol. Surv. Ala. Monog. 8:25-26, 83, 116. 1913. Pop. Sci. Monthly, 85:353-354. 1914. (See also C. D. Howe in Forestry Quarterly, 11:545-546. Dec. 1913).

†For notes on Florida weeds see the paper by Neal cited in the bibliography, and for speculations on the origin of some of our weeds see Bull. Torrey Bot. Club 35:347-360. 1908.

The lists are divided into five parts, as follows:—(1) trees, large enough to make lumber; (2) small trees or large shrubs (some of which may become good-sized trees elsewhere); (3) woody vines; (4) ordinary shrubs; (5) herbs. These categories grade into each other more or less, for Nature draws few sharp lines; but in the great majority of cases there is no doubt about which class a plant belongs in.* The cellular cryptograms (i. e., mosses, lichens, fungi, etc.) are left out entirely, partly because the writer is not one of those few persons who can identify them at sight, and partly because they are so small as to be insignificant in quantitative analyses.

In each of the five classes the species are arranged in order of percentages. The percentage figures precede the names, except in the case of a few of the smallest or least explored regions, as explained above, and toward the foot of the lists, where they are omitted because they would require too many decimal places.

A feature of these lists which seems to be entirely new is the indication, by arbitrary symbols, of species that are decidedly more or less abundant in a given region than in the whole area considered. Where a species is more abundant than in the average area a + sign is used, and where it is more abundant than in any other region the sign is doubled. Where it is less abundant than the average the fact is indicated by a — sign. Of course theoretically in any region every species mentioned is either more or less abundant than it is in northern Florida as a whole, but these symbols are used only where the apparent difference is great enough so that it is not likely to be reversed by future investigations.

This scheme has both a scientific and a practical value. First, it shows at a glance what species are most characteristic of each region, and which may be assumed to prefer the particular soil conditions that prevail in that region. Some interesting conclusions are brought out in this way in some of the regional descriptions. Second, any one who is looking for a supply of any particular kind of timber, or any herb, can tell by the double + marks just where

*In a few of the lists the same species (e. g., *Nyssa Ogeche*) appears both as a large tree and as a small tree or shrub, but not without reason. The persimmon (*Diospyros Virginiana*) is often a full-sized tree, but shrubby specimens are more numerous than arborescent ones, and consequently it appears in most of the lists under the head of small trees or shrubs. The same is true of the sassafras, except that it rarely becomes a regular tree in Florida.

in northern Florida that species is most abundant. To obviate the necessity of looking through nineteen or twenty lists, the pages on which the double + marks appear are all indicated in the index.

The technical name of every species is given, the names being mostly the same as in the second edition of Small's Flora of the Southeastern United States, 1913. (Where that book is not followed it is usually because the subdivision of genera and species is carried farther in it than the facts seem to warrant.)

The names of evergreens are printed in bold-face type, so that they will be more conspicuous, as the plants themselves are in winter. In the case of a few species that are semi-evergreen only half the name is printed in bold-face.

The names of weeds are followed by (X), or in doubtful cases (X?). In deciding which are weeds no dependence has been placed on statements in botanical manuals, for in such books many species which are unquestionably weeds are not distinguished in any way from native plants. The only reliable test of weediness is habitat, a matter which is greatly neglected by most systematists. When a species is found in a given region only in habitats created or modified by civilization it is assumed that it did not exist in that region originally; whether the history of its introduction is known or not, and even whether the same species is known in any foreign country or not. The application of this criterion results in classing as weeds many species which have probably never been thus stigmatized before. (It is interesting and probably significant that very few of the weeds are evergreen).

The technical names are followed by common names, if such are known. Nearly all the trees have common names, but some of the smaller plants are so inconspicuous or unimportant that they have never been named except by botanists. For many such plants alleged common names can indeed be found in botanical books, but these are often mere translations of the technical names, and would mean no more to the average reader than the technical names do. The common names adopted here are *bona-fide* ones, known to be used in Florida by persons who did not get them from books, but in a few cases names used in other states, which may be familiar to some readers, are given in parentheses.

In the last column the usual habitat of each species is indicated in a few words, but no special study of habitats is attempted here, as previously explained.

After each plant list are a few remarks on characteristic species, species conspicuous by their absence or scarcity, and other noteworthy features of the vegetation, including particularly a summation of the percentages of evergreens, Ericaceae and Leguminosae, which are correlated as far as possible with soil characters. In this way some conclusions are drawn which have never been possible before, and which it is hoped will be of some value.

Economic features. The most important use made of the native vegetation is converting the pines into lumber and naval stores; but no satisfactory statistics of the production of these commodities for areas smaller than states seem to be available, so that the status of the industries can be indicated only in a general way. In all the regions a great deal of wood is consumed for fuel (for coal is little used in Florida except on the railroads and in the cities); and the native grasses and other herbage furnish pasturage for cattle, which have free range in every region here described except one. Another way in which the vegetation is converted to the use of mankind through the agency of animals is in the production of honey, which is an important item in some of the counties, and might be made so in nearly all.

The statistics of population, improved land, etc., are derived mostly from the 13th U. S. census (of 1910) by the tedious process of dividing up the figures for each county proportionately to the area of the several regions represented therein, and adding all the figures for each region. This involves the assumption that the population is uniformly distributed in each county, which of course is not quite correct; but the errors arising from this cause counterbalance each other to some extent. For total population (but not for race and sex) the figures are given in the census reports for precincts as well as for counties, but in the absence of maps showing the location of the precincts no geographical advantage can be taken of that fact.

The crop statistics in the government census reports are unsatisfactory because they do not give values for areas smaller than states, and do not separate the two kinds of cotton, and the numerous kinds of vegetables that are raised in Florida. The information about crops given herein is derived mostly from the biennial report of the state Commissioner of Agriculture for 1911 and 1912. The production of any one crop varies so from year to year that it is hardly worth while to publish the figures for the several regions, but the crops of each region are arranged as nearly as possible in order of value. The rank of the different crops varies from one region to another much like that of the native trees, though not to so great an extent, for differences in soil are now overcome in large measure by the use of fertilizers.

The amount of improved land and the density and other features of the population are usually correlated pretty closely with soil, topography and vegetation. For example, where rich soils and deciduous forests predominate there is nearly always a larger area under cultivation, a denser population and more negroes than in the pine regions with poorer soil;* but the population is increasing faster at present in some of the poor soil regions than in the richer ones, because the latter have more nearly reached the limit of density of purely agricultural population (which in the eastern United States seems to be about 40 inhabitants per square mile.)

Illustrations. The illustrations have been selected with a view of giving typical examples of the vegetation and other scenery of each region, but several times as many would be necessary to do the subject justice. Except where otherwise specified they are from the writer's own photographs. Figures 51, 54, 55, 63, 64, 66, 76, and 84-88 are reprinted from previous annual reports, and 72 from the Popular Science Monthly. The rest are published here for the first time. In order to simplify the binding, and also make them easy to find, they are assembled together at the end of the last regional description.

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*In this connection see E. A. Smith, Tenth Census U. S. 6:71-74. 1884.

Fig. 40. MAP OF NORTHERN FLORIDA, SHOWING GEOGRAPHICAL DIVISIONS.
(Scale 1 to 3,600,000.)

The divisions are as follows:

1. Marianna red lands.
2. West Florida lime-sink region.
3. Apalachicola River bluffs.
4. Knox Hill country.
5. Holmes Valley.
6. West Florida lake region.
7. West Florida pine hills.
8. West Florida coast strip.
9. Apalachicola flatwoods.
10. Middle Florida hammock belt.
11. Tallahassee red hills.
12. Bellair sand region.
13. Wakulla hammock country.
14. Panacea country.
15. Gulf hammock region.
16. Middle Florida flatwoods.
17. Peninsular lime-sink region.
18. Peninsular lake region.
19. East Florida flatwoods.
20. East coast strip.

The regions (six in number) which have less than 60 per cent of their vegetation evergreen are indicated by oblique shading. The dotted line extending northward from the north end of region 18 is Trail Ridge.

THE REGIONS IN DETAIL.

The location and area of the several regions are shown by the outline map (page 190). The following synopsis, which is patterned after a taxonomic key, brings out the contrasts between neighboring regions about as well as it can be done in so few words.

SYNOPSIS OF GEOGRAPHICAL DIVISIONS.

Soil largely red clay. Topography rather hilly.
  Streams common.
    Limestone outcrops frequent. Caves and natural bridges present.... 1. *Marianna Red Lands.*
    Limestone impure, cropping out only on bluffs. No caves.......... 3. *Apalachicola River Bluffs.*
    No rock outcrops ....4. *Knox Hill Country.*
  Streams scarce.
    No lakes ....5. *Holmes Valley.*
    Lakes and ponds common ....11. *Tallahassee Red Hills.*
Soil and topography various. Hammocks common .... 10. *Middle Florida Hammock Belt.*
Soil prevailingly sandy.
  Topography normally dissected. Streams common.................. 7. *West Florida Pine Hills.*
  Topography mostly wind-formed.
    Salt marshes scarce ....8. *West Florida Coast Strip.*
    Salt marshes well developed ....20. *East Coast Strip.*
  Topography pitted.
    Sand thin, on clay subsoil........2. *West Florida Cypress Pond Region.*
    Sand deep and loose.
      Sand coarse but rich ....13. *Wakulla Hammock Country.*
      Sand fine and somewhat loamy.
        Small limestone outcrops frequent.
          No phosphate ....12. *Bellair Sand Region.*
          Phosphate beneath the sand in many places.................. 17. *Peninsular Lime-sink Region.*
        No rock on uplands.
          Lakes common.
            Uplands flattish ....6. *West Florida Lake Region.*
            Uplands undulating ....18. *Peninsular Lake Region.*
          Bays common; no lakes ....14. *Panacea Country.*
  Topography essentially flat.
    Limestone outcrops abundant ....15. *Gulf Hammock Region.*
    No limestone on uplands.
      Clay scarce.
        Region bordering Gulf coast ....9. *Apalachicola Flatwoods.*
        Region about 20 miles inland ....16. *Middle Florida Flatwoods*
      Clay usually within a few feet of surface .... 19. *East Florida Flatwoods.*

1. MARIANNA RED LANDS.

(FIGURES 12, 41, 42)

References. Matson & Clapp (57), Matson & Sanford (77, 327-329), E. A. Smith 2 (196-197, 218), J. D. Smith, and U. S. soil survey of the "Marianna area" (by Jones, Rowe, Britton, Hardison and Zappone, 1910).

This region embraces something like 450 square miles in Florida, situated on both sides of the Chipola River in Jackson County, and it extends a few miles into Alabama. Its nearest counterpart elsewhere is in the red lands of Dougherty County, Georgia, and the lime hills of southwestern Alabama, which are characterized by the same or similar geological formations.

Geology and Soils—The underlying rock is a Lower Oligocene limestone which has been called Vicksburg in Mississippi, St. Stephens or White Limestone in Alabama, and Marianna in Florida. It is the oldest formation known to come to the surface in this state. It crops out in many places, especially near the Chipola River,* and is quite pure, an average sample analyzing 94 per cent of calcium carbonate. Where exposed naturally on the uplands it is moderately hard, but a few feet below the surface it is soft enough to be cut with a saw. This rock is used very largely in the red lands and neighboring regions for chimneys and underpinning, and occasionally for the walls of buildings. (It is probably safe to say that at the present time the majority of the chimneys in Jackson County are of this material; and its use is equally common in the corresponding parts of southwestern Alabama.)

On many of the hills the Vicksburg or Marianna formation is overlaid by a more clayey limestone belonging to the Chattahoochee formation (Upper Oligocene). The prevailing soil on the uplands is a red loam, containing from about 15 per cent to 70 per cent of silt and clay. Some of it is evidently derived from the weathering of the Vicksburg and Chattahoochee limestones, while some may represent newer superficial formations, such as the Lafayette. The sandiest soils are usually on the highest elevations, remote from

*In the soil survey of the "Marianna area" it was estimated that there are 384 acres of rock outcrop in the area surveyed, which is mostly west of the river; and there is probably enough rock east of the river to bring the total up to a square mile, or approximately 1-5 of 1 per cent of the whole area of the region.

streams. In virgin forests, especially on slopes and in valleys, there is considerable humus.

The following mechanical analyses of five typical upland soils of this region are taken from the soil survey of the "Marianna area," published in the fall of 1910. (The dimensions of the seven classes of soil particles are not given in that publication, but have been taken from other publications of the U. S. Bureau of Soils.) The first is the "Greenville clay," a reddish or brownish clay loam believed to be mostly residual from the underlying limestone. The second is the "Greenville sandy loam," which differs from the first in being more sandy, and is believed to be derived mostly from the Lafayette formation. The third is the "Orangeburg fine sandy loam," a gray, brown, or reddish-brown fine sandy loam with red sandy clay subsoil, both soil and subsoil usually containing many small ferruginous concretions. The fourth is the "Orangeburg coarse sandy loam," somewhat coarser than the preceding, as its name implies. The fifth is the "Norfolk fine sandy loam," a gray or light brown medium fine sandy loam with yellow sandy clay subsoil, presumably derived from the Lafayette formation, like the two preceding. Percentage figures for both soil and subsoil are given in the publication cited, but only those for the top soil are reproduced here.

MECHANICAL ANALYSES OF SOILS OF MARIANNA RED LANDS.

	1	2	3	4	5
Fine gravel (2-1 mm.)	0.9	2.8	1.2	2.3	1.0
Coarse sand (1-.5 mm.)	3.2	15.1	10.4	27.8	12.3
Medium sand (.5-.25 mm.)	2.0	11.6	8.3	16.1	12.4
Fine sand (.25-.1 mm.)	13.6	31.4	35.7	24.3	37.8
Very fine sand (.1-.05 mm.)	11.0	12.8	25.7	9.1	18.3
Silt (.05-.005 mm.)	10.3	11.7	10.0	8.9	10.3
Clay (.005-0 mm.)	59.0	14.9	8.8	11.7	7.9
Total	100.0	100.3	100.1	100.2	100.0

Very little has been done in the way of correlating such figures as these with vegetation, but presumably when other things are equal the soil that has the largest proportion of fine particles has the most available potassium and other minerals.

Dr. Eugene A. Smith in the 6th volume of the Tenth Census, page 197, gives the following analysis of red loam soil from the lowlands of Spring Creek near Campbellton, where the principal trees were hickory, sweet gum, post, red and Spanish oaks, and shortleaf pine. The sample represents a depth of ten inches, and the land when fresh was said to yield about 1,500 pounds of seed cotton per acre. (The percentages given do not represent the total of each constituent, but the amounts soluble in hydrochloric acid.)

Water and organic matter	4.053	per cent
Potash (K_2O)	.072	" "
Soda (Na_2O)	.019	" "
Lime (CaO)	.266	" "
Magnesia (MgO)	.105	" "
Phosphoric acid radicle (P_2O_5)	.222	" "
Sulphuric acid radicle (SO_3)	.033	" "
Brown oxide of manganese (Mn_3O_4)	.077	" "
Peroxide of iron (Fe_2O_3)	1.456	" "
Alumina (Al_2O_3)	6.885	" "
Soluble silica	3.250	" "
Insoluble matter	84.240	" "

This is one of the richest soils in Florida. As compared with the three other northern Florida soils analyzed in the same report, it has the most organic matter, lime, magnesia, alumina and soluble silica, and the least insoluble matter, and is next to the highest in potash and iron. It is somewhat deficient in potash as compared with soils of regions that have colder winters and drier summers, however.

Topography and Hydrography—The topography is undulating to moderately hilly, and diversified in the rocky places by a few sinks, caves, low cliffs, etc. Streams are fairly common, but some of the drainage is subterranean. The Chipola River and one or two of its tributaries run underground for short distances, forming natural bridges. Some of the creeks have sufficient fall to be utilized for water-power. There are quite a number of small springs, issuing from beneath limestone cliffs, and a few large ones, the best known of which is the Chipola or Long Moss Spring, at the head of Spring Creek, about six miles E. N. E. of Marianna. In dry weather the water in most of the streams is clear and bluish, on account of the limestone dissolved in it. The ground-water in many places lies so deep that force-pumps are required to raise it to the surface for domestic use.

Vegetation Types—The most characteristic vegetation types of this region are those of the rock outcrops and of the residual red clay, where deciduous trees predominate, and form rather dense forests. The streams are bordered by swamps whose width is approximately proportional to the volume of water. On the sandy uplands there is considerable long-leaf pine, black-jack oak, and other trees more characteristic of the region to be described next. There are a few shallow ponds which dry up in spring, and these too are more characteristic of region no. 2.

Forest fires are comparatively rare here, as in other regions where hardwood trees predominate, and except in the long-leaf pine forests they are a negligible factor.

Plants—The following list is based on observations made on four days in March, one in April, three in May, two in June, three in September, and one in December; total fourteen. (See page 186 for explanation of symbols, figures, etc.).

TREES

+13.7	**Pinus Taeda**	Short-leaf pine*	Various situations
—10.4	**Pinus palustris**	Long-leaf pine	Sandy soils
+ 7.3	**Pinus echinata**	Short-leaf pine	Dry soils
+ 5.7	Liquidambar Styraciflua	Sweet gum	Various situations
+ 5.0	Quercus falcata	Red oak†	Dry woods
+ 4.1	Cornus florida	Dogwood	Dry woods
+ 3.8	**Pinus glabra**	Spruce pine	Rich woods
++ 3.7	**Juniperus Virginiana**	Cedar	Rock outcrops mostly
++ 3.6	Quercus Marylandica	Black-jack oak	Dry woods
3.1	**Magnolia grandiflora**	Magnolia‡	Rich woods
+ 3.0	Fagus grandifolia	Beech	Rich woods
2.0	Taxodium distichum	Cypress	Swamps
++ 1.9	Cercis Canadensis	Redbud	Rich woods
+ 1.7	Quercus stellata	Post Oak	Dry woods
++ 1.6	Acer Floridanum	Sugar Maple	Rich woods
+ 1.4	**Quercus laurifolia**	(Evergreen willow oak)	Rich woods
+ 1.4	**Ilex opaca**	Holly	Rich woods
1.3	Quercus **nigra**	Water oak	Low grounds
1.3	Nyssa biflora	Black gum	Swamps
+ 1.2	Quercus alba	White oak	Rich woods
+ 1.1	Ostrya Virginiana		Rich woods
+ 1.1	Carpinus Caroliniana	Ironwood	Bottoms, etc.
+ 1.0	Nyssa uniflora	Tupelo gum	Swamps and sloughs
— 1.0	**Pinus Elliottii**	Slash pine	Low grounds
+ 1.0	Hicoria alba	Hickory	Dry woods
— 0.9	**Magnolia glauca**	Bay	Swamps
+ .9	Quercus Schneckii	(Red oak)	Rich woods

*Also called loblolly pine.

†Goes by this name in all the southern states, but called "Spanish oak" in northern books.

‡This technical name is now very widely disseminated, but in some of the remotest rural districts one occasionally hears this tree called "loblolly" or some other vernacular name.

+	.9	Celtis occidentalis	Hackberry	Bottoms
—	.8	Quercus cinerea	(Turkey oak)	Sandy soils
	.7	**Quercus Virginiana**	Live oak	
+	.7	Ulmus Floridana	Elm	Bottoms
+	.7	Melia Azedarach (X)	Chinaberry	Along fences, etc.
	.7	Fraxinus Caroliniana?	Ash	Swamps
+	.7	Halesia Carolina		Rich woods
—	.6	Acer rubrum	Maple	Swamps
—	.6	Taxodium imbricarium	Pond cypress	Ponds
	.5	Quercus Michauxii	(Swamp chestnut oak)	Bottoms
+	.5	Prunus serotina (X)	Wild cherry	Along fences, etc.
—	.5	Quercus Catesbaei	Black-jack oak	Sandy soils
	.5	Liriodendron Tulipifera	Poplar	Wet woods
+	.5	Fraxinus Americana?	Ash	Rich woods
++	.4	Quercus Muhlenbergii	Oak	Rich woods
+	.4	Ulmus Americana?	Elm	Bottoms
+	.4	Quercus lyrata	Swamp post oak	Bottoms
+	.4	Nyssa sylvatica	Black gum	Dry or rich woods
+	.3	Populus deltoides	Cottonwood	Ditches, etc.
	.3	Persea Borbonia	Red bay	Bottoms
+	.3	Morus rubra	Mulberry	Bottoms
++	.3	Quercus Phellos	Willow oak	Low grounds
	.2	Salix nigra	Willow	Low grounds
++	.1	Juglans nigra	Walnut	Rich woods

SMALL TREES OR LARGE SHRUBS

+	.14	Batodendron **arboreum**	Sparkleberry	Dry woods
	.08	Cyrilla **racemiflora**	Tyty	Swamps
+	.08	Prunus angustifolia (X)	Wild plum	Old fields, etc.
	.07	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
	.06	**Myrica cerifera**	Myrtle	Rich woods, etc.
+	.05	Viburnum rufidulum	Black haw	Dry woods, etc.
	.04	**Osmanthus Americanus**		Rich woods
	.04	Prunus umbellata	Wild plum	Dry woods
	.04	Symplocos **tinctoria**		Rich woods
+	.04	Prunus Americana	Wild plum	Rich woods
	.03	Sassafras variifolium	Sassafras	Old fields, etc.
	.03	Crataegus aestivalis	May haw	Small ponds
	.02	Chionanthus Virginica	Graybeard	Rich woods

WOODY VINES

+	.01	Rhus radicans	Poison ivy	Swamps, etc.
	.01	Parthenocissus quinquefolia	Virginia creeper	Rich woods, etc.
		Gelsemium sempervirens	Yellow jessamine	Various situations
		Decumaria barbara		Wet woods
		Tecoma radicans	(Cow-itch)	Various situations
		Smilax lanceolata	(Wild smilax)	Various situations
		Ampelopsis arborea		Low grounds

	Berchemia scandens	Rattan vine	Swamps and bottoms
	Bignonia crucigera	Cross vine	Woods
	Vitis rotundifolia	Muscadine or bullace	Various situations

SHRUBS

+ .02	**Sabal glabra**	Palmetto	Bottoms
+ .01	Cornus stricta?*		Bottoms
+ .01	**Hypericum galioides pallidum**		Bottoms
+ .01	Aesculus Pavia	Buckeye	Dry or rich woods
+ .01	Rhamnus Caroliniana		Rock outcrops mostly
+ .01	Hydrangea quercifolia	Seven-bark	Rich woods and bluffs
.01	Aralia spinosa	Prickly ash	Rich woods
.01	Cephalanthus occidentalis	Elbow-bush	Ponds and swamps
	Rubus cuneifolius (X)	Blackberry	Sandy roadsides, etc.
-	**Ilex glabra**	Gallberry	Low pine land
	Viburnum obovatum		Bottoms, etc.
	Itea Virginica		Swamps
	Asimina parviflora	Pawpaw	Rich or dry woods
	Rhus copallina	Sumac	Dry woods, etc.
	Callicarpa Americana	French mulberry	Dry woods, etc.
+	Viburnum semitomentosum		Rich woods
	-Sebastiana ligustrina		Bottoms
	Amorpha fruticosa		Bottoms
—	**Serenoa serrulata**	Saw palmetto	Sandy soils
	Euonymus Americanus	(Strawberry bush)	Rich woods
	Hypericum fasciculatum		Around ponds
	Ceanothus Americanus	(Red-shank)	Dry woods
++	Adelia ligustrina		Rock outcrops
+	**Rhapidophyllum Hystrix**	(Needle palm)	Rich woods

HERBS

+ .004	**Tillandsia usneoides**	Spanish moss	On trees
+ .001	Baptisia alba		Dry woods
+ .001	Asclepias variegata	Milkweed	Dry or rich woods
++ .001	Sanicula gregaria		Rich woods
++	**Asplenium resiliens**	(A fern)	Cliffs, etc.
+	Hartmannia speciosa (X)		Roadsides, etc.
+	Dryopteris patens?	(A fern)	Rocky places
++	Thaspium barbinode Chapmani		Rocky places
	Mitchella repens	(Partridge berry)	Rich woods
	Juncus repens		Shallow ponds
+	**Nymphaea chartacea**	Bonnets	Chipola River
++	Solidago amplexicaulis	**Goldenrod**	Rich woods
+	Salvia lyrata		Dry woods
++	Mesadenia diversifolia		Bottoms

*Some of this may be *C. asperifolia*, which was not always distinguished in my field notes.

++	Scrophularia Marylandica		Rich woods
+	Polystichum acrostichoides	(A fern)	Rich woods
++	Aquilegia australis	(Columbine)	Cliffs
	Atamosco Atamasco		Rich woods
	Andropogon scoparius (X?)	Broom-sedge	Old fields, etc.
+	Sorghum Halepense (X)	Johnson grass	Old fields, etc.
	Smilax pumila		Rich woods
	Viola affinis?	Violet	Rich woods
	Nothoscordum striatum	(X?)	
	Triadenum petiolatum		Swamps
+	Conopholis Americana		Rich woods
++	Sanguinaria Canadensis	(Bloodroot)	Rich woods
++	Isopyrum biternatum		Cliffs
	Myriophyllum laxum?		Springs
+	Arisaema Dracontium		Rich woods
	Rudbeckia sp.		
+	Dicerandra linearifolia		Sandy soils
	Dryopteris Thelypteris	(A fern)	Low grounds
++	**Pachysandra procumbens**		Rich woods
+	Urticastrum divaricatum		Rich woods
+	Senecio obovatus?		Dry woods
+	Carex Harperi	(A sedge)	Wet woods
+	Polymnia Uvedalia	Bear-foot	Rich woods
	Gratiola Floridana?		Wet woods
	Gratiola sphaerocarpa?		Wet woods
	Hymenocallis sp.	Spider-lily	Bottoms
+	Trillium Hugeri		Rich woods
—	Sarracenia flava	Pitcher plant	Low pine land
	Sarothra gentianoides (X)	(Poverty weed)	Old fields, etc.
+	Epiphegus Virginiana		Rich woods, on beech
	Sagittaria natans lorata?		Springs
	Dasystoma Virginica		Dry or rich woods
	Anthemis Cotula (X)	(Dog-fennel)	Roadsides, etc.
	Daucus pusillus (X)	(Wild carrot)	Roadsides, etc.
+	Sanicula Marylandica		Rich woods
+	Meibomia laevigata	(Beggar-lice)	Rich woods
	Morongia uncinata		Sandy soils
	Cnidoscolus stimulosus	(Nettle)	Dry woods
+	Meibomia nudiflora		Rich woods
	Erianthus sp.	(A grass)	Dry woods
	Eupatorium compositifolium (X)	Dog-fennel	Old fields, etc.
+	Collinsonia anisata		Dry or rich woods
	(and about 125 others)		

The following trees which are more or less common either in different regions not far away, or in other red clay regions in the South, are rare or absent here: *Pinus serotina, Hicoria glabra, Betula nigra, Quercus geminata, Quercus Catesbaei, Magnolia macrophylla, Platanus, Gleditschia, Tilia, Sassafras,* and

Oxydendrum. The soil is evidently too rich for some of these, while others prefer alluvial soils or other special conditions not well developed in this region.

The species which seem to be more abundant in this region than in other parts of Florida are indicated by double + marks, as explained on page 186. A few of these are confined to rock outcrops and are presumably lime-loving. The two commonest oaks, *Quercus falcata* and *Q. Marylandica,* appear to require ferruginous soils, while some other species probably prefer this region on account of the abundance of humus and infrequency of fire. The *Aquilegia* and *Pachysandra* are not known elsewhere in Florida, or even in the neighboring parts of Georgia and Alabama.

The percentages for evergreens add up only 49, which is the lowest figure for any region of equal extent in Florida. Only 1.6 per cent of the shrubs are Ericaceae; a very small proportion for Florida, doubtless correlated with the comparative richness of the soil. The percentage of Leguminosae among the herbs is 10.4, which is about the average.

Economic Features. The long-leaf pine, the most important timber tree of the South, is not abundant enough here to invite extensive lumbering and turpentining operations, but it and many of the other trees have been used for fuel, building material, and numerous other purposes on the farms. The cedar is used for fence-posts and pencil-wood.

According to the census of 1910 Jackson County had about 30 per cent of its area in improved land. (Allowing 10 per cent for old fields and other unclassified areas, this leaves about 60 per cent forest). There were 31 inhabitants to the square mile, an increase of 27 per cent since 1900, and 52 per cent of them were white. For the fertile red lands under consideration, which cover a little less than half of the county, the proportion of woodland must be considerably less, the density of the population somewhat greater, and the decennial increase and the percentage of whites considerably less, in the rural districts at least.

The principal crops in 1912, in order of value, were as follows: Upland or short-staple cotton, corn, peanuts, sweet potatoes, sugar cane, (grass) hay, oats, watermelons, velvet beans, field peas including hay thereof), peaches and pecans.

2. WEST FLORIDA LIME-SINK OR CYPRESS POND REGION.

(FIGURES 43-48)

References. Harper 1 (219), Matson & Clapp (57-58, 145), Matson & Sanford (78, 325-329), Sellards 1 (67-68), Sellards & Gunter 3 (111-113) Smith 2 (224, 225), and U. S. soil survey of the "Marianna area." Illustrated in 2nd Ann. Rep., pl. 2.2; 4th Ann. Rep., pl. 13.2, 15.2, 15.3, 16.1, 16.2.

This region embraces about 1,600 square miles in West Florida, and extends northeastward through Alabama into Southwest Georgia, if not all the way across the latter state. The boundary between it and the red lands just described is pretty sharp in some places, but not everywhere.

Geology and Soils—This region, like the first, is everywhere underlaid by the Vicksburg limestone, which is exposed in only a few places, mostly along streams and in sinks, though there is no telling how much of the clay that conceals the rocks is residual from the same formation. Over the Vicksburg limited areas of the Chattahoochee formation have been recognized. Rock Hill, about 4 1-2 miles southeast of Chipley,* is capped by a mottled argillaceous sandstone which appears to be identical with the Altamaha Grit of Georgia, and on its southern slope are large boulder-like masses of blackish ferruginous sandstone, which have been referred to the Lafayette formation. The mottled sandstone is not known to occur elsewhere in Florida, and the blackish rock is much more common a little farther north.

The soil is mostly a few inches or feet of grayish sand or sandy loam, passing downward into reddish or mottled sandy clay or clayey loam many feet thick, which may be a comparatively recent formation (Lafayette), though in some places it is evidently derived from the weathering of the underlying Tertiary strata. Where the clay is near the surface the ground is often thickly strewn with ferruginous concretions or nodules an inch or less in diameter, making what is commonly called "pimply" land, and now considered very desirable for agricultural purposes. There is nearly everywhere enough sand to make plowing easy in any kind of weather, and to keep the roads from getting muddy.

No chemical analyses of soils from this region are available; but in that part included in the "Marianna area" the most extensive

*For descriptions of this locality see Matson & Clapp (145, pl. 7.1), Harper 2, Matson & Sanford (150, pl. 12-A.)

type of soil is the "Norfolk fine sandy loam," of which a mechanical analysis was given under the head of the Marianna red lands, a few pages back.

A strip a few miles wide along the Chattahoochee-Apalachicola River has certain peculiarities which almost entitle it to be described separately. Much of its soil is a chocolate-colored sandy loam, evidently above the average of this part of the world in fertility.

Topography and Hydrography—The prevailing topography is irregularly undulating. There seem to be no extensive flat areas, except in the vicinity of some of the rivers, and these are always lower than the adjoining country, and may represent ancient terraces, though in soil and vegetation they differ little from the more elevated areas. Steep slopes are uncommon except on the immediate banks of streams, but there are quite a number of irregularly shaped and more or less isolated hills standing 50 feet or more above the surrounding country, particularly in Washington County.

The occurrence of a few lime-sinks and natural bridges shows the effects of solution on the topography, but in the present state of knowledge it is impossible to say whether solution or erosion has been the principal factor in giving the surface its present form. Much of the drainage is subterranean, and in many places one can go several miles at right angles to the general direction of the streams without crossing any running water. The region is pretty well supplied with creeks and rivers, though, and there are several large blue limestone springs. Some of the creeks furnish water-power.

Ponds of all sizes, from a fraction of an acre to a few square miles, abound. Their average size is perhaps two or three acres; and few of them are deep enough to hold water all the year round. Some are nearly circular, and some are so long and narrow that they can hardly be distinguished from branches; and there may indeed be all gradations between ponds and branches in this region. The amount of seasonal fluctuation of water varies in different ponds from about one to five feet, depending on the area and depth of the basins they occupy, the sandiness of the soil, etc. Those in which the water fluctuates least are known as bays, on account of their vegetation, which will be referred to on the next page.

Where the superficial sand and clay are thick enough water for domestic purposes is obtained from shallow dug wells and suction pumps, but where the limestone approaches the surface the ground-water level is usually lower, and force-pumps and artesian wells are used.

In the river strip above mentioned the ground-water level exhibits some curious irregularities. A few miles south of Sneads, if not elsewhere, can be found places where the water is perpetually seeping out on gentle slopes, characterized by sandy bog vegetation, and then at the bottom of the same slope, perhaps fifty yards away, may often be found a lime-sink with no water in it; showing that the ground-water surface is more irregular than the surface of the ground in such places. (See Fig. 43.)

Vegetation Types—The prevailing type of vegetation is open forests of long-leaf pine, so open that wagons can be driven through them almost anywhere (and consequently the minor roads are ill-defined and changeable). The scarcity of underbrush seems to be due primarily to the fires, set originally by lightning, and now mostly by man, either purposely or accidentally. The fires burn over every part of the pine woods nearly every year, usually in the latter part of the dry season (early spring), with little injury to the pines, as explained on page 184. The pine forests can be divided according to topography and moisture into three types, namely, high or dry, low or wet, and intermediate. These all intergrade, and have much the same general appearance, but in the low pine land the trees are mostly slash pine instead of long-leaf.

Most of the ponds are so full of trees that it would be impossible to use row-boats on them. In those where the water fluctuates three or four feet during the year the pond cypress is almost the only tree; where the annual fluctuation averages about two feet there is usually some slash pine mixed with the cypress; and where it is a foot or less there is a dense undergrowth of evergreen shrubs and vines, making a type of vegetation known as bays.* Some of the smaller ponds in the more clayey soils contain black gum or May haw instead of cypress and pine.

The streams are bordered by swamps and bottoms, varying in character with the size and fluctuation of the stream and the amount of lime or mud in the water. Strips of hammock vegeta-

*Where the fluctuation is greatest the proportion of evergreens is least, and vice versa; which seems to indicate that a constant water-level limits the availability of the potassium compounds and other mineral plant food, perhaps simply by preventing aeration. (See Wiley, U. S. Dept. Agric. Yearbook 1896:127; Harper, Torreya 11:225-234. 1911.)

tion are found along most of the creeks and rivers, and especially in the forks of streams, where fire cannot easily penetrate.

Plants—The following list is based on observations made in all four seasons, as follows: March, 5 days; April, 3; May, 6; June, 5: July, 3; September, 4; December, 2. Total, 28 days.

TREES

+46.0	**Pinus palustris**	Long-leaf pine	Uplands
+15.4	Taxodium imbricarium	Cypress	Ponds, etc.
+ 8.7	**Pinus Elliottii**	(Slash pine)	Ponds and branches
+ 3.4	Nyssa biflora	Black gum	Ponds and swamps
— 3.1	**Magnolia glauca**	Bay	Non-alluvial swamps
3.0	**Pinus Taeda**	Short-leaf pine	Richer soils
2.0	Quercus falcata	Red oak	Clayey uplands
— 1.3	Quercus Catesbaei	Black-jack oak	Sandiest places
— 1.2	Liquidambar Styraciflua	Sweet gum	Low grounds
— 1.1	**Magnolia grandiflora**	Magnolia	Hammocks, etc.
— 1.1	Quercus cinerea	(Turkey oak)	High pine land
.9	Taxodium distichum	Cypress	Richer swamps
.7	Liriodendron Tulipifera	Poplar	Branch swamps
— .7	Cornus florida	Dogwood	Loamy uplands
.7	Quercus **nigra**	Water oak	Low grounds
+ .7	Quercus Marylandica	Black-jack oak	Clayey uplands
— .6	**Pinus glabra**	Spruce pine	Hammocks, etc.
.5	Salix nigra	Willow	Low grounds
+ .5	Nyssa uniflora	Tupelo gum	Swamps and sloughs
— .5	**Pinus echinata**	Short-leaf pine	Clayey uplands
.5	**Ilex opaca**	Holly	Hammocks, etc.
— .4	Acer rubrum	Maple	Swamps
.4	**Quercus laurifolia**	Oak	Hammocks
+ .4	Planera aquatica		River swamps
+ .3	Populus deltoides	Cottonwood	River swamps
.3	Carpinus Caroliniana	Ironwood	Bottoms
.3	Fraxinus Caroliniana	Ash	Swamps
.3	Betula nigra	Birch	Along rivers
+ .2	Quercus lyrata	Swamp post oak	River bottoms
.2	Nyssa Ogeche	Tupelo gum	Swamps
— .2	Fagus grandifolia	Beech	Hammocks, etc.
— .2	**Quercus Virginiana**	Live oak	Hammocks, etc.
+ .2	Platanus occidentalis	Sycamore	Along Apalachicola R.
.16	Quercus stellata	Post oak	Clayey uplands
.15	Quercus Margaretta	Post oak	High pine land
.15	Hicoria alba	Hickory	Loamy uplands
— .15	Quercus Michauxii	(Swamp chestnut oak)	Bottoms
+ .15	Hicoria aquatica	(Swamp) hickory	Bottoms
.13	Acer rubrum tridens?	Maple	Bottoms
.12	Crataegus viridis	(Red) haw	Bottoms
.12	Cercis Canadensis	Redbud	Richest soils

.1	Ulmus alata	Elm	Rich soils
.1	Morus rubra	Mulberry	Richest soils
+ .1	Acer saccharinum	Maple	Banks of Apalachicola River
	Ulmus Floridana	Elm	Rich swamps
	Celtis occidentalis	Hackberry	Along Apalachicola R.
	Quercus alba	White oak	Rich woods
++	Tilia Floridana	Lin	Rich woods near Apalachicola River
	Ostrya Virginiana		Hammocks, etc.
	Acer Floridanum	Sugar maple	Rich woods
	Hicoria sp.	Hickory	Rich soils
	Catalpa bignonioides	Catalpa	River banks

SMALL TREES OR LARGE SHRUBS

+.27	Cyrilla **racemiflora**	Tyty	Swamps
+.25	**Ilex myrtifolia**	Yaupon	Ponds
+.10	**Cliftonia monophylla**	Tyty	Non-alluvial swamps
++.05	Crataegus aestivalis	May haw	Small ponds
.04	**Myrica cerifera**	Myrtle	Richer soils
.03	Nyssa Ogeche	Tupelo gum	Swamps
.03	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
.02	Batodendron arboreum	Sparkleberry	Hammocks, etc.
.02	**Osmanthus Americana**		Hammocks
.02	Prunus angustifolia	Wild plum	Old fields, etc.
.01	Crataegus apiifolia	Haw	Bottoms
.01	Ilex decidua		River-bottoms
.01	Chionanthus Virginica	Graybeard	Hammocks, etc.
	Symplocos **tinctoria**		Hammocks, etc.
	Prunus umbellata	Wild plum	Hammocks, etc.
	Castanea pumila	Chinquapin	Woods
	Viburnum rufidulum	Black haw	Rich woods
	Malus angustifolia	Crab-apple	Dry woods
	Crataegus Crus-Galli?	Haw	Apalachicola R. strip
	Cephalanthus occidentalis	Elbow bush	Swamps
	Bumelia lanuginosa		Hammocks
	Quercus geminata	Live oak	Sandy banks, etc.
	Amelanchier sp.	(Service-berry)	Hammocks, etc.

WOODY VINES

.006	**Smilax laurifolia**	Bamboo vine	Non-alluvial swamps
.003	Rhus radicans	Poison ivy	Rich swamps, etc.
+.003	**Pieris phillyreifolia**		Cypress ponds, bays
.002	Decumaria barbara		Wet woods
+.002	Smilax Walteri		Swamps
.002	**Gelsemium sempervirens**	Yellow jessamine	Hammocks, etc.
.001	Berchemia scandens	Rattan vine	Rich swamps
.001	**Bignonia crucigera**	Cross-vine	Woods
.001	Ampelopsis arborea		Richer soils
	Parthenocissus quinquefolia	Virginia creeper	Hammocks, etc.
	Trachelospermum difforme		May-haw ponds, etc.

SHRUBS

+.021	Hypericum fasciculatum		Around ponds, etc.
+.016	Quercus pumila	Oak runner	High pine land
.011	Ilex glabra	Gallberry	Low pine land
.005	Myrica pumila	Myrtle	Intermediate pine land
.005	Phoradendron flavescens	Mistletoe	On black gum, etc.
.004	Sabal glabra	Palmetto	Rich swamps
.004	Cephalanthus occidentalis	Elbow bush	Swamps and ponds
.004	Rubus cuneifolius (X)	Blackberry	Roadsides, etc.
.004	Gaylussacia dumosa		High pine land
.004	Chrysobalanus oblongifolius		High pine land
.004	Vaccinium nitidum	Huckleberry	High pine land, etc.
.003	Stillingia aquatica		Ponds
.003	Alnus rugosa	Alder	Swamps
.002	Pieris nitida	(Hurrah bush)	Bays, etc.
.002	Hypericum galioides?		
.002	Asimina angustifolia	Pawpaw	High pine land
.002	Aronia arbutifolia		Sandy bogs
.002	Vaccinium virgatum?	Huckleberry	Hammocks, etc.
.002	Clethra alnifolia		Edges of swamps
.001	Viburnum semitomentosum		Hammocks, etc.
.001	Viburnum obovatum		Bottoms, etc.
.001	Amorpha fruticosa		Bottoms, etc.
.001	Ceanothus Americanus		High pine land
.001	Rhus Toxicodendron	Poison oak	High pine land
.001	Gaylussacia frondosa*	Huckleberry	Intermediate pine land etc.
.001	Leucothoe racemosa		Bays, etc.
.001	Sebastiana ligustrina		Bottoms
.001	Ceanothus microphyllus		High pine land
.001	Rhus copallina	Sumac	High pine land, etc.
—.001	Serenoa serrulata	Saw-palmetto	Pine lands
	Ilex coriacea		Non-alluvial swamps
	Itea Virginica		Swamps and bays
	Myrica inodora	Myrtle	Non-alluvial swamps
	Quercus minima	Oak runner	Pine lands
	Myrica Carolinensis	Myrtle	Non-alluvial swamps
	Ilex vomitoria		Hammocks
	Kalmia latifolia	(Ivy)	Hammocks, etc.
	Styrax Americana		Swamps
	Cyrilla parvifolia?	Tyty	Bays
	Hypericum myrtifolium		Shallow ponds
	Ascyrum stans		Low pine land
	Aesculus Pavia	Buckeye	Richer soils

HERBS

+.007	Aristida stricta	Wire-grass	High pine land
+.002	Sarracenia flava	Pitcher-plant	Low pine land
+.001	Rhexia Alifanus		Intermediate pine land

*Including the var. *nana*.

.001	**Tillandsia usneoides**	Spanish moss	On trees
.001	Pteridium aquilinum	(A fern)	High pine land
+.001	Dichromena latifolia		Low pine land
+.001	Eriocaulon compressum		Ponds, etc.
.001	**Eriogonum tomentosum**		Dry sandy ridges
.001	**Helianthus Radula**		Pine lands
+.001	Baptisia lanceolata		High pine land
.001	**Eriocaulon decangulare**		Low pine land, etc.
.001	Pontederia cordata		Ponds
.001	**Castalia odorata**	Water-lily	Ponds
+.001	Andropogon Virginicus	Broom-sedge	High pine land
+.001	Chondrophora nudata		Low pine land
+.001	Polygala cymosa		Ponds
+.001	Berlandiera tomentosa		High pine land
.001	Campulosus aromaticus	(A grass)	Low pine land
.001	Helenium tenuifolium (X)	Bitterweed	Roadsides, etc.
.001	Eupatorium compositifolium (X?)	Dog-fennel	Roadsides, etc.
.001	**Aletris aurea**		Intermediate pine land
.001	Osmunda cinnamomea	(A fern)	Low pine land
+	Pluchea bifrons		Shallow ponds
	Trilisa odoratissima	Deer-tongue	Pine lands
+	Tofieldia racemosa		Low pine land
	Stillingia sylvatica		High pine land
	Drosera capillaris		Low pine land
	Facelis apiculata (X)		Waste places
+	Drosera filiformis Tracyi		Low pine land
	Vernonia angustifolia		High pine land
	Polygala ramosa		Low pine land
	Chrysopsis graminifolia		High pine land
	Croton argyranthemus		High pine land
+	Coreopsis nudata		Around ponds
	Kuhnistera pinnata	Summer farewell	Sandy soils
	Sarracenia psittacina	Pitcher-plant	Low pine land
+	Aster adnatus		Intermediate pine land
	Panicum hemitomon	Maiden-cane	Ponds
+	Chrosperma muscaetoxicum		Loamy uplands
	Eryngium virgatum		Low pine land
+	Pitcheria galactioides		High pine land
	Rhynchospora Grayii	(A sedge)	High pine land
+	Galactia erecta		High pine land
	Juncus repens		Shallow ponds
	Gaura Michauxii		High pine land
	Rhynchospora corniculata	(A sedge)	Ponds, etc.
	Erigeron vernus		Around ponds
	Chaptalia tomentosa		Low pine land
	Pentstemon hirsutus		High pine land
	Gnaphalium purpureum (X)		Fields and roadsides
	Verbena carnea		High pine land
	Panicum angustifolium?	(A grass)	High pine land
	Aletris lutea		Intermediate pine land
+	Helianthus heterophyllus		Intermediate pine land

	Xyris fimbriata		Ponds
+	**Ludwigia suffruticosa**		Around ponds
+	**Lophiola aurea**		Low pine land
	Oxypolis filiformis		Ponds, etc.
—	**Mitchella repens**	(Partridge-berry)	Hammocks
+	Sorghastrum secundum	(Wild oats)	High pine land
	Dolicholus simplicifolius	(Dollar-weed)	High pine land
	Centella repanda		Low pine land
	Polygala nana		Intermediate pine land
	Saururus cernuus		Swamps, etc.
	Stylosanthes biflora		High pine land
+	Chrysopsis oligantha		Intermediate pine land
	Solidago odora	Golden-rod	High pine land
	Eupatorium rotundifolium		Low pine land
+	Eryngium synchaetum		Intermediate pine land
	Psoralea canescens		High pine land
	Cracca **chrysophylla**		High pine land
	Polygala lutea		Low pine land
	Iris versicolor		Low pine land, etc.
	Sericocarpus bifoliatus		High pine land
	Rhexia stricta?		Around ponds, etc.
+	Muhlenbergia trichopodes*		Pine lands
	Hymenocallis sp.	Spider-lily	Swamps
	Morongia uncinata		High pine land
	Pogonia ophioglossoides	(An orchid)	Low pine land
+	Aster eryngiifolius		Low pine land
+	**Nymphaea fluviatilis**	Bonnets	Creeks, etc.
+	Ludwigia pilosa		Ponds, etc.
	(and about 275 others).		

The following trees are much less abundant here than in some of the neighboring regions, and some of them may be entirely absent: *Pinus serotina* (black pine), *Juniperus* (cedar), *Chamaecyparis* (juniper), *Hicoria glabra* (hickory), *Quercus Phellos* (willow oak), *Quercus Catesbaei* (black-jack oak), *Gordonia*, and *Persea*. Some of these prefer rich soils like those of the Marianna red lands, and some sour swamps and sandy ridges, which are much more common in the adjacent pine hill region (no. 7).

Most of the species which are more abundant here than in other regions grow in pine lands and cypress ponds. It is interesting to note that *Nyssa Ogeche, Quercus pumila, Viburnum obovatum, Facelis,* and other species not listed above are known in Georgia but not in Alabama, and *Myrica inodora, Pitcheria, Chrysopsis oligantha* and a few others in Alabama but not in Georgia, while *Cyrilla parvifolia* and one or two of the rarer herbs seem to be confined to Florida.

About 65% of the trees are evergreen, 12% of the shrubs are Ericaceae, and 6% of the herbs are Leguminosae. All these figures are not far from the average for northern Florida; but the percentage of evergreens would have been somewhat higher before the lumbermen cut out so much of the long-leaf pine.

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*Includes two forms, one in high and one in low pine land, which may some day be treated as distinct species. See Ann. N. Y. Acad. Sci. 17:293-294. 1906.

Economic Features—Converting the long-leaf and slash pines into lumber and naval stores have been, and still are, among the most important industries of this region. Long-leaf pine, which is now estimated to constitute 46 per cent of the forests here, probably stood as high as 60 per cent originally. The two cypresses are used for poles, piles, cross-ties, shingles, etc., but probably not 5 per cent of the total stand of cypress has been cut out yet. The tupelo gum, tyty, gallberry, and several less familiar species are important honey plants. The wire-grass and other native herbs furnish free pasturage for thousands of cattle here, as in other long-leaf pine regions.

In 1910 this region had less than 15 per cent of improved land, and about 22 inhabitants to the square mile, an increase of 41 per cent in ten years. Although the soil is not naturally very rich, and half a century ago was supposed to be fit for little else than raising pine timber and "native" cattle, it is very easily tilled, and responds generously to proper fertilization. Consequently in the last few decades, since practically all the richest land in the eastern United States has been appropriated, this in common with other sandy pine regions has attracted settlers in ever-increasing numbers.

The principal crops in 1912, in order of value, were: Upland cotton, corn, peanuts, sweet potatoes, sugar cane, velvet beans, (grass) hay, oats, watermelons, field peas (including pea-vine hay), peaches, sea-island cotton, pecans, Irish potatoes, figs, cabbage, grapes and pears.

3. APALACHICOLA RIVER BLUFFS AND BOTTOMS.

(FIGURES 49-51)

References. Chapman, Croom, Dall & Stanley-Brown, Gray, Harper 1 (216, 234-235), Harper 5 (225-226), Matson & Clapp (78-84, 96-97, 145), Matson & Sanford (95-101, 112-113), Nash (96-97, 103) Sellards & Gunter 1 (261-277, 285-286), and U. S. soil survey of Gadsden Co. (by Fippin and Root, 1904). Illustrated in 2nd Ann. Rep., pl. 1, 17; 3d, pl. 19.1; 4th, pl. 11.1, fig. 11.

From its beginning at the southwestern corner of Georgia to about the latitude of Bristol the Apalachicola River has on its east side some of the highest land in Florida (a part of the pine hill region described farther on), which comes out to the river in several places, making steep bluffs. Between these bluffs are deep rich valleys, some of which extend several miles back from the river. The bluff region is too narrow for its area to be estimated accurately, but it probably covers less than 50 square miles in this state. It continues northeastward into Georgia, soon diverging from the Flint River and becoming less prominent, but as the boundary between the lime-sink region and the pine hills (Altamaha Grit region) it can be traced nearly across that state, where it forms a typical inland-facing escarpment, or *cuesta.**

Geology and Soils—The underlying rocks of this region, well exposed on the river bluffs and along some of the creeks, mostly belong to the Chattahoochee and Alum Bluff formations (Upper Oligocene). Lithologically the strata vary from argillaceous limestone and marl to fuller's earth, clay and sand. There seems to be no limestone pure enough to form caves, though there are some limesinks near the state line. Much of the soil is derived from the weathering of these Tertiary rocks, and is quite fertile. In the more level places there is also considerable sand and sandy loam, which may represent the Lafayette and other comparatively recent formations. Humus is quite abundant, for reasons which will be evident. Between the hills and the river there are alluvial bottoms of varying width, with very fertile soil, as is usual in such places.

Topography and Hydrography—This region occupies a slope from the high pine land on its eastern border, 200 to 300 feet above sea level, to the river, which in this latitude is something like 50 feet above sea level at low water. Aspalaga Bluff, in Gadsden Coun-

*For notes on this escarpment in Georgia, see Bull. Torrey Bot. Club 32:144-145, 1905; Ann. N. Y. Acad. Sci. 17:17-18. 1906.

ty, rises about 175 feet in a distance of a quarter of a mile from the water's edge, and Alum Bluff, in Liberty County, has a very precipitous face about 160 feet high, which is perhaps the most conspicuous topographic feature in all Florida. The topography is everywhere hilly, and dissected by numerous ravines and small valleys, many of which head in amphitheaters or "steep-heads" at the edge of the upland. All the valleys contain streams, and most of the steep-heads have one or more small springs in them. Two or three of the creeks extend back from the river ten or twelve miles. The Apalachicola River, which heads among the mountains of Georgia, and traverses the red hills of the Piedmont region for a long distance, is the only stream in Florida which derives any of its water from outside of the coastal plain. It is always muddy, and where it is formed by the union of the Flint and Chattahoochee it fluctuates at least 30 feet. Its high-water period is usually in spring, because a large part of its drainage basin, unlike Florida, has wet winters and dry summers.

Vegetation Types—Next to the river are alluvial swamps (described in the 3d Annual Report), with a heavy growth of deciduous trees, presumably indicating a soil rich in potassium. The rich slopes of bluffs and ravines are covered with short-leaf pines and hardwoods, among which the magnolia and other evergreens are conspicuous. A small pine woods element is found at the upper or eastern edge and in the sandier soils lower down.

On account of the broken topography and the presence of the river on one side, fires are not common in this region, which is one reason, perhaps the principal reason, why there is so much humus in the forests. Obviously no fire can approach from the west, on account of the river, and the fires which sweep through the pine woods on the east are not likely to travel down the bluffs very far; so that there is probably no area of equal extent on the mainland of northern Florida that is better protected from fire.

Plants—The following list is based on observations made on 16 different days, in the following months: March, 8; May, 1; June, 4; September, 1; December, 2. Most of the herbs were noted in the first half of March, 1909, when the writer with other members of the Geological Survey camped for several days at Aspalaga. That was just about the season of the year when the number of flowers in rich shady woods in this latitude is at a maximum, for a little later the trees leaf out and cast too dense a shade for many flowers.

TREES

+	15.7	**Pinus Taeda**	Short-leaf pine	Various situations
++	9.5	**Magnolia grandiflora**	Magnolia	Bluffs and ravines
—	6.4	**Pinus palustris**	Long-leaf pine	Sandiest soils
++	5.6	**Pinus glabra**	Spruce pine	Bluffs and ravines
+	4.3	Liquidambar Styraciflua	Sweet gum	Various situations
++	4.1	Fagus grandifolia	Beech	Ravines, etc.
++	4.0	**Tumion taxifolium**	Stinking cedar	Bluffs and ravines
	3.7	**Magnolia glauca**	Bay	Wet ravines
++	3.5	**Ilex opaca**	Holly	Bluffs and ravines
+	2.8	Liriodendron Tulipifera	Poplar	Wet ravines
+	2.4	Taxodium distichum	Cypress	Swamps and bottoms
+	2.4	**Pinus echinata**	Short-leaf pine	Uplands
++	2.0	Quercus Michauxii	(Swamp chestnut oak)	Bottoms
+	1.9	Quercus **nigra**	Water oak	Bottoms, etc.
++	1.9	Platanus occidentalis	Sycamore	River banks and bottoms
+	1.8	Carpinus Caroliniana	Ironwood	Bottoms
	1.7	Cornus florida	Dogwood	Uplands
+	1.5	Salix nigra	Willow	River banks, etc.
++	1.5	Ostrya Virginiana		Ravines and bluffs
	1.3	Quercus falcata	Red oak	Uplands
+	1.3	**Juniperus Virginiana**	Cedar	Rocky bluffs, etc.
++	1.3	Populus deltoides	Cottonwood	River-bottoms
+	1.3	**Quercus laurifolia**		Uplands
+	1.3	Acer Floridanum	Sugar maple	Ravines and bluffs
+	1.2	Betula nigra	Birch	River banks
	1.1	Acer rubrum	Maple	Along branches, etc.
++	.9	Oxydendrum arboreum	Sourwood	Uplands
+	.8	Quercus alba	White oak	Ravines and bluffs
+	.8	Halesia diptera		Ravines and bluffs
—	.8	Quercus Catesbaei	Black-jack oak	Sandiest soils
+	.8	Quercus Schneckii?	(Red oak)	Rich woods
+	.7	Planera aquatica		River banks, etc.
+	.6	Cercis Canadensis	Redbud	Rich woods
+	.5	Quercus lyrata	Swamp post oak	Bottoms
+	.4	Melia Azedarach (X)	Chinaberry	Waste places
	.4	Ulmus Americana	Elm	River banks, etc.
	.4	Hicoria sp.	Hickory	Rich woods
+	.4	Morus rubra	Mulberry	Bottoms, etc.
—	.4	Quercus cinerea	(Turkey oak)	Sandy uplands
+	.4	Malus angustifolia	Crab-apple	Uplands
++	.4	Prunus Americana	Wild plum	Rich woods
+	.3	Tilia sp.	Lin	Bluffs, etc.
++	.3	Ulmus fulva	Slippery elm	Rich woods
	.3	Fraxinus sp.	Ash	
+	.3	Celtis occidentalis	Hackberry	Bottoms
+	.2	**Prunus Caroliniana**	(Mock orange)	Ravines, etc.
+	.1	Fraxinus Americana	Ash	Rich woods
+	.1	Acer saccharinum	Maple	River-banks

+	.1	Quercus pagodaefolia	Red oak	Bottoms
+	.1	Juglans nigra	Walnut	Rich woods
+	.1	Acer Negundo	Box elder	River-banks
+	.1	Quercus Muhlenbergii	Oak	Bluffs, etc.
++	.1	**Taxus Floridana**		Alum Bluff
+	.1	Hicoria aquatica	(Swamp) hickory	Bottoms
	.1	Nyssa sylvatica	Black gum	Uplands

SMALL TREES OR LARGE SHRUBS

+	.24	**Myrica cerifera**	Myrtle	Ravines and bluffs
	.10	Cyrilla **racemiflora**	Tyty	Branch-swamps, etc.
+	.08	**Osmanthus Americana**		Ravines and bluffs
	.08	Batodendron **arboreum**	Sparkleberry	Uplands
+	.06	Ilex decidua		River-bottoms
+	.04	Symplocos **tinctoria**		Ravines and bluffs
	.04	**Cliftonia monophylla**	Tyty	Branch-swamps
+	.03	Bumelia **lycioides**		Calcareous bluffs
	.03	Viburnum rufidulum	Black haw	Uplands
+	.03	Adelia acuminata		River-banks
	.03	Prunus umbellata	Wild plum	Uplands
+	.02	Crataegus spathulata	Red haw	Uplands
+	.01	Styrax grandifolia		Ravines and bluffs
	.01	Rhus copallina	Sumac	Bluffs, etc.

WOODY VINES

+	.007	Rhus radicans	Poison ivy	Bottoms, etc.
+	.006	Decumaria barbara		Wet ravines
	.005	**Bignonia crucigera**	Cross-vine	Various situations
	.003	Vitis rotundifolia	Muscadine or bullace	Various situations
	.003	Berchemia scandens	Rattan vine	Bottoms, etc.
	.003	Parthenocissus quinquefolia	Virginia creeper	Shady places
	.003	**Smilax laurifolia**	Bamboo vine	Branch-swamps
++	.003	Schizandra coccinea		Shaded bluffs
	.002	Vitis aestivalis	Wild grape	Bluffs, etc.
	.001	**Smilax lanceolata**	(Wild smilax)	Ravines and bluffs
	.001	Tecoma radicans	(Cow-itch)	Bottoms, etc.
	.001	**Gelsemium sempervirens**	Yellow jessamine	Various situations

SHRUBS

++	.028	**Sabal glabra**	Palmetto	Swamps
++	.015	Alnus rugosa	Alder	Along creeks and branches
+	.013	Aesculus Pavia	Buckeye	Woods
	.012	**Phoradendron flavescens**	Mistletoe	On trees
++	.012	**Arundinaria macrosperma**	Reed	River-banks
+	.012	Hydrangea quercifolia	Seven-bark	Ravines and bluffs
++	.012	Dirca palustris		Ravines and bluffs
+	.011	Callicarpa Americana	French mulberry	Uplands
+	.009	**Sebastiana ligustrina**		Bottoms

+.008	**Rhapidophyllum Hystrix**	(Needle palm)	Ravines and bottoms
.007	**Euonymus Americanus**	Strawberry bush	Ravines and bottoms
+.005	**Illicium Floridanum**	(Stink-bush)	Ravines
+.004	Ptelea trifoliata		Bluffs
+.004	Pinckneya pubens		Branch-swamps
.004	**Ilex glabra**	Gallberry	
++.004	Clinopodium dentatum		Near Bristol
++.004	**Kalmia latifolia**	Ivy	Ravines, etc.
+.004	Hamamelis Virginiana	Witch-hazel	Ravines, etc.
.003	**Ilex coriacea**		Wet ravines
.003	Aralia spinosa	Prickly ash	Ravines and bluffs
.003	Cephalanthus occidentalis	Elbow-bush	Swamps, etc.
.003	Azalea nudiflora	Honeysuckle	Bluffs, etc.
.002	Aronia arbutifolia		Along branches
.002	**Leucothoe axillaris**		Ravines, etc.
++.001	**Hypericum aureum**		Bluffs
++.001	Xanthorrhiza apiifolia		Wet ravines
+.001	Adelia ligustrina		Bluffs
.001	Viburnum obovatum		Bottoms

HERBS

.0025	**Tillandsia usneoides**	Spanish moss	On trees
++.0015	**Adiantum Capillus-Veneris**	Maidenhair fern	Limestone cliffs
++.001	Croomia pauciflora		Ravines and bluffs
+.001	**Smilax pumila**		Ravines and bluffs
+.001	Conopholis Americana		Ravines and bluffs
+.001	**Dryopteris patens?**	(A fern)	Limestone outcrops
+	**Mitchella repens**	(Partridge-berry)	Ravines and bluffs
+	Oplismenus setarius	(A grass)	Ravines and bluffs
+	**Polystichum acrostichoides**	(A fern)	Ravines and bluffs
+	Trillium Hugeri?		Ravines and bluffs
+	Lithospermum tuberosum		Bluffs
+	Senecio lobatus		Bottoms
+	Epiphegus Virginiana		On roots of beech
++	Syndesmon thalictroides		Bluffs
++	**Hepatica triloba**		Ravines and bluffs
++	**Viola multicaulis**	Violet	Bluffs
+	Dioscorea villosa		Ravines and bluffs
—	**Aristida stricta**	Wire-grass	Edge of uplands
+	**Asplenium resiliens**	(A fern)	Limestone cliffs
++	**Selaginella apus**		Damp ravines, etc.
+	Sanguinaria Canadensis	(Blood-root)	Ravines and bluffs
++	Campanula Americana		Bluffs
++	Melica mutica	(A grass)	Bluffs
+	Phlox divaricata		Bluffs
	Polypodium polypodioides	(A fern)	On trees
+	**Viola villosa**	Violet	Bluffs
++	**Euphorbia commutata**		Ravines
+	Arisaema Dracontium		Ravines and bluffs

+	Atamosco Atamasco		Ravines, etc.
+	Phegopteris hexagonoptera	(A fern)	Ravines and bluffs
++	Trillium lanceolatum		Ravines and bluffs
+	Aristolochia Serpentaria	(Snake-root)	Ravines and bluffs
—	**Eriogonum tomentosum**		Dry sandy places
	Berlandiera tomentosa		Dry uplands
++	Alsine pubera		Ravines and bluffs
+	**Yucca filamentosa**	Bear-grass	Bluffs, etc.
+	**Galium uniflorum**		Ravines and bluffs
++	Dentaria laciniata?		Ravines and bluffs
+	Polygonatum biflorum		Ravines and bluffs
+	**Tipularia discolor**	(An orchid)	Ravines and bluffs
++	Onoclea sensibilis	(A fern)	Bottoms
	Saururus cernuus		Bottoms
	(and about 35 others).		

To the botanist this is one of the most interesting regions in Florida. The two representatives of the yew family, *Tumion taxifolium* (formerly *Torreya taxifolia*) and *Taxus Floridana,* do not grow wild anywhere else in the world, as far as known, not even in the same region in Georgia. A good deal has been written about the former,* but very little, strange to say, about the latter, which according to the percentage figures given above is forty times rarer. One of the shrubs, *Clinopodium dentatum,* is likewise endemic.

Several other species in the list are not known elsewhere in Florida, most of them being commoner much farther north. Among these seem to be *Dirca, Xanthorrhiza, Croomia, Syndesmon, Hypericum aureum, Campanula, Euphorbia commutata, Trillium lanceolatum, Alsine pubera, Dentaria,* and some rarer species not listed; most of which prefer cool, rich woods with plenty of humus. *Platanus, Populus, Acer saccharinum, Quercus pagodaefolia, Bumelia lyciodes, Arundinaria macrosperma, Kalmia latifolia,* and *Selaginella apus* seem to extend into Florida only or chiefly along the Chattahoochee-Apalachicola River.

There seem to be more species of trees here than in any equal area in northern Florida. About 55% of the forest is evergreen, 7.1% of the shrubs are Ericaceae, and about 2% of the herbs are Leguminosae; all of which figures are below the

*Those who have imagined that the *Tumion* was in danger of extinction will be interested to learn now that it stands seventh in the list of trees, and seems to constitute about 4 per cent of the forest.

average for northern Florida, presumably indicating more potassium and more humus in the soil than in most of the other regions.

Economic Features—This region contains a large amount of hardwood timber, which has not been utilized much yet, but will doubtless be more appreciated in the future. The area is so narrow and irregularly shaped that it is impracticable to work out any statistics of its population and agricultural features. Although the soil is rich enough, the broken topography interferes with cultivation to a considerable extent.

4. KNOX HILL COUNTRY.
(FIGURE 52)

References. Matson & Clapp (106-117), Matson & Sanford (111, 121, 129), Sellards 3 (291 or 45), Sellards & Gunter 3 (107), Smith 2 (224), Williams.

This region is confined to the eastern part of Walton County, where it covers about 50 square miles, lying between the lime-sink region and the pine hills somewhat like the Apalachicola River bluff region, of which it is in some respects a counterpart. There is a small and ill-defined area of similar country a few miles farther west, near Alaqua Creek, but otherwise there is nothing exactly like it elsewhere. It bears a considerable resemblance, however, to parts of the central short-leaf pine belt of Alabama,* which is quite different geologically.

Geology and Soils—Outcrops of rock or fossiliferous strata are rare, but it would appear from available geological maps that the region is underlaid by Upper Oligocene and Miocene strata, belonging to the Alum Bluff and Choctawhatchee formations. Exposures of the former have been reported from ravines near Knox Hill and Eucheeanna and of the latter from near Red Bay, by Matson and his associates on the pages above cited.

The prevailing soil is a reddish to brownish clay or loam, largely if not chiefly derived from the weathering of the underlying Tertiary strata. Some of the hills are rather sandy, but on the whole this region probably contains the most clayey soil in the State. In hardly any other part of Florida does it seem necessary to overcome the stickiness of the clay in the roads by covering the worst spots with small poles ("corduroy") or sand. No analyses are available, but in the parts of Alabama and Mississippi that have similar vegetation the percentage of magnesium in the soil is rather high, and of phosphorus rather low. Humus is quite abundant, on account of the density of the forests.

Topography and Hydrography—This region is rather hilly for Florida, there being in some places as much as 100 feet difference in elevation between hills and adjacent valleys. There are few or no evidences of solution, the topography being of the kind produced by normal erosion. The larger valleys contain creeks, bordered by more or less swamp, but in many of the smaller ones the branches

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*For description of that part of Alabama, including a quantitative list of trees, see Geol. Surv. Ala. Monog. 8:72-76. 1913.

stop running in dry weather, as is the case in many other clayey regions. Some of the ravines have small springs at their heads.

Vegetation Types—On the sandier uplands there is a good deal of long-leaf pine and its common associates, while on the more extensive clayey uplands and valley slopes the usual vegetation is a mixture of short-leaf pines and various hardwoods (mostly second growth, for the reason given under Economic features). Some of the valleys are a little sandier than others, and in such places the proportion of evergreens seems to be above the average for the region. The swamps present no striking features.

Fire is infrequent here, as in most other places where the forests are dense and the ground covered with humus, which is usually too damp or too thoroughly decomposed to burn readily.

Plants—This region is so small and remote from railroads that I have been through it only twice, and consequently my vegetation statistics for it cannot be very accurate. But by combining the list of plants with that for Holmes Valley, another small region (to be described next) with very similar flora, the chances of error are decreased, and considerable repetition is avoided. The following list is based on observations made in the Knox Hill country on March 7, 1910, and May 6 and 7, 1914, and in Holmes Valley on May 8, 9 and 10, 1914. Percentage figures are omitted, because they cannot be depended upon in this case. The names of plants seen only in the Knox Hill country are preceded by K, and those seen only in Holmes Valley by H.

TREES

++	**Pinus Taeda**	Short-leaf pine*	Nearly everywhere
+	**Pinus echinata**	Short-leaf pine†	Loamy uplands
—	**Pinus palustris**	Long-leaf pine	Sandy uplands
+	Liquidambar Styraciflua	Sweet gum	Various situations
+	Cornus florida	Dogwood	Dry woods
+	Quercus falcata	Red oak	Loamy uplands
+	Fagus grandifolia	Beech	Valleys
+	**Magnolia grandiflora**	Magnolia	Valleys
	Magnolia glauca	Bay	Swamps
++	Quercus alba	White oak	Valleys
+	**Ilex opaca**	Holly	Valleys
+	**Pinus glabra**	Spruce pine	Valleys
+	Oxydendrum arboreum	Sourwood	Loamy uplands, etc.
	Nyssa biflora	Black gum	Swamps
+	Quercus stellata	Post oak	Loamy uplands

*Also called "black pine" in the Knox Hill country.
†Sometimes distinguished here as "rosemary pine."

	Quercus nigra	Water oak	Low grounds
+K	Quercus Marylandica	Black-jack oak	Sandy uplands
++	Nyssa sylvatica	Black gum	Loamy uplands
+	Hicoria alba	Hickory	Loamy uplands
+	Ostrya Virginiana		Valleys
—	Quercus Catesbaei	Black-jack oak	Sandy uplands
+	Carpinus Caroliniana	Ironwood	Bottoms
+	Quercus laurifolia		Valleys
	Acer rubrum	Maple	Swamps
—	Quercus cinerea	(Turkey oak)	Sandy uplands
+	Nyssa uniflora	Tupelo gum	Swamps
	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
+K	Castanea pumila	Chinquapin	Dry woods
+	Taxodium distichum	Cypress	Swamps
	Liriodendron Tulipifera	Poplar	Branch-swamps
	Quercus Michauxii	(Swamp chestnut oak)	Bottoms
+K	Cercis Canadensis	Redbud	Rich woods
+	Acer Floridanum	Sugar maple	Valleys
K	Juniperus Virginiana	Cedar	
K	Betula nigra	Birch	Creek-banks
K	Quercus Margaretta	Post oak	Sandy uplands
+H	Melia Azedarach (X)	Chinaberry	Roadsides, etc.
—K	Pinus Elliottii	(Slash pine)	Sandy low grounds
—K	Pinus serotina	(Black pine)	Sandy low grounds

SMALL TREES OR LARGE SHRUBS

++	Magnolia macrophylla	Cucumber tree	Valleys
+	Batodendron arboreum	Sparkleberry	Dry woods
	Myrica cerifera	Myrtle	Valleys
+	Symplocos tinctoria		Valleys
K	Cyrilla racemiflora	Tyty	Swamps
	Osmanthus Americana	[illegible]	Valleys
++	Magnolia pyramidata	Cucumber tree	Valleys
+K	Amelanchier sp.	(Service berry)	Valleys
	Salix nigra	Willow	Swamps
	Prunus angustifolia (X)	Wild plum	Old fields
	Prunus umbellata	Hog plum	Dry woods

WOODY VINES

+	Gelsemium sempervirens	Yellow jessamine	Various situations
	Vitis rotundifolia	Muscadine (bullace)	Various situations
	Tecoma radicans	(Cow-itch)	Various situations
	Bignonia crucigera	Cross-vine	Woods
	Parthenocissus quinquefolia	Virginia creeper	Valleys
	Decumaria barbara		Swamps
K	Smilax lanceolata	(Wild smilax)	Valleys, etc.

SHRUBS

++K	Vaccinium virgatum?	Huckleberry	Dry woods
++	**Illicium Floridanum**	(Stink-bush)	Valleys
	Callicarpa Americana	French mulberry	Dry woods
+K	Viburnum semitomentosum		Valleys
++	Stuartia Malachodendron		Valleys
K	**Ilex glabra**	Gallberry	Sandy low grounds
+	Hamamelis Virginiana	Witch-hazel	Valleys
+	Aesculus Pavia	Buckeye	Woods
+K	**Kalmia latifolia**	Ivy	Valleys
	Cephalanthus occidentalis	Elbow-bush	Swamps
	Rubus cuneifolius (X)	Blackberry	Roadsides, etc.
	Itea Virginica		Swamps
+	Asimina parviflora	Pawpaw	Valleys
K	Rhus copallina	Sumac	Uplands
H	Sambucus Canadensis (X?)	Elder	Low grounds
K	Gaylussacia dumosa	Huckleberry	Sandy uplands
K	**Ilex vomitoria**		Valleys
H	Aralia spinosa	Prickly ash	Valleys
K	**Sabal glabra**	Palmetto	Swamps
+K	Azalea nudiflora	Honeysuckle	Woods
+K	Polycodium stamineum?	Gooseberry	Woods
K	Alnus rugosa	Alder	Swamps
++H	Viburnum densiflorum		Rich woods
+H	Styrax grandifolia		Rich woods

HERBS

	Tillandsia usneoides	Spanish moss	On trees
+	**Mitchella repens**	(Partridge-berry)	Rich woods
+H	Andropogon scoparius (X)	Broom-sedge	Old fields
+	**Smilax pumila**		Valleys
+	Asclepias variegata	Milkweed	Dry woods
++K	Danthonia sericea	(A grass)	Open woods
K	Chrosperma muscaetoxicum		Open woods
K	**Trilisa odoratissima**	Deer-tongue	Sandy uplands
H	**Juncus effusus**	Rush	Wet places
+H	Rumex hastatulus (X)	Sorrel	Fields
+K	**Polystichum acrostichoides**	(A fern)	Valleys
	Eupatorium compositifolium (X)	Dog-fennel	Roadsides, etc.
	Osmunda cinnamomea	(A fern)	Low grounds
+	Epidendrum conopseum	(An orchid)	On trees in valleys
—K	**Aristida stricta**	Wire-grass	Sandy uplands
K	Berlandiera tomentosa		Sandy uplands
K	Stillingia sylvatica	(Queen's delight)	Sandy uplands
K	Asarum arifolium	Heart-leaf	Rich woods
K	Croton argyranthemus		Sandy uplands
K	Kneiffia linearis		Sandy uplands
H	Polygonum hydropiperoides	(Smart-weed)	Around ponds
	Pteridium aquilinum	(A fern)	Sandy uplands
	Lorinseria areolata	(A fern)	Swamps

Asplenium Filix-foemina	(A fern)	Wet woods
+ Epiphegus Virginiana		On roots of beech
K Pentstemon hirsutus		Rich woods
+K Trillium Hugeri		Sandy uplands
H Carex debilis	(A sedge)	Wet woods
+K Tipularia discolor	(An orchid)	Rich woods
K Phlox amoena		Dry woods
K Polygala nana		Open woods

The common short-leaf pine (*Pinus Taeda,* the "loblolly pine" of the books and of the Marianna red lands, here called "black pine"), the two little cucumber trees (*Magnolia macrophylla* and *pyramidata*), the tall huckleberry (*Vaccinium virgatum*), the handsome shrub *Stuartia,* with flowers looking like those of the dogwood at a little distance, and the grass *Danthonia,* all seem to be more abundant in one or both of these regions than anywhere else in Florida; but they are all commoner in Alabama. They evidently prefer rather rich soil, but just what element or combination of elements it is that determines their abundance cannot be stated, in the absence of analyses.

The pond cypress, cedar, all hickories, live oak, mulberry, elm, hackberry, poplar, crab-apple, haws, plums and saw palmetto are scarce or absent in the Knox Hill country, though more or less common in neighboring regions.

In the two regions together about 56% of the trees are evergreens, 25% of the shrubs are Ericaceae, and about 1% of the herbs are Leguminosae. This is a high proportion of Ericaceae and low of Leguminosae for such clayey soils; but the shrubs form a comparatively small part of the vegetation, so that the proportion of Ericaceae to total vegetation is not very high. And if notes could be made in this region in summer and fall the proportion of Leguminosae would doubtless be increased, though such plants are not usually very abundant where there is plenty of humus.

Economic Features—The Knox Hill country, on account of its clayey soils and large proportion of deciduous trees, attracted settlers early in the history of Florida, when sandy pine lands were considered almost worthless. A colony of Scotchmen settled there in 1823, and Scotch names still predominate in that region and for a considerable distance around it. Up to 1883, when a railroad was built through Walton County, this small area probably contained most of the inhabitants of the county, and Eucheeanna was the county-seat. It is said that most of the land was under cultivation before the Civil War; but with the drift of population toward more sandy lands, that has been going on throughout the South for the last few decades, many farms have reverted to forest, and the proportion of cleared land at present is probably not over 25 per cent. As nearly as can be estimated from the census returns for the precincts lying in this region, there were about 26 inhabitants to the square mile in 1910. The proportion of white people appears to be larger than in most other parts of northern Florida with equally rich soil, though no statistics on this point are available.

The principal use made of the native vegetation other than for fuel and other common farm purposes is the extraction of naval stores from the pines. A large part of the turpentine, curiously enough, comes from the short-leaf pine, *P. echinata,* which is rarely turpentined elsewhere. The woods furnish considerable pasturage for cattle and hogs, as usual. The leading crops are cotton and corn.

5. HOLMES VALLEY.

(FIGURE 53)

References. Sellards 3 (291-292, or 45-46), Sellards & Gunter 3 (113-115), Smith 2 (225), Williams.

This is a narrow strip, perhaps 25 square miles in extent, lying between the lime-sink or cypress pond region and the lake region, in Washington County. It has no counterpart elsewhere, but is similar in vegetation to the Knox Hill country, and in some other respects to the Tallahassee red hills, described farther on.

Geology and Soils—No rocks or fossils seem to have yet been discovered in this region, and therefore nothing definite is known about its geology; but it lies wholly within a belt mapped by Matson as Choctawhatchee marl (Miocene).*

The soil seems to be mostly residual from the Tertiary formations, and is clayey in some places and sandy in others; the sand being rather coarse. It is evidently above the average of Florida soils in fertility, as indicated by the density of the native vegetation, and the large proportion of the land that is under cultivation. Dr. Smith, on the page above cited, mentions a case in this region where in 1880, 13 acres of land that had been cultivated 35 years without fertilization produced 12 bales of cotton. The vegetation seems to indicate a little more phosphorus in the soil than in the case of the Knox Hill country.

Topography and Hydrography—In the longitude of Vernon the edge of the lake region south of Holmes Valley is at least 100 feet higher than the lime-sink region north of it, and the "valley" is not much more than a mile wide, so that in that neighborhood it might be regarded as nothing but an inland-facing escarpment, or *cuesta* (a characteristic feature of some parts of the coastal plain, particularly in Alabama). But in the longitude of Wausau the "valley" is about four miles wide, and not much higher or lower than the country on either side of it, and is a belt of low hills rather than a valley. Most of the depressions between the hills have miry ponds or stagnant sloughs in them instead of streams. But there are a few small branches that start near the high southern edge of the region south of Vernon, flow in a general northerly direction for a short distance,

*In some cuts on the B. C & St. A. R. R. a few miles south of Wausau can be seen several feet of clayey and shaley strata with pronounced folds, but apparently devoid of fossils.

and then soak into the ground. Some of the eastern part of the "valley" may be drained by Pine Log Creek.

Vegetation Types—The original forest that remains, mostly on steep slopes, consists of hardwoods and short-leaf pines, and is rather dense. In the second-growth woods the pine is relatively more abundant, and dogwood is very common. The sloughs and ponds have the vegetation usually found in such places where the soil is pretty rich. Fire is a negligible factor, as in other fertile regions with dense forests and a large proportion of cleared land.

Plants—These have already been listed in connection with those of the Knox Hill country, as above explained. Most of the remarks about the plant list of that region will apply also to this. One shrub in the list, *Viburnum densiflorum,* has not been seen by the writer outside of Holmes Valley, but it differs very little from *V. acerifolium,* a species characteristic of rich woods in the Piedmont region of Georgia and Alabama. It is noteworthy that less than 2 per cent of the shrubs observed in Holmes Valley are Ericaceae, which is quite a different state of affairs from that in the Knox Hill country. No Leguminosae whatever were noticed here, but a visit to the region in late summer or fall would doubtless reveal a few members of that family. Short-leaf pine (*P. echinata*), birch, black-jack oak (both kinds) and ashes are perceptibly scarcer here than in the Knox Hill country.

Economic Features—Although this region is mostly under cultivation, it seems to be an illustration of the general principle that in the southeastern United States, if not elsewhere, the most fertile regions are not the most salubrious.* For this reason, and probably also on account of the scarcity of running water, most of the farmers who till its fields (the majority of them negroes, apparently) live just outside of the "valley," either north or south of it. Cotton and corn are the prevailing crops, as usual. No important use seems to be made of the remaining native vegetation.

*This correlation seems never to have been satisfactorily explained. The mosquito theory of malaria, perfected in 1900, explains it partly, but not entirely.

6. WEST FLORIDA LAKE REGION.

(FIGURE 54)

References. Sellards 2 (33, one sentence near bottom of page), Sellards & Gunter 3 (113, 114, 115), and U. S. soil survey of the "Marianna area." Two photographs of lakes in this region have been published; one by Clapp in the 2nd Annual Report of this Survey, plate 2, fig. 1 (reproduced herewith), and again in U. S. G. S. Water Supply Paper 319, plate 3 B. entitled "Sink hole containing pond, 10 miles southeast of Vernon, Washington County," and the other by Sellards and Gunter in the 4th Annual Report of the Florida Survey, plate 15, fig. 1, entitled "Porter's Pond twenty miles south of Chipley, in Washington County."

The boundaries of this region have not been determined except at a few points, but it probably covers between 300 and 400 square miles. There is nothing like it in any other state, but it bears considerable resemblance to the peninsular lake region, described farther on.

Geology and Soils—Nothing definite is known about the geology, as no rock outcrops have been observed. The prevailing soil is a loamy sand, or very sandy loam, probably underlaid by clay, though none of the railroad cuts seem to be deep enough to reach the bottom of the sand.

In that part of the region lying within the "Marianna area" of the government soil survey the greater part of the soil is classed as "Norfolk sand" (named for Norfolk, Va.) The following mechanical analysis, representing the average of two localities, is taken from that publication. (The localities are not specified, and may or may not be in the lake region.) The first column of percentages represents the soil and the second the subsoil (depths not specified).

MECHANICAL ANALYSIS OF "NORFOLK SAND," JACKSON COUNTY.

	Soil	Subsoil
Fine gravel (2-1 mm.)	4.5	3.1
Coarse sand (1-.5 mm.)	26.4	23.7
Medium sand (.5-.25 mm.)	16.4	15.9
Fine sand (.25-.1 mm.)	31.2	34.5
Very fine sand (.1-.05 mm).	10.9	11.4
Silt (.05-.005 mm.)	7.4	6.3
Clay (.005-0 mm.)	33.9	5.2
Total	100.7	100.1

It will be observed that the differences between the soil and subsoil are slight; and the same is true also of the "Norfolk coarse sand," a much less extensive soil of the same region. This may be due in part to the abundance of salamanders, which keep the soil within a foot or two of the surface pretty well stirred up.

Topography and Hydrography—This region seems to be a little higher than most of the surrounding country, but no measurements of altitudes are available. It might be described as a comparatively level upland, pitted with many approximately circular depressions varying from several acres to a few hundred acres in extent and 30 to 50 feet deep, and containing lakes. The number of lakes averages perhaps one to a square mile, though in some places two or three can be seen at once. Streams are comparatively scarce, but the soil map of the "Marianna area" shows several branches in the northeastern portion, and Pine Log Creek traverses the region near its center. As in most other very sandy regions, the seasonal fluctuation of the water is comparatively small.

Vegetation Types—The uplands are covered with open forests of long-leaf pine, plentifully interspersed with black-jack and turkey oaks, and carpeted with wire-grass and other herbs. Some of the lakes are bordered by cypress, tyty, and other water-loving trees and shrubs, and some of the smaller depressions are completely filled with vegetation of the "bay" type. Fires are frequent in the pine forests, but where a steep slope going down to water gives sufficient protection there is likely to be hammock vegetation.

Plants—The following list is based on two round trips across the region by rail, one on the A. & St. A. B. Ry. on June 25 and 26, 1909, and one on the B. C. & St. A. R. R. on May 10, 1914; and a brief examination of its northern edge about three miles south of Vernon on May 8, 1914. As it represents only about three hours of field work, it is doubtless far from complete; and the percentage figures are omitted.

TREES

+	**Pinus palustris**	Long-leaf pine	Always in sight
+	Quercus Catesbaei	Black-jack oak	Pine forests
	Taxodium imbricarium	Pond cypress	Around lakes
+	Quercus cinerea	Turkey oak	Pine forests
	Magnolia glauca	Bay	Bays, etc.
	Magnolia grandiflora	Magnolia	Hammocks
	Liriodendron Tulipifera	Poplar	Branch-swamps, etc.
	Pinus Elliottii	(Slash pine)	Branch-swamps, etc.
	Pinus serotina	(Black pine)	Bays, etc.
	Quercus Margaretta?	Post oak	Pine forests
	Quercus laurifolia		Hammocks

	Hicoria glabra	Hickory	Hammocks
	Cornus florida	Dogwood	Hammocks

SMALL TREES OR LARGE SHRUBS

+	**Cliftonia monophylla**	Tyty	Bays, etc.
	Diospyros Virginiana	Persimmon	
	Cyrilla **racemiflora?**	Tyty	Swamps

SHRUBS

++	Chrysobalanus **oblongifolius**		Pine forests
	Serenoa serrulata	Saw-palmetto	Pine forests
	Hypericum fasciculatum		Lake shores
	Gaylussacia dumosa		Pine forests
	Asimina angustifolia	Pawpaw	Pine forests
	Rhus Toxicodendron	Poison oak	Pine forests
	Vaccinium nitidum	Huckleberry	Pine forests

HERBS

+	**Aristida stricta**	Wire-grass	Pine forests
+	Pitcheria galactioides		Pine forests
+	**Eriogonum tomentosum**		Pine forests
+	Eupatorium compositifolium (X)	Dog-fennel	Roadsides, etc.
++	Batschia Carolinensis		Pine forests
+	Andropogon Virginicus	Broom-sedge	Pine forests
	Tillandsia usneoides	Spanish moss	On trees
+	Berlandiera tomentosa		Pine forests
	Pteridium aquilinum	(A fern)	Pine forests
	Chamaecrista fasciculata	Partridge-pea	Pine forests, etc.
	Vernonia angustifolia	(Ironweed)	Pine forests
	Croton argyranthemus		Pine forests
	Scleria glabra	(A sedge)	Pine forests
	Baptisia lanceolata		Pine forests

(and 13 others seen only once).

Few if any important conclusions can be drawn from such a short list, but it appears that the long-leaf pine is relatively more abundant here than in almost any other region (perhaps chiefly on account of the scarcity of swamps), though the amount of it per acre may be exceeded in some other regions, where the trees grow closer together. The little shrub *Chrysobalanus* and the Borraginaceous herb *Batschia Carolinensis** also seem to be more abundant here than elsewhere. About 75 per cent of the trees are evergreen. No vines were noticed, but no doubt a few could be found in the hammocks and bays. (Vines are rare in places subject to fire.) Many trees that indicate fertile soil are absent.

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*Also known as *Lithospermum Gmelini.* See Bull. Torrey Bot. Club 33:241. 1906.

Economic Features—This region is very thinly settled as yet, because its deep sandy soil does not invite extensive agricultural operations. The principal industry is converting the long-leaf pine into lumber and naval stores, a good deal of which must have been hauled to St. Andrew's Bay and shipped from there before the present railroads were built. (Neither of them is more than ten years old).

7. WEST FLORIDA PINE HILLS.

(FIGURES 55-57)

References. Harper 1 (218-219, 248-250, 252-254, 295-297), Matson & Sanford (301-304, 401-403, 422-425), Sellards 3 (290 or 44), Sellards & Gunter 3 (90-110, etc.), Smith 2 (199, 219, 223-224), and U. S. soil surveys of Escambia and Gadsden Cos. Illustrated in 3d Ann. Rep. pl. 22, figs. 18 & 30; 4th Ann. Rep., figs. 6 & 8.

This region is in two parts, with the lake region between them. The eastern part covers about 750 square miles in Florida, and extends northeastward through Georgia (where it has been called the Altamaha Grit region*) nearly to the Savannah River, and is everywhere separated from the coast by flat pine lands of varying width, as well as several other kinds of country. The western part covers about 3,200 square miles in Florida and extends westward across Alabama† and Mississippi. Only a narrow strip of islands, dunes, etc. (described next) lies between it and the coast.

Geology and Soils—Toward its inland edge this region is underlaid by various Upper Oligocene and Miocene formations, which are exposed along some of the streams, but have little effect on soil or topography. Over the greater part of the area, however, the material within 100 feet of the surface is Pleistocene (or perhaps in part Pliocene) sand and clay, interstratified, cross-bedded, mottled, or mixed in various proportions, but all essentially non-calcareous and devoid of fossils. Wells penetrating these strata, and springs flowing from them, yield water that is scarcely surpassed anywhere for purity.‡ Rock outcrops are limited to a few ledges and boulders of sandstone formed by local induration, and are found usually on hills.

The soil is much like that of the lime-sink or cypress pond region already described, being prevailingly sandy at the surface, and passing into reddish sandy clay at a depth of a few inches or feet. Near the coast the subsoil seems to be more sandy than it is in the interior. The surface sand may be derived from the underlying loamy material (Lafayette?) by weathering, or it may be a later

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*For description of the Altamaha Grit region and its vegetation, see Ann. N. Y. Acad. Sci. vol. 17, part 1. 1906.

†See Geol. Surv. Ala. Monog. 8:113-123. 1913.

‡The city water of Pensacola, which comes from wells averaging 130 feet deep, is said to contain from 22 to 35 parts per million of dissolved solids. (Sellards & Gunter 3, p. 99). The water of springs and shallow wells in the same region is probably even purer.

formation, or both conditions may occur. Where the red loam approaches the surface small ferruginous concretions are common, as already noted in the lime-sink region.

A brick-red loam, commonly referred to the Lafayette formation, and more characteristic of localities farther inland, where the summers are a little drier, is common at and near the surface in the northern part of Escambia County, and perhaps elsewhere. Around the head-waters of Alaqua Creek in Walton County there is a few square miles of reddish clayey soil much like that in the Knox Hill country, and with similar vegetation, but apparently completely isolated, and too small to be treated separately. Running east and west through the middle of Walton County is a broad sandy ridge (followed by the L. & N. R. R.) whose origin has not been explained. On this ridge, as in deep dry sand in other parts of the region, salamanders are abundant and gophers common.

The following chemical analysis from Dr. Eugene A. Smith's report on Florida in the 6th volume of the Tenth Census (page 199) represents nine inches of soil near Mt. Pleasant, Gadsden County, where the vegetation was long-leaf pine, narrow-leaf black-jack (*Quercus cinerea*), round-leaf black-jack (*Quercus Marylandica*), red oak (*Quercus falcata*), post oak, hickory, oak runners (*Quercus pumila?*), huckleberries, wire-grass, devil's shoestring, (*Cracca Virginiana*), wild oats (*Sorghastrum secundum?*), vanilla (*Trilisa odoratissima?*), etc.

Water and organic matter	2.422%
Potash	.045%
Soda	.018%
Lime	.064%
Magnesia	.005%
Brown oxide of manganese	.220%
Phosphoric acid	.066%
Sulphuric acid	.091%
Peroxide of iron	.941%
Alumina	1.339%
Soluble silica	1.721%
Insoluble matter	93.362%

As compared with other northern Florida soils analyzed in the same report, this has the lowest percentages of potash, magnesia and phosphoric acid, next to the lowest of lime, and the highest of manganese and sulphur. (Little is known about the relations of the two last-named constituents to vegetation.)

Mechanical analyses of several typical upland soils of the same region have been taken from the government soil surveys of Gadsden and Escambia Counties, published in 1904 and 1907 respectively. In the case of the Escambia soils each represents the average of two localities, but the localities are not specified, and the depths are not given. The soils are as follows:

1. "Norfolk sandy loam" from two miles southwest of Mt. Pleasant, Gadsden Co.; depth 10 inches. This is the most extensive soil of the Gadsden County plateau, and is described as a light grayish sandy soil resting on a yellow sandy loam. Ferruginous pebbles are common. The vegetation is mostly open forests of long-leaf pine, with practically the same undergrowth as that mentioned above in connection with the chemical analysis; the location being nearly the same.

2. Subsoil of same, 10 to 36 inches.

3. "Norfolk sand," Escambia Co. This is described as an incoherent light-gray or yellowish medium sand about 5 inches deep, underlaid by yellowish or reddish sand of the same texture to a depth of 36 inches or more. It is said to cover nearly half of Escambia County, and to be characterized by salamander hills, long-leaf pine, and some "scrub oak" (doubtless *Quercus Catesbaei*) and dogwood. Very little of it is in cultivation.

4. "Norfolk fine sandy loam," Escambia Co. This is a fine sandy loam or loamy fine sand from 8 to 18 inches deep," becoming gradually yellowish and clayey with increasing depth, with numerous ferruginous concretions. The vegetation is long-leaf pine and wire-grass.

5. "Norfolk loam," Escambia Co. "A loam from 6 to 10 inches deep It is usually brown or grayish in color for the first 4 or 5 inches, but below this it changes to a light yellow." The subsoil is said to be clayey and impervious. The vegetation is a very heavy growth of long-leaf pine and wire-grass.

6. "Orangeburg sandy loam" (named for Orangeburg, S. C.). This differs from the "Norfolk" soils in being redder and more clayey, and is most common in the northern half of Escambia County. "The native vegetation is quite generally a strong and vigorous growth of long-leaf pine." The soil is said to be so productive in its natural state that very little fertilizer has been used on it in the short time it has been under cultivation. "A general appearance of prosperity is noticed where this type forms the principal farming land."*

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*This soil is found in the part of Florida where the summers are driest (see climatological data for Flomaton, on page 183), and a chemical analysis would doubtless show it to be above the state average in potash and some other minerals. The prevalence of long-leaf pine on it may be due to the fact that it occurs in comparatively small bodies which have no protection from fire, and long-leaf pine resists fire better than any other upland tree in that part of the state.

MECHANICAL ANALYSES OF SOILS OF WEST FLORIDA PINE HILLS.

	1	2	3	4	5	6
Fine gravel (2-1 mm.)	.78	.64	2.1	0.9	0.6	2.3
Coarse sand (1-.5 mm.)	10.64	9.24	20.9	5.1	4.5	13.6
Medium sand (.5.25 mm.)	21.52	22.84	25.5	5.1	4.4	11.5
Fine sand (.25-.1 mm.)	43.10	44.34	32.5	29.7	19.7	27.9
Very fine sand (.1-.05 mm.)	12.78	14.98	6.7	25.4	17.4	17.0
Silt (.05-.005 mm.)	6.50	5.18	7.8	21.9	28.5	17.7
Clay (.005-0 mm.)	4.68	2.70	4.4	11.6	23.8	9.3
Total	100.00	99.92	99.9	99.7	98.9	99.3
Organic matter	.54	.15	?.	?	?	?

If the texture of a soil was a reliable indication of its fertility the "Norfolk loam" should be much richer than the "Orangeburg sandy loam," as it contains nearly twice as much silt and clay; but a chemical analysis might tell a different story.

Topography and Hydrography—This region includes the highest land in Florida; about 275 feet above sea-level along the east and west ridge in Walton County and 300 feet at the inland edge of the uplands in Gadsden County. Escambia Bay is bordered on the west by bluffs which rise steeply from near the water's edge to a height of 50 or 75 feet, and altitudes of over 100 feet can be found within half a mile of the bay. Alum Bluff, on the Apalachicola River, 160 feet high (mentioned on page 211, and illustrated in 2nd Annual Report, pl. 17. 1), is another example of the high land of this region.

There are some shallow cypress ponds, mostly in the part east of the lake region; and on the sandy ridge, in the neighborhood of DeFuniak Springs, there are a few lakes much like those in the lake region previously described. With these exceptions the topography is due almost entirely to normal erosion processes. Valleys containing small branches are numerous, there being few areas more than a mile square without running water. The smallest valleys vary from broadly V-shaped, with almost no swamp, to flattish and savanna-like, with acres of boggy wet pine land. Some of them, particularly on both sides of the DeFuniak ridge, head in amphitheaters or steepheads,* 50 feet deep or more.

Many of the smaller branches are so swift that the sound of running water is audible several yards away—which is rather exceptional in Florida. A few of the branches and creeks have been dammed up to furnish power for small mills. There are many small

*The stations of Bear Head and Mossy Head, on the L. & N. R. R., evidently derive their names from such features.

springs, discharging a few gallons a minute, and there are said to be a few rather large ones tributary to Alaqua Creek. Except for the Apalachicola, Yellow and Escambia Rivers, the streams are practically free from mineral sediment. The smallest branches are almost perfectly clear, and the creeks usually coffee-colored from dissolved and suspended vegetable matter.*

Vegetation Types—The prevailing type of vegetation is open forests of long-leaf pine. On the driest uplands or where the sand is deepest there is a considerable admixture of small black-jack oaks and a few other deciduous trees with small or thick leaves. The wet slopes of the broader branch-valleys have a characteristic bog or wet pine-barren flora, more richly developed in this region than anywhere else in Florida. There are all gradations between dry and wet pine land, as in the neighboring cypress pond region. At the heads of some of the streams are dense tyty bays (one of which was figured in the Third Annual Report, p. 253). Swamps are common, and vary in character with the size of the stream traversing them, and the distance from the coast; the largest streams, which fluctuate the most, being bordered by vegetation indicating richer soil than that of the non-alluvial and the estuarine swamps. Shallow ponds with cypress, slash pine or black gum occur in the flatter places, but much less frequently than in region no. 2.

Fire is frequent in the pine forests and rare in the swamps. Small areas of upland protected from fire by being partly surrounded by swamps are characterized by hammock vegetation, here as in other long-leaf pine regions.

Plants—The following list of plants is based on observations made on 34 different days, distributed as follows: March, 5; April, 1; May, 1; June, 10; July, 2; September, 6; October, 1; December, 8. It ought to be reasonably complete as far as it goes; but a few trees and shrubs seen only once or twice, and all herbs noted less than seven times, are omitted for the reasons given on page 185. In order to bring out certain local irregularities in distribution, which are more or less significant, the percentages for the two parts of the region are given separately. The first column is for the part west of the lake region, and the second for the smaller eastern part.

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*For a discussion of the classification of these and other Florida streams see 3d Annual Report, pp. 230-231.

TREES

+51—58	**Pinus palustris**	Long-leaf pine	Uplands
+8.7—2.7	Quercus Catesbaei	Black-jack oak	Sandy uplands
—7.5—4.2	**Pinus Elliottii**	Slash pine	Branch-swamps etc,
+6.2—4.7	**Magnolia glauca**	Bay	Non-alluvial and estuarine swamps
—2.9—5.0	Taxodium imbricarium	(Pond) cypress	Ponds, branches, etc.
+3.4—1.4	Quercus cinerca	Turkey oak	Uplands
+2.3—3.0	Nyssa biflora	Black gum	Ponds and swamps
—1.9—2.8	**Pinus Taeda**	Short-leaf pine	Creek bottoms, etc.
++2.4—1.2	**Chamaecyparis thyoides**	Juniper	Sour swamps
2.1—1.0	**Magnolia grandiflora**	Magnolia	Hammocks
1.2—1.5	Quercus falcata	Red oak	Loamy uplands
0.3—3.8	**Pinus serotina**	(Black pine)	Branch-swamps, etc.
+0.8—1.1	Liriodendron Tulipifera	Poplar	Branch-swamps
+1.0—0.3	Quercus laurifolia		Hammocks
— .9— .2	**Pinus echinata**	Short-leaf pine	Loamy uplands
— .8— .1	**Pinus glabra**	Spruce pine	Hammocks
— .6— .5	Quercus **nigra**	Water oak	Bottoms, etc.
+ .5— .3	Quercus Margaretta	Post oak	Sandy uplands
— .3— .6	Liquidambar Styraciflua	Sweet gum	Richer soils
+ .3— .5	Oxydendrum arboreum	Sourwood	Hammocks, etc.
— .3— .4	Cornus florida	Dogwood	Hammocks, etc.
— .3— .3	**Ilex opaca**	Holly	Hammocks
— .3— .2	Acer rubrum	Maple	Swamps
.2— .6	Quercus Marylandica	Black-jack oak	Loamy uplands
.4— 0	**Pinus Caribaea?**		Near coast
— .2— .4	Fagus grandifolia	Beech	Hammocks
— .2— 0	**Pinus clausa**	Spruce pine	Sterile sand near coast
— .2— 0	Betula nigra	Birch	River-banks
— .1— 0	Taxodium distichum	Cypress	Alluvial swamps
— .1— 0	Ostrya Virginiana		Hammocks
—	Hicoria alba?	Hickory	Hammocks
	Fraxinus Caroliniana	Ash	Swamps

SMALL TREES OR LARGE SHRUBS

+.51—.37	**Cliftonia monophylla**	Tyty	Sour swamps and bays
.21—.17	Cyrilla **racemiflora**	Tyty	Creek swamps, etc.
.14—.02	**Myrica cerifera**	Myrtle	Hammocks & swamps
.02—.16	**Ilex myrtifolia**	Yaupon	Shallow ponds
.07—.01	**Quercus geminata**	Live oak	Sterile sands
.06—.04	**Osmanthus Americana**		Hammocks
++.07— 0	Crataegus lacrimata?	Haw	Sandy ridges
.03—.03	**Persea pubescens**	Red bay	Non-alluvial swamps
.03— 0	**Ilex vomitoria**		Hammocks
.03— 0	**Ilex Cassine**		Non-alluvial swamps
.02—.02	Symplocos **tinctoria**		Hammocks
.02—.02	Batodendron **arboreum**	Sparkleberry	Sandy hammocks

0—.06	Crataegus aestivalis	May haw	Shallow ponds
	Castanea pumila	Chinquapin	Hammocks
	Chionanthus Virginica	Graybeard	Hammocks
	Nyssa Ogeche	Tupelo gum	Swamps
—	Salix nigra	Willow	River-banks, etc.

WOODY VINES

+.023—.002	**Smilax laurifolia**	Bamboo vine	Non-alluvial swamps
.005— 0	Smilax Walteri		Swamps
+.002— 0	**Pieris phillyreifolia**		Swamps and ponds
	Gelsemium sempervirens	Yellow jessamine	Hammocks
	Vitis rotundifolia	Muscadine or bullace	Hammocks, etc.
	Rhus radicans	Poison ivy	Swamps

SHRUBS

+.025—.006	Chrysobalanus **oblongifolius**		High pine land
+.015—.022	**Ilex glabra**	Gallberry	Low pine land
—.017—.011	**Serenoa serrulata**	Saw-palmetto	Pine lands
.010—.024	**Hypericum fasciculatum**		Around ponds, etc.
+ 0—.038	Quercus pumila	Oak runner	High pine land
+.010— 0	**Chrysoma pauciflosculosa**		Sand near coast
.008—.003	**Pieris nitida**	(Hurrah bush)	Sour swamps and bays
.005—.011	**Myrica pumila**	Myrtle	Intermediate pine land
+.007—.005	**Myrica Carolinensis**	Myrtle	Wet pine land
+.008— 0	Viburnum nudum		Branch-swamps
.007—.003	Gaylussacia dumosa		High pine land
+.003—.011	**Illicium Floridanum**	(Stink-bush)	Edges of swamps
+.006—.001	**Myrica inodora**	Myrtle	Branch-swamps, etc.
+.005—.001	**Ilex coriacea**		Non-alluvial swamps
+.005— 0	**Clinopodium coccineum**		Sand near coast
.003—.003	**Phoradendron flavescens**	Mistletoe	On trees
.003—.002	Ceanothus Americanus	(Red-shank)	High pine land
.003—.001	Clethra alnifolia		Edges of swamps
.004— 0	Rhus Vernix	Poison sumac	Non-alluvial swamps
	Aronia arbutifolia		Branch-swamps, etc.
	Pinckneya pubens		Branch-swamps
	Arundinaria tecta	Reed	Along branches
	Gaylussacia hirtella		Non-alluvial swamps
	Azalea viscosa	Honeysuckle	Non-alluvial swamps
	Alnus rugosa	Alder	Along creeks, etc.
	Vaccinium nitidum	Huckleberry	Pine lands
	Kalmia latifolia	Ivy	Hammocks
	Gaylussacia frondosa*	Huckleberry	Low pine land, etc.
	Rhus copallina	**Sumac**	Loamy uplands
	Hypericum galioides?		Creek-banks, etc.
	Rubus cuneifolius (X)	Blackberry	Roadsides, etc.

*Including the var. *nana*.

Sabal glabra	Palmetto	Richer swamps
Fraxinus Caroliniana	Ash	Estuarine swamps
Ascyrum stans		Low pine land
Ceanothus microphyllus		High pine land
Rhus Toxicodendron	Poison oak	High pine land
Ceratiola ericoides	Rosemary	Sterile sand near coast
(and about 30 others).		

HERBS

+.009—.012	Aristida stricta	Wire-grass	High pine land
+.003—.002	Eriogonum tomentosum		Sandy ridges
+.003— o	Pitcheria galactioides		High pine land
+.002—.001	Pteridium aquilinum	(A fern)	High pine land
+.001—.003	Sarracenia flava	Pitcher-plant	Wet pine land
+.001— o	Kuhnistera pinnata	(Summer farewell)	High pine land
+.001—.001	Eriocaulon decangulare		Low pine land
++.001—.001	Sarraccenia Drummondii	Pitcher-plant	Wet pine land, etc.
++.001— o	Mesadenia sulcata		Non-alluvial swamps
+.001—.001	Rhexia Alifanus		Intermediate pine land
+.001—.001	Baptisia lanceolata		High pine land
++.001— o	Drosera filiformis Tracyi		Wet pine land
.001— o	Juncus Roemerianus	(Rush)	Brackish marshes
+.001— o	Cladium effusum	Saw-grass	Marshes near coast
+.001— o	Chondrophora nudata		Low pine land
—.001— o	Tillandsia usneoides	Spanish moss	On trees
+	Rhynchospora Grayii	(A sedge)	High pine land
+	Croton argyranthemus		High pine land
+	Lophiola aurea		Low pine land
++	Baptisia hirsuta		Sandy ridges
	Eupatorium compositifolium	Dog-fennel	Roadsides, etc., in high pine land
++	Pleea tenuifolia		Low pine land
	Chamaecrista fasciculata	Partridge-pea	High pine land
	Helianthus Radula		Intermediate pine land
	Dolicholus simplicifolius	Dollar-weed	High pine land
	Berlandiera tomentosa		High pine land
+	Gaura Michauxii		High pine land
+	Euphorbia Floridana		Sandy ridges
++	Sorghastrum secundum	Wild oats	High pine land
	Eriocaulon compressum		Ponds and wet pine land
	Chrysopsis graminifolia		High pine land
	Oxypolis filiformis		Ponds, wet pine land, etc.
+	Batschia Carolinensis		Sandy ridges.
+	Baldwinia uniflora		Low pine land, etc.

*Occurs as a shrub in the estuaries of the Escambia and Yellow Rivers. See Third Ann. Rep. pp. 249, 322.

+	**Chrysopsis aspera**		High pine land
+	**Lycopodium alopecuroides**		Low pine land
+	**Mayaca Aubleti**		Branch-swamps, etc.
+	Actinospermum angustifolium		Sandy ridges
	Osmunda cinnamomea	(A fern)	Low pine land, etc.
+	Aster eryngiifolius		Low pine land
+	Polygala ramosa		Low pine land
+	Campulosus aromaticus	(A grass)	Low pine land
+	Eryngium virgatum		Wet pine land
	Vernonia angustifolia		High pine land
	Andropogon Virginicus	Broom-sedge	High pine land
+	Dichromena latifolia	(A sedge)	Low pine land
	Sporobolus gracilis	(A grass)	High pine land
+	Tofieldia racemosa		Low pine land
	Trilisa odoratissima	Deer-tongue	Intermediate pine land
+	Pentstemon hirsutus		High pine land
++	Juncus trigonocarpus		Wet pine land
	Chaptalia tomentosa		Low pine land
+	**Sarracenia psittacina**		Low pine land
+	Verbena carnea*		High pine land
—	**Castalia odorata**	Water-lily	Estuaries, etc.
—	Pontederia cordata		Ponds and marshes
+	**Orontium aquaticum**		Swamps
+	Laciniaria tenuifolia		High pine land
+	Psoralea canescens		High pine land
++	**Sarracenia purpurea**	Pitcher-plant	Low pine land
+	**Chrysopsis argentea?**		High pine land
++	Rhynchospora alba	(A sedge)	Low pine land
+	Salvia azurea	(Sage)	High pine land
+	**Lycopodium Carolinianum**		Low pine land
+	Rhynchospora Chapmani	(A sedge)	Low pine land
+	Leptopoda Helenium		Low pine land
+	**Chrysopsis oligantha**		Intermediate pine land
	Panicum angustifolium?	(A grass)	High pine land
+	Cracca Virginiana	Devil's shoe-string	High pine land
++	Rhynchospora Tracyi	(A sedge)	Marshes, etc.
	Xyris sp.		Low pine land, etc.
	Aletris aurea		Intermediate pine land
++	**Arenaria Caroliniana**		Sandy ridges
	Doellingeria reticulata		Low pine land
+	Polygala lutea		Low pine land
+	Stillingia sylvatica		High pine land
+	Rhexia ciliosa		Low pine land
+	Aster adnatus		Intermediate pine land
	Sagittaria lancifolia		Estuarine marshes
	Bidens coronata?		Swamps
+	Cracca chrysophylla		Sandy ridges
+	Rhynchospora axillaris	(A sedge)	Low pine land
+	Scleria glabra?	(A sedge)	High pine land

*See Bull. Torrey Bot. Club 33:242. 1906.

+	**Drosera capillaris?**		Low pine land
	Eupatorium rotundifolium		Low pine land
	Osmunda regalis	(A fern)	Swamps
++	Macranthera fuchsioides		Branch-swamps, etc.
+	Sabbatia macrophylla		Low pine land
	Onosmodium sp.		High pine land
+	Rhynchospora Baldwinii	(A sedge)	Low pine land
+	**Carphephorus Pseudo-Liatris**		Low pine land
+	Polygala cymosa		Ponds and marshes
+	Rhynchospora rariflora	(A sedge)	Low pine land
+	Polygala cruciata		Low pine land
+	Linum Floridanum		Intermediate pine land
+	Muhlenbergia trichopodes*	(A grass)	Pine lands
	Lachnocaulon anceps		Intermediate pine land
	(and about 250 others).		

The following trees which are more or less common in near-by or similar regions are notable for their scarcity or absence in this region: Cypress (*Taxodium distichum*), cabbage palmetto, hickories, willow, ironwood (*Carpinus*), white oak, post oak (*Quercus stellata*), live oak, elms, hackberry, sycamore, plums, redbud, lin (*Tilia*), *Gordonia,* tupelo gums (*Nyssa uniflora* and *N. Ogeche*), sassafras, and ashes (*Fraxinus*). Most of these prefer soils richer in potash or humus, or both, than those of the pine hills. On the other hand, *Chamaecyparis,*† *Crataegus lacrimata,* and several of the herbs are in Florida confined to this region or nearly so. *Pinus clausa, Illicium, Myrica inodora, Conradina, Baptisia hirsuta* and *Pitcheria* are not known in Georgia, and *Nyssa Ogeche, Quercus pumila, Baptisia hirsuta* and *Doellingeria reticulata* are not known in Alabama.

About 75% of the vegetation in the western part and 77% in the eastern is evergreen. (Although the difference between the two parts in this respect is slight, it is reasonable to assume that it is correlated with the wetter summers eastward). About 15% of the shrubs are Ericaceae and 9.6% of the herbs Leguminosae. The high percentage of evergreens and Ericaceae is doubtless correlated with soils below the average in potassium content; but the percentage of Leguminosae is about the average. The latter seem to prefer soils rich in calcium and potassium and poor in nitrogen or humus; and here the soils are somewhat deficient in all these constituents. Weeds are comparatively scarce.

Economic Features—As in the case of the neighboring cypress pond region (No. 2), the advantages of this kind of country may be said to have been appreciated only recently. Grazing, lumbering and turpentining have hitherto overshadowed all other industries, but agriculture is now rapidly forging to the front. As late as 1910

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*See footnote on page 208.

†This tree, commonly called white cedar in the North and juniper in the South, seems to be confined to swamps in which the water is exceptionally free from mineral matter in solution or suspension. Both in Liberty and in Santa Rosa County it grows along small creeks which are noted locally for their clearness.

only 3.6% of the area was cleared; so there is still ample room for "development." Excluding the city of Pensacola, which has a splendid harbor and has been built up mostly by foreign trade, and is therefore to a considerable extent independent of the natural resources of the country near it, this region had in 1910 about 13.3 inhabitants to the square mile; which was an increase of 51% in ten years, a rate far above the average. About 62% of the inhabitants are white.

The lumber industry of this region reached large proportions early in the state's history. From an article by Hon. P. K. Yonge, of Pensacola, in "Makers of America, Florida edition" (Atlanta, 1909), we learn that there were a few sawmills near Pensacola in the 18th century, and that in 1835 Pensacola exported nearly four million feet of lumber, and in 1855 about eighteen million feet. This was of course nearly all long-leaf pine. (Some of it may have been rafted down the rivers from Alabama, but even so, it could have come from the same kind of country.) By 1884 the total exports were over ten times as much as in 1855, to say nothing of coastwise and rail shipments. About this time some apprehension for the permanence of the supply began to be felt. Dr. Charles Mohr, of Mobile, in his day the greatest authority on the forests of the Gulf states, wrote as follows in the 9th volume of the Tenth Census (pp. 522, 523), published in 1884:

The district between the Choctawhatchee and the Perdido is the seat of the oldest and most active lumbering industry of the whole Gulf coast * * * The better class of the somewhat elevated and undulating timberlands which surround Escambia, Blackwater, and Saint Mary de Galves bay were long since stripped of their valuable timber. These forests, having been culled time after time during the last quarter of a century, are now completely exhausted. The low, wet pine barrens, with their soil of almost pure sand, which trend eastward along the shores of Santa Rosa sound and Choctawhatchee bay, have never borne a growth of pine sufficiently large to furnish more than a small supply of timber of very inferior quality. The ridges between the Choctawhatchee river and the Yellow river are also, for the most part, arid, sandy wastes, never yielding more than a few hundred feet of lumber per acre.

The well-timbered portion of west Florida commences with the southern border of Holmes county. This region is now, however, nearly exhausted along water-courses large enough for rafting, while of late years canals and ditches dug into the forest afford facilities for floating timber growing remote from streams to the mills. According to those best informed regarding the amount of timber still standing in this section, there is scarcely enough left between the Escambia and Choctawhatchee rivers, in western Florida, to keep the mills on the coast supplied for another half-dozen years, even if the whole of the pine standing could be made available.

The peninsula between the junction of the Escambia and the bay of Saint Mary de Galves is low, and along the shore-line, bordered with marshes. The timber needed to supply the mills located upon the shores of these waters has during the past forty years been drawn from this region, and when new forests have replaced the original growth they have been cut over and over again, and still furnish a small amount of timber, as the turpentine distiller has not followed the log-getter in these regions, the supply of timber here, however, at present is too small to be taken into account in view of the enormously increased demands of the mills. There are three large mills on Blackwater bay producing 40,000,000 feet of lumber a year. Three-fourths of this lumber is produced in the establishment of Messrs. Simpson & Co., near the mouth of the Blackwater river, at Bagdad, about half a mile below Milton. Mills sawing square timber are situated 20 or 30 miles above the Blackwater and use mostly water-power. * * * The exhaustion of the timber-lands through the whole breadth of western Florida, as far as the banks of the Choctawhatchee river, will certainly be accomplished before the end of the next five years.

In spite of these gloomy predictions, the lumber industry of the West Florida pine hills is still in a flourishing condition; though of course it has its little ups and downs, like most other industries. Although no statistics for single regions are available, the annual production of lumber in this region at the present time is probably nearly as great, if not as great, as it ever was. At the time Dr. Mohr wrote the words quoted above, there were no railroads in West Florida east of Pensacola, and millions of magnificent pine trees remote from the coast and waterways were inaccessible and practically unknown. Even yet lumbering operations have not extended more than a few miles from the railroads and rivers and the coast, and there is an enormous amount of timber still standing, the existence of which a traveler following the regular transportation routes would hardly suspect. In September, 1910, the writer walked for several hours through virgin pine forests that had not even been turpentined, on the west side of Alaqua Creek between Portland and DeFuniak Springs; and just a little farther west, in the same region, the government established in 1909 the "Choctawhatchee National Forest," an area of several hundred square miles very sparsely settled and well timbered. Ten months later a great deal of fine "round timber" (i. e., pines not turpentined) was seen between DeFuniak Springs and the Alabama line, and in May, 1914, the forests between Vernon and the Choctawhatchee River, in Washington County, were found to be scarcely lumbered, though nearly all turpentined.

The increasing use of substitutes for wood in the arts and trades, especially in the construction of buildings, tends to diminish the drain on our forests; but even if the *per capita* consumption of wood did not diminish, the exhaustion of the forests of West Florida would be postponed for a long time, for the simple reason that there are not enough people in those parts yet to keep the long-leaf pine cut down as fast as it grows. For the greatest inroads on the forest, in the eastern United States, have been made not by the lumberman, but by the farmer; for in cultivated areas the forest is completely destroyed, and the amount of cultivated land is steadily increasing, and the total forest area correspondingly diminishing. But until the population in these parts is two or three times as dense as it is now, no fear need be felt for the exhaustion of the timber supply in the West Florida pine hills.

The leading crops in this region in 1912, in order of value, were as follows: Corn, upland cotton, velvet beans (including hay thereof), sweet potatoes, sugar cane, peanuts, field peas (including hay), (grass) hay, oats, peaches, pecans, oranges, watermelons, sea-island cotton, Irish potatoes, pears, cabbage, figs, grapes, onions, tomatoes.

8. WEST FLORIDA COAST STRIP.

(FIGURES 58-61)

References. Harper 1 (218, 265), McAtee, Sellards 3 (290-291, or 44-45), and U. S. soil survey of Escambia Co., (by Griffen, Drake, Belden & Kolbe, 1907).

This region extends from the mouth of the Ocklocknee River west to Mississippi, in streaks and patches which are difficult to map and measure accurately. Its area in Florida is probably not over 400 square miles. It includes most of the islands* and narrow peninsulas along the coast, and on the edge of the mainland some salt and brackish marshes, and elongated belts of dry sand which seems to have been heaped up by the wind long ago. Some of these old dunes are almost completely surrounded by flatwoods belonging to the region to be described next, but they do not seem to occur more than a mile or so from tide-water (which may indicate that the position of the coast line has not changed much for thousands of years).

Geology and Soils—Except for a few marsh and estuarine deposits, shell mounds, and some ancient and modern peat, there is nothing but Pleistocene and Recent sand near enough to the surface to have any effect on soil or topography. No chemical analyses of the soils seem to have been made; but in the immediate vicinity of the coast, say within 100 yards of the beach, the sand of the beach and active dunes must contain considerable calcareous matter in the form of pulverized sea-shells. Mechanical analyses of two types of soil from this region have been taken from the government soil survey of Escambia County. The first is "Galveston sand," corresponding to the beaches and moving dunes, and the second is "Sandhill"† corresponding to the older dunes which are no longer moving. The former is not cultivated at all, and the latter very little. The depth to which the samples were taken is not indicated, but

*St. James Island, in Franklin County, is an island only by accident, as it were, for it is separated from the mainland only by a narrow fresh-water channel (Crooked River), and the greater part of it is flatwoods, indistinguishable from those of the adjacent mainland. That part of it belonging to the coast strip apparently does not average more than half a mile wide. The other islands are separated from the mainland by a mile or more of salt water (the sounds), and are much more typical.

†Typical sand-hills of the coastal plain occur along the fall-line and along rivers and creeks, and are scarcely represented in Florida.

there is said to be little difference between soil and subsoil in either case.

Mechanical Analyses of Soils of the Coast Strip, Escambia County.

	"Galveston sand"	"Sandhill"
Fine gravel (2-1 mm.)	0.0	0.1
Coarse sand (1-.5 mm.)	15.5	14.2
Medium sand (.5—.25 mm.)	56.1	45.1
Fine sand (.25—.1 mm.)	28.3	35.2
Very fine sand (.1-.05 mm.)	0.1	0.4
Silt (.05-.005 mm.)	0.0	2.9
Clay (.005-0 mm.)	0.0	1.9
Total	100.0	99.9

Both soils have remarkably low percentages of very fine sand, silt and clay, which is doubtless correlated with their lack of fertility. The localities are not given, but the "Sandhill" sample may have been taken far enough back from the coast to be influenced by ants and other subterranean animals.

The vegetation of beaches and drifting sands, though sparse, consists mostly of grasses and other plants belonging to families supposed to prefer soils well supplied with lime or potash, or both; while on the ancient dunes a little farther back, which perhaps have not moved noticeably in hundreds of years, the vegetation is quite different, consisting mostly of pines and evergreen shrubs, with practically no grasses, indicating an extremely sterile soil. It seems very probable that the lime and potash (derived from shells, seaweeds, etc.) that were in the latter soil when it was first thrown up by waves and wind have long ago been almost entirely leached out by the copious summer rains.

Salamanders, which have no known way of crossing water, seem to be entirely absent from the islands, and thus one important agent that helps maintain the fertility of some Florida soils is lacking. None have been observed on the old dunes of the mainland either, though the reason for their absence there is less obvious. Gophers and ants inhabit the soil of the oldest dunes near Lanark (and probably elsewhere), and the vegetation there is very similar to that on sandy ridges farther inland, indicating a better soil than that of the stationary dunes on the outer islands.

Topography and Hydrography—The topographic forms are those common to many sandy coasts; namely, beaches, dunes, marshes, etc. The dunes are not as extensively developed as on the

Atlantic coast, probably because the prevailing winds do not blow toward the land. Few of the moving dunes are more than ten feet high; but some of the ancient dunes on the mainland and St. James Island are 40 or 50 feet above sea-level. Among these high old dunes are some approximately circular depressions apparently identical in form with some in Middle and peninsular Florida which are supposed to have been formed by the solution of underlying limestone; but here there is no limestone anywhere near the surface, and wind seems to be the only agent which could have formed the hollows, though the details of the process are not fully understood.

Ponds, springs and streams are scarce, on account of the narrowness of the coast strip and the porosity of the sand; but in some of the dune hollows, as in similar hollows in the flatwoods close by, there are tyty bays (described in the 3d Annual Report, p. 265).

Vegetation Types—Some of these have been briefly indicated above in the discussions of geology and topography. Typical salt marshes, such as are common on the Atlantic coast, are scarce and small in West Florida, but there is a good deal of brackish marsh around the mouths of rivers and creeks. The marshes are treeless, and the moving dunes likewise. The stationary dunes nearest the coast have a sparse growth of slash pine and a few other trees, and evergreen shrubs. A little farther back there is a good deal of spruce pine (*Pinus clausa*), which thrives in the poorest sand, while on the highest old dunes on the mainland, where the leaching is counteracted to some extent by the soil fauna, long-leaf pine and blackjack oak prevail. Among or near the old dunes are areas of flat pine land with tyty bays, which may belong to the flatwoods region, but they are so intimately mixed with the dunes that it was difficult to separate them in making up the plant lists.

Fire is a negligible factor in the coast region, partly because the islands and peninsulas are well protected by water, and partly because most of the vegetation is too sparse to carry fire. In some hollows and on slopes near waterways, where there is sufficient protection from wind and sun for humus to accumulate, there is hammock vegetation.

Plants—The following list is based on observations made on 12 different days, distributed through the year as follows: April, 1; May, 2; June, 4; July, 1; August, 1; September, 1; December, 2. It cannot be very complete, though, for my opportunities for visiting the outer islands have been very limited. And it probably includes a small admixture of flatwoods plants, as explained above. For these reasons the percentage figures are omitted.

TREES

—Pinus palustris	Long leaf pine	Oldest dunes
++Pinus clausa	Spruce pine	White dunes
Pinus Elliottii	(Slash pine)	Islands, low grounds
+Quercus geminata	(Smaller) live oak	Old dunes, etc.
+Quercus Catesbaei	Black-jack oak	Oldest dunes
+Quercus cinerea	(Turkey oak)	Oldest dunes
—Magnolia glauca	Bay	Bays, etc.
Magnolia grandiflora	Magnolia	Hammocks
+Hicoria glabra?	Hickory	Hammocks
—Taxodium imbricarium	Cypress	Bays, etc.
Nyssa biflora	Black gum	Swamps
Oxydendrum arboreum	Sourwood	Hammocks
Pinus Caribaea?		

SMALL TREES OR LARGE SHRUBS

+Quercus myrtifolia	Oak	Old dunes
+Cliftonia monophylla	Tyty	Bays
+Cyrilla parvifolia	Tyty	Bays
Myrica cerifera	Myrtle	Hammocks, etc.
Batodendron arboreum	Sparkleberry	Hammocks

WOODY VINES

+Smilax laurifolia	Bamboo vine	Bays, etc.
+Smilax auriculata		Old dunes

SHRUBS

+Serenoa serrulata	Saw-palmetto	Dry sand
++Ceratiola ericoides	Rosemary	White dunes
++Chrysoma pauciflosculosa		Old dunes
++Conradina canescens		Old dunes
++Clinopodium coccineum		Old dunes
Pieris nitida	(Hurrah bush)	Bays
Hypericum fasciculatum		Edges of bays
Hypericum aspalathoides		Dune hollows
—Chrysobalanus oblongifolius		Oldest dunes
Ilex vomitoria		Hammocks
Cholisma ferruginea		Hammocks
Iva frutescens		Edges of marshes
Crookea microsepala		Around bays
Baccharis halimifolia		
Polygonella sp.		Old dunes
Callicarpa Americana.	French mulberry	Hammocks
Hamamelis Virginiana	Witch-hazel	Hammocks
(and 18 others).		

HERBS

++**Juncus Roemerianus**	Rush	Brackish marshes
+Pitcheria galactioides		Oldest dunes
+Syngonanthus flavidulus		Around bays, etc.
+Euphorbia gracilis		Oldest dunes
+Lophiola aurea		Bays
++**Rhynchospora dodecandra**	(A sedge)	Old dunes
Polygala lutea		Around bays
Anchistea Virginica	(A fern)	Bays
+Ambrosia hispida?	Ragweed	Shores of sounds
Rhynchospora Chapmani?	(A sedge)	Around bays
Centella repanda		Around bays, etc.
Cladium effusum	Saw-grass	Marshes, etc.
Rhexia Alifanus		Around bays
Baptisia LeContei?		Old dunes
Siphonychia sp.		Old dunes
Saururus cernuus		Swamps
Fuirena scirpoidea	(A sedge)	Around bays
Sarracenia psittacina	Pitcher-plant	Around bays
Panicum erectifolium?	(A grass)	Around bays
Utricularia cornuta		Peaty bays
+Rhynchospora leptorhyncha	(A sedge)	Bays
Spartina gracilis	(A grass)	Brackish marshes
+Uniola paniculata	Sea-oats	Moving dunes
+Stenophyllus Warei	(A sedge)	Old dunes
Fimbristylis spadicea	(A sedge)	Dune hollows, etc.
Kuhnistera pinnata	(Summer farewell)	Oldest dunes
+Laciniaria Chapmani		Oldest dunes

(and about 100 others).

Nearly all trees characteristic of rich soil, and even the short-leaf pines, cypress (*Taxodium distichum*), cabbage palmetto, willows, beech, most of the oaks, elms, poplar, sweet gum, haws, plums, maples, black gum, dogwood, persimmon and ashes, are rare or absent. *Pinus clausa, Quercus myrtifolia* and *Serenoa* are in West Florida chiefly confined to this region, though they are more widely distributed in the peninsula. *Chrysoma, Conradina,* and *Clinopodium coccineum* do not grow much farther south, and the *Conradina* is almost confined to this region.

The proportion of evergreens (about 80%) is probably higher than in any other region described in this volume, except the East coast strip; which presumably indicates soils very deficient in potash. The percentage of Leguminosae is low, for the same reason. There are almost no weeds.

Economic Features—On account of the narrowness of this strip no statistics of population and crops can be obtained. But there is practically no agriculture, and the principal occupations of the inhabitants seem to be fishing, lumbering and commerce. There is considerable summer resort business, particularly on St. James Island, around St. Andrew's Bay, and near Pensacola, and some winter resort business also. The large sawmills in and near the coast strip get their timber almost entirely from farther inland. In the first half of the 19th century the government reserved a strip on the coast of West Florida for the sake of the live oak timber, which was then highly valued for ship-building. Roads and wheeled vehicles are scarce in this region, and communication is mostly by boat and rail.

9. APALACHICOLA FLATWOODS.

(FIGURES 62, 63)

References. Bush, Harper 1 (221, 235-238, 294-295), Harper 5, Matson & Sanford (305-306), Sellards 3 (293 or 47,—first use of name), Smith 2 (226), and U. S. soil survey of Leon Co., 1906. Illustrated in 3d Ann. Rep., pl. 19.2, fig. 17 (two views of estuarine swamps), and in Pop. Sci. Monthly 85: 353. 1914.

This kind of country is confined to Florida, between the Choctawhatchee and Wakulla Rivers, and has an area of about 2,600 square miles.

Geology and Soils—No rocks or fossils are known in this region, except on the banks of the Sopchoppy River, and the area is usually nearly all mapped as Pleistocene. The soil is mostly sand, of several different degrees of fineness. In some places there is "hardpan"* within two or three feet of the surface, but over the greater part of the area there are no cuts or excavations deep enough to indicate what underlies the sand. In a few places in Wakulla and Franklin Counties the vegetation seems to indicate marl near the surface; and there is said to be a belt of fairly rich soil on the west side of the Sopchoppy River. Along the Apalachicola River there is of course considerable alluvium, which near the mouth of the river seems to be at least 170 feet deep.†

One of the most characteristic soils of this region has been called "Leon sand" in the soil survey above cited. It is described as a gray or white medium sand 6 to 10 inches deep, usually moist and often compact, underlaid by a pure white or light brown compact medium sand, which is saturated with water or nearly so. The vegetation is said to be mostly long-leaf pine, saw-palmetto, and wire-grass; and very little of the land is under cultivation. The following mechanical analysis of such a soil from somewhere in the south-

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*See Third Ann. Rep. 96-97, 222, 225, 294, 295; 4th Ann. Rep. 37-38; 5th Ann. Rep. 127-128.

†See Third Ann. Rep., p. 235.

western part of Leon County (locality not specified) is taken from the publication referred to. The first column of percentages is for soil and the second for subsoil; but the respective depths are not indicated.

MECHANICAL ANALYSES OF "LEON SAND," LEON COUNTY.

	Soil	Subsoil
Fine gravel (2-1 mm.)	.8	.8
Coarse sand (1-.5 mm.)	18.3	15.0
Medium sand (.5-.25 mm.)	16.5	16.2
Fine sand (.25-.1 mm.)	37.5	37.8
Very fine sand (.1-.05 mm.)	19.7	21.3
Silt (.05-.005 mm.)	5.2	5.6
Clay (.005-0 mm.)	1.5	3.1
Total	99.5	99.8

These figures indicate that there is little difference between soil and subsoil, and that the proportion of silt and clay is rather low.

Much of the soil is too damp for ants, gophers and salamanders, but crawfish are common in some places, if one may judge from their "chimneys," which are usually closed at the top, instead of open like the more familiar ones in more clayey soils farther inland.

Topography and Hydrography—The surface is essentially flat, except for shallow stream-channels and innumerable shallow ponds and bays, and a strip of rolling country along the Sopchoppy River (which has not yet been visited by the writer). It rises gradually from the coast to an elevation of 75 or possibly 100 feet at its inland edge. The ground-water stands nearly everywhere within a few feet or inches of the surface.

The streams are mostly sluggish, and all coffee-colored except the Apalachicola and Choctawhatchee Rivers, which are muddy. These rivers fluctuate more than the smaller streams, but of course not as much as they do farther inland, for near their mouths they cannot rise much above sea-level. Dead Lake, or Lake Chipola, in Calhoun County, seems to be a widening of the Chipola River, but little is known about it, as few if any scientists have ever seen it.

Vegetation Types—The greater part of the area is flat pine woods, long-leaf pine being the most abundant tree, in spite of the rather damp soil. The numerous shallow depressions contain either cypress pond vegetation or bay* vegetation, or some intermediate

*A phytogeographical term occasionally heard in this region is "bay-gall"; but I have never ascertained just what difference, if any, there is between a bay-gall and a bay.

stage, depending on the amount of seasonal fluctuation of the water, as in the lime-sink region already described (No. 2). The streams are all bordered by swamps of varying width and character.

Plants—The following list is based on observations made mostly in Franklin and Wakulla Counties, and on only 12 different days, distributed as follows: April, 5; May, 1; June, 4; August, 1; October, 1. The estuarine swamps at the mouth of the Choctawhatchee River (described in the 3d Annual Report, p. 238) may belong to this region, but their plants have not been incorporated into the following list. There are probably few or no species there which are not in the Apalachicola River swamps, however.

TREES

40.0	**Pinus palustris**	Long-leaf pine	Drier flatwoods
+12.6	Taxodium imbricarium	(Pond) cypress	Shallow ponds, etc.
+12.0	**Pinus Elliottii**	Slash pine	Shallow ponds, etc.
+ 5.8	**Magnolia glauca**	Bay	Swamps and bays
+ 5.4	**Pinus serotina**	(Black pine)	Wet flatwoods
3.0	Nyssa biflora	Black gum	Swamps
— 2.0	Liquidambar Styraciflua	Sweet gum	Richer soils
+ 1.8	Acer rubrum	Maple	Swamps
— 1.7	**Pinus Taeda**	Short-leaf pine	Richer soils
— 1.5	Quercus Catesbaei	Black-jack oak	Driest soils
+ 1.4	Salix nigra	Willow	River-banks
1.2	Taxodium distichum	Cypress	River-swamps
+ 1.0	**Sabal Palmetto**	Cabbage palmetto	River-swamps
+ 1.0	Nyssa Ogeche	Tupelo gum	River-swamps
— .8	Quercus cinerea	Turkey oak	Driest spots
.8	Quercus **nigra**	Water oak	Richer soils
.6	Liriodendron Tulipifera	Poplar	Branch-swamps
— .6	**Magnolia grandiflora**	Magnolia	Hammocks, etc.
+ .5	Nyssa uniflora	Tupelo gum	River-swamps
+ .4	Betula nigra	Birch	River-banks
+ .3	Populus deltoides	Cottonwood	River-banks
— .2	**Pinus glabra**	Spruce pine	Hammocks, bottoms
+ .2	Platanus occidentalis	Sycamore	Along Apalachicola R.
+ .2	Fraxinus profunda?	Ash	River-swamps
+ .2	Quercus lyrata	Swamp post oak	River-swamps
++.2	Populus heterophylla	Cottonwood	Along Apalachicola R.
.1	Ulmus Floridana	Elm	River-swamps
+ .1	Ulmus Americana?	Elm	River-swamps
— .1	**Pinus clausa**	Spruce pine	Sand near coast
—	Quercus Michauxii	Swamp chestnut oak	River-swamps

(and 21 others).

SMALL TREES OR LARGE SHRUBS.

+.48 **Cyrilla parvifolia**	Tyty	Bays
+.45 **Cliftonia monophylla**	Tyty	Bays
+.07 **Ilex myrtifolia**	Yaupon	Ponds and bays
.06 **Myrica cerifera**	Myrtle	Richer soils
.05 Salix longipes?	Willow	Estuarine swamps
.02 **Quercus geminata**	(Small) live oak	Dry sands
.01 Cyrilla **racemiflora**	Tyty	Branch-swamps, etc.

WOODY VINES

+.014 **Smilax laurifolia**	Bamboo vine	Bays, etc.
—.002 Vitis aestivalis?	Wild grape	River-bottoms
+.002 Wistaria frutescens	Wisteria	River-banks
.002 Ampelopsis arborea		Bottoms
.002 Smilax Walteri		Swamps and bays
.002 Parthenocissus quinquefolia	Virginia Creeper	Richer soils
.002 Rhus radicans	Poison ivy	Swamps
+.001 Brunnichia cirrhosa		Along Apalachicola R.
.001 Tecoma radicans	(Cow-itch)	Bottoms

SHRUBS

+.088 **Serenoa serrulata**	Saw-palmetto	Flatwoods
+.020 **Hypericum fasciculatum**		Around ponds and bays
+.011 **Quercus minima**	Oak runner	Flatwoods
+.009 **Ilex glabra**	Gallberry	Flatwoods
+.008 **Myrica pumila**	Myrtle	Flatwoods
++.008 Stillingia aquatica		Shallow ponds
+.007 **Cholisma fruticosa**	(Poor grub)	Flatwoods
+.007 **Vaccinium nitidum**	Huckleberry	Flatwoods
+.006 Gaylussacia frondosa*	Huckleberry	Flatwoods
.006 Cephalanthus occidentalis	Elbow-bush	Ponds and swamps
+.005 **Arundinaria macrosperma**	Reed	River-banks
+.005 **Crookea microsepala**		Flatwoods
.004 **Sabal glabra**	Palmetto	River-swamps
+.004 Pinckneya pubens		Branch-swamps
.004 Quercus pumila	Oak runner	Flatwoods
+.003 Alnus rugosa	Alder	River-banks, etc.
.003 **Phoradendron flavescens**	Mistletoe	On trees
.003 Itea Virginica		Swamps
.003 **Kalmia hirsuta**		Flatwoods
.002 Iva frutescens		Along coast
+.002 **Conradina canescens**		Sand near coast
.002 Clethra alnifolia		Bays, etc.
.002 **Myrica Carolinensis**	Myrtle	Bays, etc.
.002 **Quercus myrtifolia**	Oak	Sand near coast
.002 Hypericum **myrtifolium**		Around ponds, etc.
.002 **Ilex coriacea**		Bays

*Including the var *nana*.

.001	Viburnum nudum	(Possum haw)	Branch-swamps
.001	Cornus stricta?		Rich damp places
.001	**Gaylussacia dumosa**		Flatwoods
.001	**Hypericum opacum**		Edges of bays
.001	Chrysobalanus **oblongifolius**		Drier flatwoods
.001	Amorpha fruticosa		River-banks
.001	Rosa Carolina	Wild rose	Swamps
.001	Cholisma ligustrina		Bays
++.001	Leitneria Floridana (and 12 others).		Swamps near Apalachicola

HERBS

++.006	Rhexia Alifanus		Flatwoods
++.004	**Lophiola aurea**		Damp flatwoods
+.003	**Aristida stricta**	Wire-grass	Flatwoods
+.003	Sarracenia flava	Pitcher-plant	Damp flatwoods
+.002	Eriocaulon compressum		Ponds and bays
+.002	**Cladium effusum**	Saw-grass	Estuarine marshes
.002	**Tillandsia usneoides**	Spanish moss	Swamps, etc.
+.002	Eriocaulon decangulare		Bays, etc.
+.002	Aster eryngiifolius		Flatwoods
+.002	Campulosus aromaticus	(A grass)	Flatwoods
+.001	Aletris lutea		Flatwoods
+.001	Eryngium synchaetum		Flatwoods
+.001	Polygala cymosa		Ponds and bays
+.001	**Trilisa odoratissima**	Deer-tongue	Flatwoods
+.001	Drosera filiformis Tracyi		Damp flatwoods
+.001	Helianthella grandiflora?		Drier flatwoods
+.001	Coreopsis nudata		Damp flatwoods
+.001	Dichromena latifolia	(A sedge)	Damp flatwoods
	Sagittaria lancifolia		Estuarine marshes
+	Baldwinia uniflora		Flatwoods
+	Syngonanthus flavidulus		Flatwoods and bays
	Pterocaulon undulatum	(Black-root)	Flatwoods
+	Anchistea Virginica	(A fern)	Bays and ponds
	Eupatorium rotundifolium		Flatwoods
+	Xyris flexuosa*		Flatwoods
	Chondrophora nudata		Flatwoods
	Lachnocaulon anceps		Flatwoods
	Pontederia cordata		Ponds and marshes
	Tracyanthus angustifolius		Flatwoods
++	Euphorbia inundata?		Flatwoods
	Sabbatia macrophylla		Damp flatwoods
	Sarracenia psittacina	Pitcher-plant	Around bays
	Leptopoda Helenium		Around ponds
	Rhexia lutea		Flatwoods
+	Gyrotheca tinctoria		Bays, etc.

*X *torta* of many authors.

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	Pteridium aquilinum	(A fern)	Flatwoods
+	Rhynchospora Chapmani	(A sedge)	Damp flatwoods
+	Trilisa paniculata		Flatwoods
	Saururus cernuus		Swamps, etc.
	Diodia teres (X)		Along railroads, etc.
	Sericocarpus bifoliatus		Drier flatwoods
+	Chrysopsis oligantha		Flatwoods
	Panicum sp.	(A grass)	Damp flatwoods
	Drosera capillaris	(Sundew)	Around bays
	Juncus scirpoides compositus		Flatwoods
	Rhynchospora corniculata	(A sedge)	Ponds, etc
	Osmunda regalis	(A fern)	Swamps
+	Sarracenia Drummondii	Pitcher-plant	Damp flatwoods
	Centella repanda		Flatwoods and bays
	Polygala lutea		Flatwoods and bays
+	Eleocharis Baldwinii (X?)	(A sedge)	Damp grassy roads
	Nymphaea fluviatilis	Bonnets	Rivers
	Zizania aquatica?	(Wild rice)	Estuarine swamps
+	Scirpus validus	(Bulrush)	Estuarine marshes
	Chrysopsis graminifolia		Drier flatwoods
	Erigeron vernus		Flatwoods
	Rhynchospora semiplumosa	(A sedge)	Flatwoods
	Baptisia LeContei?		Drier places
	Osmunda cinnamomea	(A fern)	Around bays, etc.
	Senecio lobatus		Swamps
+	Ludwigia virgata		Flatwoods
+	Carphephorus Pseudo-Liatris		Flatwoods
	Afzelia cassioides		Flatwoods
++	Dianthera crassifolia		Flatwoods
+	Phragmites communis	(Reed-grass)	Estuarine marshes
	Sabbatia campanulata		Flatwoods
+	Fuirena scirpoidea	(A sedge)	Flatwoods
	Chaptalia tomentosa		Damp flatwoods
	Typha latifolia	Cat-tail	Estuarine marshes
—	Kuhnistera pinnata	(Summer farewell)	Drier spots
	Juncus Roemerianus		Brackish marshes
	Juncus biflorus		Flatwoods
	Iris versicolor		Ponds, etc.
+	Xyris pallescens		Flatwoods
	Lycopodium Carolinianum		Around bays
+	Aristida spiciformis	(A grass)	Flatwoods and bays

(and about 180 others).

The following trees which are more or less common in neighboring regions are rare or absent in this one:—Short-leaf pine (*Pinus echinata*), juniper, cedar, hickories, beech, chinquapin, most of the oaks, haws, plums, holly, dogwood and sourwood. One of the cottonwoods, *Populus heterophylla*, seems to be found in Florida only in the swamps of the lower Apalachicola,* and the same might be said of a few shrubs and herbs which are almost too rare to be listed. Only one or two weeds seem to be abundant enough to be ranked among the first 50 herbs.

About 68% of the vegetation is evergreen, 15.6% of the shrubs (or about .04% of the total vegetation) are Ericaceae, and only 1.3% of the herbs are Leguminosae.

Economic Features—In 1910 less than 3% of this region was under cultivation. There were less than 8 inhabitants to the square mile, on the average, and nearly all of those lived in towns. But the population increased about 28% between 1900 and 1910, and perhaps inventive genius will devise means for making this a flourishing agricultural region before many decades. (At the present time the expenditures for fertilizers per acre of improved land in this region seem to be below the state average.) At least 58% of the inhabitants are white.

Lumbering and turpentining and grazing are naturally the dominant industries; but bee-keeping is relatively more important here than in any other part of the State. Calhoun County, the "banner" honey county of Florida, produced in 1911-12 233,247 pounds of honey and 2,176 pounds of beeswax. The principal honey plants are the two kinds of tupelo gum, which are common in the swamps of the lower Apalachicola River; but the three kinds of tyty and the gallberry and saw-palmetto are also important.

The leading crops, in order of value, seem to be corn, sugarcane, sweet potatoes, peanuts, Irish potatoes, cabbage, oranges, upland cotton, tomatoes, beans, grapes, peaches, field peas (including hay), pears, onions, figs, plums, velvet beans, cantaloupes, oats, pecans, and (grass) hay.

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*Most books dealing with southern trees do not mention the occurrence of this species in Florida at all. Although nearly every botanist who has been to Apalachicola by way of the river (the usual route previous to 1907) must have seen it, those who took no notes had no record of it, for the trees are rather inaccessible.

10. MIDDLE FLORIDA HAMMOCK BELT.

(FIGURES 31, 33, 35, 36, 64-68)

References. Garber 2, Harper 1 (219-220, 254-255, 276-277), Matson & Clapp (98, 99, 121, 279, 287-288), Matson & Sanford (27, 113-114, 128, 263, pl. 3A, 4B), Sellards 1 (58-67), Sellards 3 (293 or 47), Sellards & Gunter 1 (263, 279-284), Sellards & Gunter 3 (143-149), Smith 2 (221, 222), and U. S soil surveys of Gadsden, Leon and Jefferson Cos. and the "Gainesville area." Illustrated in 3d Ann. Rep. pl. 7.2, 8.2, 8.3, 27.2, fig. 19; 4th Ann. Rep., pl. 12.2 fig. 15.

This is a complex and diversified region, extending in an arc approximately parallel to the Gulf coast from Liberty County up through some of the southernmost counties in Georgia and then southeastward near the axis of the Florida peninsula to Marion County. It embraces about 1,900 square miles in the area covered by this report. Within the region there are many small areas of red hills, flatwoods, and other variations, which might be entitled to rank as distinct regions if they were large enough; but it is out of the question to show them at all on the map here used. The Tallahassee red hills, which were included in the hammock belt in the Third Annual Report (though separated on the map by a dotted line) are here ranked as a distinct region, however (No. 11).

Geology and Soils—Rock outcrops are chiefly confined to river-banks and sink-holes, and those that have been identified are mostly Upper Oligocene. The rocks are nearly everywhere covered by reddish sandy clay, and often also by a few feet of more or less loamy sand. The clay is most conspicuous in the western part, and gradually diminishes eastward and southward. The soils are mostly rather sandy, but vary from red loam hills much like those of the next region to damp sour sandy flatwoods like those of region 9, gray high hammock lands, and silty second-bottom deposits; and most of these types occur in nearly every county.

No chemical analyses of soils from this region seem to be available, but the government soil surveys above cited contain many mechanical analyses and descriptions which are of considerable interest. From this source eight types have been selected, as follows:

1. "Gadsden sand," from ¾ mile northeast of Quincy, Gadsden Co. Depth 10 inches. This is described as a dark gray fine sand, or medium sandy loam, resting on a gray or yellow or brownish sandy loam slightly lighter in texture. There are some ferruginous pebbles in the soil. This soil is mostly on slopes near streams, and may be partly colluvial. Its vegetation is of the hammock type, and it is regarded as a very productive soil, for a sand.

2. "Ocklocknee clay," from 3½ miles northeast of Midway, Gadsden Co. Depth 8 inches. This is described as a heavy dark sandy loam of variable texture, resting on a stiff dark yellow or mottled red clay. (The subsoil is used for brick-making at two places in Gadsden County and at at least one place on the same side of the same river in Thomas County, Georgia.) The soil lies in the bottoms of the Ocklocknee River, and although it is occasionally overflowed, the vegetation is mostly long-leaf pine, saw-palmetto, gallberry, etc., much like that of some flatwoods, and very different from that in the flood-plains of muddy rivers. (It is doubtless low in available potash, notwithstanding its clayey character.) It is hardly ever cultivated.

3. "Norfolk sand," Jefferson Co.; average of two samples, (localities and depths not given). This is a gray, light brown, or yellow sand, medium to fine in texture, with enough organic matter to make it loamy, underlaid at a depth of 10 to 24 inches by yellowish or light gray sand of more open structure. It is the commonest upland soil in Jefferson County, and has a native vegetation of long-leaf and short-leaf pines, oaks, hickories, and many other species. A good deal of it is under cultivation, and it is evidently richer than the "Norfolk sand" of Escambia County, described on page 231, although it contains less silt and clay.

4. "Orangeburg fine sandy loam," Jefferson Co.; average of two samples (localities and depths not given). This is a "gray, brown, or reddish-brown medium to fine sandy loam, 8 to 15 inches deep," with ferruginous pebbles, and a subsoil of "very red clay containing from 40 to 60 per cent of medium to fine grades of sand with very little silt." It occurs on rolling uplands, is a fairly productive soil (making about a third of a bale of cotton to the acre without fertilizer), and is largely under cultivation.

5. "Gainesville sand," one-fourth mile west of Rutledge, Alachua Co.* Depth 6 inches. This is "a gray loamy sand 8 inches deep, containing much organic matter, underlain by a brown loamy sand of looser structure." Weathered rock fragments are common in both soil and subsoil, and usually there is calcareous clay or partly weathered limestone within three feet of the surface. It is on high uplands with subterranean drainage, and the native vegetation is large long-leaf pines and various hardwoods. It is one of the most popular soils in the "Gainesville area," and nearly half of it is under cultivation, the principal crops being corn and sea-island cotton.

6. "Portsmouth sandy loam,"† one mile northwest of Rocky Point, Alachua Co. Depth 25 inches. This name is applied to soils varying

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*See footnote on next page.

†Most other soils of the "Portsmouth" series (named for Portsmouth, Va., and confined to the coastal plain from Delaware to Mississippi) are flatwoods soils of low agricultural value. ("These soils are developed in flat to slightly depressed, poorly drained situations, and require ditching before they can be used for agriculture."—H. H. Bennett, U. S. Bureau of Soils, Bull. 96:248. 1913.) If the "Gainesville area" were reexamined, this fertile residual high hammock soil, which resembles the "Portsmouth" soils only in having a large proportion of sand and organic matter, and must be very different chemically, would probably be classified differently.

somewhat in texture, but all rather sandy, with fragments of limestone, and enough organic matter to give a very dark color. It ranges from a few inches to five feet in depth, and has a stiff gray calcareous clay subsoil. The whole seems to be derived from the weathering of Tertiary rocks in place. It occurs in rather hilly areas bordering lakes and prairies, and is dotted with lime-sinks. It has a hammock vegetation, and the trees are nearly all hardwoods. It is said to be "the strongest and most productive soil of the area, and for the purposes for which it is utilized it is probably the most valuable land in the State. The crops most generally grown, to which the soil seems best adapted, are lettuce, cabbage, peas, beans, and cantaloupes. This is the only soil [in the 'Gainesville area'] on which the production of citrus fruits has been attempted since the great freeze" [of 1895].

7. Subsoil of the preceding. Depth 25 to 36 inches. A gray heavy clay.

8. "Portsmouth fine sand," one-fourth mile southwest of Micanopy, Alachua Co.* Depth 12 inches. This is a fine to medium sand, usually dark gray or black from the presence of organic matter, and about 16 inches deep, with a chocolate brown sandy subsoil, sometimes making a sort of hardpan. This is a typical "poorly drained" flatwoods soil, presumably of sedimentary origin. Within the hammock belt the flatwoods are often, if not usually, at a lower elevation than the more loamy soils adjoining, but similar soils in the same "Gainesville area" which belong to the East Florida flatwoods (region 19) are distinctly upland soils. The prevailing vegetation is long-leaf pine, saw-palmetto, gallberry, oak runners, and other characteristic flatwoods plants.

MECHANICAL ANALYSES OF MIDDLE FLORIDA HAMMOCK BELT SOILS

	1	2	3	4	5	6	7	8
Fine gravel (2-1 mm.) -----	0.90	1.06	0.9	0.6	0.5	0.5	0.4	2.8
Coarse sand (1-.5 mm.) -----	6.40	5.48	10.1	12.2	3.1	8.1	8.8	14.6
Medium sand (.5-.25 mm.) --	11.70	7.70	14.5	13.3	9.5	20.9	18.8	29.5
Fine sand (.25-.1 mm.) ----	56.80	30.84	51.1	38.2	63.5	44.7	34.7	39.5
Very fine sand (.1-.05 mm.) --	16.90	17.10	14.2	11.8	5.6	16.9	8.0	9.7
Silt (.05-.005 mm.) ----------	2.80	14.44	5.7	11.9	6.7	5.6	2.6	2.3
Clay (.005-0 mm.) ---------	4.24	23.38	3.4	9.4	11.1	3.1	26.7	1.1
Total -----------------	99.74	100.00	99.9	97.4	100.0	99.8	100.0	99.5
Organic matter ------------	0.67	2.76	?	?	?	?	?	?

Any one examining this table (excluding No. 7, which is a subsoil), without knowing anything else about the soils, might suppose that No. 2 was the richest, on account of having the largest percentages of the three finest grades of particles, and that No. 6 was about on a par with No. 3, the comparatively poor "Norfolk sand." The facts of the case are decidedly otherwise, however, and chemical analyses would probably correlate much better with the vegetation and crops. It is significant, however, that No. 8, which contains the least silt and clay, is the poorest of all.

*In the soil survey of the "Gainesville area" the mechanical analyses of the "Gainesville sand" and the "Portsmouth fine sand" seem to have been inadvertently transposed.

Salamanders are common in the sandiest soils ("Norfolk sand," etc.), ants are ubiquitous, and no doubt other subterranean animals abound in certain places.

Topography and Hydrography—The topography of this belt varies from decidedly hilly, for Florida, to practically flat. The elevations range from over 250 feet in Gadsden County and about 200 in Columbia to about 50 feet at the coastward edge. In Gadsden County, where the steepest hills are found, the topography has been produced almost entirely by erosion, and there are many ravines containing swift branches, much as in the Apalachicola bluff region (No. 3) on the other side of the county; but farther east there are many evidences of solution, and streams are scarcer. There are a few caves, sinks, and big springs, mostly east of the Withlacoochee River (of Georgia). Most of the streams are of the coffee-colored type, but there are also a few short clear calcareous runs issuing from large springs. There are no muddy rivers, except that the Ocklocknee becomes somewhat turbid after prolonged rains (and that probably did not occur before the farmers began to clear up the country around its tributaries). Several streams which rise near the inland edge of this belt flow across it and disappear into the ground near its coastward edge. Flat-bottomed lakes which drain into sinks and are dry a good deal of the time are characteristic of this region, but not wholly confined to it. (See paper by Dr. Sellards on pages 115-159 of this volume.)

Vegetation Types—These are as varied as the soil and topography; embracing upland oak woods, high and low pine lands, hammocks of several kinds, swamps, bays, ponds, marshes, prairies, etc. Fire is frequent in the pine lands and rare in the hammocks and swamps, as usual.

Plants—In order to bring out certain local irregularities of distribution the region is divided for statistical purposes somewhat arbitrarily into three parts by means of rivers; namely: (1) that part west of the Ocklocknee River, which as far as Florida is concerned is practically the same as the part west of the Tallahassee red hills; (2) the part between the Ocklocknee and the Withlacoochee River (of Georgia); (3) the part southeast of the Withlacoochee. There are three columns of percentages, to correspond with these three divisions. The + and — marks, however, refer only to the average for the whole region (which is not necessarily the average of the three percentages, on account of the difference in size of the three divisions. For the same reason the order of abundance is not exactly the same as that of the sums of the percentages). Thus in the case of a species preceded by a + mark some one, or occasionally even two, of the percentages may fall below the average of that species for northern Florida; and *vice versa.* Where two + marks are used the highest figure of course indicates the division in which the species is more abundant than it is anywhere else; and in the other two divisions it may possibly be below the northern Florida average.

My field work has been distributed as follows: Western division, March, 6 days; April, 1; May, 1; June, 4; August, September, October, November and December, 1 each; total 17. Middle division, January, 3; February, 3; March, 7; April, 4; May, 3; June 1; July, 2; August, 1; September, 2; November, 5; December, 6; total 37. Eastern division, January, 1; February, 5; March, 3; April, 2; May, 3; July, 3; August, 1; December, 2; total, 20.

TREES

—27—18—34	**Pinus palustris**	Long-leaf pine	Sandy soils
+15—11—11	**Pinus Taeda**	Short-leaf pine	Various situations
+6.1—13.5—6.2	**Pinus Elliottii**	Slash pine	Shallow swamps, etc.
0—12.3—4.8	Taxodium imbricarium	(Pond) cypress	Ponds and bays
++6.5—7.0—1.1	**Magnolia glauca**	Bay	Non-alluvial swamps
+2.5—6.5—2.3	**Pinus serotina**	(Black) pine	Wet flatwoods
+6.5—3.8—4.2	**Magnolia grandiflora**	Magnolia	Hammocks
+4.4—3.2—5.7	Liquidambar Styraciflua	Sweet gum	Richer soils
+1.9—4.4—0.2	**Pinus echinata**	Short-leaf pine	Richer uplands
+1.2—4.1—0.6	Nyssa biflora	Black gum	Swamps and ponds
+2.1—2.0—3.1	Quercus falcata	Red oak	Richer uplands
+3.3—1.1—0.8	**Pinus glabra**	Spruce pine	Hammocks
+1.4—1.8—0.7	Cornus florida	Dogwood	Richer uplands
+1.4—1.5—1.1	Quercus **nigra**	Water oak	Various situations
—1.2—0.5—4.0	Quercus Catesbaei	Black-jack oak	Sandy uplands
1.0—1.1—1.0	Acer rubrum	Maple	Swamps
+2.2—0.9—0	Liriodendron Tulipifera	Poplar	Wet woods
+2.4—0.2—0.1	Fagus grandifolia	Beech	Ravines and hammocks
0.4—0.7—0.8	**Quercus laurifolia**		Hammocks, etc.

0.1—0.4—2.1	**Quercus Virginiana**	Live oak	Various situations
—0.7—0.3—1.2	Taxodium distichum	Cypress	Richer swamps
+1.1—0.1—1.1	Carpinus Caroliniana	Ironwood	Low grounds
+1.3—0.1—0.7	Quercus Michauxii	Swamp chestnut oak	Low grounds
1.0—0.2—0.6	**Ilex opaca**	Holly	Ravines and hammocks
+0.6—0.2—0.8	Ostrya Virginiana		Hammocks, etc.
—0.2—0.2—0.8	Quercus cinerea	Turkey oak	Sandy uplands
+0.4—0.3—0	Quercus alba	White oak	Ravines and hammocks
+0.2—0.4—0	Oxydendrum arboreum	Sourwood	Ravines and hammocks
+0.1—0 —1.1	Hicoria glabra?	Hickory	Hammocks
0.4—0.2—0.1	Salix nigra	Willow	Along streams
—0.1—0.1—0.8	Hicoria alba?	Hickory	Loamy uplands
+0 —0 —1.1	Tilia pubescens	(Lin, basswood)	Hammocks
0.4—0 —0.4	Betula nigra	Birch	River-banks
+0.4—0.2—0	Malus angustifolia	Crab-apple	Dry woods
+0.1—0.1—0.6	Hicoria sp.	Hickory	Hammocks, etc.
0.3—0.1—0	Nyssa uniflora	Tupelo gum	Swamps
0.1—0.1—0.3	Melia Azedarach (X)	Chinaberry	Borders of fields, etc.
+0 —0 —0.8	Celtis occidentalis?	Hackberry	Hammocks
—0 —0 —0.7	**Sabal Palmetto**	Cabbage palmetto	Hammocks
0.2—0 —0.3	Cercis Candensis	Redbud	Rich uplands
0.1—0.2—0.1	Fraxinus Caroliniana	Ash	Swamps
—0 —0 —0.5	**Quercus geminata**	(Smaller) live oak	Sandy soils
0.1—0.1—0.1	Prunus serotina (X)	Wild cherry	Roadsides, etc.
—0 —0.1—0.1	Quercus stellata	Post oak	Loamy uplands
0 —0 —0.4	**Persea Borbonia**	Red bay	Hammocks
0.1—0 —0.3	Quercus Margaretta	Post oak	Dry sandy soils
—0.3—0 —0	Quercus Marylandica	Black-jack oak	Red clay uplands
0 —0 —0.3	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
0 —0 —0.3	Morus rubra	Mulberry	Hammocks
0 —0 —0.3	Acer Negundo	(Box elder)	Hammocks
	(and about 20 others).		

SMALL TREES OR LARGE SHRUBS

+.23—.17—.25	**Myrica cerifera**	Myrtle	Hammocks
+.09—.24—.02	Cyrilla **racemiflora**	Tyty	Swamps
+.08—.01—.04	Crataegus aestivalis	May haw	Shallow ponds
+.08—.02—0	**Cliftonia monophylla**	Tyty	Sour swamps
+.05—.05—.03	Osmanthus Americana		Hammocks
+.02—.03—.03	Batodendron **arboreum**	Sparkleberry	Sandy hammocks
.01—.02—.06	Prunus angustifolia (X)	Wild plum	Old fields, etc.
.06—0 —0	Nyssa Ogeche	Tupelo gum	Swamps, etc.
.03—.01—.02	**Ilex myrtifolia**	Yaupon	Shallow ponds
0 —.02—.02	**Cholisma ferruginea**		Hammocks
0 —.02—.01	Prunus umbellata?	Hog plum	Hammocks
.01—.01—0	**Symplocos tinctoria**		Hammocks
.01—.01—.03	Chionanthus Virginica	Graybeard	Hammocks
0 —.02—0	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
0 —.02—0	**Persea pubescens**	Red bay	Swamps
0 —0 —.03	Xanthoxylum Clava-Herculis (X?)		Hammocks
.01—0 —.02	Planera aquatica		River-banks
0 —0 —.03	Bumelia lanuginosa (and about 12 others).		Hammocks

WOODY VINES

+.001—.020—.003	**Smilax laurifolia**	Bamboo vine	Sour swamps and bays
+.005—.004—.005	**Gelsemium sempervirens**	Yellow jessamine	Hammocks, etc.
+.001—.003—.004	**Smilax lanceolata**	(Wild Smilax)	Hammocks, etc.
0 —.005—0	Smilax Walteri		Swamps
0 —.005—0	**Pieris phillyreifolia**		Cypress ponds and bays
+.001—.001—.007	Vitis rotundifolia	Muscadine	Various situations
+.003—.001—.003	Parthenocissus quinquefolia	Virginia creeper	Hammocks, etc.
.003—.002—0	**Bignonia crucigera**	Cross-vine	Hammocks, etc.

.003—.001— 0	Decumaria barbara		Wet woods
.001—.001—.001	Rhus radicans	Poison ivy	Swamps, etc.
.001— 0 —.003	Vitis aestivalis	Wild grape	Hammocks
0 — 0 —.003	Tecoma radicans	(Cow-itch)	Various situations
0 — 0 —.002	Berchemia scandens	Rattan vine	Low hammocks, etc.

SHRUBS

+.023—.051—.062	**Serenoa serrulata**	Saw-palmetto	Flatwoods, etc.
+.019—.013—.012	**Ilex glabra**	Gallberry	Flatwoods, etc.
+.003—.012—.010	**Pieris nitida**	(Hurrah bush)	Swamps and bays
.006—.004—.016	Rhus copallina	Sumac	Hammocks, etc.
.002—.008—.003	**Phoradendron flavescens**	Mistletoe	On trees
+.006—.004—.009	Aralia spinosa	Prickly ash	Hammocks
+.016— 0 —.001	**Rhapidophyllum Hystrix**	(Needle palm)	Ravines and hammocks
.001—.005—.008	Cephalanthus occidentalis	Elbow-bush	Swamps and ponds
.001—.005— 0	**Hypericum fasciculatum**		Around ponds and bays
0 —.003—.013	Myrica pumila	Myrtle	Pine lands
+.001—.006—.002	Azalea nudiflora	Honeysuckle	Hammocks, etc.
+.003—.005—.001	**Arundinaria tecta**	Reed	Branch swamps, etc.
+.005—.004— 0	Pinckneya pubens		Branch-swamps
0 —.006— 0	**Cyrilla parvifolia**	Tyty	Bays
+.001—.005— 0	**Crookea microsepala**		Flatwoods
0 —.005— 0	Clethra alnifolia		Edges of swamps and bays
.002—.002—.003	Callicarpa Americana	French mulberry	Hammocks
0 —.004— 0	Leucothoe racemosa		Bays, etc.
.001—.001—.005	Sambucus Canadensis (X)	Elder	Swamps
.004—.001—.002	**Sabal glabra**	Palmetto	Swamps
+.004—.001— 0	**Leucothoe axillaris**		Ravines, etc.
0 —.003—.001	Itea Virginica		Swamps
.002—.001—.003	Viburnum obovatum		Low hammocks
.002—.002— 0	Quercus pumila	Oak runner	Pine lands
+.004— 0 —.001	Aesculus Pavia	Buckeye	Hammocks, etc.
0 —.002—.002	Rubus cuneifolius (X)	Blackberry	Roadsides
0 —.002—.002	**Vaccinium nitidum**	Huckleberry	Flatwoods

.001— 0 —.005	Asimina angustifolia	Pawpaw	Pine lands
0 — 0 —.007	Castanea alnifolia	Chinquapin	Pine lands
+ 0 —.001—.002	Viburnum nudum	(Possum haw)	Branch-swamps
.001—.001—.001	Aronia arbutifolia		Edges of swamps
.001—.001—.001	**Cholisma fruticosa**	(Poor grub)	Flatwoods
0 —.001—.001	Hamamelis Virginiana	Witch-hazel	Hammocks
0 —.001—.001	Vaccinium virgatum?	Huckleberry	Hammocks
.001—.001— 0	Rhus Vernix	(Poison sumac)	Swamps
0 —.001—.002	**Sebastiana ligustrina**		Swamps, etc.
.002— 0 —.001	**Hypericum galioides?**		Swamps
0 —.001— 0	Cholisma ligustrina		Edges of swamps
0 —.001—.001	Decodon verticillatus		Swamps
0 — 0 —.002	Cornus stricta?		Low hammocks
0 —.001—.002	Rosa Carolina	Wild rose	Swamps
0 —.001—.001	Gaylussacia frondosa*	Huckleberry	Flatwoods, etc.
.001— 0 —.002	**Euonymus Americanus**		Hammocks
0 — 0 —.002	**Baccharis halimifolia**		Low grounds
0—.001— 0	**Ilex coriacea** (and about 25 others).		Sour swamps

HERBS

+.002—.008—.014	**Tillandsia usneoides**	Spanish moss	On trees
.002—.001—.003	**Aristida stricta**	Wire-grass	Pine lands
+.001—.001—.003	Eupatorium compositifolium	Dog-fennel	Pine lands, etc.
+ 0 +.001— 0	Anchistea Virginica	(A fern)	Bays and ponds
+ 0 —.001— 0	Osmunda cinnamomea	(A fern)	Low pine land
+ 0 —.001— 0	Panicum hemitomon	Maiden cane	Ponds, etc.
+ 0 —.001— 0	Eupatorium rotundifolium		Flatwoods
+ 0 —.001— 0	**Castalia odorata**	Water-lily	Ponds

*Including the var. *nana*.

Pteridium aquilinum	(A fern)	Pine lands
+Pontederia cordata		Ponds
Helenium tenuifolium (X)	Bitter-weed	Roadsides, etc.
Eriogonum tomentosum		High pine land
Saururus cernuus		Swamps
Mitchella repens	(Partridge-berry)	Hammocks
Andropogon scoparius (X?)	Broom-sedge	Old fields
Cassia Tora (X)	Coffee-weed	Fields and waste places
Smilax pumila		Hammocks
Kuhnistera pinnata	(Summer farewell)	High pine land
Psoralea canescens		High pine land
Trilisa odoratissima	Deer-tongue	Flatwoods
Nymphaea macrophylla	Bonnets	Ponds
Eleocharis interstincta	(A sedge)	Ponds
Eupatorium capillifolium	Dog-fennel	Prairies, etc.
Lorinseria areolata	(A fern)	Swamps
Doellingeria reticulata		Flatwoods, etc.
Isopappus divaricatus (X)		Fields and roadsides
Stenophyllus Floridanus (X)	(A sedge)	Fields, roadsides, etc.
Ludwigia pilosa		Ponds and ditches
Rumex hastatulus (X)	(Sorrel)	Fields
Osmunda regalis	(A fern)	Swamps
Rhexia Alifanus		Flatwoods
Baptisia leucantha		Open woods
Pterocaulon undulatum	Black-root	Flatwoods
Heteropogon melanocarpus (X)	(A grass)	Old fields, etc.
Glottidium vesicarium (X)		Low grounds
Chrysopsis graminifolia		Pine lands

(and about 200 others).

There are so many different trees in this heterogeneous region that the one that heads the list is less abundant here than it is in northern Florida as a whole, and the same might be said of many others. The only tree that reaches its maximum abundance here seems to be the bay, *Magnolia glauca,* and that is true only in the western and middle divisions.

A phytogeographer could draw many interesting conclusions from a comparison of the three columns of percentages, but only a few will be pointed out here. It seems that *Pinus Taeda, Magnolia glauca, M. grandiflora, Pinus glabra, Cornus florida, Pinus echinata, Liriodendron, Fagus, Quercus Michauxii, Ilex opaca, Quercus alba, Oxydendrum, Salix, Malus, Nyssa uniflora, Quercus Marylandica, Cyrilla racemiflora, Cliftonia, Nyssa Ogeche, Symplocos, Bignonia, Decumaria, Ilex glabra, Rhapidophyllum, Arundinaria tecta, Pinckneya, Crookea, Sabal glabra, Leucothoe axillaris, Quercus pumila,* and *Aesculus* are decidedly more abundant in the western half than in the southeastern, while the reverse is true of *Pinus palustris, Liquidamber, Quercus falcata, Q. Catesbaei, Q. Virginiana, Taxodium distichum, Quercus laurifolia, Q. cinerea, Hicoria* (all species), *Tilia, Sabal Palmetto, Celtis, Persea Borbonia, Acer Negundo, Morus, Quercus Margaretta, Cholisma ferruginea, Xanthoxylum, Bumelia, Smilax lanceolata, Vitis rotundifolia, Berchemia, Tecoma, Serenoa, Rhus copallina, Cephalanthus, Myrica pumila, Sambucus, Asimina angustifolia, Castanea alnifo-*

lia, Tilllandsia, Eupatorium compositifilium, Pteridium, Kuhnistera, Psoralea, Eupatorium capillifolium, and several others. No one explanation will fit all these cases, but some of those in the former category are simply species of more northern distribution, which hardly extend down into the Florida peninsula at all, and many of the latter prefer dry soils (swamps and flatwoods being comparatively scarce in the southeastern portion of this belt).

It is quite likely also that the chemical composition of the soils has something to do with the problem. Although no definite statements can be made in the absence of chemical analyses, what is known of the geology and the relations of the same species of plants to soils elsewhere leads to the belief that phosphorus is relatively more abundant southeastward; and some of the trees in the second category seem to like phosphorus, as will be pointed out in the discussion of other regions.

The percentage of evergreens is 74.5 in the western division, 69.3 in the middle, and 66.1 in the southeastern. The percentages of Ericaceae among the shrubs are 7.7, 20.5 and 8.7, and of Leguminosae among the herbs 8.4, 1.8 and 8.2 respectively. Although these figures are not perfectly consistent, and may not be very accurate, the high percentage of Ericaceae and low percentage of Leguminosae in the middle division must have some significance. It is probably correlated with the greater development of sour flatwoods and bays in that division.

Economic Features—On account of the large amount of fertile soil in this belt it attracted settlers at an early date. Several of the old Spanish grants shown on large maps of Florida include parts of it, and the comparatively old and important cities and towns of Quincy, Monticello, Madison, Jasper, Live Oak, Lake City, Alachua, Gainesville and Micanopy (all but two of them county seats) are located in it or on its edges.* In 1910 at least 28% of the land was cleared, and there were about 28 inhabitants to the square mile, an increase of 16% in ten years. Negroes are in the majority, as in most other old agricultural regions in the South.

There is considerable lumbering and turpentining on the sandier soils, and the hardwood forests on the richer soils are of considerable importance. At Gainesville there has been for many years a hardwood sawmill which ships a great deal of lumber to foreign countries.

The 1911-12 crop statistics in the last report of the Commissioner of Agriculture are very incomplete for Gadsden and Jefferson Counties, and not much better for Madison. Some of the deficiencies have been supplied from the State census figures for 1905, but that method is not very satisfactory, for the production of each crop varies from year to year, and some must have increased consider-

*In the southern tier of counties in Georgia, Cairo, Thomasville, Quitman and Valdosta are similarly situated.

ably between 1905 and 1912. With this limitation, or source of error, the leading crops seem to be as follows: Corn, sea-island cotton, tobacco (mostly in Gadsden Co.), upland cotton, peanuts, sweet potatoes, sugar cane, lettuce (Alachua Co.), oats, (grass) hay, field peas (including hay thereof), cabbage (mostly in Alachua Co.), velvet beans, cucumbers (Alachua Co.), watermelons, beans (mostly in Alachua Co.), oranges (mostly in Alachua Co.), pecans, peaches, English peas (Alachua Co.), tomatoes (Alachua Co.), squashes (Alachua Co.), cantaloupes (mostly in Alachua Co.), grapes, beets (Alachua Co.), Irish potatoes, peppers (Alachua Co.), figs, onions (Alachua Co.), and grapefruit (Alachua Co.). It is evident from this list that the middle division is mostly devoted to general farming, while in the eastern division, particularly in Alachua County, there is much specialization in vegetables and citrous fruits, which are mostly marketed in the North.

11. TALLAHASSEE RED HILLS.

(FIGURES 32, 34, 69-73)

References. Harper 1 (282-283), Matson & Clapp (99, 144), Matson & Sanford (149, 350-353), Sellards 1 (47-49, 53-58), Sellards & Gunter 3 (133-136, 138), Smith 2, Thompson, Torrey, and U. S. soil survey of Leon County (by Wilder, Drake, Jones and Geib), 1906. Illustrated in 3d Ann. Rep., pl. 6, 7.1, 8.1 (all lake scenes), and in Pop. Sci. Monthly 85:349. 1914.

This region bears much the same relation to the adjoining hammock belt that the Marianna red lands do to the West Florida cypress pond region already described. Each is similar geologically to the country bordering it on the west, north and east, but is characterized by richer, redder soils, more hilly topography, a scarcity of long-leaf pine, and other characters correlated with the soil and topography. Furthermore, they do not differ much in area, and each is almost confined to a single county, and barely crosses the northern boundary of the State.

The Tallahassee red hills are estimated to cover 340 square miles, all in Leon County or possibly extending a little beyond its borders on the north and east. There is nothing exactly like it in any other part of Florida, or the world, except that there are limited areas very similar to parts of it in the Middle Florida hammock belt, in Jefferson and Madison Counties. Many persons have compared this hill country to the red hills of South Georgia, but the two regions are entirely disconnected, and the resemblance is only superficial, for there are fundamental differences in geology, soil, topography and vegetation.

Geology and Soils—Rock outcrops are scarce and poor in fossils, but from what is known of the surrounding country, and the records of a few wells, the underlying rocks have been mapped as Upper Oligocene. Most of the material exposed in railroad cuts and other excavations is a reddish brown sandy clay. Several feet below the surface it is sometimes purer, and mottled somewhat as in the pine regions of West and East Florida. Nodules or fragments of a gritty yellowish rock containing over 15% of phosphorus pentoxide (equivalent to over 30% of tri-calcium phosphate, or nearly half as much as in some of the phosphate rock that is mined in peninsular Florida) are common in many places, either close to the surface or a few feet down; while in many other places ferruginous concretions an inch or less in diameter are scattered over the surface, as in the "pimply lands" of South Georgia and West

Florida. Where the phosphatic rock approaches the surface the soil is browner than usual.

The prevailing surface loam looks much like the Lafayette (?) red loam of the older parts of the coastal plain, but it is not quite such a brilliant red, and it is evidently different in chemical composition. On shaded banks along roads the earth is commonly encrusted with a minute gray-green lichen, rarely seen elsewhere, and the sides of railroad cuts become clothed with grass and other vegetation much more quickly than in other parts of the South; all of which seems to point to some special element of fertility in the soil.

The surface loam is usually over three-fourths sand, and very pervious to water, and yet there is enough clay in the red soils to make vertical banks retain their shape for years. The proportion of sand is greatest in level areas, both uplands and lowlands. Gullies are almost unknown, except alongside of roads on steep grades, and furrows in the fields usually run pretty straight in almost any direction regardless of the topography, instead of being carefully leveled and terraced as they are in the superficially similar red hills of South Georgia. Most of this soil has just about the right proportions of sand and clay to make good roads, and there is probably no part of Florida where the natural or unimproved roads are better in both wet and dry weather than they are here.

The following mechanical analyses of three characteristic upland soils of this region, with their subsoils, have been taken from the government soil survey of Leon County, published in 1906. Each represents the average of two or more samples from different localities, but neither the localities nor the depths are given in the report.

1. "Orangeburg* fine sandy loam." This is a "brown, reddish, or yellow medium to fine sandy loam, from 4 to 15 inches deep," with a subsoil of "red sandy clay to a depth of 36 inches and usually much deeper;" but both soil and subsoil vary considerably from the average. This soil

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*The name "Orangeburg" for a series of soils seems to have been first used by the U. S. Bureau of Soils in connection with Darlington County, South Carolina, and Perry County, Alabama, surveyed in 1902, though it is probably derived from Orangeburg (city and county), S. C., surveyed two years later. Most of the soils thus designated are red loams of the Lafayette formation, widely distributed in the more elevated parts of the coastal plain from North Carolina to Texas. The red soil around Tallahassee differs notably from the typical "Orangeburg" in not being easily gullied, as above stated, and in the high percentage of phosphorus, indicated below, if not in other ways.

covers about one-third of the whole region, and most of it is or has been under cultivation.

2. Subsoil of same.

3. "Norfolk fine sandy loam." Typically this is said to be a grayish or light-brown fine sandy loam about 8 inches deep, underlaid by a few inches of yellow sandy loam and then yellow sandy clay or clay loam. It is almost as extensive as the "Orangeburg fine sandy loam," from which it seems to differ chiefly in being paler and therefore presumably containing less iron. Much if not most of it is under cultivation.

4. Subsoil of same.

5. "Gadsden sandy loam." This is a "brown sandy loam from 8 to 14 inches deep, underlain by grayish-yellow or yellow sand or light sandy loam to a depth of 3 feet or more." "The surface soil is very similar to some of the Norfolk fine sandy loam, but the subsoil is dissimilar in that the underlying sandy clay of that type is entirely wanting or is found only in spots at a depth of nearly 3 feet below the surface." This is said to cover 5,952 acres in Leon County, and is mostly under cultivation.

6. Subsoil of same.

MECHANICAL ANALYSES OF SOILS AND SUBSOILS OF TALLAHASSEE RED HILLS.

	1	2	3	4	5	6
Fine gravel (2-1 mm.)	0.4	0.3	0.3	0.2	0.9	0.7
Coarse sand (1-.5 mm.)	8.9	4.3	5.0	3.1	13.1	12.1
Medium sand (.5-.25 mm.)	12.3	7.6	10.5	5.8	14.1	15.1
Fine sand (.25-.1 mm.)	42.5	33.1	52.6	38.6	40.9	42.1
Very fine sand (.1-.05 mm.)	17.3	13.2	14.3	15.3	11.4	10.7
Silt (.05-.005 mm.)	5.5	5.7	7.4	4.6	5,6	4.8
Clay (.005-0 mm.)	12.6	35.4	9.8	32.2	13.8	14.3
Total	99.5	99.6	99.9	99.8	99.8	99.8

In addition to these there is considerable "Norfolk sand" in this region, but as it occurs also in other parts of Leon County, and the localities are not specified, it would not be safe to quote the analyses in the soil survey report as pertaining to the Tallahassee red hills.

We are fortunate in having a few chemical analyses of soils from this region. The first is from the 6th volume of the Tenth Census, p. 198. It represents 9 inches of brown loam upland soil from 6 miles northeast of Tallahassee, where the vegetation was "post, red and Spanish oaks, short-leaf pine, hickory and sweet gum," collected in 1880 by Dr. Eugene A. Smith, and analyzed under his direction at the University of Alabama by Chappell Cory. Like other analyses published in the same volume, this was made by Peter's acid digestion method (described by Hilgard in Tenth Census, 5:72; Soils 340-343; and elsewhere). The percentages of the various constituents represent what is dissolved by hot hydrochloric acid in five days, and in some cases may be much less than the total;

but this method is believed to give results more compatible with the observed productivity of soils than any other.

The analysis is as follows:

Water and organic matter	3.982	per cent
Potash (K_2O)	.065	" "
Soda (Na_2O)	.013	" "
Lime (CaO)	.243	" "
Magnesia (MgO)	.023	" "
Phosphoric acid anhydride (P_2O_5)	.323	" "
Sulphuric acid anhydride (SO_3)	.011	" "
Brown oxide of manganese (Mn_3O_4)	.024	" "
Peroxide of iron (Fe_2O_3)	1.491	" "
Alumina (Al_2O_3)	3.977	" "
Soluble silica	2.640	" "
Insoluble matter	86.460	" "

As compared with other northern Florida soils analyzed in the same report, this is the highest in iron and phosphorus, and the lowest in soda, manganese, and sulphur. It is considerably above the world's average in phosphorus, but, like most other Florida soils, rather low in potassium.

Two samples of soils with corresponding subsoils were collected by the writer near Tallahassee in the summer of 1914 and partially analyzed by L. Heimburger, Assistant State Chemist. The methods used* are somewhat different from those used in the Tenth Census, but the results seem similar enough, as far as they go.

The samples are as follows:

1. Rich dense woods near top of hill on St. Augustine road about a mile east of Tallahassee. Gray sandy loam with considerable humus, 0—6 inches.

2. Subsoil of same, a little more yellow in color, 6—12 inches.

3. Open short-leaf pine woods on north side of railroad about 2 miles east of Tallahassee. Similar to No. 1, but with less humus. A few earthworms were encountered in digging this sample, strange to say. 0—6 inches.

4. Subsoil of same. 6—12 inches.

Both localities seem to be in areas mapped as "Orangeburg fine sandy loam" on the government soil map, but the second is most like the "Orangeburg" soils of other states.

*See appendix.

ANALYSES

	1	2	3	4
Moisture (H_2O)	1.07	.67	.60	.35
Volatile matter	7.30	4.59	4.74	3.01
Nitrogen	.219	.142	.167	.121
Potash (K_2O)	.045	.060	.050	.050
Lime (CaO)	.505	.335	.37	.29
Phosphoric acid (P_2O_5)	.272	.276	.138	.108
Iron and alumina (Al_2O_3, Fe_2O_3)	5.10	7.21	4.30	4.86
Insoluble matter	87.36	88.45	91.17	92.43

In both cases the moisture, volatile matter and nitrogen (which come from the humus) are of course more abundant in the soil than in the subsoil, and the same is true of the lime; while the potash, iron and alumina, and insoluble matter are more abundant in the subsoil (except that in the short-leaf pine soil the potash seems to be the same in both soil and subsoil). The phosphoric acid does not seem to vary much with the depth. In the rich woods it is above the world's average, though not as high as in the sample collected by Dr. Smith; whether on account of an actual difference in the soil or merely the different method of analysis it is impossible to say. In the short-leaf pine woods the phosphorus content is only fair, however; and the significance of this fact will be pointed out farther on in discussing the vegetation. The short-leaf pine soil is poorer in all volatile and soluble constituents (except potash) than the other, as might have been expected.

Salamander-hills are occasionally seen within three or four miles of the southern edge of this region, the animals probably wandering in from the very sandy region bordering it on the south (which will be described next). Moles and earthworms occur here also; perhaps more commonly than in other parts of Florida.

Topography and Hydrography—The topography is everywhere hilly, probably more so on the average than in any equal area in Florida. Differences of elevation of 100 feet in less than half a mile are not uncommon, especially near the southern edge of the region, where the highest hills are a little over 200 feet above sea-level. A mile or so east of Tallahassee is a railroad cut about 40 feet deep, which seems to be the deepest one in the State. But there are almost no bluffs, ravines, or hills too steep for wagons to climb, and some of the roads run nearly straight for several miles, regardless of the hills. The valleys are mostly broad and more or less flat-bottomed, and probably were not formed altogether by surface erosion, for running water is scarce. There are no caves or natural bridges, however, such as are characteristic of some regions of solution topography.

No rivers traverse the region, but there are a few sluggish creeks and branches, running into lakes or ponds, where the water sinks into the ground or evaporates, or both. The low grounds around Tallahassee are said to be lower than the nearest point on the Ocklocknee River, seven or eight miles away; and all the drainage from Tallahassee, that does not evaporate or soak into the ground first, goes through Munson's Pond or Lake, about five miles south (Fig. 75), and then to a sink a few miles farther south.

The most characteristic hydrographic feature of this region, distinguishing it from most other red hill regions, is its large lakes, three or four in number. These are several square miles in area, irregularly shaped, all shallow and flat-bottomed, with sink-holes at their edges or elsewhere, and are often nearly dry for several years at a time. (See Sellards 1 in bibliogaphy.) They were at their lowest stage about 1910, and at their highest (perhaps eight or ten feet above low water) about 1912. In addition to the large lakes there are several smaller ones, from a few hundred acres down to mere ponds an acre or so in extent. All are essentially treeless, except that there is a good deal of cypress in the eastern half of Lake Lafayette.

Except in the immediate vicinity of lakes and streams, the ground-water lies at a considerable distance below the surface. Consequently wells are less numerous than houses, and good ones are scarce. Springs are almost wanting, too, so that one walking any considerable distance through this region in warm dry weather is likely to get rather thirsty. The city of Tallahassee gets an unfailing supply of good water from artesian wells, in which the water stands nearly 100 feet below the surface (or not very far from sea-level).

Vegetation Types—The drier uplands seem to have been covered originally with comparatively open forests of short-leaf pine (*Pinus echinata*), red oak, hickory, dogwood, etc. Considerable areas of this forest still remain, though a good deal of it may be second growth. On sandier soils near the center of the region there are limited areas (perhaps several hundred acres) of long-leaf pine forest, differing from the typical piney woods of other regions in the scarcity or absence of saw-palmetto and wire-grass among the undergrowth. Both the short-leaf and the long-leaf pine forests are subject to occasional fires. On some of the hillsides and richer uplands dense hardwood forests with considerable humus can be seen, and the branches and creeks are bordered by wet woods or swamps. The lakes and ponds of course have their characteristic vegetation. Finally, the old fields, roadsides, railroad rights-of-way, etc., which cover a large part of the area, have a characteristic weed vegetation, probably more conspicuous here than in any other part of Florida.

Plants—The following list is based on observations made in every month in the year except January and February, and it ought to be fairly accurate as far as it goes.

TREES

++24	**Pinus echinata**	Short-leaf pine	Uplands
+8.8	**Pinus Taeda**	Short-leaf pine	Low grounds mostly
++7.6	Liquidambar Styraciflua	Sweet gum	Various situations
+6.8	Cornus florida	Dogwood	Dry woods
+4.5	Quercus falcata	Red oak	Uplands
—4.2	**Pinus palustris**	Long-leaf pine	Poorer soils
—4.2	Taxodium imbricarium	(Pond) cypress	Lake Lafayette
++4.2	**Quercus Virginiana**	Live oak	Various situations
++2.8	Quercus **nigra**	Water oak	Various situations
+2.5	**Magnolia grandiflora**	Magnolia	Rich woods
+2.2	Prunus serotina (X)	Wild cherry	Roadsides, etc.
+2.1	Hicoria alba	Hickory	Uplands
++2.0	Melia Azedarach (X)	Chinaberry	Roadsides, etc.
++1.8	Quercus stellata	Post oak	Uplands
—1.7	**Magnolia glauca**	Bay	Wet woods
—1.7	Nyssa biflora	Black gum	Swamps
—1.5	**Pinus Elliottii**	Slash pine	Near Centerville
+1.2	**Quercus laurifolia**		Rich woods, etc.
+1.0	Salix nigra	Willow	Low grounds
+0.9	Fagus grandifolia	Beech	Rich woods
0.9	**Pinus glabra**	Spruce pine	Rich woods
+0.9	Malus angustifolia	Crab-apple	Dry woods
0.8	Acer rubrum	Maple	Wet woods
+0.8	Nyssa uniflora	Tupelo gum	Swamps and sloughs
+0.8	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
+0.7	Quercus Marylandica	Black-jack oak	Dry uplands
++0.7	Quercus velutina	(Black oak)	Dry uplands
+0.7	Ostrya Virginiana		Rich woods
+0.6	Quercus alba	White oak	Rich woods
+0.6	Hicoria glabra?	Hickory	Uplands
+0.6	Quercus Michauxii	(Swamp chestnut oak)	Low grounds
0.6	**Ilex opaca**	Holly	Rich woods
+0.5	Tilia pubescens	(Lin, basswood)	Rich woods
+0.5	Morus rubra	Mulberry	Rich woods
+0.5	Cercis Canadensis	Redbud	Rich woods

—0.2 Liriodendron Tulipifera	Poplar	Wet woods
+0.2 Nyssa sylvatica	Black gum	Dry woods
0.2 Acer rubrum tridens?	Maple	Swamps
+0.2 Oxydendrum arboreum	Sourwood	Uplands
0.2 Taxodium distichum	Cypress	Swamps
0.2 Carpinus Caroliniana	Ironwood	Low grounds
+0.2 Halesia diptera (and 8 or 10 others).		Rich woods

SMALL TREES OR LARGE SHRUBS

++.17 Sassafras variifolium (X)	Sassafras	Old fields, etc.
.14 Cyrilla racemiflora	Tyty	Swamps
+.12 Viburnum rufidulum	Black haw	Rich woods
+.09 Batodendron arboreum	Sparkleberry	Dry woods
++.09 Prunus angustifolia (X)	Wild plum	Old fields
+.04 Crataegus sp.	Red haw	Dry woods
.04 Myrica cerifera	Myrtle	Rich woods
+.03 Prunus sp.* (X)	(Plum)	Roadsides, etc.
+.03 Symplocos tinctoria		Rich woods
+.03 Osmanthus Americana		Rich woods
.02 Bumelia lanuginosa		Woods
.02 Celtis pumila	Hackberry	Dry woods, etc.
.02 Crataegus aestivalis	May haw	Small ponds
.02 Chionanthus Virginica (and 6 others).	Graybeard	Rich woods.

VINES

++.027 Parthenocissus quinquefolia	Virginia creeper	Woods
+.020 Smilax lanceolata	(Wild smilax)	Various situations
+.015 Rhus radicans	Poison ivy	Low grounds, etc.
+.015 Rubus trivialis (X)	Dewberry	Old fields, etc.
+.011 Lonicera Japonica (X)	Japanese honeysuckle	Roadsides, etc.
+.010 Tecoma radicans	(Cow-itch)	Various situations
+.010 Vitis rotundifolia	Bullace or muscadine	Places exempt from fire
+.010 Gelsemium sempervirens	Yellow jessamine	Places exempt from fire
+.009 Lonicera sempervirens	Honeysuckle	Roadsides, etc.
++.008 Rosa laevigata (X)	Cherokee rose	Roadsides
+.007 Smilax glauca		Dry woods and old fields
+.006 Vitis aestivalis?	Wild grape	Woods, etc.
.004 Bignonia crucigera	Cross-vine	Woods, etc.
.002 Decumaria barbara		Wet woods

*A small tree resembling *P. umbellata*, the hog plum, but with red fruit, more or less edible, and ripening any time between May and October.

.002 Smilax rotundifolia?		Woods
.002 Ampelopsis arborea (and a few others).		Low grounds mostly

SHRUBS

+.028 Rubus cuneifolius (X)	Blackberry	Old fields, etc.
+.022 Ceanothus Americanus	(Red-shank)	Dry woods
+.021 Rhus copallina	Sumac	Dry woods, old fields
+.020 Cephalanthus occidentalis	Elbow-bush	Around lakes and ponds
+.014 Callicarpa Americana	French mulberry	Places exempt from fire
+.011 Aralia spinosa	Prickly ash	Rich woods, etc.
++.011 Lantana Sellowiana (X)		Roadsides
+.011 Castanea alnifolia	Chinquapin	Dry woods
+.010 Sambucus Canadensis (X)	Elder	Low grounds
++.008 Lantana Camara (X)		Roadsides
+.008 Polycodium stamineum?	Gooseberry	Dry woods
.007 Quercus pumila	Oak runner	Dry pine woods, etc.
+.007 Styrax Americana		Swamps
.006 Rhus Toxicodendron	Poison oak	Dry woods
+.005 Baccharis halimifolia (X)		Roadsides, etc.
+.005 Salix humilis?	Willow	Low grounds
.004 Arundinaria tecta	Reed	Damp woods
+.004 Crataegus uniflora	Haw	Dry woods
+.004 Rhus radicans (?)*	Poison oak	Rich woods
.003 Itea Virginica		Swamps
+.003 Asimina parviflora	Pawpaw	Woods
.003 Azalea nudiflora	Honeysuckle	Woods
.003 Phorandendron flavescens	Mistletoe	On trees
+.003 Euonymus Americanus		Rich woods
.003 Rhus Vernix	Poison sumac	Wet woods
.002 Cornus sp.		Woods
.002 Aesculus Pavia (and about 14 others).	Buckeye	Dry woods etc.

HERBS

++.012 Tillandsia usneoides	Spanish moss	On trees
++.004 Andropogon sp.† (X?)	Broom-sedge	Old fields, etc.
++.004 Ambrosia artemisiaefolia (X)	Ragweed	Waste places
++.004 Trifolium Carolinianum (X)	Clover	Fields and roadsides
++.004 Plantago Virginica (X)	(Plantain)	Old fields, etc.
++.003 Panicum hemitomon	Maiden cane	Lakes and ponds
++.003 Sporobolus Indicus (X)	(A grass)	Roadsides, etc.

*A low form growing only a few inches high.

†Probably mostly *A. scoparius*, but also includes *A. argyraeus* and perhaps other species which are difficult to distinguish before they bloom.

+.003	Pontederia cordata		Lakes and ponds
++.003	Lepidium Virginicum (X)	Peppergrass	Waste places
++.002	Heteropogon melanocarpus (X)	(A grass)	Old fields
++.002	Cassia Tora (X)	Coffee-weed	Waste places
+.002	Helenium tenuifolium (X)	Bitter-weed	Roadsides, etc.
+.002	Erianthus sp.	(A tall grass)	Dry woods, etc.
++.002	Chaerophyllum sp. (X)		Waste places
+.002	Pteridium aquilinum	(A fern)	Dry woods, etc.
+.002	Syntherisma sanguinale (X)	Crab grass	Fields and roadsides
+.002	Capriola Dactylon (X)	Bermuda grass	Fields and roadsides
+.002	Sida rhombifolia (X)	(Tea-weed)	Waste places
++.002	Cyperus rotundus (X)	Nut-grass	Cultivated fields, etc.
+.002	**Castalia odorata**	Water-lily	Lakes and ponds
+.001	**Mitchella repens**	(Partridge-berry)	Rich woods, etc.
++.001	Apium Ammi (X)		Waste places
++.001	Specularia perfoliata (X)		Roadsides, etc.
+.001	Eupatorium compositifolium (X)	Dog-fennel	Old fields, etc.
+.001	**Juncus effusus** (X?)	(Rush)	Low grounds
++.001	Oxalis stricta? (X)		Waste places
+.001	Eupatorium capillifolium (X?)	Dog-fennel	Low grounds
+.001	Spermolepis divaricatus (X)		Waste places
+.001	Chamaecrista fasciculata (X?)	(Partridge pea)	Old fields, etc.
++.001	Geranium Carolinianum (X)		Waste places
+.001	Rumex hastatulus (X)	(Sorrel)	Fields, etc.
++.001	**Asplenium platyneuron** (X?)	(A fern)	Shaded roadsides, etc.
+.001	Diodia teres (X)		Railroads, etc.
.001	**Chrysopsis graminifolia**		Pine woods
+.001	Sitilias Caroliniana (X)		Waste places
+.001	Gnaphalium purpureum (X)		Waste places
+.001	Richardia scabra (X)		Fields, etc.
+.001	Linaria Canadensis (X)		Fields and roadsides
+.001	Oenothera biennis (X)	(Evening primrose)	Old fields, etc.
+.001	Leptilon Canadense (X)		Fields
+.001	Cnidoscolus stimulosus	(Nettle)	Dry woods, etc.
+	Erigeron ramosus (X)		Old fields, etc.
+	Elephantopus tomentosus?		Dry woods
+	Angelica hirsuta		Dry woods
+	Solanum Carolinense (X)		Waste places
+	Lespedeza striata (X)	Japan clover	Waste places, etc.

+	Salvia lyrata		Dry woods, etc.
	Lorinseria areolata	A fern	Wet woods
++	Medicago Arabica (X)	Bur-clover	Waste places
+	Meibomia purpurea (X)	Beggar-weed	Fields, etc.
+	Anthemis Cotula (X)	(Dog-fennel)	Waste places
+	Paspalum sp. (X)	(A grass)	Roadsides, etc.
+	Baptisia leucantha		Dry woods, etc.
	Sericocarpus bifoliatus		Pine woods
++	Sonchus asper (X)		Waste places
++	Mesosphaerum sp.* (X)		Roadsides, etc.
+	Isopappus divaricatus (X)		Fields, etc.
+	Boehmeria cylindrica		Low grounds
++	Cenchrus echinatus (X)	Sand-spur	Fields and roadsides
+	Chaetochloa sp. (X)	(A grass)	Waste places
+	Erythrina herbacea		Woods, etc.
+	Sanicula Marylandica		Dry woods
+	Eupatorium perfoliatum	Boneset	Low grounds
	Smilax pumila		Rich woods
	Solidago odora		Pine woods
	Dasystoma Virginica	Goldenrod	Dry woods
+	Bidens bipinnata (X)	Spanish needles	Waste places
+	Brasenia purpurea		Lakes and ponds
+	Eleusine Indica (X)	(A grass)	Waste places
++	Utricularia inflata		Lakes
+	Helianthemum Carolinianum		Dry woods
+	Polymnia Uvedalia	(Bear-foot)	Rich woods, etc.
+	Lespedeza hirta		Dry woods
+	Polygonum hydropiperoides	(Smart-weed)	Miry places
+	Sagittaria latifolia		Miry places
+	Sida acuta (X)		Roadsides, etc.
++	Heliotropium anchusaefolium (X)		Roadsides, etc.
+	Panicum gibbum (X?)	(A grass)	Miry places
	Osmunda cinnamomca	(A fern)	Sandy low grounds
	Saururus cernuus		Swamps, etc.
	Phaseolus polystachyus	(Wild bean)	Rich woods
++	Nelumbo lutea	(Winkapin, yankapin)	Lakes and ponds
+	Daucus pusillus (X)		Roadsides, etc.
+	Kneiffia sp.		Dry woods
+	Panicum commutatum?	(A grass)	Rich woods
+	Dioscorea villosa?	(Wild yam)	Rich woods
+	Morongia uncinata		Dry woods

*A tall much-branched weed apparently not described in any work on plants of the southeastern states. It is common in the streets of Tallahassee and some old towns in other parts of the state.

	Polypodium polypodioides	(A fern)	On trees
+	Hymenopappus Carolinensis (X)		Sandy roadsides, etc.
+	Argemone Mexicana (X)		Waste places
+	Chrysopsis Mariana		Dry woods
+	Amaranthus spinosus (X)	Careless	Waste places
++	Gerardia fasciculata (X)		Old fields, etc.
+	Phytolacca rigida (X)	Pokeberry	Waste places
	Bidens coronata		Miry places
+	Croton glandulosus (X)		Waste places
+	Aeschynomene Virginica (X)		Ditches, etc.
++	Euphorbia heterophylla (X)		Waste places
+	Sorghastrum nutans*	(A grass)	Old fields, etc.
++	Panicum proliferum (X)	(A grass)	Ditches
	Cenchrus tribuloides	Sand-spur	Railroads, pastures, etc
	(and about 300 others.)		

In a region so unique in soil and topography it seems strange that there are no species peculiar to it, and very few rare plants. In this respect it contrasts strongly with the Apalachicola bluff region (No. 3). Although that is much smaller than the Tallahassee red hills, and does not differ much from many places in Georgia and Alabama, it has two trees confined to it, and several species which are rare elsewhere. There are indeed many species more abundant in the Tallahassee region than elsewhere in Florida, but nearly all of these are pretty widely distributed in other states.† They may be divided into several categories, according to the reasons for their abundance here.

From what is known of their distribution elsewhere it seems probable that the sweet gum, live oak and water oak are most abundant here because they like phosphorus. It is noteworthy that they all three grow in the rich woods a mile east of Tallahassee, where the soil is above the world's average in phosphorus, but not in the short-leaf pine woods two miles east, where the percentage of phosphorus is only about half as much (nor in central Illinois, where the soil is rich in almost everything except phosphorus). In like manner it is inferred that the short-leaf pine (*Pinus echinata*), dogwood, red oak, hickory (*Hicoria alba*), post oak, black-jack oak (*Quercus Marylandica*) and black oak are partial to iron or alumina, or both, and that *Pinus Taeda, Magnolia grandiflora, Quercus laurifolia, Fagus, Ostrya, Hicoria glabra, Parthenocissus,* and many shrubs and herbs are common here on account of the abundance of humus.

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*Formerly called *Chrysopogon avenaceus*. Our plant is mostly the glaucous form. *S. Linneanum* and *S. secundum* also occur in this region, but less abundantly.

†At least 70% of the species above listed grow also in the southeastern corner of Virginia and neighboring parts of North Carolina, a region differing considerably from this in soil, topography and climate. (See Torreya 9:223-224. 1909; Bull. Torrey Bot. Club 34:366. 1907; 37:420-422. 1910.)

The abundance of wild cherry, chinaberry, persimmon, sassafras, wild plum, Cherokee rose, lantanas, and the multitude of herbaceous weeds is easily explained by the fact that this region has been longer and more extensively cultivated than any other area of the same size in Florida. This is the only region in the state in which weeds predominate (in bulk, not necessarily in species) over native herbs. Some of the weeds doubtless have their soil preferences too, and might not thrive in the more sandy parts of Florida. It is significant that almost none of the weeds are evergreen.

In the case of some of the species whose names are followed by (X) in the foregoing plant list, one finds no intimation in current botanical manuals that they are not indigenous in Florida, and some of them are probably here branded as weeds for the first time. But they grow only in artificial or unnatural habitats, such as fields and roadsides, and could hardly have existed here before the country was inhabited (though some of them were probably here with the Indians several centuries ago). Whether or not they are native anywhere else in the United States is a question that does not need to be considered here.

The following trees, which are more or less common not far away, or in other red hill regions, are rare or wanting here:—*Pinus serotina*, *P. clausa*, *Taxodium distichum*, *Juniperus*, *Sabal Palmetto*, *Juglans*, *Hicoria aquatica*, *Populus*, *Salix longipes*, *Betula*, *Quercus geminata*, *Q. Phellos*, *Q. cinerea*, *Q. Catesbaei*, *Ulmus* (all species), *Magnolia macrophylla*, *Liriodendron*, *Platanus*, *Gleditschia*, *Persea*, and *Fraxinus*. Some of these prefer poor sandy soils and some alluvial soils, both of which are almost wanting here; while the reasons for the absence of a few of them are less evident.

The proportions of evergreens and Ericaceae are rather low, 53.1% and 8% respectively, while that of Leguminosae is above the average; all of which indicates fertile soils. (It is hardly worth while to figure out the exact percentage of Leguminosae for this region, as most of them are weeds.) Grasses are quite abundant here too, a fact of interest to the stockman and dairyman.

The evergreens generally keep their leaves about two years, and the deciduous trees seven or eight months.

Economic Features—For the whole of Leon County in 1910 the proportion of improved land was estimated at 24%, the density of population 27 per square mile (a little less than in 1900), and the proportion of whites 24%. For the red hill portion of the county the proportion of improved land is considerably higher, probably at least 40% (and adding abandoned fields to this doubtless makes the forests less than half the area), the density of population is greater, perhaps as much as 40 inhabitants to the square mile, and the percentage of whites, outside of Tallahassee, even less.

This region was cultivated by the Indians long before the white man came, and until within the last few decades it was the leading agricultural section of the State in proportion to its size, with the possible exception of the Marianna red lands. Even yet, after three-quarters of a century of cultivation by whites and negroes, most of the farmers do not consider it necessary to use commercial fertilizers. According to the last census there were in Leon County 109,-349 acres of improved land, and the expenditure for fertilizer in 1909 was $31,510, or about 29 cents per acre (as compared with $2 per acre for the whole State). And no doubt most of the fertilizer was used in the more sandy parts of the county, leaving the amount used in the red hills much smaller than the figures would indicate.

This seems to be the only part of northern Florida, outside of cities, where cattle and hogs are not allowed to run at large. (The stock law, or no-fence law, is pretty closely correlated with the amount of woodland, for wherever cultivated fields occupy only a small part of the area, as is the case in most parts of Florida, the fields are fenced and cattle are allowed to graze in the woods; while where fields predominate it is more economical to put fences around the pastures and leave the fields unfenced.)

Other interesting features of this region, not so easily explained, are that the ox is the favorite beast of burden among the negro farmers; and that here, more than anywhere else in northern Florida, large areas are owned and preserved for hunting and other purposes by persons who usually spend only the winter months in the South.

The leading crops in 1912, in order of value, were approximately as follows: Corn, upland cotton, sweet potatoes, sugar-cane, field peas (and hay thereof), peanuts, (grass) hay, velvet beans, oats, pecans, pears, watermelons, tobacco, peaches and figs.

Long-leaf pine being scarce, there is hardly any lumbering or turpentining, and little use is made of the forests except for fuel and other common farm purposes. Some wild smilax (*Smilax lanceolata*) and other evergreens are gathered for Christmas decorations, but there seems to be no large trade in them as there is in southern Alabama. Some Spanish moss is used for mattress-making, and probably shipped away to some extent. This industry would seem to be capable of great development, for the supply of moss is practically inexhaustible.

12. BELLAIR SAND REGION.

(FIGURES 74, 75)

References—Nash (101,107) and U. S. soil survey of Leon Co.

This embraces about 250 square miles in Leon and Wakulla Counties. In the Third Annual Report it was treated as a part of the peninsular lime-sink region (described farther on); but as it is entirely disconnected from that, and differs somewhat in vegetation and other characters, it is now described separately.

Geology and Soils—The whole area seems to be underlaid by a limestone of Oligocene age, which crops out occasionally through the surface sands in boulder-like patches a few square feet in area and a few inches high, usually too small to have any vegetation on them. This type of rock outcrop (namely, calcareous rocks surrounded by sand) is not found in any of the regions previously described, but it is rather common in some parts of the Florida peninsula. Such outcrops are not found on every square mile, however, and they constitute only an infinitesimal fraction of the whole area. Some excavations in the neighborhood of ponds and streams have disclosed a pale reddish sandy clay, similar to that in various other long-leaf pine regions, but it seems never to approach the surface nearer than a foot or two, and at present there is no way of knowing just how extensive it is.

The prevailing surface material is a pale buff loamy sand from one to several feet deep,* remarkably homogeneous throughout except that the uppermost few inches, influenced by the vegetation, are of course a little grayer. It is of rather fine texture in Leon County, but a little coarser in Wakulla. In some places where the ground-water is nearer the surface the sand is firmer, and the vegetation considerably different.

The deep dry sand is called "Sandhill"† in the government soil survey of Leon County, and the mechanical analyses of it in

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*Some railroad cuts ten feet deep do not reach the bottom of the sand. On account of the character of the soil, this region, like other very sandy regions (the northern part of the lower peninsula of Michigan, for example) is traversed by a maze of ill-defined, "heavy" and changeable roads. But in a few places the underlying clay has been dug out and used for surfacing the roads, with very satisfactory results.

†Nearly all the other areas hitherto classed as "Sandhill" by the U. S. Bureau of Soils are along the fall-line in North and South Carolina (the same type is also extensively developed in Georgia, but not yet mapped by

that publication are reproduced herewith. The locality from which the samples were taken is not specified, nor are the respective depths. The first column is for soil and the second for subsoil.

MECHANICAL ANALYSES OF "SANDHILL," LEON COUNTY.

	Soil	Subsoil
Fine gravel (2-1 mm.)	0.2	(Trace)
Coarse sand (1-.5 mm.)	8.6	9.3
Medium sand (.5-.25 mm.)	24.5	25.8
Fine sand (.25-.1 mm.)	51.9	49.7
Very fine sand (.1-.05 mm.)	11.1	11.4
Silt (.05-.005 mm.)	1.1	1.0
Clay (.005-0 mm.)	2.3	2.4
Total	99.7	99.6

There is comparatively little difference between soil and subsoil; a fact brought out also by the chemical analysis given below. Samples of soil and subsoil were collected by the writer on dry sandy uplands about 3½ miles south of Tallahassee, July 22, 1914, and analyzed by L. Heimburger, Assistant State Chemist, in the manner described in the appendix. The first column of figures represents the first six inches from the surface, and the second, six to twelve inches.

PARTIAL CHEMICAL ANALYSES OF "SANDHILL," LEON COUNTY.

	Soil	Subsoil
Moisture	.12	.04
Volatile matter	1.67	.99
Nitrogen (N)	.089	.085
Potash (K_2O)	.030	.035
Lime (CaO)	.185	.195
Phosphoric acid (P_2O_5)	.032	.022
Iron and alumina (Fe_2O_3, Al_2O_3)	1.15	1.51
Insoluble matter	97.38	97.69

Although this soil is of course poorer than that of the neighboring red hills in humus and all soluble constituents, it is not the poorest soil there is by any means, and there are many small farms scattered over it.

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them as such), along creeks and rivers in the coastal plain of the Carolinas and Georgia, and near the Gulf coast of Florida. The area under consideration belongs to neither of these classes, but in soil and vegetation it is very similar to typical sand-hills. (For descriptions of the vegetation of the fall-line sand-hills of the Carolinas see Bul. Torrey Bot. Club 37:413. 1910; 38:225. 1911; and for that of the fluvial sand-hills of Georgia see Ann. N. Y. Acad. Sci. 17:82-89. 1906.)

Ants and salamanders are common in this soil, and gophers, moles, doodle-bugs and other subterranean animals occasional.

Topography and Hydrography—The topography is mostly gently undulating, a little hilly in some places and nearly flat in others, and pitted with numerous basin-like depressions.* The records of the G., F. & A. Ry. give the altitude of Spring Hill as 169 feet and Hilliardville (Benhaden P. O.) as 142; but whether these figures refer to sea-level or some assumed datum is not known. Springs are unknown, or at least very scarce, and streams are not common, but there are a few sluggish sloughs and drains, and many ponds and lakes. These bodies of water vary in size from an acre or so to several hundred acres. Some of the smaller ponds are shallow enough to be dry a large part of the time, while others are permanent. The seasonal fluctuation of the water in different ponds seems to vary from about two to ten feet; and some of those which fluctuate the most are connected with sink-holes. As the slopes are usually very gentle, some of the ponds have considerable areas around them which are sometimes inundated and sometimes exposed. The water in both ponds and streams is neither muddy nor calcareous, but coffee-colored from dissolved and suspended vegetable matter.

Vegetation Types—The prevailing upland vegetation is very open forests of rather small long-leaf pines, with a comparatively dense "lower story" of small black-jack and turkey oaks, usually not over 15 feet tall and often shrub-like, and a herbaceous undergrowth which does not cover the ground completely, but exposes some of the sand to the sun. There are, however, few bare spaces large enough to afford much protection from the fires which sweep through this as other long-leaf pine regions, so that plants (such as annual herbs and thin-barked shrubs) which cannot stand frequent fires are chiefly confined to railroads, fields and other clearings, or to hammocks and swamps. Within a few miles of the county line, where the ground-water is nearer the surface than the average, the oaks are almost wanting and the pines and herbage grow more densely.

The areas between high and low water marks around the

*This sort of topography is commonly supposed to indicate solution rather than erosion, but it is possible that the wind has had something to do with it too, for circular basins occur among the old dunes of the West Florida coast, where solution seems to be out of the question, as already pointed out.

ponds which fluctuate several feet are usually treeless, with a characteristic vegetation of herbs and scattered shrubs, which in the case of ponds which dry up completely covers the whole basin. Such areas usually pass abruptly into the surrounding pine forests, without any intervening fringe of hammock vegetation; which presumably indicates that the pond-margin vegetation is no barrier to fire in the dry season.

The ponds which fluctuate least usually contain cypress, at least around their edges, where the water is not too deep. Just outside of the cypress there is commonly a narrow belt of bay vegetation, and next to that more or less hammock, which is protected from fire on one side by the pond.

The streams are bordered by narrow swamps which seem to present no peculiar features, and some of them have hammocks besides. Near some of the streams and ponds, especially within a mile or two of the adjacent flatwoods (regions 9 and 16), there are small areas of low pine land.

Plants—The following list is based on observations made on 17 days in eight different months, as follows: January, 1; March, 2; April, 5; June, 3; July, 1; September, 2; October, 2; December, 1.

TREES

++53.0	**Pinus palustris**	Long-leaf pine	Uplands
++14.5	Quercus Catesbaei	Black-jack oak	Uplands
+ 5.3	Quercus cinerea	Turkey oak	Uplands
—4.4	Taxodium imbricarium	(Pond) cypress	Ponds, etc.
—1.6	**Pinus Elliottii**	(Slash pine)	Low pine land
—1.2	**Pinus Taeda**	Short-leaf pine	Richer soils
—1.0	Nyssa biflora	Black gum	Swamps
+1.0	**Quercus geminata**	Live oak	Around ponds, etc.
0.7	**Quercus Virginiana**	Live oak	Hammocks, etc.
—0.6	Liquidambar Styraciflua	Sweet gum	Richer soils
+0.6	Quercus Margaretta	Post oak	Uplands
—0.5	**Magnolia glauca**	Bay	Swamps
0.5	**Quercus laurifolia**	Oak	Hammocks
0.4	Hicoria alba	Hickory	Richer soils
—0.3	**Pinus serotina**	(Black pine)	Low pine land
—0.2	Quercus falcata	Red oak	Richer soils
—0.2	Quercus **nigra**	Water oak	Richer soils
—0.2	**Magnolia grandiflora**	Magnolia	Hammocks
—0.2	Acer rubrum*	Maple	Swamps
—0.2	Taxodium distichum	Cypress	Sloughs, etc.
0.1	Hicoria glabra	Hickory	Hammocks
—0.1	Ostrya Virginiana		Hammocks

*Probably including the var. *tridens*.

SMALL TREES OR LARGE SHRUBS

+.14	**Cyrilla racemiflora**	Tyty	Swamps, etc.
+.07	**Ilex myrtifolia**	Yaupon	Around ponds
+.06	**Cyrilla parvifolia**	Tyty	Around ponds
.05	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
.03	Nyssa Ogeche	Tupelo gum	Along creeks
+.02	Crataegus Michauxii?	Haw	Uplands
.02	**Osmanthus Americana**		Hammocks
—.01	**Myrica cerifera**	Myrtle	Hammocks

WOODY VINES

.004	**Smilax laurifolia**	Bamboo vine	Swamps
+.002	Smilax Walteri		Swamps
.002	Vitis rotundifolia	Bullace or muscadine	Hammocks
.002	**Gelsemium sempervirens**	Yellow jessamine	Hammocks
.001	Vitis aestivalis	Wild grape	Hammocks
.001	Ampelopsis arborea		Creek swamps
.001	Berchemia scandens	Rattan vine	Creek swamps

SHRUBS

++.035	Quercus Catesbaei*	Black-jack oak	Sandy uplands
+.030	**Hypericum fasciculatum**		Around ponds
++.027	**Gaylussacia dumosa**		Uplands
+.025	Chrysobalanus **oblongifolius**		Uplands
+.020	**Vaccinium nitidum**	Huckleberry	Mostly near ponds
+.013	Cephalanthus occidentalis	Elbow-bush	Ponds
—.013	**Serenoa serrulata**	Saw-palmetto	Mostly near ponds
++.010	Pieris Mariana		Margins of ponds
.008	Rubus cuneifolius (X)	Blackberry	Clearings, etc.
+.008	Hypericum **myrtifolium**		Around ponds
.007	Rhus copallina	Sumac	Clearings, etc.
.007	Asimina angustifolia	Pawpaw	Uplands
.004	Leucothoe racemosa		Bays, etc.
.004	**Quercus minima**	Oak runner	Uplands
—.004	**Ilex glabra**	Gallberry	Mostly near ponds
.003	Polycodium caesium?	Gooseberry	Hammocks, etc.
.003	Styrax Americana		Swamps
.003	Batodendron **arboreum**	Sparkleberry	Hammocks, etc.
.003	**Myrica pumila**	Myrtle	Uplands
.003	**Pieris nitida**		Bays, etc
.002	Rhus Toxicodendron	Poison oak	Uplands
.002	**Cholisma ferruginea**		Hammocks
.001	Viburnum obovatum		
++.001	Quercus cinerea	Turkey oak	Uplands
+.001	Quercus Margaretta	Post oak	Uplands

*Specimens of this oak about knee-high are the most conspicuous feature of the woody undergrowth, so that it is classed as a shrub as well as as a tree. Two other normally arborescent oaks are treated the same way in this list.

.001	Quercus pumila	Oak runner	Uplands
.001	Clethra alnifolia		Edges of swamps
.001	Ceanothus Americanus		Uplands
.001	**Ceanothus microphyllus**		Uplands
.001	**Crookea microsepala**		Flatwoods, etc.

HERBS

+.012	**Aristida stricta**	Wire-grass	Uplands
++.011	Kuhnistera pinnata	(Summer farewell)	Uplands
—.003	**Tillandsia usneoides**	Spanish moss	On trees
+.002	Eupatorium compositifolium (X)	Dog-fennel	Clearings
++.002	Laciniaria tenuifolia		Uplands
++.002	Chrysopsis flexuosa		Uplands
+.002	**Chrysopsis graminifolia**		Uplands
..002	Pteridium aquilinum	(A fern)	Uplands
+.002	**Syngonanthus flavidulus**		Around ponds
+.002	Sericocarpus bifoliatus		Uplands
+.002	Berlandiera tomentosa		Uplands
++.002	**Ludwigia suffruticosa**		Pond margins
+.001	Sarothra gentianoides (X)		Old fields, railroads, &c
++.001	Euphorbia gracilis		Uplands
.001	Vernonia angustifolia		Uplands
+.001	Sporobolus gracilis	(A grass)	Uplands
+.001	Croton argyranthemus		Uplands
+.001	Eupatorium aromaticum		Richer uplands
++.001	Triplasis Americana (X?)	(A grass)	Along railroads mostly
+.001	**Chrysopsis gossypina**		Uplands
+.001	Diodia teres (X)		Along railroads, etc.
.001	Solidago odora	Goldenrod	Uplands
++.001	Amsonia ciliata*		Uplands
++.001	Laciniaria Chapmani		Uplands
.001	Helianthus Radula		Uplands
+.001	Gibbesia Rugelii		Along railroads mostly
.001	Isopappus divaricatus (X)		Old fields, etc.
+.001	Nymphaea orbiculata	Bonnets	Ponds
.001	Psoralea canescens		Uplands
.001	Panicum hemitomon	Maiden cane	Ponds
+.001	Stenophyllus ciliatifolius		Uplands
++.001	Eupatorium leptophyllum?	(Dog-fennel)	Pond margins
++.001	Gerardia divaricata		Uplands
+.001	Pentstemon multiflorus		Clearings, etc.
+.001	Euthamia Caroliniana (X?)		Around ponds, etc
++.001	Euphorbia Floridana		Uplands
++.001	Eriocaulon septangulare		Pond margins
+.001	Cenchrus tribuloides (X)	Sand-spur	Along railroads, etc.
.001	Cnidoscolus stimulosus	(Nettle)	Uplands

*Chiefly the var. *filifolia* See Bull. Torrey Bot. Club 33: 240-241. 1906.

.001	**Centella repanda**		Around ponds, etc.
+.001	Stenophyllus Floridanus (X)	(Water grass)	Fields, railroads, etc.
.001	Stillingia sylvatica	(Queen's delight)	Uplands
++.001	Psoralea Lupinellus		Uplands
.001	Castalia odorata	Water-lily	Ponds
++.001	Dicerandra linearifolia (X?)*		Along railroads
+	Brasenia purpurea		Ponds
+	Eleocharis melanocarpa	(A sedge)	Pond margins
+	Dicholus simplicifolius	(Dollar-weed)	Uplands
	Chamaecrista fasciculata	(Partridge pea)	Uplands
	Crotalaria rotundifolia		Uplands
+	Calophanes oblongifolia		Uplands
++	Polygonella gracilis		Along railroads, etc.
	Rhynchospora Grayii	(A sedge)	Uplands
+	Andropogon Virginicus	Broom-sedge	Uplands
++	**Lupinus villosus**	(Lupine)	Uplands
+	**Anastrophus paspaloides** (X?)	(A grass)	Pond margins
+	Lygodesmia aphylla		Uplands
	Morongia uncinata		Uplands
	Stylosanthes biflora		Uplands
+	Aster concolor		Uplands
+	Polypremum procumbens (X)		Around ponds, etc.
+	**Juncus repens**		Dried-up ponds, etc.
+	Ludwigia pilosa		Swamps
	Drosera capillaris		Pond margins
	Erigeron vernus		Pond margins
	Cracca chrysophylla		Uplands
	Lycopus sp.		Around ponds, swamps
+	Lechea sp.		Uplands
+	**Chrysopsis aspera**		Uplands
+	Crotonopsis spinosa (X)		Clearings
	Sorghastrum secundum	(Wild oats)	Uplands
+	Eragrostis simplex (X)	(A grass)	Railroads
++	Polypteris integrifolia		Uplands
—	**Trilisa odoratissima**	Deer-tongue	Low pine land
+	Scleria glabra	(A sedge)	Uplands
+	**Mayaca Aubleti**		Around ponds
	Afzelia pectinata		Uplands
+	Breweria humistrata		Uplands
—	Pterocaulon undulatum	(Black-root)	Near ponds, etc.
++	Scutellaria multiglandulosa		Uplands
+	Asclepias humistrata	Milkweed	Uplands

*This handsome and fragrant annual is native on some sand-hills in South Georgia, but here it seems to be confined to railroads, perhaps because those are the only dry sunny places in this region that are sufficiently protected from fire. *Pentstemon multiflorus* and a few other species behave in a similar manner.

+	Laciniaria elegans		Richer uplands
	Rhexia Mariana		Around ponds
—	Pluchea bifrons		Around ponds
—	Acanthospermum australe (X)		Along railroads, etc.
—	Helenium tenuifolium (X)	Bitter-weed	Roads and clearings
—	**Eriogonum tomentosum**		Uplands
++	Juncus abortivus		Pond margins
	Aristida spiciformis	(A grass)	Low pine land
+	Euphorbia cordifolia		Along railroads
+	Ruellia humilis		Uplands
+	Chamaecrista nictitans	(Partridge pea)	Uplands
—	Eupatorium capillifolium (X?)	Dog-fennel	Low grounds
+	Laciniaria gracilis		Uplands
	Galactia regularis		Uplands
	Eupatorium album		Uplands
	Xyris sp.		Around ponds
	Verbena carnea		Uplands
	Asclepias tuberosa		Uplands
—	Pontederia cordata		Around ponds
—	Mesosphaerum radiatum		Near swamps
+	Cyperus speciosus?	(A sedge)	Pond margins
	Lachnocaulon sp.		Pond margins
+	Indigofera Caroliniana		Uplands
+	Petalostemon albidus		Uplands
++	Psilocarya corymbiformis	(A sedge)	Pond margins
++	Eleocharis acicularis?	(A sedge)	Pond margins
	Juncus scirpoides compositus		Pond margins
+	Ludwigiantha arcuata		Pond margins

(and about 125 others seen less than 4 times).

The following plants which are common either in near-by regions or in regions with similar soil are rare or absent here: *Pinus serotina, P. echinata* (the common short-leaf pine of the Tallahassee red hills), *Salix* (willow), *Carpinus* (ironwood), *Fagus* (beech), *Ostrya, Quercus Michauxii, Q. falcata* (red oak), *Q. Marylandica* (round-leaf black-jack oak), *Ulmus* (elms), *Magnolia grandiflora, Liriodendron* (poplar), *Malus* (crab-apple), *Crataegus* (haws), *Prunus* (plums and cherries), *Ilex opaca* (holly), *Cornus florida* (dogwood), *Persea* (red bays), *Fraxinus* (ashes), *Cliftonia* (tyty), *Serenoa* (saw-palmetto), *Ilex glabra* (gallberry), *Eriogonum, Pitcheria,* and *Helenium tenuifolium* (bitterweed).

Some of these prefer richer and some wetter soils than are prevalent here; but the scarcity of *Eriogonum* and *Pitcheria,* which abound in similar soils in the same latitude (in the West Florida lake region, for instance), is hard to explain. Neither is there any apparent reason for the scarcity of bitterweed, which is too common in most other parts of northern Florida. Vines are comparatively rare, doubtless because there are few areas sufficiently protected from fire for them to flourish.

On the other hand, this region contrasts with those just north and south of it in the number of rare plants. *Cyrilla parvifolia* and *Juncus abortivus* seem to be confined to Florida, and *Laciniaria Chapmani* nearly so. *Pieris Mariana* and *Eriocaulon septangulare* are rare elsewhere in the South, but common enough here. *Chrysopsis flexuosa,* discovered first by Mr. Nash near Bellair in 1895, was not known outside of this region, or outside of Leon County, until the past summer, when the writer found it in the Panacea country (region 14).* The *Eupatorium* (dog-fennel), that grows on the treeless margins of ponds that fluctuate several feet, is not common elsewhere. *Psilocarya corymbiformis* is another rare plant.

The genera *Chrysopsis* and *Laciniaria,* each with four or five representatives, seem to make up a larger proportion of the vegetation here than in any other part of Florida, and are very conspicuous in the fall, when they bloom.

About 60% of the trees are evergreen, and 30% of the shrubs (or .07% of the total vegetation) are Ericaceae, while 17.4% of the herbs are Leguminosae. The figures for *both* Ericaceae and Leguminosae are considerably above the average, which is rather remarkable, and not easy to explain.

Economic Features—The deep sand is not well adapted to agriculture, and probably not over 5% of the area is under cultivation. There has been considerable lumbering, but the pines were never as large in this region as in some others, and the best ones have been cut out. Turpentining seems to be the leading industry at present. Much if not most of the fuel used in Tallahassee is long-leaf pine and black-jack oak, from this region. The wire-grass affords pasturage to many cattle. The bulbs of *Laciniaria tenuifolia* a few years ago were made the basis of a patent medicine by a doctor in Tallahassee.

No statistics of population are available, but there are probably not over ten inhabitants to the square mile, and negroes appear to be in the majority. Bellair, in the northern edge of the region, about four miles south of Tallahassee, was in ante-bellum days a favorite summer resort for the aristocracy of the capital, who went there mostly to escape malaria, apparently.† The place is now almost extinct, probably partly because improved transportation facilities now enable Tallahasseeans to reach more attractive summer resorts quickly, and partly because we now know better ways to avoid malaria than running away from it (and that disease is much less prevalent now than formerly).

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*The genus *Chrysopsis* is remarkable for the limited range of some of its species. One species, *C. pinifolia,* discovered by Stephen Elliott about 100 years ago on the fall-line sand-hills of what is now Taylor County, Georgia, is still known only from that county, though it is as common there as *C. flexuosa* is around Bellair.

†This is one more illustration of the correlation between soil and health that has never been fully explained. Just why malarial mosquitoes should have been more numerous in the red hills than in the sand country with its numerous ponds and sloughs is not obvious; unless possibly the water in sandy regions is lacking in some nutriment that they require.

13. WAKULLA HAMMOCK COUNTRY.
(FIGURES 76-78)

References—Smith 2, p. 227 (a few notes on vegetation, evidently derived from Eagan's pamphlet). Illustrated in 3d Ann. Rep. pl. 21.1; 4th, Fig. 13.

Confined to the central part of Wakulla County, or nearly so, this little region has an area of perhaps 150 square miles. There seems to be nothing exactly like it elsewhere.

Geology and Soils—This region, like the preceding, seems to be underlaid by Oligocene limestone, which protrudes through the soil in a few places in much the same way, and crops out around a few sinks. At a deep sink containing water, a mile or two south of Wakulla Spring, there is a little reddish clay overlying the limestone, but no other exposures of clay are known to the writer. The prevailing soil is an exceptionally coarse sandy loam, with not enough clay to make it coherent. Samples were taken by the writer on Oct. 8, 1914, from the same spot shown in Fig. 77, representing the first and third foot from the surface, and there is no perceptible difference between the two except a small amount of organic matter in the surface soil. Both are light brown or buff in color. A partial mechanical analysis has been made by the writer, with a series of sieves having apertures 1, ½, and ¼ millimeters in diameter, respectively, with the following results:

	Soil	Subsoil
Fine gravel (above 1 mm.)	12.3	10.7
Coarse sand (1 - .5 mm.)	35.7	37.9
Medium sand (.5-.25 mm.)	40.0	40.3
Fine sand, silt and clay (.25 - 0 mm.)	12.0	11.1
Total	100.0	100.0

Unfortunately it was not feasible to separate the silt and clay, but these figures at least show the remarkably high proportion of gravel and coarse sand. This coarseness is not strictly confined to the region under consideration, though, for neighboring portions of regions 9 and 12 seem to have coarser soils than the average for those regions. (No explanation for this state of affairs can be suggested at the present writing.)

Although this is one of the coarsest soils in Florida, it is also one of the richest. The sample was selected from a patch of apparently virgin forest in which the trees are nearly all deciduous; and if the same correlations between soils and deciduous trees that have been observed elsewhere in the South hold true here the soil should be rather high in potassium, if nothing else. (A chemical analysis will be inserted near the end of this report if it is obtained in time.) Within a stone's throw of where the photograph and samples were taken a part of the same forest had been deadened a few months before (some of the trees were not quite dead at the time) and planted in cotton, which in October was about five feet tall, and was expected to produce about a bale to the acre. Similar soils which have been cultivated for a generation or more without fertilizer are still producing about half a bale of cotton to the acre, it is said.

All soils in the region are not like this, however. Long-leaf pine is the prevailing tree in many places, and there the soil is paler and doubtless poorer, though it may be richer than the average long-leaf pine land. And some of the hardwood forests contain a considerable proportion of evergreens, presumably indicating a dearth of potassium; but no examination has yet been made of these poorer soils. Salamanders are common in the pine land.

Topography and Hydrography—The topography is everywhere gently undulating, never flat, unless some flatwoods areas which have been seen in this region are really parts of it and not outliers of the Apalachicola flatwoods on the west. Where the flatwoods occur (for example six miles east of Crawfordville on the road to St. Marks) they seem to be a little higher than the surrounding country. There are a few lime-sinks, sloughs and small ponds, but hardly any surface streams except the Wakulla River. This river has its source in Wakulla Spring, the greatest natural wonder in the region. As far as dimensions are concerned it is the largest spring in Florida, and perhaps the largest in the world, being about 400 feet in diameter and over 80 feet deep. In volume of water, however, it may be exceeded by the noted Silver Spring, in Marion County. Its water, like that of other limestone springs, is transparent with a slight bluish tinge. One or two creeks which rise northwest of this region sink into the ground near its edge, and one of these may be the main source of supply for Wakulla Spring.*

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*Although these creeks have coffee-colored water, as is usual with coastal plain streams, such water in passing through limestone for any considerable distance has its vegetable matter precipitated and comes out clear, except when the volume of water is too great for the precipitation to be completed in the

Vegetation Types—The poorest soils have a vegetation composed mostly of long-leaf pine and black-jack oak, like that which prevails in the neighboring Bellair sand region already described. But there are all gradations between that and shady forests of red oak, hickory, dogwood, and other deciduous trees. In a few places the hardwood forests contain a good deal of magnolia, evergreen willow oak, and other broad-leaved evergreens; a difference presumably correlated with the composition of the soil. The occurrence of a few patches of flatwoods has been mentioned above. The Wakulla River is bordered by swamps, and the few ponds and sloughs have some characteristic vegetation around them.

The high pine land and flatwoods nearly everywhere bear the marks of fire, which naturally does not invade the hardwood forests much. Where broad-leaved evergreens are common the vegetation may have been pine originally, and the protection from fire afforded by deciduous forests on one side may have allowed hammock vegetation to develop, as seems to have happened in many other places in the coastal plain.

Plants—The following list is based on observations made in walking through the region four times, in April, June, July and October.

TREES

—29.7	**Pinus palustris**	Long-leaf pine	Poorer soils
+5.8	Quercus falcata	Red oak	Uplands
++5.5	Hicoria alba	Hickory	Uplands
+5.5	Cornus florida	Dogwood	Uplands
+4.5	Quercus Catesbaei	Black-jack oak	Poorer soils
+3.9	**Quercus laurifolia**	(Evergreen willow oak)	Hammocks
++3.3	Quercus stellata	Post oak	Uplands
+3.1	**Pinus echinata**	Short-leaf pine	Uplands
+3.1	Quercus cinerea	(Turkey oak)	Poorer soils
+2.6	**Magnolia grandiflora**	Magnolia	Hammocks
++2.6	Sassafras variifolium	Sassafras	Uplands
—2.3	**Pinus Taeda**	Short-leaf pine	Hammocks, etc.
—1.9	Liquidambar Styraciflua	Sweet gum	Various situations
+1.8	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
++1.6	Quercus alba	White oak	Richer soils
+1.6	Tilia pubescens	(Lin)	Hammocks

time it remains underground. A few instances of springs in Florida in which the water is sometimes clear and sometimes coffee-colored are mentioned on page 284 of the Third Annual Report. (To the reference there given for Ichetucknee Spring can now be added Matson & Sanford, p. 287.)

+1.4 **Ilex opaca**	Holly	Hammocks
+1.4 Castanea pumila	Chinquapin	Uplands
1.3 Taxodium distichum	Cypress	Swamps
+1.1 Fagus grandifolia	Beech	Hammocks
—0.9 **Pinus serotina**	(Black pine)	Flatwoods
+0.9 Malus angustifolia	Crab-apple	Rich woods
+0.7 Nyssa uniflora	Tupelo gum	Sloughs, etc.
0.7 Quercus **nigra**	Water oak	
0.7 **Quercus Virginiana**	Live oak	Hammocks, etc.
+0.7 Prunus serotina (X)	Wild cherry	Roadsides, etc.
0.7 Acer rubrum	Maple	Swamps
+0.7 Ostrya Virginiana		Hammocks
+0.6 Hicoria glabra	Hickory	Hammocks
+0.4 **Persea Borbonia**	Red bay	Hammocks
+0.4 Quercus Margaretta	Post oak	High pine land
—0.4 Nyssa biflora	Black gum	Swamps
0.4 Quercus Michauxii	(Swamp chestnut oak)	Hammocks
+0.4 Fraxinus Americana	Ash	Rich woods
—0.4 **Pinus glabra**	Spruce pine	Hammocks
0.3 Quercus Marylandica	Black-jack oak	Uplands
0.3 Carpinus Caroliniana	(Ironwood)	Swamps, etc.
0.2 Fraxinus Caroliniana?	Ash	Swamps
—0.1 **Magnolia glauca**	Bay	Swamps
(and about 10 others).		

SMALL TREES OR LARGE SHRUBS

++.16 Viburnum rufidulum	Black haw	Rich woods
+.14 Batodendron **arboreum**	Sparkleberry	Uplands
++.13 Crataegus sp.	(Red) haw	Uplands
+.10 Prunus umbellata?*	Plum	Uplands
+.07 **Osmanthus Americana**		Hammocks
+.06 Cercis Canadensis	(Redbud)	Hammocks
.04 Cyrilla **racemiflora**	Tyty	Swamps, etc.
+.04 Symplocos **tinctoria**		Hammocks
+.03 Crataegus Michauxii?	(Red) haw	Uplands
.03 **Ilex vomitoria**		Hammocks
.03 Bumelia lanuginosa		Hammocks
.03 Salix longipes?	Willow	Swamps
.03 **Cholisma ferruginea**		Hammocks
(and 6 others seen only once).		

WOODY VINES.

++.033 Vitis aestivalis	Wild grape	Uplands
+.010 Rhus radicans	Poison ivy	Hammocks & swamps
+.009 Vitis rotundifolia	Bullace or muscadine	Hammocks, etc.
.004 Berchemia scandens	Rattan vine	Swamps
.001 Parthenocissus quinquefolia	Virginia creeper	Hammocks

*The same as one that grows in region 11. See page 273.

SHRUBS

+.026	Rhus copallina	Sumac	Uplands
++.021	Sassafras variifolium	Sassafras	Old fields
+.019	Callicarpa Americana	French mulberry	Hammocks, etc.
+.017	Rubus cuneifolius (X)	Blackberry	Roadsides, etc.
—.013	**Serenoa serrulata**	Saw-palmetto	Flatwoods, etc.
+.011	Cornus asperifolia?		Hammocks
+.011	Hamamelis Virginiana	Witch-hazel	Hammocks
.010	**Myrica cerifera**	Myrtle	Hammocks
.009	Cephalanthus occidentalis	Elbow-bush	Swamps, etc.
+.009	Ascyrum **hypericoides**		Uplands
.009	**Vaccinium nitidum**	Huckleberry	Flatwoods, etc.
.007	Rhus Toxicodendron	Poison oak	High pine land
.006	Chionanthus Virginica	Graybeard	Hammocks
+.006	Polycodium sp.	Gooseberry	Uplands
—.006	**Ilex glabra**	Gallberry	Flatwoods, etc.
—.005	Chrysobalanus **oblongifolius**		High pine land
.004	Gaylussacia frondosa nana	Huckleberry	Flatwoods
+.004	Crataegus uniflora	Haw	Uplands
.003	**Cholisma fruticosa**		Flatwoods
.003	Asimina angustifolia	Pawpaw	High pine land
.003	Asimina parviflora	Pawpaw	Hammocks
.003	Rosa Carolina	Wild rose	Swamps
.003	**Gaylussacia dumosa**		High pine land
.003	Itea Virginica		Swamps
.002	Aesculus Pavia	Buckeye	Rich woods
.002	**Baccharis halimifolia** (and about 12 others).		

HERBS

+.005	**Tillandsia usneoides**	Spanish moss	On trees
+.004	Eupatorium compositifolium (X)	Dog-fennel	Old fields, etc.
+.044	Isopappus divaricatus (X)		Old fields
+.003	Richardia scabra (X)	(Mexican clover)	Fields
+.002	Diodia teres (X)		Roadsides
.002	**Aristida stricta**	Wire-grass	High pine land
.002	Pteridium aquilinum	(A fern)	High pine land
+.002	Stenophyllus Floridanus (X)	(Water-grass)	Fields and roadsides
+.002	**Smilax pumila**		Hammocks
+.001	Cassia Tora (X)	Coffee-weed	Fields, etc.
.001	Solidago odora	Goldenrod	High pine land
+.001	Baptisia LeContei?		Uplands
.001	Stillingia sylvatica	(Queen's delight)	High pine land
.001	Andropogon scoparius* (X)	Broom-sedge	Old fields, etc.

*And probably other species.

.001	Croton argyranthemus		High pine land
.001	Sericocarpus bifoliatus		High pine land
+.001	Crotonopsis spinosa (X)		Roadsides, etc.
+.001	Heteropogon melanocarpus (X)	(A grass)	Old fields
.001	Acanthospermum australe (X)		Roadsides
.001	Vernonia angustifolia		High pine land
+.001	**Sagittaria natans lorata?**		Wakulla River
.001	Eupatorium aromaticum		Uplands
.001	Chamaecrista fasciculata	(Partridge pea)	Uplands
.001	Cenchrus tribuloides (X)	Sand-spur	Roadsides
.001	**Polypodium polypodioides**	(A fern)	On trees
.001	Ambrosia artemisiaefolia (X)	Ragweed	Roadsides, etc.
+.001	Helianthemum sp. (X)		Roadsides
.001	Bidens bipinnata (X)	Spanish needles	Fields and roadsides
.001	Sarothra gentianoides (X		Roadsides, etc.
.001	Laciniaria elegans		Uplands
.001	Cyperus retrofractus	(A sedge)	Uplands
.001	**Mitchella repens**	(Partridge-berry)	Hammocks
	Meibomia purpurea (X)	Beggar-weed	Old fields
	Leptilon Canadense (X)		Old fields
	Eupatorium capillifolium (X)	Dog-fennel	
	Syntherisma sanguinale (X)	Crab-grass	Fields, etc.
	Kuhnistera pinnata	(Summer farewell)	High pine land
	Chaetochloa sp. (X)	(A grass)	
	Berlandiera tomentosa		High pine land
+	Phytolacca rigida (X)	Pokeberry	Along fences, etc.
+	Oenothera cruciata (X)	(Evening primrose)	Fields
	Lespedeza striata (X)	Japan clover	Roadsides, etc.
	Scirpus validus	(Bulrush)	Wakulla River
	Aristida purpurascens? (X)	(A grass)	Old fields
	Euphorbia gracilis		High pine land
	Cracca spicata		Uplands
	Petalostemon albidus		High pine land
	Ipomoea pandurata (X?)	Morning-glory	Roadsides, etc.
+	Paronychia riparia (X?)		Roadsides
	Dolicholus simplicifolius	(Dollar-weed)	High pine land
	Spermolepis divaricatus (X)		Old fields
	Lepidium Virginicum (X)	Peppergrass	Roadsides, etc.
	Laciniaria tenuifolia		High pine land
	Erianthus sp. (X?)	(A grass)	Along fences
	Eragrostis ciliaris (X)	(A grass)	Roadsides
	Monarda punctata (X?)		Old fields, etc
	Rhynchospora Grayii	(A sedge)	High pine land

	Sporobolus gracilis	(A grass)	High pine land
	Lechea sp.		High pine land
	Psoralea canescens		High pine land
	Stylosanthes biflora		High pine land
	Oplismenus setarius	(A grass)	Hammocks
	Epidendrum conopseum	(An orchid)	On trees in hammocks
	Galactia mollis?		High pine land
	Meibomia rigida	(Beggar-weed)	High pine land
+	**Ceratophyllum demersum**		Wakulla River
	(and about 80 others).		

The following trees which are more or less common in other parts of Wakulla or in some adjoining county are rare or absent here: *Pinus Elliottii* (slash pine), *Taxodium imbricarium* (pond cypress), *Juniperus* (cedar), *Sabal Palmetto* (cabbage palmetto), *Salix* (willow), *Quercus geminata* (one of the live oaks), *Q. Marylandica, Celtis* (hackberry), *Magnolia glauca* (bay), *Liriodendron* (poplar), *Oxydendrum* (sourwood), and *Halesia.* As in the case of the Tallahassee red hills, there are remarkably few rare plants, for such a unique region. None of the species listed are confined to Florida.

But there are decidedly more species of trees in this region than in the small regions immediately north and south of it, and some of them are exceptionally well developed. The dogwood seems to be more abundant here than in any other part of Florida, with the possible exception of the Tallahassee red hills, and trees of it a foot in diameter are not uncommon. Several oaks and hickories, magnolia, chinquapin, sassafras, grape vines, and a few other species, are also notably large or abundant, or both.

Weeds are rather abundant, for a region without railroads, but this is doubtless a consequence of long cultivation, as in the case of the Tallahassee red hills already mentioned. Fungi (none of which are listed) seem to be commoner here than in most other parts of Florida.

Only about 48% of the trees (and still fewer of the other plants) are evergreen, which is the smallest proportion yet found in any equal area in the state, and presumably indicates soils well supplied with potassium compounds. About 11% of the shrubs are Ericaceae, but if the flatwoods areas were excluded this figure would be considerably less. About 12% of the herbs, including weeds, are Leguminosae, which is not far from the average; the fire-swept pine lands where these plants are abundant being just about counterbalanced by the rich shady woods where they are scarce.

Economic Features—The long-leaf pine is turpentined here as elsewhere, but there is hardly enough of it to invite extensive lumbering operations. The large and abundant dogwood and hickory have been utilized a little, it is said, but most manufacturers have overlooked the supply of these important hardwoods in this region, probably chiefly on acount of the lack of railroads. They will be an important resource for the future. Some Spanish moss is gathered for mattress-making, but perhaps used only locally.

As this region is much smaller than a county no statistics of its population and the amount of improved land can be obtained from the census reports. White people seem to be in the majority around Crawfordville, the county-seat, and negroes near the Wakulla River. (Some of the negro houses have chimneys of a type which seems to be peculiar to this region, the lower part built of rough limestone boulders and the upper part of the familiar sticks and mud.)

The amount of cleared land is perhaps 25%, but not all of this is in cultivation at one time. The use of commercial fertilizer seems to be almost unknown* (as in Holmes Valley previously described), and probably for this reason it is found advantageous to let the land lie fallow part of the time. Although no crop statistics for this region by itself are available, it probably includes most of the cultivated area of Wakulla County; and the following were the leading crops of the county in 1912, in order of value: Corn, sweet potatoes, peanuts, sugar-cane, upland cotton, velvet beans, oats, field peas (and hay thereof), watermelons, pears, peaches, pecans, (grass) hay, and grapes. (A region where wild grapes and muscadines are so abundant ought to be well adapted for grape culture.)

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*The average annual expenditure for fertilizers, per acre of improved land, in Wakulla County was about six cents by the state census of 1905 and four cents by the government census of 1910; or approximately 1/40 as much per acre as for the state as a whole. As most of the fertilizer was presumably used in the flatwoods parts of the county (regions 9 and 15), it is evident that practically none is used in this region; which corroborates the testimony of the farmers (see page 290).

14. PANACEA COUNTRY.

(FIGURE 79)

Reference—Sellards & Gunter 3, p. 142 (analyses of water from Panacea Springs).

An area of perhaps 60 square miles around Panacea Springs, in the southern part of Wakulla County, although it has no striking peculiarities, differs too much from all neighboring regions to be incorporated with any of them. Topographically and in some other ways it resembles the Bellair sand region (no. 12) most, and if it was contiguous to that it might have been treated as a part of it. Its vegetation, however, has much in common with the neighboring Apalachicola flatwoods (no. 9).

Geology and Soils—No outcrops of rock are known, and no definite statement can be made about the geology. The soil is a somewhat loamy sand of unknown depth, very similar to that in region 12. Salamander-hills and ant-hills are common in it, and gopher-holes occasional. The comparatively highly mineralized waters of Panacea Springs indicate some peculiar formations below the surface, which however seem to have no effect on vegetation.

Topography and Hydrography—The surface is nearly everywhere undulating, with many small basins. In the middle of the region some of the basins may be 20 feet deep or more, but toward the coast the whole topography gradually flattens out. Most of the basins contain water, which fluctuates comparatively little, on account of its nearness to sea-level. Between Sopchoppy and Panacea there are two southward-flowing creeks, Buckhorn Creek on the west and Otter Creek on the east, with sour coffee-colored water. Nothing is known at present of where they originate, as they are not shown on any available maps, but it is evident from the vegetation along them that they do not pass through any distinctly calcareous or clayey country.

Vegetation Types—The prevailing vegetation is of the high pine land or black-jack ridge type, as in the Bellair region. Most of the basins, however, contain bay vegetation, much like that in the flatwoods a few miles to the westward. (The difference between these bays and the cypress ponds and open ponds of region 12 is doubtless correlated with differences in the amount of seasonal fluctuation of the water, as pointed out under region 2.*) But

*In this connection see also Bull. Torrey Bot. Club 38:231-232. 1911.

most of those within a mile or two of the coast are devoid of woody plants (the reason for this is not yet evident), and might be designated as savannas or prairies. The vegetation along Otter Creek is much like that along small creeks in the flatwoods, while that along Buckhorn Creek includes short-leaf pine, sweet gum, and other plants indicating a moderately rich soil. The coast is bordered by salt and brackish marshes.

Plants—The following list is based on observations made on April 21 and June 19, 1910, and July 30, 1914. It cannot be very complete, especially for plants that bloom in fall, and the percentage figures are omitted.

TREES

+ **Pinus palustris**	Long-leaf pine	Uplands
+ Taxodium imbricarium	(Pond) cypress	Bays and ponds
+ Quercus Catesbaei	Black-jack oak	Uplands
— **Pinus Elliottii**	(Slash pine)	Bays and swamps
+ Quercus cinerea	Turkey oak	Uplands
Nyssa biflora	Black gum	Swamps
+ Nyssa Ogeche	Tupelo gum	Along creeks
— **Magnolia glauca**	Bay	Bays and swamps
— **Pinus serotina**	(Black pine)	Bays, etc.
+ **Persea pubescens**	Red bay	Swamps
— **Pinus Taeda**	Short-leaf pine	Along Buckhorn Creek
+ **Pinus Caribaea?**	(Pitch pine)	Near coast
— Liquidambar Styraciflua	Sweet gum	Along Buckhorn Creek
Liriodendron Tulipifera	Poplar	Swamps
— **Magnolia grandiflora**	Magnolia	Hammocks
Quercus Margaretta	Post oak	Uplands

SMALL TREES OR LARGE SHRUBS

+ **Cyrilla parvifolia**	Tyty	Bays
+ **Ilex myrtifolia**	Yaupon	Bays
+ **Cliftonia monophylla**	Tyty	Bays
Myrica cerifera	Myrtle	Hammocks
Osmanthus Americana		Hammocks

WOODY VINES

+ **Pieris phillyreifolia**		Bays
Smilax laurifolia	Bamboo vine	Bays

SHRUBS

++ **Gaylussacia dumosa**		High pine land
+ **Serenoa serrulata**	Saw-palmetto	Pine lands
Chrysobalanus **oblongifolius**		High pine land
+ **Quercus minima**	Oak runner	Pine lands
Ilex glabra	Gallberry	Low grounds
Quercus pumila	Oak runner	High pine land

+	**Pieris nitida**	(Hurrah bush)	Bays and swamps
	Vaccinium nitidum	Huckleberry	Pine lands
	Viburnum nudum		Swamps
	Hypericum **myrtifolium**		Around bays
+	**Myrica inodora**	Myrtle	Bays and swamps
+	**Myrica Carolinensis**	Myrtle	Bays and swamps
	Myrica pumila	Myrtle	Pine lands
+	**Crookea microsepala**		Low pine land
	Itea Virginica		Swamps
	Gaylussacia fromdosa nana	Huckleberry	Low pine land
	Rhus Vernix	Poison sumac	Swamps
	Clethra alnifolia		Edges of swamps
	Hypericum fasciculatum		Around bays

HERBS

+	**Aristida stricta**	Wire-grass	High pine land
++	Baptisia lanceolata		High pine land
+	Baptisia LeContei?		High pine land
+	Scleria glabra	(A sedge)	High pine land
+	Vernonia angustifolia		High pine land
+	Kuhnistera pinnata	(Summer farewell)	High pine land
+	Eriocaulon compressum		Bays
+	Pitcheria galactioides		High pine land
+	Morongia uncinata		High pine land
+	Chamaecrista fasciculata	(Partridge pea)	High pine land
+	Pluchea bifrons		Ponds, etc.
+	Pteridium aquilinum	(A fern)	High pine land
+	Sporobolus gracilis	(A grass)	High pine land
+	Chrysopsis flexuosa		High pine land
+	**Chrysopsis gossypina**		High pine land
+	Croton argyranthemus		High pine land
+	Cracca chrysophylla		High pine land
	Pterocaulon undulatum	(Black-root)	Pine lands
	Helianthus Radula		High pine land
+	Lygodesmia aphylla		High pine land
+	Sisyrinchium sp.	(Blue-eyed grass)	High pine land
	Erigeron vernus		Around ponds
+	Rhynchospora Grayii	(A sedge)	High pine land
	Rhexia Alifanus		Low pine land
	Chrysopsis graminifolia		High pine land
	Cladium effusum	Saw-grass	Ponds near coast
,	Stillingia sylvatica	(Queen's delight)	High pine land
	Berlandiera tomentosa		High pine land
+	**Fuirena scirpoidea**	(A sedge)	Low pine land
	Osmunda regalis	(A fern)	Creek swamps
	Crotalaria rotundifolia		High pine land
+	Gratiola ramosa		Shallow ponds
+	Monniera Caroliniana		Shallow ponds
—	**Tillandsia usneoides**	Spanish moss	On trees
+	**Juncus Roemerianus**		Brackish marshes

	Sericocarpus bifoliatus		High pine land
++	Baptisia simplicifolia		High pine land
	Cnidoscolus stimulosus	(Nettle)	High pine land
+	Cyperus Martindalei	(A sedge)	High pine land
	Lechea sp.		High pine land
+	Euphorbia gracilis		High pine land
	Dichromena latifolia	(A sedge)	Ponds, etc.
	Laciniaria gracilis?		High pine land
	Polygala nana		Pine lands
	Stylosanthes biflora		High pine land
	Solidago odora	Goldenrod	High pine land
	Sagittaria lancifolia		Ponds near coast
+	Dolicholus simplicifolius	(Dollar-weed)	High pine land
	Polygala lutea		Edges of swamps
+	Aster adnatus		Pine lands
	Lespedeza hirta		High pine land
+	**Lupinus villosus**	(Lupine)	High pine land
	Campulosus aromaticus	(A grass)	Low pine land
+	Eupatorium Mohrii?		Around ponds
+	Indigofera Caroliniana	(Indigo)	High pine land
	Juncus scirpoides compositus		Around ponds
+	Polypteris integrifolia		High pine land
+	Sabbatia decandra		Ponds
+	Chrysopsis oligantha		Pine lands
+	Aeschynomene viscidula		High pine land
+	Lupinus perennis	(Lupine)	High pine land
+	Aster concolor		High pine land
	Panicum sp.	(A grass)	
	Polygala grandiflora		High pine land
	Psoralea canescens		High pine land
+	Eupatorium purpureum		Along Buckhorn Creek
	Osmunda cinnamomea	(A fern)	Edges of swamps
	Andropogon Virginicus	Broom-sedge	High pine land
	(and about 45 others).		

Many plants which prefer rich, calcareous, clayey or alluvial soils are of course conspicuous by their absence here. There do not seem to be even any hickories, willows, elms, haws, maples, dogwood or persimmon. But this region, like no. 12, has decidedly more rare plants than the larger and more fertile region immediately north of it. *Cyrilla parvifolia, Crookea, Chrysopsis flexuosa* and *Baptisia simplicifolia* are not known outside of Florida, and *Pieris phillyreifolia, Myrica inodora, Pitcheria* and *Polypteris* are comparatively rare in other states. The fact that there are four species of *Myrica* and three of *Baptisia* is noteworthy. There seem to be almost no weeds.

About 66% of the trees and a still larger proportion of the shrubs and vines are evergreen. As in the Bellair sand region, the percentages of Ericaceae (among the shrubs) and Leguminosae (among the herbs) are both well above the average, being 31 and 28 respectively. Although more thorough exploration might reduce these figures a little, it is safe to say that this region contains a larger proportion of native leguminous plants than any other in northern

Florida. Practically all of them grow in the high pine land, and probably the best explanation of their abundance is that the high pine land, with its lack of humus (which these plants seem to have little use for, as already pointed out) covers nearly the whole area.

Economic Features—This region is sparsely settled and little cultivated. Turpentining and grazing seem to be the principal industries. Panacea Springs, on the shore of Dickson's Bay, is a watering-place of considerable repute, with the additional attractions of boating and fishing, and has a hotel open all the year. Before automobiles became so common it was connected with Sopchoppy, the nearest railroad station, by a horse-car line nearly seven miles long.

15. GULF HAMMOCK REGION.

(FIGURES 80, 81)

References—Gillmore (975), Harper 1 (222-223, 240, 242-244), Harper 4, Matson & Sanford (413-415), Sellards 3 (294 or 48), Smith 2 (205, 206, 227, 234, 235), and U. S. soil survey of Jefferson Co. (by Jones, Tharp & Belden, 1908).

This region, which is very distinct from any other, borders the Gulf coast from about St. Mark's to Tarpon Springs. In the area under consideration (i. e., west of the Suwannee River) it extends 15 or 20 miles inland, and covers about 1,470 square miles.

Geology and Soils—The country is everywhere underlaid by limestone, most of which has been mapped as Upper Oligocene. Outcrops of it a few square feet in extent and projecting a few inches above the surface are very abundant. In some places there may be as many as a hundred such exposures to the acre, and again they may be wanting over several square miles. This rock extends out into the Gulf for an unknown distance, making a rocky bottom in many places. Alternating with the hard rock are unconsolidated beds of marl. The reddish clay that is common in most of the regions previously described is rare here, if it occurs at all. The greater part of the surface material is a more or less loamy sand, a few inches to several feet deep, presumably Pleistocene.

In the drier places the limestone seems to have little or no influence on vegetation; but the swamps, sloughs, low hammocks and damp flatwods contain many plants that are very characteristic, and presumably correlated with the presence of limestone. Neither mechanical nor chemical analyses of the soils are available yet, but the following analysis of marl from a low hammock in Wakulla County, given by Dr. Eugene A. Smith in the 6th volume of the Tenth Census, page 205, is of some interest in this connection:

Moisture driven off at 100 C.	1.915%
Combined water	1.159%
Carbonic acid	24.253%
Lime	30.986%
Magnesia	.424%
Potash	.372%
Soda	.338%
Phosphoric acid	.014%

Sulphuric acid	.331%
Brown oxide of manganese	.134%
Peroxide of iron	.534%
Alumina	1.196%
Soluble silica	3.456%
Insoluble matter	35.555%
Total	100.667%

(The percentage of lime given corresponds to about 55% of calcium carbonate, or limestone).

The so-called Wakulla volcano, a column of smoke which is said to have been visible from Tallahassee and other high points in that neighborhood during most of the 19th century, must have been in this region. No one ever succeeded in reaching it, and it remains, and probably always will remain unless it becomes active again, entirely unexplained.*

Topography and Hydrography—The whole region is less than 100 feet above sea-level, and the surface is for the most part level or nearly so; but there are some undulating areas with lime-sink topography, scarcely distinguishable from the lime-sink region described farther on (no. 17). One such area, covering several square miles at least, is in Taylor County, about half way between Perry and the coast. As in most other parts of Florida, shallow depressions of various sizes are very common. There are natural bridges as well as rocky shoals on several of the creeks and rivers a few miles from their mouths, but apparently no caves or open lime-sinks, probably because the ground-water is too near the surface in most places.

Most of the streams have practically no valleys, the flatwoods extending almost to their banks.† They are all sluggish, except at the rocky rapids above mentioned, and most of them are coffee-colored, like the majority of coastal plain streams. There are, however, several clear runs from limestone springs, which are rather common along and near the inland edge of the region. Shallow

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*Perhaps the most reliable account of this phenomenon is in Norton's Handbook of Florida, 3d edition (1892), p. 346. There is a wood-cut of it and some descriptive matter, rather fanciful though, in the article by Barton D. Jones in Lippincott's Magazine for March, 1882, p. 221 (see bibliography), and one of the chapters in Maurice Thompson's novel, "A Tallahassee Girl," is based on it.

†Where the Atlantic Coast Line R. R. crosses the Steinhatchee River on the boundary between Taylor and Lafayette Counties the rails are not perceptibly lower over the stream than they are a mile or two away on either side.

sloughs or drains which carry water only in wet weather are common in some portions.

Vegetation Types—The prevailing type of vegetation is open pine woods subject to frequent fires, with a low shrubby and herbaceous undergrowth, not very different from that of the strictly non-calcareous flatwoods (regions 9, 16 and 19). But within a few miles of the coast, and occasionally farther inland, the vegetation of the flatwoods, while having about the usual aspect, is quite different in composition, including many plants which are known or believed to prefer calcareous soils, and a few which are most commonly found in or near brackish marshes. There is usually nothing on the surface to indicate any reason for this floristic difference, but a chemical examination of the ground-water in such places ought to reveal something of interest.* In the absence of any definite information it is assumed that the soil in such places is more calcareous than usual, and in the list below the plants characteristic of such situations are assigned to "calcareous flatwoods." In an extreme phase of the calcareous flatwoods trees are wanting, and such places might be called savannas or prairies.

Cypress ponds and bays similar to those already described are frequent. Most of the streams and sloughs, of whatever size, are bordered by low calcareous hammocks which are very characteristic of this region. The coast, which is unique in having practically no sandy beaches, as pointed out in the Third Annual Report (pp. 222-223†), is bordered by marshes, which have been little studied as yet.

Plants—The following list is based on observations made on 12 different days, as follows: January, 3; March, 5; May, 1; June, 1; July, 1; September, 1.

TREES

44.1	**Pinus palustris**	Long-leaf pine	Uplands
+11.7	**Pinus Elliottii**	(Slash pine)	Ponds, etc.
—5.9	Taxodium imbricarium	(Pond) cypress	Ponds and bays
++4.1	Taxodium distichum	Cypress	Swamps and low hammocks
4.1	**Pinus Taeda**	Short-leaf pine	Low hammocks, etc.
+3.3	**Sabal Palmetto**	Cabbage palmetto	Low hammocks, etc.
2.5	Liquidambar Styraciflua	Sweet gum	Low hammocks

*A chemical analysis of soil from such a place will be inserted in the appendix if received in time.

†See also F. P. Gulliver, Proc. Am. Acad. Arts & Sci. 24:23-235. 1899.

+1.9	**Pinus Caribaea?**		Mostly near coast
+1.7	Acer rubrum (etc.)	Maple	Swamps
—1.7	**Magnolia glauca**	Bay	Swamps, etc.
+1.4	**Quercus Virginiana**	Live oak	Hammocks, etc.
++1.3	**Quercus hybrida?**	(Water oak)	Low hammocks
++1.3	Carpinus Caroliniana	Ironwood	Low hammocks
+1.2	Fraxinus Caroliniana?	Ash	Swamps, etc.
++1.2	Ulmus Floridana	Elm	Low hammocks
—1.2	Quercus Catesbaei	Black-jack oak	Driest spots
+1.0	Quercus **nigra**	Water oak	Low hammocks, etc.
—1.0	**Pinus serotina**	Black pine	Flatwoods and bays
—0.9	**Magnolia grandiflora**	Magnolia	Hammocks
—0.7	Nyssa biflora	Black gum	Swamps
+0.6	**Juniperus Virginiana**	Cedar	Low hammocks
++0.6	Gleditschia triacanthos?	(Honey) locust	Sloughs, etc.
++0.5	Crataegus sp.	Haw	Low hammocks
++0.5	Crataegus viridis	Haw	Sloughs, etc.
+0.5	Taxodium sp.*	Cypress	Sloughs, etc.
+0.3	**Persea Borbonia**	Red bay	Low hammocks
+0.3	Morus rubra	Mulberry	Low hammocks
—0.3	Quercus cinerea	Turkey oak	Driest spots
0.3	**Ilex opaca**	Holly	Hammocks
++0.3	Crataegus Crus-Galli?	Haw	Calcareous flatwoods
0.3	Quercus Michauxii	(Swamp chestnut oak)	Low hammocks
—0.2	Celtis occidentalis?	Hackberry	Low hammocks
+0.2	Cercis Canadensis	Redbud	Hammocks
—0.2	Quercus falcata	Red oak	Richer
—0.1	Hicoria alba?	Hickory	Richer soils
0.1	Fraxinus sp.	Ash	Sloughs, etc.
—0.1	Cornus florida	Dogwood	Richer soils
—0.1	**Quercus laurifolia**	Oak	Hammocks
0.1	Tilia pubescens	(Lin)	Low hammocks
—0.1	Quercus stellata	Post oak	Richer soils
0.1	Quercus Schneckii?	(Red oak)	Low hammocks
+0.1	Ulmus alata	Elm	Hammocks
—0.1	**Pinus echinata**	Short-leaf pine	Richer soils
0.1	Hicoria sp.	Hickory	Hammocks

SMALL TREES OR LARGE SHRUBS

++.51	**Myrica cerifera**	Myrtle	Hammocks
++.18	Salix longipes?	Willow	Ponds, sloughs, etc.
+.07	**Cyrilla parvifolia**	Tyty	Bays
.04	Diospyros Virginiana (X)	Persimmon	Old fields, etc.
.04	Cyrilla **racemiflora**	Tyty	Swamps
+.03	Chionanthus Virginica	Graybeard	Hammocks
.02	Batodendron **arboreum**	Sparkleberry	Hammocks
.01	**Quercus geminata**	Live oak	Poorest soils

*Apparently an intermediate form or connecting link between *T. distichum* and *T. imbricarium*.

+.01	Crataegus apiifolia	Haw	Low hammocks
.01	**Ilex Cassine**		Low hammocks
.01	**Cholisma ferruginea**		Hammocks
.01	**Osmanthus Americana**		Hammocks
.01	Ilex decidua		Sloughs, etc

WOODY VINES

+.008	Rhus radicans	Poison ivy	Low hammocks, etc.
++.007	Berchemia scandens	Rattan vine	Low hammocks, etc.
+.005	Decumaria barbara		Low hammocks
+.004	Parthenocissus quinquefolia	Virginia creeper	Low hammocks
.002	**Smilax laurifolia**	Bamboo vine	Bays, etc.
+.002	Ampelopsis arborea		Low hammocks, etc.
.002	Vitis aestivalis	Wild grape	Hammocks, etc.
.002	**Bignonia crucigera**	Cross-vine	Low hammocks
.002	Tecoma radicans	(Cow-itch)	Sloughs
.001	Smilax Walteri		Swamps
.001	Vitis rotundifolia	Bullace or muscadine	Hammocks, etc.

SHRUBS

+.075	**Serenoa serrulata**	Saw-palmetto	Flatwoods
+.023	**Ilex glabra**	Gallberry	Flatwoods
+.013	Cephalanthus occidentalis	Elbow-bush	Ponds and sloughs
+.012	**Quercus minima**	Oak-runner	Flatwoods
++.011	Viburnum **obovatum**		Low hammocks
++.009	Cornus stricta?*		Sloughs, etc.
+.008	Stillingia aquatica		Ponds
.008	**Myrica pumila**	Myrtle	Flatwoods
+.007	**Crookea microsepala**		Flatwoods
+.006	**Sabal glabra***	Palmetto	Low hammocks, etc.
.005	Hypericum **myrtifolium**		Around ponds, etc.
.004	**Ilex vomitoria**		Hammocks
.004	**Vaccinium nitidum**	(Huckleberry)	Flatwoods
.004	Aesculus Pavia	Buckeye	Richer soils
+.004	Iva frutescens		Near coast
.003	**Pieris nitida**	(Hurrah bush)	Bays, etc.
+.003	Rosa Carolina	Wild rose	Sloughs, etc.
+.003	Amorpha fruticosa		Low hammocks, etc.
.003	**Hypericum fasciculatum**		Around bays, etc.
+.003	**Baccharis angustifolia**		Near coast
.002	**Cholisma fruticosa**		Flatwoods
.002	Itea Virginica		Swamps, etc.
.002	Quercus pumila	Oak runner	Drier flatwoods
.002	**Quercus myrtifolia**		Sterile sands
++.002	Sageretia minutiflora		Low hammocks
+.002	Styrax Americana		Swamps, etc.
.002	Rhus copallina	Sumac	Richer soils

*Probably including also C. *asperifolia*, which I did not always distinguish in the field.

+.001	**Sebastiana ligustrina**		Low hammocks
—.001	Chrysobalanus **oblongifolius**		High pine land
.001	Aronia arbutifolia		Around bays, etc.
.001	**Hypericum galioides pallidum**		Swamps
.001	Vaccinium virgatum?	Huckleberry	Around bays, etc.
.001	**Rhapidophyllum Hystrix**	(Needle palm)	Low hammocks
.001	**Kalmia hirsuta**		Flatwoods
— .001	**Gaylussacia dumosa** (and about 15 others).		High pine land

HERBS

.004	**Aristida stricta**	Wire-grass	Pine lands
.004	**Tillandsia usneoides**	Spanish moss	On trees
+.002	**Cladium effusum**	Saw-grass	Marshes, ponds, etc.
+.002	**Chondrophora nudata**		Flatwoods
++.001	Mesosphaerum radiatum		Calcareous flatwoods, etc.
+.001	Pterocaulon undulatum	(Black-root)	Flatwoods
+.001	Pluchea bifrons		Flatwoods, etc.
+.001	Chamaecrista fasciculata	(Partridge pea)	Drier flatwoods
++.001	Dichromena colorata	(A sedge)	Calcareous flatwoods
+.001	**Chrysopsis graminifolia**		Flatwoods
++.001	Atamosco Atamasco		Calcareous flatwoods
+.001	Pteridium aquilinum	(A fern)	Flatwoods
++.001	**Muhlenbergia filipes**	(A grass)	Savannas, etc.
+.001	**Juncus Roemerianus**		Brackish marshes and calcareous flatwoods
+.001	Saururus cernuus		Swamps, low hammocks, etc.
++.001	**Rhynchospora miliacea**	(A sedge)	Low hammocks
++.001	Rudbeckia foliosa		Calcareous flatwoods
.001	Kuhnistera pinnata	(Summer farewell)	High pine land
.001	Eupatorium compositifolium (X)	Dog-fennel	Roadsides, etc.
++	**Tubiflora Carolinensis**		Low hammocks
+	**Helianthus Radula**		Flatwoods
++	Chaetochloa imberbis	(A grass)	Savannas, etc.
+	**Lippia sp.**		Calcareous flatwoods
+	**Iris versicolor**		Shallow sloughs, ets.
+	**Tillandsia tenuifolia**	Air-plant	Swamps, etc.
++	Salvia lyrata		Hammocks
++	Ambrosia sp.	(Ragweed)	Calcareous flatwoods
+	Trilisa paniculata		Flatwoods
+	**Centella repanda**		Flatwoods, etc.
++	Dryopteris mollis?	(A fern)	Low hammocks, etc.
++	Helenium autumnale		Calcareous flatwoods
+	**Chaptalia tomentosa**		Low pine land
+	Mikania scandens?		Edges of marshes, etc.
+	Laciniaria spicata		Flatwoods

—	Helenium tenuifolium (X)	Bitter-weed	Roadsides, etc.
+	**Sagittaria lancifolia**		Marshes, etc.
+	Afzelia cassioides		Flatwoods
	Stillingia sylvatica	(Queen's delight)	Drier flatwoods
+	Aster adnatus		Flatwoods
++	Lythrum lanceolatum?		Calcareous flatwoods
++	Eupatorium mikanioides		Calcareous flatwoods etc.
++	Monniera acuminata		Calcareous flatwoods
+	Petalostemon albidus		Drier flatwoods
+	Aristida spiciformis	(A grass)	Sour flatwoods
++	**Carex styloflexa?**	(A sedge)	Low hammocks
+	Euthamia Caroliniana		Around ponds, etc.
+	**Polypodium polypodioides**	(A fern)	On trees in hammocks etc.
+	Pinguicula pumila		Low flatwoods
	Sericocarpus bifoliatus		Drier flatwoods
+	Elephantopus elatus?		Flatwoods
++	Flaveria sp.		Calcareous flatwoods
	Cenchrus tribuloides (X)	Sand spur	Along railroads, etc.
+	Eupatorium aromaticum		High pine land
	Syngonanthus flavidulus		Around bays, etc.
+	Viola lanceolata?	White violet	Margins of ponds
++	Vicia acutifolia		Low hammocks
++	Ludwigia lanceolata?		Ponds, etc.
	Sporobolus gracilis	(A grass)	High pine land
+	Xyris Elliottii?		Around ponds
++	Uniola nitida	(A grass)	Low hammocks
++	Cyperus articulatus	(A sedge)	Sloughs, etc.
	Laciniaria tenuifolia		High pine land
	Gerardia sp.		Flatwoods
++	Elionurus tripsacoides	(A grass)	Calcareous flatwoods
+	**Spartina Bakeri**	(A grass)	Savannas, etc.
+	Baldwinia uniflora		Flatwoods
	Berlandiera tomentosa		High pine land
	Epidendrum conopseum	(An orchid)	On trees in hammocks
	Chrysopsis aspera		Drier flatwoods
++	Juncus megacephalus		Calcareous flatwoods
++	Hibiscus incanus		Around marshes, etc.
+	Ipomoea sagittifolia	Morning-glory	Near coast
+	Typha latifolia	Cat-tail	Marshes
++	Nama corymbosa		Low calcareous flatwoods
+	**Dryopteris Floridana**	(A fern)	Low hammocks
+	Panicum virgatum	(A grass)	Savannas, etc.
++	Buchnera elongata		Calcareous flatwoods
	(and about 150 others).		

Although there are more species of trees and shrubs in this region than in some of the others, quite a number which are common not far away are decidedly rare here, if they occur at all. Among such are *Pinus echinata* (short-leaf pine), *P. glabra* (spruce pine), *Hicoria* (hickories), *Salix nigra* (willow), *Ostrya, Betula* (birch), *Fagus* (beech), several of the oaks, *Liriodendron* (poplar), *Prunus* (plums and cherries), *Gordonia, Cornus florida* (dogwood), *Oxydendrum* (sourwood), and *Cliftonia* (tyty). Most of these grow best in drier and more clayey soils than the average of the Gulf hammock region, but the absence of the last-named (and a few others) is probably best explained by its aversion to lime. The genus *Crataegus* (haws) seems to make up a larger proportion of the forests here than in most other parts of Florida (between 1 and 2%), which accords with the common belief that these little trees are partial to limestone regions.

Most of the species which are more abundant here than elsewhere in northern Florida grow in low hammocks and calcareous flatwoods. Some of them are rather rare plants. For example, the *Ambrosia* which stands 27th in the list of herbs is known only in calcareous flatwoods within a few miles of St. Mark's, and in a similar place near the southeastern corner of Georgia (where it was found by the writer in 1902, in company with *Lippia, Elionurus*, and a few other species included in the above list). Some species too scarce to be listed here are probably still more limited in distribution. Very few weeds are abundant enough in this region to be included among the first 200 species, a natural consequence of the sparse population.

The percentage of evergreens is about 74.3, which is a little above the average for northern Florida. The fact that this distinctly calcareous region has decidedly more evergreens than regions 4, 5, 11 and 13, where limestone is not much in evidence, seems to indicate once more that there is no close relation between calcium (or limestone) and evergreens. Limestone probably has some effect on the Ericaceae (heath family) though, for only 6.8% of the shrubs are of that family, and practically none of these grow in calcareous flatwoods and low hammocks. The percentage of Leguminosae among the herbs seems to be 5.8, which is also below the average; the explanation probably being that few leguminous plants thrive in damp soils.

Economic Features—Agriculture is not yet very extensively developed here. In 1910 less than 5% of the area was cultivated, and there were only about 7 inhabitants to the square mile—an increase of 35% since 1900. (Most of this increase was in Taylor County, which acquired several new railroads during the decade). About 60% of the population is white.

Lumbering and turpentining of the long-leaf and slash pines are flourishing industries, and considerable cedar is cut for pencil-wood near the coast. Large numbers of cattle graze in the pine woods all the year round, producing beef at very little expense to their owners.

The principal crops, judging from the returns from Taylor County in the State census of 1905 (no crop statistics having been received from the county in 1912), seem to be as follows: Corn, sea-island cotton, peanuts, sugar-cane, sweet potatoes, oats, velvet beans, upland cotton.

16. MIDDLE FLORIDA FLATWOODS.

References. Gillmore (975, 1005), Harper 1 (221), Harper 4 (222-224), Sellards 3 (294 or 48), and U. S. soil survey of Jefferson County (by Jones, Tharp & Belden, 1908). Illustrated in 3d Ann. Rep., pl. 23.2.

The above designation is applied to two disconnected areas parallel to the Gulf Coast and about 20 miles from it: one in Middle Florida and one in East Florida. In the Third Annual Report they were not separated from what is here called the Apalachicola flatwoods (region 9), but their different geographical location entitles them to separate treatment, and some differences in vegetation are discernible. There are about 1,000 square miles of this kind of country in the area under consideration, and a few hundred additional in Levy County. It has no counterpart in any other region. The greater part of the portion west of the Suwannee River is known as San Pedro Bay (a name which appears on few maps).

Geology and Soils—This region is presumably underlaid by the Oligocene limestones which characterize the country on both sides of it, but no outcrops are known, and the limestone has little effect on soil or topography. There are a few spots where the vegetation seems to indicate that there is marl within reach of the roots of trees, but the prevailing soil is mostly fine sand, mixed with more or less vegetable matter, well supplied with water, and probably underlaid by hardpan in many places.

In that part of the region lying in Jefferson County most of the soil is mapped in the government report above cited as "Portsmouth fine sand." The following mechanical analyses of a soil, subsoil, and lower subsoil (depths not indicated) are taken from that report. The soil is described as "a black fine sand with a depth of 6 or 8 inches," with a subsoil of "gray sand changing to reddish brown at about 24 inches below the surface." The dark color of the surface soil is said to be due entirely to vegetable matter; and the dark material which cements the lower subsoil into "hardpan" seems to be also mostly vegetable, with a small amount of iron compounds. This soil is said to be entirely uncultivated, except on its edges where it merges into the "Norfolk fine sand."

MECHANICAL ANALYSES OF "PORTSMOUTH FINE SAND," JEFFERSON COUNTY.

	Soil.	Subsoil.	Lower subsoil.
Fine gravel (2-1 mm.)	0.9	0.6	0.4
Coarse sand (1-.5 mm.)	3.4	4.6	4.8
Medium sand (.5-.25 mm.)	6.8	7.4	7.3
Fine sand (.25-.1 mm.)	35.4	36.1	33.9
Very fine sand (.1-.05 mm.)	41.5	46.5	47.9
Silt (.05-.005 mm.)	6.6	3.8	3.0
Clay (.005-0 mm.)	5.2	1.6	2.6
Total	99.8	100.6	99.9

The distribution of "silt" and "clay" in the soil and subsoil seems to indicate that these materials are mostly vegetable matter rather than true silt and clay. This analysis differs somewhat from those of the soil similarly named in the East Florida flatwoods (quoted farther on), but just what the differences indicate is not clear.

Topography and Hydrography—The surface is level or nearly so, and dotted with many very shallow depressions which are permanently wet and contain peat, indicating that the ground-water is near the surface and fluctuates very little. San Pedro Bay is said by Gillmore to be 85 feet above sea-level, and perceptibly higher than the country around it. As in other flatwoods regions, there are many sluggish creeks and branches with coffee-colored water.

Vegetation Types—The prevailing vegetation on the drier areas is open forests of long-leaf pine and a few other trees, bearing marks of fire as usual. In the depressions there is much pond cypress, sometimes in almost pure stands (cypress ponds), but more commonly mixed with evergreen vines and bushes (bays). The streams are bordered by swamps of the non-alluvial type.

Plants—The following list is based on observations made on three days in January and one each in March, May and July, and does not pretend to be at all complete. Percentage figures are therefore omitted.

TREES

—	**Pinus palustris**	Long-leaf pine	Drier soils
++	Taxodium imbricarium	(Pond) cypress	Bays and ponds
+	**Pinus Elliottii**	(Slash pine)	Bays and ponds
++	**Pinus serotina**	(Black pine)	Low pine land
—	Quercus cinerea	Turkey oak	High pine land
—	**Magnolia glauca**	Bay	Swamps
+	Acer rubrum	Maple	Swamps
—	Nyssa biflora	Black gum	Swamps

+	**Gordonia Lasianthus**	(Red bay)	Bays and swamps
	Taxodium distichum	Cypress	Marly (?) swamps
—	Liquidambar Styraciflua	Sweet gum	Richer soils
—	Quercus Catesbaei	Black-jack oak	Driest spots
—	**Pinus Taeda**	Short-leaf pine	Richer soils
—	**Magnolia grandiflora**	Magnolia	Hammocks
—	Quercus **nigra**	Water oak	Richer soils

(and a few others seen only once).

SMALL TREES OR LARGE SHRUBS

++	**Cyrilla parvifolia**	Tyty	Bays
+	**Cliftonia monophylla**	Tyty	Bays
+	**Myrica cerifera**	Myrtle	Hammocks, etc.
+	**Ilex myrtifolia**	Yaupon	Bays and ponds
	Ilex Cassine		Swamps

WOODY VINES

++	**Smilax laurifolia**	Bamboo vine	Bays, etc.
++	**Pieris phillyreifolia**		Bays and ponds
	Smilax Walteri		Bays and swamps
	Berchemia scandens	Rattan vine	Low hammocks

SHRUBS

+	**Serenoa serrulata**	Saw palmetto	Flatwoods
++	**Pieris nitida**	(Hurrah bush)	Bays, etc.
+	**Ilex glabra**	Gallberry	Flatwoods
++	**Crookea microsepala**		Flatwoods
+	**Hypericum fasciculatum**		Around ponds, etc.
+	**Myrica pumila**	Myrtle	Flatwoods
	Quercus pumila	Oak runner	Flatwoods
+	Aronia arbutifolia		Around bays
	Itea Virginica		Bays and swamps
+	Clethra alnifolia		Around bays
+	Leucothoe racemosa		Bays
	Quercus minima	Oak runner	Flatwoods
	Phoradendron flavescens	Mistletoe	On trees
	Cholisma fruticosa		Flatwoods
+	**Ilex coriacea**		Swamps
+	**Kalmia hirsuta**		Flatwoods

(and about 10 others).

HERBS

++	Anchistea Virginica	(A fern)	Bays and ponds
+	**Tillandsia usneoides**	Spanish moss	On trees
++	Pontederia cordata		Ponds
++	Polygala cymosa		Ponds
—	**Aristida stricta**	Wire-grass	Pine lands
	Pteridium aquilinum	(A fern)	Pine lands
	Pterocaulon undulatum	(Black-root)	Flatwoods
+	**Cladium effusum**	Saw grass	Ponds, etc.
	Sagittaria lancifolia		Ponds
+	Eriocaulon decangulare		Bays, etc.

Trilisa odoratissima	Deer-tongue	Flatwoods
Chryscpsis graminifolia		Flatwoods
+ **Sarracenia psittacina**	Pitcher-plant	Around bays
+ Bartonia verna		Flatwoods
+ Panicum hemitomon	Maiden-cane	Ponds
Osmunda cinnamomea	(A fern)	Around bays, etc.
+ Xyris fimbriata		Ponds
+ Eriocaulon compressum		Ponds
+ Cuscuta compacta	Love-vine	On bushes in swamps
+ **Syngonanthus flavidulus**		Around bays
+ **Lycopodium alopecuroides**		Around bays
Helianthus Radula		Flatwoods
— Eupatorium compositifolium (X)	Dog-fennel	Roadsides, etc.
Mesosphaerum radiatum		Marly (?) places
+ **Castalia odorata**	Water-lily	Ponds
++ Polygala Rugelii		Flatwoods
+ Eupatorium rotundifolium		Flatwoods
(and about 40 others).		

Most of the species of trees indigenous to northern Florida, especially those preferring rich soils, are wanting here. None of the species listed are very rare, but *Cyrilla parvifolia, Crookea,* and *Polygala Rugelii* are confined to Florida, or nearly so. About 69% of the trees, and a still larger proportion of the small trees, shrubs and vines, are evergreen. The percentage of Ericaceae among the shrubs is 18.4, which is above the average. No leguminous plants have been noticed, but they cannot be entirely wanting. The figures for evergreens, Ericaceae and Leguminosae are all pretty close to the corresponding ones for the Apalachicola flatwoods, and indicate acid soils deficient in potassium if not in other minerals. Weeds are scarce, for obvious reasons.

Economic Features—As this region does not cover as much as half of any one county, it is difficult to make an accurate estimate of its population, etc. But it is evidently very sparsely settled, and probably not more than 3% of the area is under cultivation at present. Lumbering, turpentining and grazing are the leading industries. The abundant cypress will doubtless be a source of wealth some time.

Many regions with prevailingly acid soils are particularly rich in honey-yielding plants, and that is the case here. The two most abundant small trees and the saw-palmetto and gallberry are noted honey plants, and many less common species are frequented by bees. The 9,274 pounds of honey reported from Madison, Taylor and Lafayette Counties by the State census of 1905 (and 14,525 pounds by the government census of 1910) probably came mostly from San Pedro Bay and vicinity; and this industry is doubtless capable of much greater development. This is therefore a land of honey, if not of "milk and honey."

17. PENINSULAR LIME-SINK REGION.

(FIGURES 82, 83)

References. Harper 1 (221), Matson & Sanford (359-361, 408-412), Sellards, 3d Ann. Rep. 21-32, Sellards 2 (29), Sellards 3 (294-295 or 48-49), and U. S. soil survey of the "Gainesville area" (by Rice & Geib, 1905). Illustrated in 2nd Ann. Rep., pl. 4.1, 8.1; 4th, pl. 5.1.

This well-marked region extends from a few miles north of the Georgia line southward through the western half of the peninsula to Pasco County at least. About 2,000 square miles of it are included in the arbitrary limits of this report. It bears some resemblance to the West Florida lime-sink region (no. 2), and still more to the Bellair sand region (no. 12), but differs perceptibly from both in its vegetation.

Geology and Soils—The bed-rock here is the Vicksburg limestone, which is overlaid in many places by formations of later age, particularly the hard-rock phosphate beds (Alachua or Dunnellon formation), and nearly everywhere by several feet of pale loamy sand. The rock protrudes through the sand in many places, as in regions 12 and 15. Clay often lies between the rock and sand, especially northward, but exposures of it are rare, and consequently its areal extent is not definitely known. All the hard-rock phosphate mined in Florida comes from this region, and the soil probably contains more phosphorus than the average, though no analyses of it are available at this writing.*

The salamander seems to be more abundant in this region than anywhere else, and its hills, a foot or more in diameter and a few inches high, are nearly always in sight in the drier soils, particularly in early spring just after the woods are burned over. Ants, gophers, and no doubt several other subterranean animals are common, and influence the soil in much the same way that the salamander does.

Topography and Hydrography—This region has a characteristic solution, or *karst*, topography (though possibly influenced some by the wind, as suggested elsewhere), with a profusion of low hills and basin-like depressions, the smallest of which are nearly circular.

*In that part of the lime-sink region included in the "Gainesville area" the soil is nearly all classed as "Norfolk sand" in the government soil survey above cited. But the two mechanical analyses of it given there both represent samples from the hammock belt (no. 10), so that it would not be proper to quote them here.

The highest elevations are about 200 feet above sea-level. In the most hilly portions there may be differences of elevation of 50 feet in half a mile; but there seem to be no steep slopes except on the immediate banks of rivers and sinks. At the other extreme the country may be nearly flat. Some of the depressions contain permanent water and some are dry most of the time. There are a few open sinks, caves, and natural bridges, formed by solution in the usual manner. The best known natural bridge is probably that of the Santa Fe River.

Streams are decidedly scarce, and most of those which do occur are rivers which rise in other regions and flow through this one without receiving any tributaries except a few short spring runs. Consequently swamps are likewise scarce. There are whole townships without any running water, and many square miles without any surface water at all. The rain-water sinks into the sand almost immediately, and gradually finds its way into subterranean channels in the porous limestone. Large limestone springs are fairly common, and some of them are health and pleasure resorts.

In the more elevated areas the ground-water lies so deep that it can be raised to the surface only by buckets or force-pumps. For this reason, and also because of its hardness, many houses in the rural districts have cisterns instead of wells. Practically all the towns have artesian wells.

Vegetation Types—At least nine-tenths of the area was originally covered with park-like open forests of large long-leaf pines, with a "lower story" of black-jack and turkey oaks in many places. The limestone outcrops are too small and often also too silicified to have any perceptible effect on vegetation, except where they are close to streams or sinks and thus protected from fire. There is hammock vegetation along some of the streams and around some of the deeper sinks, where the fires which periodically sweep the pine forests can approach from only one side. Swamps are chiefly confined to the banks of the Suwannee River, and are not very extensive even there. The ponds are nearly all treeless, probably because the water-level fluctuates too much, as is the case with some of the ponds in region 12.

Plants—The following list is based on observations made on 22 different days, distributed through the year as follows: January, 4; February, 5; March, 2; April, 6; May, 1; July, 1; August, 1; December, 2. No doubt some fall-blooming plants have been overlooked, but otherwise the list ought to be reasonably accurate.

TREES

++73.8	**Pinus palustris**	Long-leaf pine	Always in sight
+ 6.7	Quercus Catesbaei	Black-jack oak	Uplands
++ 5.5	Quercus cinerea	Turkey oak	Uplands
2.6	Liquidambar Styraciflua	Sweet gum	Hammocks, etc.
1.5	Quercus falcata	Red oak	Richer soils
— 0.9	**Pinus Taeda**	Short-leaf pine	Along Suwannee R.
0.7	**Quercus Virginiana**	Live oak	Hammocks, etc.
— 0.5	Taxodium imbricarium	Pond cypress	Shallow ponds
— 0.5	Taxodium distichum	Cypress	Swamps
0.4	**Quercus laurifolia**		Hammocks
0.4	**Quercus geminata**	Live oak	Uplands
— 0.3	Cornus florida	Dogwood	Hammocks, etc.
0.3	**Juniperus Virginiana**	Cedar	Along Suwannee R.
— 0.3	**Magnolia grandiflora**	Magnolia	Hammocks
— 0.3	**Pinus Elliottii**	(Slash pine)	Shallow ponds, etc.
0.2	Hicoria alba	Hickory	Richer soils
+ 0.2	Planera aquatica		Along Suwannee R.
0.2	Salix nigra?	Willow	River-banks, etc.
+ 0.2	Quercus Margaretta	Post oak	Uplands
0.2	Fraxinus Caroliniana	Ash	Swamps
0.2	Betula nigra	Birch	Along Suwannee R.
0.1	Acer rubrum	Maple	Swamps
+ 0.1	Gleditschia aquatica?	Honey locust	Along Suwannee R.
0.1	Ulmus Floridana	Elm	Swamps
— 0.1	**Ilex opaca**	Holly	Hammocks
— 0.1	**Pinus glabra**	Spruce pine	Along Suwannee R.
— 0.1	Quercus nigra	Water oak	Low grounds
0.1	Cercis Canadensis	Redbud	Richer soils
0.1	Crataegus viridis	Haw	Along Suwannee R.
— 0.1	**Sabal Palmetto**	Cabbage palmetto	Along Suwannee R.
0.1	Acer rubrum tridens?	Maple	Along Suwannee R.
0.1	**Persea Borbonia**	Red bay	Hammocks
0.1	Quercus lyrata	(Swamp post oak)	Along Suwannee R.
0.1	**Quercus hybrida?**		Low hammocks
	(and 14 others).		

SMALL TREES OR LARGE SHRUBS

+ .04	Diospyros Virginiana (X?)	Persimmon	Uplands
+ .03	Crataegus aestivalis	May haw	Ponds and swamps
+ .02	**Ilex myrtifolia**	Yaupon	Shallow ponds, etc.
+ .02	Adelia acuminata		Along Suwannee R.
+ .01	Crataegus Michauxii	Haw	Uplands
.01	Prunus angustifolia **(X)**	Wild plum	Old fields
— .01	**Myrica cerifera**	Myrtle	Hammocks
.01	Cyrilla **racemiflora**	Tyty	Swamps
.01	Batodendron **arboreum**	Sparkleberry	Hammocks
.01	Chionanthus Virginica	Graybeard	Hammocks
.01	Sassafras variifolium (X)	Sassafras	Old fields
.01	Prunus umbellata?	Hog plum	Hammocks, etc.
.01	Crataegus apiifolia	Haw	Along Suwanee R.

WOODY VINES

.001	Parthenocissus quinquefolia	Virginia creeper	Hammocks, etc.
.001	Berchemia scandens	Rattan vine	Swamps
.001	Ampelopsis arborea		Edges of swamps
	Wistaria frutescens	Wisteria	Along Suwannee R.
	Vitis rotundifolia	Bullace or Muscadine	Hammocks, etc.
	Vitis aestivalis	Wild grape	Hammocks

SHRUBS

—.027	**Serenoa serrulata**	Saw palmetto	Pine lands
++.025	**Myrica pumila**	Myrtle	Pine lands
++.018	Rhus copallina	Sumac	Various situations
++.015	Castanea alnifolia	Chinquapin	High pine land
++.014	Asimina speciosa	Pawpaw	High pine land
+.012	Quercus pumila	Oak runner	High pine land
.009	Chrysobalanus **oblongifolius**		High pine land
+.005	**Ceratiola ericoides**	Rosemary	Poorest soils
.003	Cephalanthus occidentalis	Elbow-bush	Ponds and swamps
+.003	Asimina angustifolia	Pawpaw	High pine land
+.002	Rhus Toxicodendron	Poison oak	High pine land
—.002	**Pieris nitida**	(Hurrah bush)	Around ponds
.001	Cornus stricta?		Swamps
.001	Viburnum **obovatum**		Swamps
.001	Polycodium sp.	Gooseberry	Sandy hammocks, etc.
.001	**Phoradendron flavescens**	Mistletoe	On trees
.001	Aralia spinosa	Prickly ash	Low hammocks
.001	Asimina parviflora	Pawpaw	Hammocks
+.001	**Ceanothus microphyllus**		High pine land
—	Itea Virginica		Swamps
	Rubus cuneifolius (X)	Blackberry	Roadsides, etc.
	Amorpha fruticosa (and 10 or 12 others).		Along Suwannee R.

HERBS

++.018	**Aristida stricta**	Wire-grass	High pine land
+.007	Kuhnistera pinnata	Summer farewell	High pine land
++.006	Eupatorium compositifolium (X?)	Dog-fennel	High pine land etc.
++.004	Pteridium aquilinum	(A fern)	High pine land
.003	**Tillandsia usneoides**	Spanish moss	On trees
++.003	**Eriogonum tomentosum**		High pine land
++.002	Chamaecrista fasciculata	Partridge-pea	High pine land
++.002	Psoralea canescens		High pine land
++.001	Eupatorium aromaticum		High pine land
++.001	Andropogon Virginicus	Broom-sedge	High pine land
+.001	Pterocaulon undulatum	Black-root	Pine lands
++.001	**Zamia integrifolia**	Coontie	High pine land, Alachua Co.
++.001	Carphephorus corymbosus		High pine land
++.001	Crotonopsis spinosa (X?)		Roadsides, etc.

+.001	Croton argyranthemus		High pine land
+.001	Sporobolus gracilis	(A grass)	High pine land
++.001	Actinospermum angustifolium		High pine land
+	Andropogon scoparius (X?)	Broom-sedge	Old fields
+	Lespedeza hirta		High pine land
	Helenium tenuifolium (X)	Bitter-weed	Roadsides, etc.
	Acanthospermum australe	(X)	Roadsides, etc.
++	Lygodesmia aphylla		High pine land
+	Rumex hastatulus (X)	(Sorrel)	Fields
+	Stillingia sylvatica	(Queen's delight)	High pine land
+	Amsonia ciliata		High pine land
+	Glottidium vesicarium (X)		Waste places
++	Berlandiera subacaulis		High pine land
+	Vernonia angustifolia		High pine land
++	Piriqueta Caroliniana		High pine land
+	Heteropogon melanocarpus (X)	(A grass)	Old fields
+	Cnidoscolus stimulosus	Nettle	High pine land
+	Baptisia LeContei?		High pine land
++	Silphium compositum		High pine land
	Erigeron ramosus (X)		Old fields, etc.
	Euthamia Caroliniana (X?)		Around ponds, etc.
	Chrysopsis aspera?		High pine land
	Dolicholus simplicifolius	(Dollar-weed)	High pine land
+	Opuntia vulgaris	Prickly pear	High pine land
+	Hymenopappus Carolinensis (X)		Old fields, etc.
+	Indigofera Caroliniana		High pine land
+	Eupatorium album		High pine land
	Leptilon Canadense (X)		Fields, etc.
+	Dactyloctenium Aegyptium (X)	Crowfoot grass	Cultivated fields
	Cassia Tora (X)	Coffee-weed	Waste places
	Sericocarpus bifoliatus		High pine land
+	Calophanes oblongifolia		High pine land
+	Scutellaria multiglandulosa		High pine land
	Scleria glabra	(A sedge)	High pine land
+	Stenophyllus Warei	(A sedge)	High pine land
	(and about 75 others).		

Most trees which prefer damp soils or clayey soils are scarce or absent in this region. Small trees, shrubs and vines are relatively scarce, too, doubtless because most such plants cannot stand much fire, and areas sufficiently protected from fire for them to flourish (such as swamps) are very limited. The most abundant shrub, the saw-palmetto, is less abundant here than it is in most other parts of Florida. The first seven shrubs and some of the others have thick underground stems which quickly send up new shoots after a fire, while the eighth, which is very sensitive to fire, grows only in the poorest soils, where the vegetation is too sparse to carry flames readily. (See fig. 82.) Most of the herbs grow in the dry long-leaf pine forests, and quite a number of them are more abundant here than in any other region previously described.

About 79.3% of the trees are evergreen, only 2.3% of the shrubs are Ericaceae, and over 20% of the herbs are Leguminosae. The figure for evergreen trees is mostly made up by one species, the long-leaf pine, which prefers richer soils than some other evergreens, and the proportion of evergreens among the shrubs and herbs is perceptibly lower. The very low figure for Ericaceae is partially explained by the scarcity of low pine land, sour bays, non-alluvial swamps, etc., but not wholly, for *Gaylussacia dumosa,* the commonest Ericaceous shrub in the somewhat similar Bellair sand region, has not been observed in the lime-sink region at all. It is possible that the soil is a little too limy for these plants, as was suggested in the case of the Gulf hammock region. The percentage of Leguminosae is among the highest, and is doubtless correlated with the prevalence of fire and consequent scarcity of humus, as well as the dry and somewhat calcareous nature of the soil.

Economic Features—Although the prevailing dry sandy soil might look very unpromising, to a person unaccustomed to such soils, it is capable of producing excellent crops. In 1910 about 22% of the area was improved land (a pretty high figure for Florida), and there were about 24 inhabitants to the square mile, an increase of 12% in ten years. White people are slightly in the majority. Probably the chief drawback to residence in this region is the scarcity of water, but that same condition also makes mosquitoes scarce, which is no small compensation.

Some of the largest sawmills in the State have operated here, turning out a vast amount of long-leaf pine lumber, and the supply is far from being exhausted yet. Turpentining is of course also an important industry. Around the phosphate mines, particularly in Alachua County, the pine has been cut out pretty thoroughly for fuel for drying the phosphate rock, leaving most desolate landscapes (see fig. 83). But thickets of young pines are springing up in many places, (there seemed to be more of them in 1914 than in 1909), and if more conservative methods of drying the rock are adopted soon, or even if the present depression in the phosphate export trade continues long enough, the forests may have a good chance to restore themselves.

The only county which is mostly in this region is Suwannee, and no crop returns were received from that by the State agricultural department in 1912. But according to the State census of 1905 its leading crops, in order of value, were as follows: Sea-island cotton, corn, peanuts, sugar-cane, sweet potatoes, field peas, (grass) hay, oats, velvet beans, pecans, peaches, and watermelons.

18. PENINSULAR LAKE REGION.

(FIGURE 84)

References. Harper 1 (223-224), Harper 7 (359), Matson & Sanford (391-393), Sellards, 2nd Ann. Rep. 242-243, Sellards 2 (12, 30-31), Sellards 3 (295-296, or 49-50), Sellards & Gunter 2 (93-94, 153), Smith 2 (232, 233). Illustrated in 3d Ann. Rep., pl. 12.1; 4th, pl. 10.1; 5th, pl. 11.1.

This region is distinctly peculiar to Florida, with no counterpart elsewhere. It extends from the vicinity of Lake Kingsley in Clay County southward down the axis of the peninsula for some 200 miles. This report considers only that part included in Clay and Putnam Counties, about 500 square miles.

Geology and Soils—Rock outcrops are very rare, and chiefly confined to the vicinity of large springs, none of which are known in the portion of the lake region under consideration; consequently no definite statement can be made about the Tertiary geology. The lowest stratum exposed in railroad cuts and other excavations is a pale, more or less mottled clay, which is usually rather sandy, but in some places is pure enough to be mined for kaolin. On the uplands the surface is everywhere several feet of more or less loamy sand, about like that of the lime-sink region just described. (Neither mechanical nor chemical analyses of it are available at this writing.) Its prevailing color is cream or pale buff, but in the areas known as scrub (described further under the head of vegetation) it is usually almost snow-white, on the surface at least. In many depressions several feet of peat overlies the sand.

Salamanders, gophers, and other burrowing animals are almost as common here as in the lime-sink region, but they seem to avoid the white sand of the scrub.

Topography and Hydrography—The prevailing topography is much like that of the lime-sink region, with rounded hills and basins and few streams or valleys, but on a somewhat larger scale. Some of the basins may be as much as 100 feet deep (i. e., if filled with water to overflowing the water would have that depth). It is said that Lake Kingsley averages 60 feet deep, and has some places in it considerably deeper. In the vicinity of the Ocklawaha and St. Johns Rivers there are wide stretches of flatwoods scarcely distinguishable from the East Florida flatwoods (described next), with which they are indeed connected. The rolling topography of the uplands is not so evidently the result of solution as is that of the lime-sink region, and no satisfactory explanation of it has yet been offered. Lime-sinks, caves and natural bridges are unknown, and springs rare.

The ground-water level is generally nearer the surface and more constant here than in the lime-sink region. Nearly all the depressions contain beautiful lakes, averaging at least one to the square mile, and ranging in size from an acre to several square miles. Lakes only a short distance apart sometimes differ considerably in elevation, showing that the ground-water surface is irregular, probably conforming approximately with that of the clay substratum. Some of the smallest lakes have become filled with peat, and some of the larger ones show plainly the effects of wave action on their shores. Some of the lakes have remarkably clear water, but in most of them, as in the few streams, it is tinged brown from vegetable matter, though practically free from lime or mud.

Vegetation Types—The uplands are covered mostly with high pine land vegetation, subject to fire every year or two, much like that of the lime-sink region. A very different upland type of vegetation, in northern Florida almost confined to the lake region, is known as scrub. This is almost wholly evergreen, and practically devoid of grasses and Leguminosae. Both in the lake region and elsewhere this sort of vegetation occurs almost always on white sand with very little animal life in it. Fire sweeps through the scrub on the average about once in the average life-time of the dominant tree (*Pinus clausa*), and kills the pines, but they soon come up again from seed.

The more level areas, or flatwoods, have low pine land vegetation not very different from that in some of the other regions. In the flatwoods near the Ocklawaha River there are places where the vegetation seems to indicate marl near the surface, both in the fire-swept pine forests and in shady low hammocks something like those in the Gulf hammock region. Sandy hammocks, or high hammocks, occur near some of the streams and lakes, especially on peninsulas. The streams and lakes are bordered in many places by non-alluvial swamp vegetation, and there are quite a number of peat prairies or marshes, like those described in the Third Annual Report (pp. 274-275).

Plants—The following list is based on observations made on 3 days in January, 5 in May, 2 in July and 1 in December; only 11 in all. It therefore cannot be considered very complete, especially for fall flowers, and some of the percentages for herbs may not be very accurate.

TREES

+52.0	**Pinus palustris**	Long-leaf pine	Uplands
+10.2	Quercus Catesbaei	Black-jack oak	Uplands
+ 8.0	**Pinus serotina**	(Black pine)	Low pine land
— 5.1	**Pinus Elliottii**	(Slash pine)	Low pine land
+ 4.4	Quercus cinerea	Turkey oak	High pine land
+ 4.3	**Pinus clausa**	Spruce pine	Scrub
3.0	**Magnolia glauca**	Bay	Swamps
+ 2.5	**Sabal Palmetto**	Cabbage palmetto	Low hammocks
— 1.4	Liquidambar Styraciflua	Sweet gum	Low hammocks, etc.
— 1.2	**Magnolia grandiflora**	Magnolia	Hammocks
— 1.2	Taxodium imbricarium	(Pond) cypress	Shallow ponds
1.0	Acer rubrum	Maple	Swamps
+ 0.8	**Gordonia Lasianthus**	(Red bay)	Non-alluvial swamps
— 0.8	**Pinus Taeda**	Short-leaf pine	Low hammocks
— 0.4	Taxodium distichum	Cypress	River-swamps, etc.
— 0.3	**Quercus Virginiana**	Live oak	Hammocks
0.3	Fraxinus Caroliniana?	Ash	Swamps
0.2	Fraxinus sp.	Ash	Swamps
— 0.2	Liriodendron Tulipifera	Poplar	Low hammocks
— 0.2	**Quercus laurifolia**		Hammocks
+ 0.2	**Quercus Chapmani**		Sandy hammocks
0.2	Carpinus Caroliniana	Ironwood	Low hammocks, etc.
— 0.1	Quercus **nigra**	Water oak	Swamps, etc.
— 0.1	Quercus Margaretta (and 5 others).	Post oak	High pine land

SMALL TREES OR LARGE SHRUBS

+ .16	**Quercus geminata**	(Smaller) live oak	Scrub, etc.
+ .12	**Quercus myrtifolia**		Scrub
.13	**Myrica cerifera**	Myrtle	Low hammocks, etc.
+ .11	**Cholisma ferruginea**		Scrub mostly
+ .03	**Ilex Cassine**		Non-alluvial swamps
.02	Batodendron **arboreum**	Sparkleberry	Sandy hammocks
.02	**Persea pubescens?**	Red bay	Non-alluvial swamps
.02	**Ilex opaca?**	Holly	Scrub
++ .01	**Persea humilis**		Scrub
.01	Prunus angustifolia (X)	Wild plum	Old fields, etc.
.01	**Osmanthus Americana**		Sandy hammocks

WOODY VINES

+.013	**Smilax laurifolia**	Bamboo vine	Non-alluvial swamps
—.002	Vitis rotundifolia	Bullace or Muscadine	Hammocks, etc.
+.001	**Smilax auriculata**		Scrub
.001	Parthenocissus quinquefolia (and 4 others).	Virginia creeper	Low hammocks

SHRUBS

.077	**Serenoa serrulata**	Saw-palmetto	Various situations, including scrub
+.024	Chrysobalanus **oblongifolius**		High pine land
+.011	Asimina speciosa	Pawpaw	High pine land
+.011	**Hypericum fasciculatum**		Around lakes
+.011	**Ilex glabra**	Gallberry	Flatwoods
+.009	**Pieris nitida**	(Hurrah bush)	Non-alluvial swamps, etc.
+.008	**Cholisma fruticosa**		Flatwoods
+.007	**Vaccinium nitidum**		Low pine land, etc.
.007	**Myrica pumila**	Myrtle	Pine lands
+.006	**Ceratiola ericoides**	Rosemary	Scrub
++.005	**Garberia fruticosa**		Scrub
.004	Diospyros Virginiana (X)	Persimmon	Uplands
+.003	**Ceanothus microphyllus**		High pine land
.003	Rhus copallina	Sumac	Uplands
+.003	**Bejaria racemosa**		Low pine land, etc.
+.003	**Quercus minima**	Oak runner	Flatwoods
.002	**Sabal glabra**	Palmetto	River-swamps
.002	Gaylussacia frondosa	Huckleberry	Low pine land, etc.
.002	Sambucus Canadensis (X?)	Elder	Swamps
—.002	Cephalanthus occidentalis		Swamps, etc.
.002	**Kalmia hirsuta**		Flatwoods
.001	**Phoradendron flavescens**	Mistletoe	On trees
.001	Rubus cuneifolius (X)	Blackberry	Uplands
.001	Aralia spinosa	Prickly ash	Low hammocks, etc.
	(and about 10 others).		

HERBS

+.007	**Aristida stricta**	Wire-grass	High pine land
+.005	**Tillandsia usneoides**	Spanish moss	On trees
+.005	Kuhnistera pinnata	(Summer farewell)	High pine land
+.003	Osmunda cinnamomea	(A fern)	Low pine land
+.003	Eupatorium compositifolium (X?)	Dog-fennel	Roadsides, etc.
+.002	**Eriogonum tomentosum**		High pine land
+.001	Pterocaulon undulatum	(Black-root)	Pine lands
+.001	Panicum hemitomon	Maiden cane	Lake shores, etc.
+.001	Psoralea canescens		High pine land
+.001	Anchistea Virginica	(A fern)	Low pine land, etc.
+.001	**Cladium effusum**	Saw-grass	Marly (?) places
.001	Pluchea bifrons		Marly (?) flatwoods
+.001	Actinospermum angustifolium		High pine land
+.001	Andropogon Virginicus	Broom-sedge	High pine land
.001	Rhexia Alifanus		Low pine land
.001	**Pteridium aquilinum**	(A fern)	High pine land

.001	Sporobolus gracilis	(A grass)	High pine land
+.001	Doellingeria reticulata		Low pine land
+.001	**Spartina Bakeri**	(A grass)	Around lakes, etc.
+.001	**Nymphaea macrophylla**	(Bonnets)	Lakes, etc.
.001	Silphium compositum		High pine land
	Sarracenia minor	Pitcher-plant	Flatwoods
	Fuirena scirpoidea	(A sedge)	Lake shores
	Lygodesmia aphylla		High pine land
+	**Eryngium aromaticum**		High pine land
+	Helianthella grandiflora?		Pine lands
+	Stenophyllus ciliatifolius	(A sedge)	High pine land
+	**Castalia odorata**	Water-lily	Lakes
—	Helenium tenuifolium (X)	Bitter-weed	Roadsides, etc.
+	Indigofera Caroliniana		High pine land
+	Mesadenia Floridana		High pine land
	Ludwigia virgata		Flatwoods
	Sericocarpus bifoliatus		High pine land
+	**Rhynchospora dodecandra**	(A sedge)	Scrub
+	Juncus scirpoides compositus		Lake shores, etc.
+	**Piaropus crassipes** (X)	Water-hyacinth	Lakes and rivers
+	Stenophyllus Warei	(A sedge)	High pine land
++	Chapmania Floridana		High pine land
	Croton argyranthemus		High pine land
	Froelichia Floridana (X)		Fields
	Acanthospermum australe (X)		Roadsides, etc.
+	Andropogon Elliottii?	(A grass)	High pine land
+	**Lachnocaulon Beyrichianum?**		Lake shores
+	**Aletris lutea**		Flatwoods
	Polygala cymosa		Peat prairies, etc.
	Campulosus aromaticus	(A grass)	Flatwoods
	(and about 75 others).		

The following trees which are more or less common in other regions in the same latitude are rare or absent in the northern part of the lake region:—*Pinus echinata* (short-leaf pine), *P. glabra* (spruce pine), *Taxodium* (cypresses), *Chamaecyparis* (juniper), *Juniperus* (cedar), *Hicoria* (hickories), *Salix* (willows), *Ostrya*, *Betula* (birch), *Fagus* (beech), several species of *Quercus* (oaks), *Morus* (mulberry), *Ulmus* (elms), *Celtis*, (hackberry), *Malus* (crab-apple), *Crataegus* (haws), *Prunus* (plums), *Cercis* (redbud), *Ilex opaca* (holly), *Tilia* (lin, basswood), *Nyssa* (black and tupelo gums), *Cornus florida* (dogwood), *Oxydendrum* (sourwood), and *Halesia*. Most of these seem to be partial to clayey, calcareous phosphatic or alluvial soils, and their absence is thus easily explained. Weeds are likewise scarce, on account of the small amount of cleared land.

Persea humilis, Garberia, and several herbs too rare to appear in the above list are almost confined to the lake region, and their usual habitat is the scrub. *Chapmania*, a characteristic though not very common plant of the high pine land, is confined to Florida, but grows in the lime-sink region as well. *Pinus clausa* is almost confined to Florida, but grows along the coasts, like several other scrub plants. (Farther south in the lake region there are many plants peculiar to it.)

About 79.6% of the trees are evergreen, 15.4% of the shrubs are Ericaceae, and 15.2% of the herbs are Leguminosae. This is a much larger proportion of Ericaceae and a smaller proportion of Leguminosae than in the lime-sink region, and doubtless indicates significant differences in the soil. It is noteworthy that the percentage of evergreens among the small trees, shrubs and vines is considerably higher here than in the lime-sink region, though that of evergreen trees is nearly the same in both.

Economic Features—For some reason, or combination of reasons, lumbering and turpentining do not seem to be practised as extensively in this region as in most other parts of Florida. There is not very much farming either, and what little there is is much more typically Floridian than that in the lime-sink region, where the crops are mostly the staples common to all the southeastern states. In the lake region, unlike any previously described, citrous fruits lead, and cotton and corn are of secondary importance. The leading crops in Putnam County in 1912, in order of value, were as follows: Oranges, Irish potatoes, grapefruit, corn, sweet potatoes, peaches, sea-island cotton, field peas (and hay thereof), watermelons, peanuts, pears, oats, tomatoes, cabbage, plums, pecans, rice and upland cotton. If the flatwoods which cover about half the county could be excluded, it would probably make Irish potatoes, corn and cotton take a still lower rank.

The proportion of improved land in Clay and Putnam Counties (including both lake region and flatwoods) in 1910 was less than 4%, and the density of population about 15 per square mile, an increase of 12% in ten years. White people are evidently in the majority in the lake region.

One of the greatest assets of this region is its scenery. This together with the climate for which Florida is famous attracts many winter visitors of an unostentatious class, who like to enjoy themselves in a simple way.

19. EAST FLORIDA FLATWOODS.

(FIGURES 85, 86)

References. Gillmore (974), Harper 1 (224-225, 250-251, 272, 287-290), Harper 3 (229-232, 235), Matson & Clapp (29, 108-113), Matson & Sanford (126, 267-270, 283-287, 296-301, 373-376, 394-398). Sellards & Gunter 2 (126, 135-137, 141-143), Smith 2 (230-233), and U. S. soil surveys of the "Gainesville area" (1905), "Jacksonville area" (1911), and Bradford Co. (1914). Illustrated in 2nd Ann. Rep., pl. 6.2; 3d, pl. 10.1, 14.3, 23.1, 28, fig. 24; 4th, fig. 3; 5th, pl. 13.3, 14.1.

The flatwoods of northeastern Florida extend northward along the coast to the vicinity of the Savannah River, where their character gradually changes. Going inland in Georgia this region passes gradually at a distance of 50 to 100 miles from the coast into the Altamaha Grit region or rolling wire-grass country, which is a direct continuation of the West Florida pine hills already described (region 7). In the area under consideration these flatwoods cover about 5,300 square miles. Farther south there is nothing exactly similar, for the extensive flatwoods of peninsular Florida differ in several ways.

Geology and Soils—Fossiliferous marly strata are exposed on the banks of a few creeks and rivers in the eastern half of this region, and have been mapped as Miocene. Throughout the greater part of the area the marl seems to be overlaid by several feet of essentially non-calcareous sandy clay, and that in turn by a few feet or inches of grayish sand, which is regarded by some as a distinct Pleistocene formation and by others as a mere product of weathering. In many places, however, particularly on Trail Ridge (described under Topography, below) the sand passes at a depth of two or three feet into blackish "hardpan," and in such places there are usually no excavations deep enough to disclose whether clay is present beneath the hardpan or not. Another variation in the arrangement of the surface formations (if the sand and clay be regarded as such) is that within 25 miles of the coast there are many low spots where the vegetation seems to indicate the proximity of marl to the surface, and consequently the sand and clay must be thin or wanting.

The sand which forms the surface everywhere except in the marly spots and where covered by muck or peat is fine-grained and usually rather dark-colored from admixture of vegetable matter. In all three of the government soil surveys above cited the most extensive type of soil in the flatwoods is called "Portsmouth fine sand." (In the "Gainesville area," which is mostly in regions 10 and 17, this soil is said to cover 11.5%, or 35,840 acres; in Bradford County, which is about nine-tenths flatwoods, 39.3%; and in the "Jacksonville area," which is all flatwoods, 46.5%. And some of the other soils which cover large parts of these areas differ from this one but slightly). The following mechanical analyses of this soil and its subsoil are taken from the Gainesville and Jacksonville reports (none being given in the Bradford County report).

1. One mile northwest of Paradise, Alachua Co.* A gray medium sand, 0 to 20 inches.
2. Subsoil of same. A brown medium sand, 20 to 36 inches.
3. Average of four localities in Duval County. Soil (depth not given).
4. Subsoil of same. Depth not given.
5. Lower subsoil, average of two localities. Depth not given.

MECHANICAL ANALYSES OF "PORTSMOUTH FINE SAND," EAST FLORIDA FLATWOODS

	1	2	3	4	5
Fine gravel (2-1 mm.)	0.4	0.8	0	0	0
Coarse sand (1-.5 mm.)	10.4	10.3	0.8	0.5	0.4
Medium sand (.5-.25 mm.)	23.1	22.5	2.4	2.5	2.1
Fine sand (.25-.1 mm.)	49.8	46.8	84.9	83.7	83.8
Very fine sand (.1-.05 mm.)	12.5	13.1	4.0	5.9	5.7
Silt (.05-.005 mm.)	2.4	2.5	4.9	3.8	4.1
Clay (.005-0 mm.)	1.1	3.7	2.7	3.5	3.3
Total	99.7	99.7	99.7	99.9	99.4

If these are all typical samples the soil is evidently of coarser texture in Alachua County than in Duval; but what significance, if any, is to be attached to this is not at present evident.

A chemical analysis of soil from the same region is given in the Tenth Census, vol. 6, p. 202. The sample represents 10 inches depth of "second-class pine land," with long-leaf pine and wiregrass, 5 miles north of Lake City, Columbia County; collected by Dr. Eugene A. Smith in the summer of 1880 and analyzed under his direction at the University of Alabama by John B. Durrett, by the acid digestion method mentioned on preceding pages.

*In the Gainesville report as published (page 20 of the advance sheets or page 284 of the whole volume) this was inadvertently placed in a table headed "Gainesville sand."

Water and organic matter	1.807	per cent
Potash	.117	" "
Soda	.064	" "
Lime	.058	" "
Magnesia	.042	" "
Phosphoric acid	.092	" "
Sulphuric acid	.058	" "
Brown oxide of manganese	.049	" "
Peroxide of iron	.224	" "
Alumina	.473	" "
Soluble silica	.879	" "
Insoluble matter	95.630	" "
Total	99.493	" "

As compared with the three other northern Florida soils analyzed in the same report, this has the most potash, soda, and insoluble matter, and the least organic matter, lime, iron, alumina, and soluble silica. Just why the potash should be so high in such a soil is a puzzle; unless possibly the woods had been burned over shortly before the sample was taken. Additional analyses from the same region would be very desirable.

The soils of this region, as in other pine flatwoods regions, are prevailingly acid. The soil survey of Bradford County gives the amounts of lime (CaO) and limestone ($CaCO_3$) necessary to neutralize the acidity of an acre of soil a foot thick for two of the principal soil types. The following are the figures for the "Portsmouth fine sand," in pounds:

	Lime	Limestone
Surface soil	3,850	7,700
Hardpan stratum	6,300	12,600
Subsoil	2,450	5,900

Salamanders are common in the driest soils, but in much of the area the ground-water seems to be too close to the surface for them.

Topography and Hydrography—The topography is for the most part flat, as in some of the regions previously described, but the land rises gradually in leaving the coast, until at the inland edge of the region it reaches elevations of about 150 feet at Jasper, 200 at Welborn and Lake City, and 175 at Gainesville. It is noteworthy that all along this edge the flatwoods are higher than the adjacent hammock belt, which slopes westward toward the Gulf. Near the edge are several deep sinks where the strata overlying the limestone have caved in.* South of Waldo the topography is a little undulating, and may indicate somewhat different geological conditions.

The most striking topographic feature of the region is Trail Ridge, which extends from a few miles west of Jesup, Georgia, southward parallel to the coast and about forty miles distant from it, until it merges with the western edge of the lake region. (It is indicated by a dotted line on the map.) Its summit is said to be 210 feet above sea-level at Highland, and 238 feet east of Starke.† Its origin has never been satisfactorily explained. In Florida it coincides for some distance with the Atlantic and Gulf divide, but that is probably merely accidental, for it has no such relation in Georgia.

About fifteen miles east of Trail Ridge, and parallel to it, both in Georgia and in Florida, is another ridge so low that a person not specially looking for it would hardly notice it;‡ but in some ways it seems more significant than Trail Ridge. For it causes the Satilla and St. Mary's Rivers to flow parallel to the coast for many miles just before they break through it, and the marly spots mentioned in a preceding paragraph nearly all lie east of it.

The stream valleys are mostly narrow and but little depressed below the general surface, though in some of them there is a slight development of the same sort of rolling topography that characterizes the West Florida pine hills. Springs are rather scarce, but there are a few large limestone springs, of which Green Cove Springs, in the town of the same name, is probably the best known. The streams are practically all coffee-colored, bordered by swamps, and not subject to much fluctuation. The St. John's River is nota-

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*Probably the most noted of these sinks is the "Devil's Millhopper," in Alachua County, about three miles west of Paradise or six miles northwest of Gainesville. It is over 100 feet deep, nearly circular, and surrounded by level flatwoods. For additional notes on it, see Dall, U. S. Geol. Surv. Bull. 84:108. 1892; Vaughan, U. S. Geol. Surv. Min. Res. 1901:932. 1902; Sellards, Fla. Geol. Surv. Bull. 1:29. 1908; Matson & Clapp, Sellards & Gunter, 2nd Ann. Rep. 71-72, 288. 1910; Sellards, 4th Ann. Rep. 34-35. 1912.

†In U. S. Geol. Surv. Bulletin 516, p. 17 (1912), the elevation of a point 2.6 miles northwest of Lake Kingsley, which must be on or near the summit of Trail Ridge, is given as 238.382 feet. This agrees remarkably well with a statement by Dr. W. I. Burnett in Am. Jour. Sci. 67:408 (1854) that a point "one mile west of Kingsley's pond and seven miles east of Sampson's pond" is 237½ feet above low tide.

‡For references to previous literature relating to this ridge see Bull. Torrey Bot. Club 38:230. 1911. The Georgia end of it has since been described (as a terrace) by Otto Veatch in Geol. Surv. Ga. Bull. 26:36, 426, 434. (Jan. 1912).

ble for being a tidal estuary all the way through this region, a distance of nearly 100 miles.

Shallow ponds and bays a few acres in extent, which dry up in spring, are frequent throughout, and west of Trail Ridge there are several large shallow lakes.* The ground-water is nearly everywhere close enough to the surface to be easily raised by suction pumps. Old-fashioned "well-sweeps" can still be seen in a few places. Artesian wells are common, and furnish good water in abundance, which rises above the surface nearly everywhere east of the low ridge or terrace above mentioned.

Vegetation Types—Open forests of long-leaf pine, with an undergrowth of saw-palmetto, gallberry, wire-grass, etc., and bearing the marks of frequent fires, are the dominant feature of the landscape. On the highest and driest spots the black-jack oak is a conspicuous feature, as in the high pine land of several other regions. The streams are all bordered by swamps or hammocks, or both. The shallow ponds are all full of trees, either black gum, cypress, slash pine, or bay vegetation predominating, according to the nature of the soil and the amount of seasonal fluctuation of the water. Treeless marshes occur in some places along the St. John's River and its tributaries, passing gradually into the brackish marshes of the coast. The vegetation of marly spots, referred to above, is much like that of the low hammocks of the Gulf hammock region. A few miles back from the coast in St. John's County there are a few areas of scrub vegetation, probably indicating old dunes.

Plants—In order to bring out certain differences, as well as similarities, between the western and eastern halves of the region the percentages have been computed separately for the portions on opposite sides of Trail Ridge. The first column of figures is for the western division and the other for the eastern. Field work in the western portion has been done on 30 different days, distributed through the year as follows: January, 3; February, 1; March, 1; April, 2; May, 8; July, 11; August, 2; December, 2. The eastern portion has been explored on 21 different days, as follows: January, 3; February, 1; March, 2; May, 8; July, 2; August, 1; December, 4. As I have no notes for either portion between the first week in August and the second week in December no doubt many of the fall-blooming herbs do not figure as largely in the following list

*See 3d Ann. Rep., p. 272.

as they should. But with this exception it ought to be reasonably accurate.

TREES

+47—40	**Pinus palustris**	Long-leaf pine	Flatwoods
++20—17	**Pinus Elliottii**	Slash pine	Low grounds
+18—13	Taxodium imbricarium	(Pond) cypress	Ponds, etc.
+1.4—9.0	**Pinus serotina**	(Black pine)	Low grounds
+2.6—2.8	Nyssa biflora	Black gum	Ponds and swamps
—1.0—2.7	Liquidambar Styraciflua	Sweet gum	Richer soils
—1.4—2.2	Quercus Catesbaei	Black-jack oak	Driest soils
—1.8—1.4	**Magnolia glauca**	Bay	Swamps
—1.4—1.5	**Pinus Taeda**	Short-leaf pine	Richer soils
0.3—1.5	Acer rubrum	Maple	Swamps
++0.5—1.0	**Gordonia Lasianthus**	(Red bay)	Swamps and bays
—0.5—1.0	Quercus cinerea	Turkey oak	Driest soils
—0.5—0.8	Taxodium distichum	Cypress	Swamps
0.2—0.7	**Sabal Palmetto**	Cabbage palmetto	Low hammocks, etc.
—0.2—0.7	**Magnolia grandiflora**	Magnolia	Hammocks
—0 —0.7	**Pinus clausa**	Spruce pine	Old dunes?
0.2—0.5	**Pinus Caribaea?**	(Pitch pine)	
—0.2—0.2	Quercus **nigra**	Water oak	Low grounds
—0.2—0.2	**Quercus geminata**	Live oak	Poorest soils
—0.1—0.2	**Quercus Virginiana**	Live oak	Hammocks
—0 —0.2	Carpinus Caroliniana	(Ironwood)	Low hammocks, etc.
—0.3—0	Quercus falcata	Red oak	Loamy uplands
0.1—0.2	Fraxinus sp.	Ash	Swamps
0.1—0.1	Hicoria glabra?	Hickory	Hammocks
0 —0.2	Fraxinus Caroliniana	Ash	Swamps
—0 —0.2	**Juniperus Virginiana**	Cedar	Marly (?) swamps
—0.1—0	**Quercus laurifolia**		Hammocks
—0. —0.1	Liriodendron Tulipifera	Poplar	Branch-swamps
0 —0.1	Ulmus Floridana?	Elm	Low hammocks
0 —0.1	Morus rubra	Mulberry	Low hammocks
0 —0.1	Fraxinus profunda?	Ash	Swamps
—0.1—0	Ostrya Virginiana		Hammocks
—0.1—0	Cornus florida	Dogwood	Loamy uplands
0 —0.1	Fraxinus lanceolata	Ash	Swamps
	(and about 20 others).		

SMALL TREES OR LARGE SHRUBS

+.09—.23	**Myrica cerifera**	Myrtle	Low hammocks
+.06—.04	**Ilex myrtifolia**	Yaupon	Shallow ponds
.02—.02	Cyrilla **racemiflora**	Tyty	Swamps
0 —.03	Salix longipes?	Willow	Marly (?) spots
.02—.01	Nyssa Ogeche	Tupelo gum	Along creeks, etc.
.01—.01	Diospyros Virginiana	Persimmon	Various situations
+.01—.01	**Persea pubescens**	Red bay	Swamps

0 —.01	**Cholisma ferruginea**		Poorest soils
0 — 0	**Ilex Cassine**		Swamps
	(and 5 others).		

VINES

.012—.006	**Smilax laurifolia**	Bamboo vine	Bays and swamps
—.002—.001	Vitis rotundifolia	Bullace or Muscadine	Hammocks, etc.
0 —.002	Rhus radicans	Poison ivy	Low hammocks, etc.
.002— 0	Smilax Walteri		Bays and swamps
0 —.002	Berchemia scandens	Rattan vine	Low hammocks
.001— 0	**Gelsemium sempervirens**	Yellow jessamine	Hammocks, etc.
0 —.001	Ampelopsis arborea		Low hammocks
.001— 0	Tecoma radicans	(Cow-itch)	Various situations
0 —.001	Parthenocissus quinquefolia	Virginia creeper	Hammocks, etc.
0 —.001	Vitis aestivalis?	Wild grape	Hammocks, etc.
0 — 0	Decumaria barbara		Swamps
	(and 4 others).		

SHRUBS

+.103—.096	**Serenoa serrulata**	Saw-palmetto	Flatwoods, etc.
+.045—.019	**Ilex glabra**	Gallberry	Flatwoods
+.012—.006	**Myrica pumila**	Myrtle	Flatwoods
+.014—.004	**Pieris nitida**	Hurrah bush	Bays, etc.
+.012—.004	**Hypericum fasciculatum**		Around ponds, etc.
+.010—.002	**Quercus minima**	Oak runner	Flatwoods
+.009—.002	**Vaccinium nitidum**		Flatwoods
++.009—.002	**Bejaria racemosa**		Flatwoods
++.008—.002	**Cholisma fruticosa**	(Poor grub)	Flatwoods
+.001—.004	Asimina speciosa?	Pawpaw	Drier soils
.003—.002	Cephalanthus occidentalis	Elbow-bush	Swamps, etc.
.004—.001	Quercus pumila	Oak runner	Flatwoods
+.001—.004	**Phoradendron flavescens**	Mistletoe	On black gum mostly
.001—.003	Aralia spinosa	Prickly ash	Low hammocks, etc.
0 —.002	Rhus copallina	Sumac	Uplands
.002—.001	Chrysobalanus **oblongifolius**		Drier soils
+.002—.001	Gaylussacia frondosa nana		Flatwoods, etc.
.001—.001	**Ceanothus microphyllus**		Drier soils
0 —.002	**Quercus myrtifolia**		Poorest soils
.002— 0	Viburnum nudum		Branch-swamps
+.002— 0	**Kalmia hirsuta**		Flatwoods
.002— 0	Rubus cuneifolius (X)	Blackberry	Roadsides, etc.
0 —.001	**Sabal glabra**	Palmetto	Low hammocks, etc.
—.002— 0	**Gaylussacia dumosa**		Drier soils

.002— 0	Asimina angustifolia	Pawpaw	Drier soils
.001—.001	Aronia arbutifolia		Edges of swamps
.001— 0	Azalea viscosa	Honeysuckle	Branch-swamps, etc.
0 —.001	**Baccharis halimifolia**		Low hammocks, etc.
0 —.001	Amorpha fruticosa		Marly (?) swamps
0 —.001	**Ceratiola ericoides**	Rosemary	Old dunes (?)
.001— 0	**Hypericum opacum**		Flatwoods
+.001— 0	Decodon verticillatus		Swamps
.001— 0	Hypericum **myrtifolium**		Around ponds
.001— 0	Alnus rugosa	Alder	Along creeks, etc.
0 —.001	Cornus stricta?		Low hammocks
0 — 0	Itea Virginica		Swamps
	(and about 25 others).		

HERBS

+.005—.004	**Tillandsia usneoides**	Spanish moss	On trees
++.005—.002	Pterocaulon undulatum	Black-root	Flatwoods
+.003—.003	**Aristida stricta**	Wire-grass	Pine lands
+.002—.002	Anchistea Virginica	(A fern)	Bays and ponds
++.002—.001	**Sarracenia minor**	Pitcher-plant	Flatwoods
+.001—.001	Osmunda cinnamomea	(A fern)	Low grounds
++.001—.001	**Aletris lutea**		Flatwoods
+.001—.001	Pteridium aquilinum	(A fern)	Flatwoods, etc.
.002— 0	Eupatorium compositifolium (X)	Dog-fennel	Roadsides, etc.
+0 —.001	Rhexia Alifanus		Flatwoods
+.001—.001	Polygala cymosa		Ponds
+0 —.001	Campulosus aromaticus	(A grass)	Flatwoods
++.001—.001	Doellingeria reticulata		Flatwoods, etc.
+0 —.001	**Chondrophora nudata**		Flatwoods
+0 —.001	**Trilisa odoratissima**	Deer-tongue	Flatwoods
++0 —.001	**Galactia Elliottii**		Flatwoods, etc.
++0 —.001	Rhexia lutea		Flatwoods
+0 —.001	Dichromena latifolia	(A sedge)	Flatwoods, etc.
++0 —.001	**Piaropus crassipes** (X)	Water-hyacinth	Rivers, etc.
+0 —.001	Panicum hemitomon	Maiden cane	Ponds
+0 —.001	**Juncus Roemerianus**		Brackish marshes
+0 — 0	**Cladium effusum**	Saw-grass	Ponds and marshes
+0 — 0	Polygala ramosa		Flatwoods
++0 —.001	Helianthus heterophyllus		Flatwoods
++0 — 0	Eupatorium rotundifolium		Flatwoods
++0 — 0	Eryngium synchaetum		Flatwoods
+0 —.001	**Eriocaulon decangulare**		Around ponds
+	Pontederia cordata		Ponds
	Saururus cernuus		Swamps
	Psoralea canescens		Drier soils

+	Eupatorium Mohrii?		Flatwoods
+	Spartina stricta	(A grass)	Marshes near coast
++	**Tillandsia tenuifolia**	(Air-plant)	Swamps
	Berlandiera tomentosa		Driest soils
	Helenium tenuifolium (X)	Bitter-weed	Roadsides, etc.
++	Teucrium Nashii		Marly spots
	Glottidium vesicarium (X)		Waste places
	Pluchea bifrons		Shallow ponds
++	Aristida spiciformis	(A grass)	Flatwoods
	Spartina Bakeri	(A grass)	Marshes, etc.
++	Fimbristylis puberula	(A sedge)	Flatwoods
+	Polygala lutea		Flatwoods, etc.
++	Aster squarrosus		Flatwoods
++	Xyris flexuosa*		Flatwoods
+	Coreopsis nudata		Around ponds
	Juncus effusus	(Rush)	Low grounds
+	**Helianthus Radula**		Flatwoods
	Centella repanda		Around ponds, etc.
+	Osmunda regalis	(A fern)	Swamps
	Eriogonum tomentosum		Driest soils
+	Limodorum tuberosum?	(An orchid)	Flatwoods
++	Marshallia graminifolia		Flatwoods
+	**Sagittaria lancifolia**		Marshes, etc.
++	Canna flaccida	(Wild canna)	Marly (?) spots
+	Ipomoea sagittifolia	(Morning-glory)	Marly (?) spots
	Silphium compositum		Drier soils
++	Phlox Drummondii (X)		Waste places
++	Polygala setacea		Flatwoods
+	**Lachnocaulon anceps**		Flatwoods
+	Leptopoda Helenium		Around ponds, etc.
+	**Nymphaea macrophylla**	Bonnets	Creeks, etc.
	Chrysopsis graminifolia		Flatwoods
	(and about 200 others).		

The following trees which are more or less common elsewhere in the same latitude are rare or wanting here:—*Pinus echinata* (short-leaf pine), *P. glabra* (spruce pine), *Chamaecyparis* (juniper), *Salix nigra* (willow), *Betula* (birch), *Fagus* (beech), *Quercus alba* (white oak), and several other oaks, *Liriodendron* (poplar), *Crataegus* (haws) *Prunus* (plums), *Ilex opaca* (holly), *Tilia* (lin, basswood), *Cornus florida* (dogwood), and *Nyssa uniflora* (tupelo gum). Most of these probably prefer more clayey soils than those of the East Florida flatwoods, but some no doubt are kept away by other reasons.

Two trees, *Pinus Elliottii* and *Gordonia,* two shrubs, *Bejaria* and *Cholisma fruticosa,* and many herbs, are evidently more abundant here than elsewhere in northern Florida; but just what combination of environmental conditions it is that makes them so it is hard to say. The shrubs that grow in the flatwoods nearly all have extensive underground stems, which are not killed by fire, as already noticed in the lime-sink region; while those that grow in hammocks and swamps probably have no such protective device. The great majority of the herbs grow in the open pine forests, and nearly all of them have perennial under-

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*X. *torta* of many authors.

ground parts too. (The percentage of annuals has not been estimated, but it must be very small). Few if any of the species are confined to Florida.

Comparing the two columns of percentages in the plant list brings out some very interesting and significant facts. It is evident that *Quercus falcata, Q. laurifolia, Cornus florida, Ostrya, Betula, Ilex opaca, Smilax laurifolia, Vitis rotundifolia, Smilax Walteri,* and many shrubs and herbs are more abundant west of Trail Ridge than east thereof, while the reverse is true of many other species. (It would take up entirely too much space to repeat their names here, but they can easily be picked out from the list by any one who is sufficiently interested). The first category includes the most shrubs, especially Ericaceous shrubs, while the second includes about twice as many trees, small trees and herbs as the first. If we could explain the reason for all these differences in vegetation it would be an important contribution to ecological science; but the problem is by no means a simple one. For the differences between the two halves of the region, although mostly small in amount, are of course of every conceivable kind; and any one of them might prove to be the key in some particular case. Just a few suggestions toward solving the problem will be given here.

From what is known of their distribution elsewhere it appears that some of the species which are more abundant in the western division prefer somewhat clayey soils, some acid (or non-calcareous) soils, and a few are weeds which have come in with the farmers; but this leaves the majority of cases still unaccounted for. Many of the species more abundant eastward are partial to the low hammocks or marly spots, which are scarcely represented west of Trail Ridge (or even west of the smaller ridge 15 miles east of it). The greater abundance of *Liquidambar* (sweet gum), *Quercus cinerea* (turkey oak), and *Q. Virginiana* (live oak) eastward may possibly be correlated with phosphorus in the soil, for these species have been observed elsewhere to thrive in decidedly phosphatic soils, and phosphorus is generally more abundant coastward. Still others are confined to the sterile sands or old dunes a few miles back from the coast, while a few grow in or near marshes and perhaps belong more properly to the next region.

The percentage of evergreens is about 74.7 west of the ridge and 73.9 east; of Ericaceae among the shrubs 19 west and 7 east; and of Leguminosae among the herbs 1.7 west and 4.4 east. If we had several chemical analyses of typical soils from both halves of the region we would be in a better position to interpret these figures; but a few suggestions can be made even with our present inadequate information.

The evergreen percentages, which are both above the average for northern Florida, ought to indicate soils rather low in potassium, notwithstanding the chemical analysis given a few pages back (which must be abnormal in that respect). One of the figures for Ericaceae is above the average and the other below; and the fact that the first is nearly three times as great as the second is probably correlated with the fact that the western division is essentially non-calcareous, while the eastern has marl near the surface in many places. For the distribution of Ericaceae (particularly those that are not evergreen) seems to be governed by lime more than by potash, as already intimated under the

Gulf Hammock region.* The percentages of Leguminosae are both very low, probably for the same reason as in regions 9, 10 (middle division), 15 and 16: namely, the proximity of the ground-water level to the surface. But the Leguminosae are over twice as abundant in the eastern division as in the western, perhaps for the same reason that the Ericaceae are less so, for a high percentage of the one often goes with a low percentage of the other.

Weeds are comparatively scarce here as yet, a natural consequence of the limited development of agriculture, pointed out below.

Economic Features—Lumbering, turpentining and grazing have been the leading industries here, as in most other parts of Florida, but they are being gradually superseded by agriculture. The level topography has favored logging operations, and the best pines have been removed, leaving some rather desolate landscapes. But the long-leaf and slash pines reproduce themselves very well in this kind of country, and will doubtless continue to do so until nearly all the upland is occupied by farms.

In 1910 the western part had not over 14% of improved land, and less than 20 inhabitants per square mile, 59.6% of them white. The population increased 12.4% in the decade immediately preceding. The eastern part had between 2 and 3% of improved land, and nearly 34 inhabitants to the square mile. But counting out the city of Jacksonville, which owes its development to its excellent transportation facilities, and trade with all parts of the State, rather than to the natural resources of the surrounding flatwoods, there were only 16.2 inhabitants to the square mile in the eastern division; and outside of Duval County only 14.3. The increase of population between 1900 and 1910 was for the whole eastern division 76%, but outside of Jacksonville only 30%, and outside of Duval County 26%. (Even the last figure is above the average, though). About 53% of the inhabitants, with or without Duval County, are white.

At first thought it seems strange that the eastern part of the flatwoods, with its apparently more calcareous soils, should have so

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*On the Florida Keys, where the rock is all limestone, with little or no soil on top of it, no Ericaceae at all have been found.

The observation of the aversion of Ericaceae to calcareous soils is nothing new (see Hilgard, Soils 522. 1906; Science II. 27:140-143. 1908; Coville, U. S. Dept. Agr. Bur. Plant Industry, Bull. 193. 1911), but most persons who have made such correlations before have regarded lime (or calcium) as the most important factor in soils, and hardly considered potassium at all. It is possible that phosphorus is just as inimical to the Ericaceae as calcium is, for some parts of northern Florida which have few Ericaceae are known to have decidedly phosphatic soils.

much less improved land than the western; but the explanation is probably that the most fertile soils are too wet to cultivate without artificial drainage, which has not been undertaken very extensively here as yet.

The leading crops in 1912, in order of value, were as follows. In the western division, sea-island cotton, strawberries, corn, peanuts, beans, sweet potatoes, sugar-cane, velvet beans, (grass) hay, oats, oranges, Irish potatoes, field peas (including hay thereof), millet, tomatoes, pecans, upland cotton, peaches, watermelons. In the eastern division, Irish potatoes, sweet potatoes, corn, oranges, (grass) hay, lettuce, beans, sugar-cane, onions, cabbage, peppers, grapes, tomatoes, peaches, field peas (including hay thereof), pears, watermelons, strawberries, sea-island cotton, figs, oats, pecans, velvet beans, cantaloupes, peanuts.

In this region more than anywhere else in northern Florida is exhibited the tendency—much more pronounced farther south—to raise special crops, particularly vegetables, in restricted areas. The order of importance of the several crops is very different in the two divisions, and although soil no doubt has something to do with it, there are also some complex human factors to be taken into consideration. It would be rather difficult to explain, for instance, why sea-island cotton ranks first in the western division and 19th in the eastern, strawberries second in the western and 18th in the eastern, and Irish potatoes first in the eastern and 12th in the western. The special vegetable crops bring a much higher return per acre than ordinary field crops, and the total value of agricultural products in the East Florida flatwoods is considerably greater than that of some other regions which have a larger area in cultivation.

20. EAST COAST STRIP.

(FIGURES 87-90)

References. Curtiss, Harper 1 (226), Leeds; Matson & Sanford (155-166), Mayer (858, 864, 865-868). Illustrated in 2nd Ann. Rep., pl. 7.2; 3d, pl. 11.1, 14.1, 17.1; 4th, pl. 3.1, 11.2; 5th, pl. 10.1, 13.1.

The coast of Georgia is bordered by low sandy islands, behind which are salt marshes several miles wide, intersected by an intricate system of crooked tidal channels. The same sort of country extends into Florida, gradually narrowing, until in the southern part of St. John's County it is reduced to little more than a straight sandy beach strip not over a mile wide, sometimes with a narrow lagoon behind it, and sometimes connected with the mainland. This coast strip covers probably not more than 200 square miles in Nassau, Duval and St. John's Counties.

Geology and Soils—The beaches and outermost dunes are composed of cream-colored sand of Recent age, mixed with a varying proportion of shell fragments. Usually the shell material is hardly noticeable, but near the north end of Anastasia Island, and at various places farther south, it makes up almost the whole of the mass, and is more or less cemented together (especially on the surface), forming a sort of rock called coquina. More sand is continually being washed up on the beach and piled by the wind into dunes, but at a distance of 100 yards or so from high-water mark it is practically motionless. The dune sand that has been stationary for many years is usually nearly white, probably on account of the leaching out of the soluble material (as was suggested in connection with the West Florida coast strip). There are no salamanders or gophers on the islands to counteract the leaching, and other subterranean animals (other than fiddler-crabs in the marshes) are probably scarce. The soil of the salt and brackish marshes, as in similar situations in other states, is a very impure peat or muck, with a somewhat sulphurous odor. Neither mechanical nor chemical analyses of any of the soils are available, but the dune sand, especially that of the older dunes, must be very poor in soluble minerals, while the marsh muck is probably just the opposite.

Topography and Hydrography—The beaches are generally very smooth, firm and straight, so that they make good paths for automobiles. The dune areas, both modern and ancient, are characterized by a very wavy or knobby topography, with pretty steep slopes in some places and a maximum elevation of perhaps 25 feet above the sea. Some of the hollows among the dunes are small, rounded and concave, like the basins in the lime-sink region, while others are larger, elongated, and flat-bottomed. The surface of the marshes corresponds pretty closely with mean high-tide level.

Most of the surface water in the coast strip is salt, but just behind the cuspate foreland at South Beach, on Anastasia Island, if not in similar places elsewhere, there are some small shallow pools of fresh water. There are practically no springs or streams, but fresh water can be obtained a few feet below the surface in many places, and deep wells yield a strong flow of rather hard and sulphurous, but wholesome water.

Vegetation Types—On the outer beaches, below high-water mark, there is usually no vegetation at all. Between that point and the dunes, a short distance farther back, the vegetation is very sparse, and consists mostly of running vines and a few tufted plants. The outer or active dunes are characterized by some of the same species as on the upper beach, together with sea-oats and a few other grasses, and a few other plants, all or nearly all belonging to families well represented in the arid southwestern states and northern Mexico; and the resemblance of this vegetation to that of a desert is rather striking. The next older dunes, which have been stationary a comparatively short time, have a vegetation composed mostly of evergreen shrubs; and the oldest are well covered with trees, forming hammocks. On the coquina areas cedar is the most prominent tree, and there are a few other species which are commonly supposed to be lime-loving.

The vegetation of the moist dune hollows is meadow-like, and rather dense. It consists mostly of herbs which seem to like lime (if not also phosphorus, sulphur, or something else) as well as moisture, and includes some of the same species already noted as characteristic of marly flatwoods in the Gulf hammock region. The salt marsh vegetation comprises a few very abundant species, mostly tall stiff grasses and rushes. On Amelia Island there are flatwoods something like those of the mainland, but without long-leaf pine.* Fire seems to be a negligible factor throughout the coast strip.

Plants—The flora of different islands and beaches differs considerably, for no apparent reason. (The same state of affairs has been observed also in the corresponding parts of Georgia.) The

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*See 3d Ann. Rep., pl. 11.1, or 5th, pl. 10.1. Most if not all of the trees in that picture (which was taken by Dr. Sellards) are probably *Pinus serotina*.

following list is based on a few hours' work on three islands in different counties; namely, near Fernandina on May 12, 1909, around Mayport the next day, and on Anastasia Island, opposite St. Augustine, on July 8, 1914. The percentage figures are omitted, as has been done in the case of some of the other smaller regions.

TREES

++	**Sabal Palmetto**	Cabbage palmetto	Various situations
+	**Quercus geminata**	Live oak	Hammocks
+	**Magnolia grandiflora**	Magnolia	Hammocks
+	**Juniperus Virginiana**	Cedar	Dune hollows and coquina areas
+	**Persea Borbonia?**	Red bay	Hammocks
+	**Quercus Virginiana**	Live oak	Hammocks
+	**Quercus laurifolia**		Hammocks
+	Liquidambar Styraciflua	Sweet gum	Various situations
	Pinus serotina	(Black pine)	Flatwoods, Amelia I.
	Pinus Elliottii?	(Slash pine)	Edges of marshes, etc.
	Ilex opaca	Holly	Hammocks
	(and 3 or 4 others).		

SMALL TREES OR LARGE SHRUBS

+	**Myrica cerifera**	Myrtle	Dune hollows, etc.
+	**Quercus myrtifolia**		Old dunes
++	**Yucca aloifolia**	Spanish bayonet	Dunes
++	**Bumelia tenax?**		Older dunes
	Batodendron **arboreum**	(Sparkleberry)	Hammocks
++	**Ilex vomitoria**		Hammocks
+	**Osmanthus Americana**		Hammocks
++	Xanthoxylum Clava-Herculis		Hammocks
	Salix longipes?	Willow	Coquina hollows

VINES

+	Vitis rotundifolia	Muscadine	Hammocks, etc.
+	Parthenocissus quinquefolia	Virginia creeper	Hammocks, etc.
++	**Smilax auriculata**		Old dunes
	Vitis aestivalis?	Wild grape	Hammocks

SHRUBS

	Serenoa serrulata	Saw-palmetto	Old dunes
+	Aralia spinosa	Prickly ash	Hammocks
+	**Cholisma ferruginea**		Old dunes
+	Rhus copallina	Sumac	Hammocks, etc.
+	Callicarpa Americana	French mulberry	Hammocks
+	Ilex ambigua		Hammocks
++	Iva frutescens		Edges of marshes

+	**Baccharis halimifolia**		Near marshes
++	Batis maritima		Salt marshes
++	Borrichia frutescens		Edges of marshes
	Polycodium sp.	(Gooseberry)	Hammocks
++	Iva imbricata		Upper beach
+	Sageretia minutiflora		Hammocks
	Ceratiola ericoides	Rosemary	Old dunes
	Asimina parviflora	Pawpaw	Hammocks
+	Rhamnus Caroliniana		Coquina areas
—	**Ilex glabra**	Gallberry	Flatwoods
—	**Vaccinium nitidum**		Flatwoods
	Lantana Camara	Lantana	Coquina areas

HERBS

++	Spartina stricta	(A grass)	Salt marshes
+	**Juncus Roemerianus**	(Rush)	Brackish marshes
++	**Lippia sp.**		Dune hollows
++	Dichromena colorata	(A sedge)	Dune hollows
++	Croton maritimus		Active dunes
++	Ipomoea Pes-caprae	(Morning-glory)	Dunes and beaches
	Pteridium aquilinum	(A fern)	Hammocks
+	Boehmeria cylindrica		Dune hollows
++	Dryopteris Thelypteris	(A fern)	Dune hollows
++	Kosteletzkya sp.		Dune hollows
++	Uniola paniculata	Sea-oats	Active dunes
+	**Spartina Bakeri**	(A grass)	Dune hollows
++	Heterotheca subaxillaris (X?)		Waste places mostly
++	Scirpus Americanus	(A sedge)	Dune hollows
+	Juncus megacephalus		Dune hollows
+	**Muhlenbergia filipes?**	(A grass)	Dune hollows
++	Oenothera humifusa		Active dunes
++	Ipomoea littoralis	(Morning-glory)	Dunes and beaches
+	**Galactia Elliottii**		Old dunes
+	Cnidoscolus stimulosus	(Nettle)	Hammocks, etc.
+	Ambrosia sp.	(Ragweed)	Dune hollows
+	**Lemna sp.**	(Duckweed)	Fresh-water pools
+	**Centella repanda**		Dune hollows
+	**Scleria triglomerata**	(A sedge)	Hammocks
++	Distichlis spicata	(A grass)	Salt marshes
+	**Sagittaria lancifolia**		Dune hollows
++	Fimbristylis spadicea?	(A sedge)	Dune hollows
+	Chamaecrista sp.		Dunes
++	Ludwigia maritima		Dune hollows
+	Chaetochloa sp.	(A grass)	Dune hollows
++	Cyperus dentatus?	(A sedge)	Dune hollows
++	Phyllanthus sp. (X?)		Along car-tracks
+	Carduus sp.	Thistle	Dune hollows
—	**Tillandsia usneoides**	Spanish moss	Hammocks

++	Salicornia sp.	(Samphire)	Salt marshes
++	Cyperus cylindrostachys?	(A sedge)	Dune hollows
++	**Opuntia Pes-corvi**	Prickly pear	Older dunes
++	Gaura angustifolia (X?)		Waste places, etc.
—	Eupatorium capillifolium (X?)	Dog-fennel	Low grounds
++	Sabbatia stellaris		Dune hollows
++	**Solidago Chapmani?**	Goldenrod	Hammocks
++	Houstonia angustifolia		Coquina areas
	Saururus cernuus		Dune hollows
	Polypodium polypodioides	(A fern)	Hammocks
+	Teucrium Nashii		Dune hollows
	Smilax pumila		Hammocks
	Mitchella repens	(Partridge-berry)	Hammocks
	Epidendrum conopseum	(An orchid)	Hammocks
	Monarda punctata (X?)		Clearings
+	Chenopodium ambrosioides	(X)	Waste places
	(and about 30 others).		

A list of plants that are common farther inland and conspicuous by their absence or scarcity here would be a long one; but the following trees at least deserve special mention in this connection: *Pinus palustris* (long-leaf pine, entirely absent), *P. Taeda* and *P. echinata* (short-leaf pines), *P. glabra* and *P. clausa* (spruce pines), *Taxodium* (cypresses), *Chamaecyparis* (juniper), *Hicoria* (hickories), *Salix* (willows), *Carpinus, Ostrya, Fagus* (beech), nearly all oaks except the live oaks, *Morus* (mulberry), *Ulmus* (elms), *Magnolia glauca* (bay), *Liriodendron* (poplar), *Crataegus* (haws), *Prunus* (plums and cherries), *Acer* (maples), *Tilia* (basswood or lin), *Gordonia, Nyssa* (black gums and tupelo gums), *Cornus florida* (dogwood), *Oxydendrum* (sourwood), *Diospyros* (persimmon), and *Fraxinus* (ashes). Most of these prefer somewhat clayey soils, which are entirely absent in the coast strip; but of course no one explanation will fit all cases. It may be that some of them are averse to salt, lime and phosphorus.

None of the trees and shrubs seem to be specially characteristic of this region except the *Yucca* and perhaps the *Bumelia* on dunes, *Iva frutescens, Batis* and *Borrichia* in and around salt marshes, and *Iva imbricata* on upper beaches. Many of the herbs, however, especially those of salt marshes and dune hollows, are almost confined to this region; and nearly all the herbs which grow here at all are more abundant here than in the average of northern Florida (as indicated by the + marks).

About 94% of the trees (but not so many of the other plants) are evergreen and 10% of the shrubs Ericaceae, and there are very few Leguminosae; all of which indicates the prevalence of very poor soils. The salt marshes and dune hollows, which contain few or no evergreens or Ericaceae, are evidently much richer than the average, though.

Economic Features—As in the case of the West Florida coast strip, there is practically no lumbering and no agriculture in this region. The fertile marshes and dune hollows cannot be cultivated without extensive diking and ditching to get rid of the salt water (as has been done successfully in Holland), and the population is hardly dense enough yet to warrant such undertakings. The permanent inhabitants, outside of Fernandina, are mostly fishermen, persons engaged in some branch of navigation or commerce, and those who cater to the wants of tourists. The coquina rock has been used largely for building purposes in and around St. Augustine, for over 300 years.

ILLUSTRATIONS

OF THE

GEOGRAPHY AND VEGETATION
OF NORTHERN FLORIDA

MARIANNA RED LANDS

Jackson County

(Pages 193-200)

Fig. 41. Upland hardwood forest on red clay soil derived from limestone, about 7 miles northwest of Marianna. Trees mostly *Fagus grandifolia* (beech) and *Quercus Schneckii* (red oak), with a bushy undergrowth of *Cercis* (red-bud) and a few oak sprouts. May 11, 1914.

FIGURE 41

MARIANNA RED LANDS

(Pages 193-200)

FIG. 42. Rocky hillside near the Chipola or Long Moss Spring, with hardwood forest composed of *Fagus* (beech), *Celtis* (hackberry), *Ulmus fulva* (slippery elm), *Magnolia grandiflora* (magnolia), and other trees. The rock is limestone. March 10, 1910.

WEST FLORIDA LIME-SINK REGION

(Pages 201-209)

FIG. 43. Scene about 3 miles south of Sneads, Jackson Co., showing wet pine land vegetation (*Sarracenia flava,* etc.) on slope in foreground, and a lime-sink with denser growth of hardwood trees at bottom of same slope. April 27, 1910.

FIG. 44. Small dry lime-sink in comparatively level long-leaf pine forest in extreme eastern part of Walton County, between Sandy and Reedy Creeks. The pines are all turpentined. The broad-leaved trees are mostly *Liquidambar* (sweet gum), and the dark patch of vegetation in the sink is *Osmunda cinnamomea* (a fern). May 7, 1914.

WEST FLORIDA LIME-SINK REGION

(Pages 201-209)

FIG. 45. Scene in open pine woods with no underbrush, and "pimply" soil, on a hill near Hinson's (or Douglass) Crossroads, about 9 miles west of Vernon, Washington County, looking toward a similar hill about a quarter of a mile away. (The house is in the saddle between the two hills.) The trees are all long-leaf pine, and the herbaceous vegetation is mostly wire-grass. May 7, 1914.

FIG. 46. Interior of a bay about 8 miles west of Vernon, Washington County. The tree in the center is *Taxodium imbricarium* (pond cypress), and the shrubbery is mostly *Ilex coriacea, Itea Virginica,* and *Leucothoe racemosa.* (Flowers of the last close to bottom of picture.) May 7, 1914.

WEST FLORIDA LIME-SINK REGION

(Pages 201-209)

FIG. 47. Permanent pond with open water and scattered cypress trees (*Taxodium imbricarium*) about 2 miles north of Vernon, Washington County. The scattered shrubs in the water, barely visible in the picture, are *Hypericum fasciculatum*. May 8, 1914.

FIG. 48. Interior of a small May-haw pond (dry at the time), about 8 miles west of Vernon, Washington County. Trees all *Crataegus aestivalis*. May 7, 1914.

APALACHICOLA RIVER BLUFF REGION

(Pages 210-216)

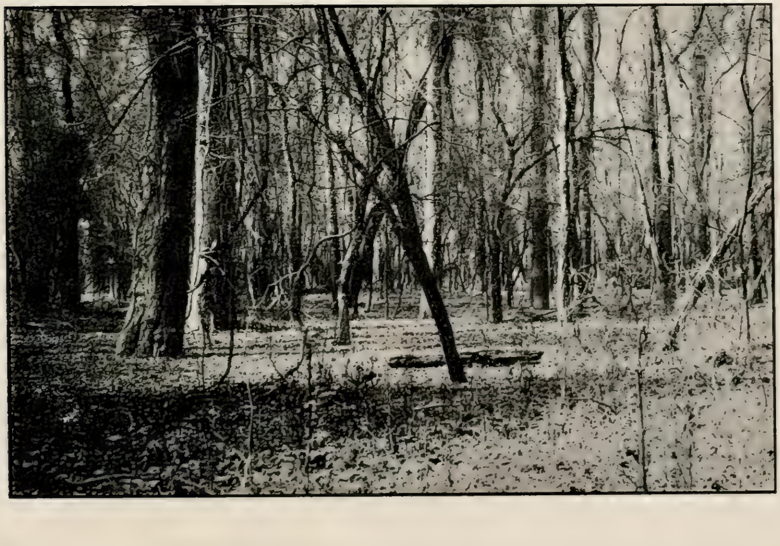
FIG. 49. Looking north over hills and river-bottoms from near top of Aspalaga Bluff, Gadsden County. This view having been taken in early spring when the deciduous trees were still leafless gives an idea of the proportion of evergreens. Most of those in the picture are *Pinus Taeda* (short leaf pine). The trees in the bottoms are all deciduous. March 7, 1909.

APALACHICOLA RIVER BLUFF REGION

(Pages 210-216)

FIG. 50. Looking up one of the shady ravines of Aspalagà Bluff, Gadsden County. Foliage of *Tumion taxifolium* (stinking cedar) conspicuous in foreground and elsewhere. (This is probably the first photograph of this tree in its native haunts ever published.) March 5, 1909.

FIG. 51. Muddy swamp of Apalachicola River in northern part of Liberty County. Trees all deciduous. The larger ones are mostly *Liquidambar* (sweet gum), and the small leaning one in the foreground is *Ilex decidua.* March 8, 1909.



KNOX HILL COUNTRY

Walton County

(Pages 217-222)

Fig. 52. Dense second growth of *Pinus Taeda* (short-leaf pine) about 3 miles southeast of Eucheeanna and 5 miles southwest of Knox Hill. May 6, 1914.

HOLMES VALLEY

Washington County

(Pages 223, 224)

Fig. 53. Looking north across Holmes Valley from near its high southern edge, about 2 miles south of Vernon. May 8, 1914.

WEST FLORIDA LAKE REGION

(Pages 225-228)

Fig. 54. Small circular lake surrounded by long-leaf pine forest, about 10 miles southeast of Vernon, Washington County. Photograph by F. G. Clapp, 1908. (From 2nd Annual Report, plate 2.1.)

WEST FLORIDA PINE HILLS

(Pages 229-241)

Fig. 55. Looking upstream from foot-bridge in estuarine swamp of Blackwater River opposite Milton, Santa Rosa County. The trees are mostly *Pinus Elliottii* (slash pine), the bushes in the middle distance *Hypericum fasciculatum,* and the grass-like vegetation in the foreground *Cladium effusum* (saw-grass). This vegetation is growing in peat too deep for roots to reach the bottom of it. June 22, 1909.

WEST FLORIDA PINE HILLS

(Pages 229-241)

Fig. 56. Scene about 2 miles southeast of DeFuniak Springs, Walton County, showing open pine forests, a small branch-swamp with *Magnolia glauca* (bay) and *Cyrilla racemiflora* (tyty), and a wet slope with characteristic vegetation in foreground. May 6, 1914.

Fig. 57. Scene about half way between DeFuniak Springs and Portland, showing a branch-swamp full of *Cliftonia* (tyty), bordered by a boggy slope devoid of trees. September 23, 1910.

WEST FLORIDA COAST REGION

(Pages 242-247)

Fig. 58. Looking west along shore of St. George's Sound near Lanark, Franklin County, at or about flood tide. This shore is pretty well protected from wave action by Dog Island, a narrow barrier-beach two or three miles out. The coarse grasses near the water are mostly *Spartina junciformis* and *S. Bakeri*, and the trees are mostly *Pinus Elliottii* (or perhaps *P. Caribaea*). June 9, 1909.

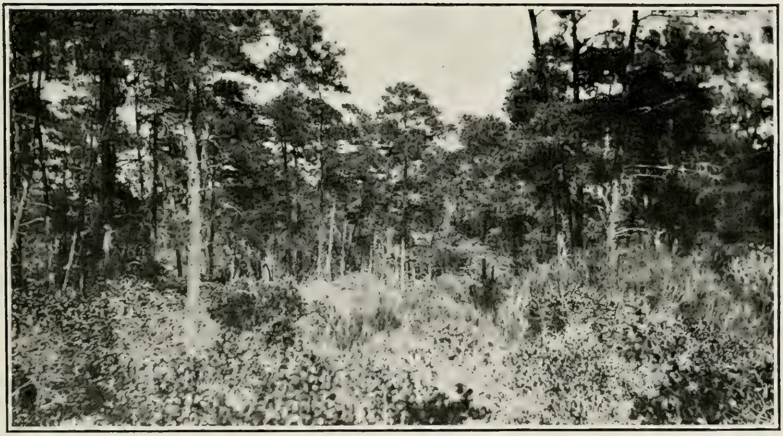
WEST FLORIDA COAST REGION

(Pages 242-247)

FIG. 59. Stationary dunes on narrow treeless part of Dog Island, about 5 miles due south of Carrabelle, Franklin County. Vegetation nearly all evergreen shrubs. *Serenoa* (saw-palmetto) at right, *Conradina* (the grayish shrub) and *Ceratiola* (smaller and darker) in foreground. Fire is impossible in such vegetation. May 28, 1914.

FIG. 60. Forest of *Pinus clausa* (spruce pine) on narrow peninsula of ancient dune sand on south side of Escambia Bay, Santa Rosa County. The shrubs in the foreground are mostly *Quercus myrtifolia* (a dwarf evergreen oak), and there is also some *Ceratiola* (rosemary), which the picture does not bring out well. This locality is about 50 feet above sea-level, and the vegetation is evidently in a more advanced stage than that shown above. No traces of fire were observed here. September 19, 1910.

FIG. 61. Looking south from a pine tree on highest old dunes near Lanark, Franklin County, about 50 feet above sea-level. St. George's Sound and Dog Island in distance. Gophers and ants inhabit the soil here, but there are no salamanders. Vegetation mostly *Pinus palustris* (long-leaf pine) and *Quercus Catesbaei* (black-jack oak). August 2, 1914.

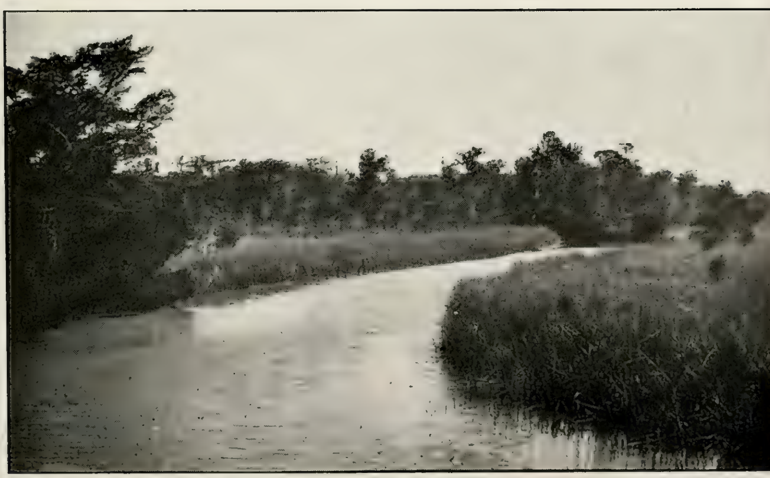


APALACHICOLA FLATWOODS

(Pages 247-253)

FIG. 62. Typical flatwoods scene on St. James Island about a mile inland from Lanark, Franklin County. Long-leaf pine and saw-palmetto in foreground, tyty bays in distance. August 2, 1914.

FIG. 63. Looking down muddy bayou in estuarine swamps of Apalachicola River about 7 miles north of Apalachicola. The trees are mostly *Taxodium distichum* (cypress), with some *Juniperus Virginiana* (cedar). Floating leaves of *Nymphaea fluviatilis* (bonnets) in foreground, *Scirpus validus* (bulrush) at water's edge, and *Cladium effusum* (saw-grass) a little farther back. April 24, 1910.

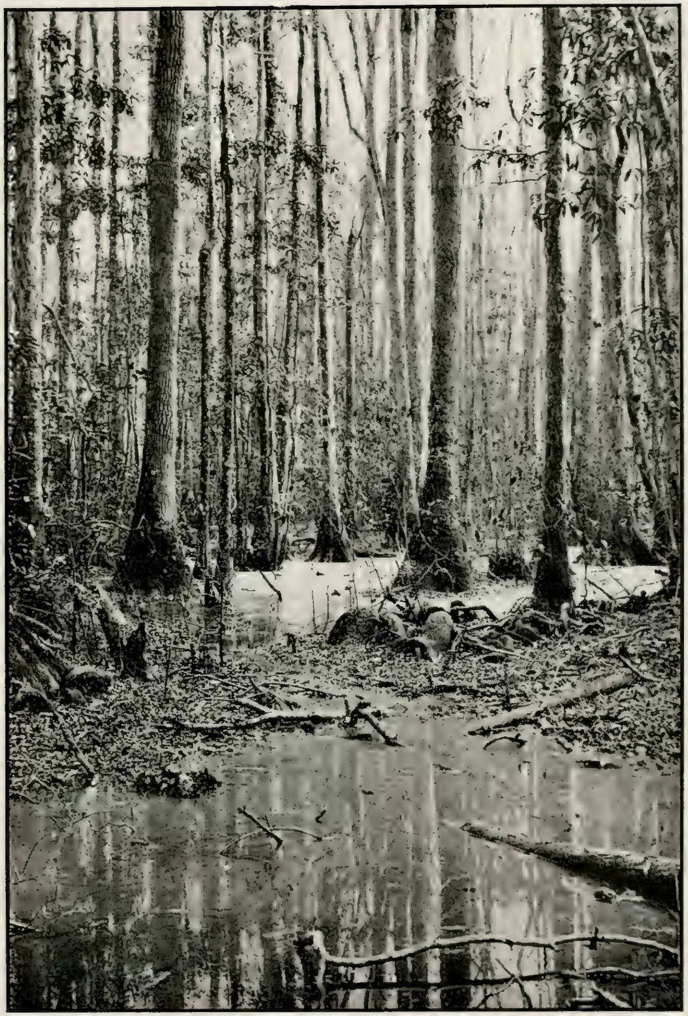


MIDDLE FLORIDA HAMMOCK BELT

(Pages 254-265)

FIG. 64. Interior of gum swamp or bay about 5 miles W.N.W. of Tallahassee, Leon County. The larger trees are mostly *Nyssa biflora* (black gum), and the smaller ones *Magnolia glauca* (bay). February 27, 1909. (Reprinted from 3d Annual Report, p. 255, where additional information about the place can be found.)

FIGURE 64



MIDDLE FLORIDA HAMMOCK BELT

(Pages 254-265)

FIG. 65. Flatwoods near Capitola, in the extreme eastern part of Leon County. The trees are *Pinus palustris* and *P. serotina,* and the shrubby undergrowth is mostly *Serenoa* (saw-palmetto) and *Ilex glabra* (gallberry). March 21, 1910.

FIG. 66. Large marsh, or marshy prairie, with several feet of peat, about 5 miles east of Greenville, Madison County. Trees all *Taxodium imbricarium* (pond cypress). May 24, 1910. (Described in 3d Annual Report, pp. 276-277.)

MIDDLE FLORIDA HAMMOCK BELT

(Pages 254-265)

FIG. 67. Looking up Santa Fe River from bridge near Worthington Springs. (Bradford County on the left, Alachua on the right.) Hammock and bottom vegetation on both sides. May 26, 1909.

FIG. 68. Field of peanuts on rich gray loamy sand (which is very characteristic of this part of the hammock belt), about 3 miles south of Alachua, Alachua County; showing horizontal circular rows following contours around a dry lime-sink, with patch of weeds in center. Hardwood forests in background, solitary sweet gum tree at left. July 14, 1914. (The soil here is probably well supplied with phosphorus, among other things, and the sweet gum is one of the trees that seems to prefer phosphatic soils.)

TALLAHASSEE RED HILLS.

Leon County

(Pages 266-279)

Fig. 69. Looking about north across fields and hills about 1 1-2 miles west of Tallahassee. Some of the hills are crowned with forests of *Pinus echinata* (short-leaf pine), probably mostly second growth in this case. November 24, 1910. (The prevailing colors of the landscape at this season are dark green, gray and brown, the last including the soil.) The entire absence of gullies is noteworthy.

Fig. 70. Looking east across fields of brown loam about 5 miles east of Tallahassee, showing two ponds at different levels, and a few dead live oaks (which are as characteristic of cultivated fields in this region as dead pines are in the long-leaf pine regions). April 4, 1914.

Fig. 71. View of eastern part of Lake Lafayette, showing *Taxodium imbricarium* (pond cypress), *Tillandsia usneoides* (Spanish moss), and a dense growth of *Panicum hemitomon* (maiden cane) in middle distance. Water near its highest stage. March 24, 1914. (At this time the cypress trees were just beginning to put out their leaves.)

TALLAHASSEE RED HILLS.

LEON COUNTY

(Pages 266-279)

FIG. 72. Short-leaf pine woods on uplands about 5 miles northeast of Tallahassee. Trees nearly all *Pinus echinata.* April 4, 1914. (Reprinted from Popular Science Monthly, October, 1914.)

FIG. 73. Dry woods about 3 miles north of Chaires. Trees mostly *Quercus falcata* (red oak) and *Cornus florida* (dogwood), both in bloom. *Tillandsia usneoides* (Spanish moss) abundant. April 4, 1914.

BELLAIR SAND REGION

(Pages 280-288)

FIG. 74. *Pinus palustris* (long-leaf pine) and *Quercus Catesbaei* (black-jack oak) on deep dry sand about 1-2 mile south of Bellair (or 4 1-2 miles S.S.E. of Tallahassee). The black-jack oaks are rather small here, most of them being mere shrubs. The absence of Spanish moss is noteworthy. September 26, 1914.

FIG. 75. Looking east across Munson's Lake, or Pond, about 5 miles south of Tallahassee, at low water or nearly so. (The shore in the foreground is evidently all inundated at high water.) The trees standing alone are all *Taxodium imbricarium* (pond cypress). June 20, 1914.

WAKULLA HAMMOCK COUNTRY

Wakulla County

(Pages 289-296)

Fig. 76. Looking up Wakulla River from upper bridge, about 2 miles southwest of Wakulla station, and 3 miles below the great spring of the same name. The trees are *Taxodium distichum* (cypress), and the vegetation in the foreground is mostly *Sagittaria lancifolia*. April 9, 1910.

Fig. 77. Forest of red oak, hickory and dogwood, with a very few long-leaf pines (none of which show in the picture), about a mile north of Crawfordville. June 20, 1914. (This is the precise locality where the soil samples mentioned herein were taken a few months later.)

WAKULLA HAMMOCK COUNTRY

WAKULLA COUNTY

(Pages 289-296)

FIG. 78. Scene about 6 1-2 miles east of Crawfordville on road to St. Mark's, overhung by long-leaf pine, red oak, wild grape vines, etc. June 19, 1914.

PANACEA COUNTRY

WAKULLA COUNTY

(Pages 297-301)

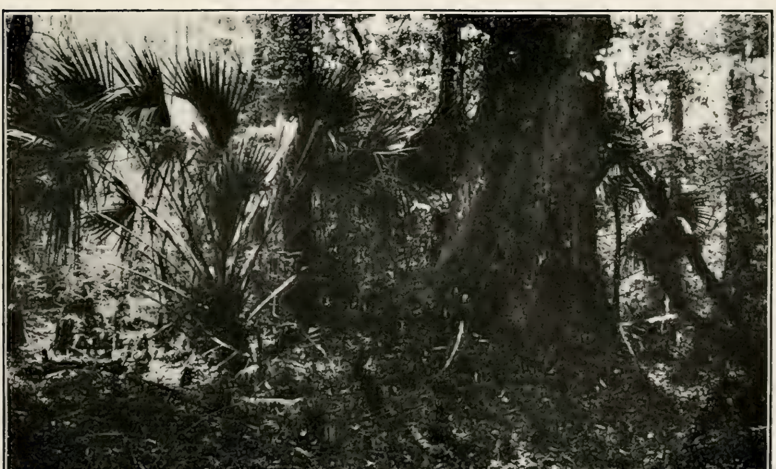
FIG. 79. Small bay about 2 miles northwest of Panacea Springs, with *Taxodium imbricarium* (pond cypress), *Cyrilla parvifolia* and *Ilex myrtifolia.* High pine land in foreground, with a decided slope down to the bay. July 30, 1914.

GULF HAMMOCK REGION

(Pages 302-309)

FIG. 80. Marly(?) flatwoods about 8 miles southeast of Hampton Springs, Taylor County. Trees mostly *Pinus Elliottii* and *Sabal Palmetto*. March 30, 1910.

FIG. 81. Interior of "Pumpkin Swamp," a large low hammock near Hines, Lafayette County, showing young trees of *Sabal Palmetto* (cabbage palmetto) and a large trunk of *Taxodium distichum* (cypress). March 31, 1910.



PENINSULAR LIME-SINK REGION

(Pages 314-319)

Fig. 82. High pine land about 2 miles west of Archer, Alachua County, showing especially *Ceratiola ericoides* (rosemary), which is rare in this region. This is a place where the soil is so poor that the vegetation is sparse enough to afford the rosemary sufficient protection from fire (to which it is very sensitive). April 27, 1909.

Fig. 83. Looking about north or northwest from Buda (or Clark), Alachua County, showing high pine land almost completely deforested to supply fuel for phosphate mines in the vicinity. The topography here is somewhat rolling, though the picture does not bring it out very well. There is no surface water within several miles. July 15, 1914.

PENINSULAR LAKE REGION

(Northern Part)

(Pages 320-325)

Fig. 84. Scrub vegetation on white sand on east side of Lake Kingsley, Clay County. The pines are *Pinus clausa,* and the shrubs in the foreground are *Ceratiola ericoides.* There is almost no herbaceous vegetation, and consequently fires are very infrequent. May 14, 1909. (This view was selected because it is very characteristic of the lake region, but it is not at all typical; i. e., the average appearance of the region is quite different. But no typical view of the small part of the lake region covered by this report happened to be available.)

EAST FLORIDA FLATWOODS.

(Pages 326-337)

Fig. 85. Cypress pond near Bellamy, Alachua County. Trees mostly *Taxodium imbricarium,* with some *Pinus Elliotti.* July 17, 1910.

Fig. 86. Looking north across Lake Butler, Bradford County, from near edge of the town of the same name. The trees are *Taxodium imbricarium* (pond cypress), draped with *Tillandsia usneoides* as usual. May 27, 1909.

EAST COAST STRIP

(Pages 338-343)

FIG. 87. Exposure of coquina rock on shore of Anastasia Island, St. John's County. Photograph by F. G. Clapp, December, 1907. (From 2nd Annual Report, pl. 7. 2.)

FIG. 88. Salt marshes near Mayport, Duval County, with dunes in distance. The grass in the foreground seems to be all *Spartina stricta.* The cause of the circular pools is not obvious. May 13, 1909.

EAST COAST STRIP

(Pages 338-343)

FIG. 89. Salt marsh and hammock on inner side of Anastasia Island, looking west toward St. Augustine. The hammock is on an ancient dune rising abruptly from the marsh, which makes up about half of the apparent height of the trees. The trees are mostly live oaks. The smoothness of the top of the forest is probably due largely to the effects of wind. July 8, 1914.

FIG. 90. Looking north from summit of outermost dunes on Anastasia Island about a mile south of South Beach, showing beach and surf at right, dunes in center, and shrubby thickets or dwarf hammocks at left. *Ipomoea Pes-caprae* (seaside morning-glory) conspicuous in foreground. July 8, 1914.

STATISTICAL SUMMARY

In the foregoing pages some of the fundamental and significant characteristics of each region have been expressed numerically. It will now be very instructive to bring together as many as possible of such numbers in a single table for purposes of comparison, and see what conclusions may be drawn from them.

It has been stated in the introduction that in northern Florida, if not elsewhere, the differences in vegetation, density of population, etc., between neighboring regions seem to depend on soil and topography more than anything else. And one of the purposes of this report is to show how a study of the native vegetation may indicate the character of the soil, and more particularly its agricultural value. But unfortunately our knowledge of the soil in this area is still so imperfect that it is difficult to make definite correlations. We have indeed many physical or mechanical analyses of soils, thanks to the activity of the U. S. Bureau of Soils, but no one seems to have ever pointed out any close correlations between such analyses and the vegetation or even the productivity, beyond the bare fact that a good soil ought to have a certain amount of silt and clay. Chemical composition seems to be more significant (though some limiting factors often have to be taken into consideration, as intimated in the footnote on pp. 175-176), and some correlations between evergreens and potash, Ericaceae and lime, etc., have already been indicated. But at present we have chemical analyses from only ten of the twenty geographical divisions, and seven of those are represented by only one analysis each; and it is of course impossible for a single soil sample, no matter how carefully selected, to be typical of a somewhat diversified region. Consequently it would be rather risky to base any important conclusions on these data.

Another index of the fertility of the soil is the amount of fertilizer used by the farmers. Of course in the long run nearly as much mineral plant food should be put back into the soil as is removed by crops, regardless of the original fertility; but in most parts of Florida agriculture is as yet a comparatively undeveloped industry, and the farmers are still drawing on the natural resources of the soil to a considerable extent. Consequently the least fertilizer is generally used on the richest soils, and vice versa.

Statistics of the annual expenditure for fertilizers in each county are readily obtained from both state and government census reports (but were discovered too late to be mentioned in the earlier pages of this report). But naturally there are several chances of error in trying to obtain the average amount of fertilizer used per acre in different regions from the census returns. First, in regions where the amount of cultivated land is very small a slight variation in the total amount of fertilizer used in different years may make a considerable difference in the amount per acre, and the census year might not be an average year. Second, in regions which do not cover as much as half of any one county it is impossible to apportion the fertilizer among different regions in the same county accurately. A similar difficulty was encountered in apportioning the population and improved land (see p. 188), but it is more accentuated in the case of fertilizer, which seems to vary more from one region to another than the population, in Florida at least, and is not so easily checked up by personal observation. For example, in Wakulla County probably most of the tilled land is in region 13, which covers less than one-fourth of the county, and practically no fertilizer is used there (see p. 296); but about half the county is in region 9, where fertilizer is used at the rate of about a dollar's worth per acre per year. So instead of the flatwoods part of the county having half the tilled land and using half the fertilizer, it probably has something like one-tenth of the tilled land and uses nine-tenths of the fertilizer. Third, economic conditions sometimes cause the use of much more fertilizer than the ordinary staple crops would naturally require, as in Gadsden County, where large areas are devoted to tobacco, which requires a great deal of potash, and in the neighborhood of cities and along trunk lines of railroad, where truck-farming is carried on extensively.

The first column of figures in the table is for areas, in square miles, and the next three for the percentages of evergreens, Ericaceae (among the shrubs) and Leguminosae (among the herbs), most of which have already been given in the regional descriptions. The fifth is for the percentage of original forest remaining, which is of course a little less than the difference between that of improved land and 100%. The sixth column represents the amount expended in 1909 for fertilizer, per acre of improved land, according to the 13th U. S. census. The seventh is for density of population (number of inhabitants per square mile), and the last for the percentage of whites. (The cities of Pensacola and Jacksonville are excluded from the calculations of density of population, for the reasons given on pages 229 and 336.) It did not seem worth while to insert in this table the rates of increase of population, which have been mentioned in some of the regional descriptions, for although they differ greatly in different regions, they vary too much from one decade to another to have much geographical significance.

All the figures of course are only approximate, but in the first five columns the average error is probably not more than 10% one way or another. The last three columns are less reliable. on account of the lack of minute detail in the census reports, as already explained; but the averages for the whole of northern Florida, at the bottom of these columns, are just as accurate as the work of the census enumerators, if not more so. In some of the columns figures unknown but believed to be above the average for northern Florida in that particular thing are indicated by + and the reverse by —, somewhat as was done in the plant lists. Where no such guess can be safely made an interrogation point is used.

STATISTICAL TABLE

REGIONS	Area	Vegetation Percentage of Everg.	Eric.	Legum	Amt. of forest	Expend. for fert.	Density of popul.	Per cent white
1. Marianna red lands	440	49	2	10	50?	.15?	40?	40?
2. W. Fla. lime-sink region	1600	65	12.	6	85	.99	22	69
3. Apalachicola bluffs	50	55	7	2	90?	—	?	?
4. Knox Hill country	50	56	25	1	75?	—	26	?
5. Holmes Valley	30				50?	0	—	—
6. West Fla. lake region	350	75	?	?	97?	?	—	+
7. West Fla. pine hills— Western division	3200	75	15	10	95	2.33	13*	62
Eastern division	750	77						
8. West Fla. coast strip	400	80	7	8	99	?	—	+
9. Apalachicola flatwoods	2600	68	16	1	97	1.00	8	58
10. Middle Fla. hammock belt— Western division	440	74	8	8	?	3.46	+	—
Middle division	800	69	20	2	70	.21	27	32
Eastern division	650	66	9	8	75	.48	26	50
11. Tallahassee red hills	340	53	8	9	40?	.10?	40?	25?
12. Bellair sand region	240	60	30	17	95	?	—	?
13. Wakulla hammock country	150	48	11	12	75?	0	+	?
14. Panacea country	60	66	31	28	99	?	—	?
15. Gulf hammock region	1470	74	7	6	95	.20	7	60
16. Middle Fla. flatwoods	1000	69	18	—	98	?	—	+
17. Peninsular lime-sink region	2000	79	2	20	75	.35	24	51
18. Peninsular lake region	500	80	15	15	95	+	15	+
19. East Fla. flatwoods— Western division	2050	75	19	2	85	1.00	20	60
Eastern division	3250	74	7	4	96	3.78	16†	53
20. East coast strip	180	94	10	4	99	?	?	?
Northern Florida	22600	70	12	7	89	.89	20	54

*Excluding Pensacola.
†Excluding Jacksonville.

It will be noticed that in general high percentages of evergreens and Ericaceae go with much virgin forest, considerable expenditure for fertilizers (in regions that have been cultivated enough to get any fertilizer statistics from), and sparse population with whites predominating; and *vice versa*. There are some exceptions, of course, but most of those are due to somewhat accidental or psychological factors, and have been partly explained in the regional descriptions. It is certain at least that the six small regions with less than 60% of evergreens (indicated by shading on the map) have required very little fertilizer as yet, and most of them have at least 25% of their area cleared, and more negroes than white people. The relations of leguminous plants to soils and economic features are not quite so simple ,but some of them have been suggested in the regional descriptions.

It is also evident that nearly all the regions that spend over a dollar an acre a year for fertilizer have more evergreens than the average, and also more white people. In region 9 the evergreen percentage is a little below the average, on account of the Apalachicola River swamps, in which deciduous trees predominate, but those fertile swamps are almost too wet to cultivate, and therefore do not perceptibly increase the amount of land that is cultivated with little or no fertilizer. In the western division of region 10 the percentage of whites is evidently below the average, but the high expenditure for fertilizer there is mainly due to the tobacco industry, whose concentration there may be very largely accidental. (The influence of the trucking industry on fertilizer expenditure is shown plainly in the eastern division of region 19, and less so in the eastern division of region 10.)

Although one very rarely sees any such statement in print, it must be a fact that the pioneer farmers in northern Florida (if not in most other eastern states), who of course know little about soil physics or chemistry, and cannot afford to experiment much, in selecting land for cultivation must have been guided largely by the proportions of evergreen and deciduous trees in the forests.* And deciduous forests are nearly always cleared first, provided their location, drainage, etc., are suitable. Just how much the average farmer reacts to the presence of Ericaceae, Leguminosae, and other indicative plants it is hard to say, for he cannot be expected to have an intimate acquaintance with them. But probably almost every farmer knows that huckleberry bushes (Ericaceae) generally indicate poor soil, and clover and beggar-weed (Leguminosae) the opposite.

Our very sandy hammocks, which although pretty well supplied with humus (as nearly all hammocks are) are characterized by a preponderance of evergreens, are quite generally left uncultivated, as are the sour flatwoods and scrub, in which the vegetation is nearly all evergreen. And it cannot be doubted that the early settlers who began to clear up the land around Crawfordville in the first half of the 19th century, when most of Wakulla County was a "howling wilderness," were attracted by the predominance of deciduous trees in the forests, and not deterred by the coarse and unpromising appearance of the soil.

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*Quite a number of botanists and soil investigators have discussed the problem of determining the agricultural value of virgin soils by means of vegetation, particularly Hilgard (Tenth Census 5:68-69, 229; Soils, xviii-xx, 313-318, 487-526), Mohr (Contr. U. S. Nat. Herb. 6:821-824. 1901), Kearney (Contr. U. S. Nat. Herb. 5:481-484. 1901), Shantz (U. S. Dept. Agr., Bur. Plant Industry, Bull. 201. 1911), and Kearney, Shantz and others (Jour. Agric. Research, 1:365-417, pl. 42-47. Feb. 1914) ; but all these studies have been merely or mainly qualitative, as explained on page 173, and therefore of little value to one who does not happen to know the plants discussed. And they usually make no special reference to the percentage of evergreens, which is one of the most prominent and easily determined features of any forest. (That evergreens have practically the same significance as far north as upper Michigan—latitude 46°—that they do here has been pointed out by the writer in Rep. Mich. Acad. Sci. 15:197. 1914.)

ADDITIONAL INFORMATION ABOUT SOILS.

In the regional descriptions a number of mechanical analyses of soils have been quoted from government soil surveys; but in those published since 1905 the localities and depths of the samples are not given. Some of the missing data have just been obtained from the records of the U. S. Bureau of Soils through the kindness of Prof. C. F. Marbut, in charge of the soil survey work, and are given here, having been received too late for insertion in the proper places.

Region 1, p. 194. The sample of "Norfolk fine sandy loam" came from 3 miles north of Aycock, and should therefore have been given under region 2, on page 202.

Region 6, page 225. Both samples of "Norfolk sand" are from localities outside of the lake region; but perhaps there is no essential difference between them and the lake region soils, in texture at least.

Region 9, page 248. The "Leon sand" is from one mile north of Grand Bay, which would be about in S. 24, T. 1 S., R. 4 W. The depths of soil and subsoil are 0-8 and 8-36 inches respectively.

Region 10, page 255. The samples of "Norfolk sand" from Jefferson County are from ¾ mile south of Ashville and 2 miles south of Lloyd's.

Region 11, page 268. It turns out that neither sample of "Norfolk sand" from Leon County was from the Tallahassee red hills, so that its omission from the table was justified.

Region 16, page 310, The "Portsmouth fine sand" samples from Jefferson County were taken 2 miles north of Delph (now called Fanlew), which would probably be in S. 20, T. 2 S., R. 3 E. The depths are 0-8, 8-20, and 20-36 inches.

Six additional chemical analyses of soils have been made by L. Heimburger, Assistant State Chemist, since the printing of the foregoing pages was well advanced. As in the case of those given on pages 270 and 281, he used the A. O. A. C. methods for fertilizers, described in Bulletin 107 of the Bureau of Chemistry, U. S. Dept. of Agriculture, revised edition of 1912. To be more specific, the phosphoric acid was determined by method 3(a) (2) (a2) on page 2, the nitrogen by method 4(d) (modified Gunning method) on page 8, and the potash by method 5(a) (2) (b) on page 11. The sodium, sulphur, magnesium, manganese, and several other minor or less important constituents were not determined for lack of time. The volatile matter includes nitrogen.

The samples are as follows:

1. (Region 2, page 201.) Pine land on east side of Choctawhatchee River, 8½ miles northeast of Cerro Gordo, Holmes Co. Collected by Dr. E. H. Sellards.

2. (Region 9, page 247.) Flatwoods near 32-mile-post on G., F. & A. Ry. (between Hilliardville and Arran), Wakulla Co. Oct. 8, 1914. A rather coarse gray sand, 0-1 ft. Vegetation long-leaf pine, saw-palmetto, gallberry, wire-grass, deer-tongue, and several less familiar plants. (This would probably be classed as "Leon sand" by the U. S. Bureau of Soils.)

3. (Region 13, page 289.) Coarse yellowish sandy loam from rich woods about a mile north of Crawfordville, Wakulla Co. (The same spot shown in fig. 77.) Oct. 8, 1914. Vegetation mostly red oak, hickory and dogwood, with very little underbrush or herbaceous vegetation. Sample taken to a depth of one foot.

4. Same locality, 2 to 3 feet below surface. Subsoil, very similar in appearance to surface soil. (See mechanical analysis on page 289.)

5. (Region 15, page 304.) Calcareous flatwoods, close to sea-level, about a mile northwest of St. Mark's, Wakulla Co. Sept. 19, 1914. A blackish medium sand, with almost no silt and clay, taken to a depth of 6 inches. Vegetation *Ambrosia sp., Flaveria sp., Chondrophora nudata, Pluchea bifrons, Cladium effusum* (saw-grass), *Mesosphaerum radiatum, Monniera acuminata, Lippia sp., Dichromena colorata, Centella repanda, Eupatorium mikaniodes,* and a few other peculiar herbs, with wire-grass and small scattered long-leaf pines. A few earthworms found here, strange to say.

6. (Region 17, page 314.) High pine land near Wade, Alachua Co. Depth of sample 0-3 feet. Collected by Dr. E. H. Sellards.

ANALYSES.

	1	2	3	4	5	6
Moisture (H_2O)	0.29	0.06	0.33	0.09	0.63	0.03
Volatile matter	2.08	1.35	2.30	1.00	3.07	0.52
Nitrogen	.115	.110	.120	.083	.145	.075
Potash (K_2O)	.090	.029	.044	.033	.072	.033
Lime (CaO)	.145	.085	.090	.060	.190	.115
Phosphoric acid (P_2O_5)	.064	.044	.064	.044	.050	.072
Iron and alumina (Fe_2O_3,Al_2O_3)	3.83	0.33	1.38	1.14	1.53	0.60
Insoluble matter	93.56	98.35	96.08	97.86	94.87	98.89

Although these analyses do not all come out exactly as was expected, they are not wholly inconsistent with what was already known of the vegetation and agricultural resources of their respective regions.

No. 1 is a pretty good average soil for northern Florida, and the statistics given a few pages back for the region from which it comes (the West Florida lime-sink or cypress pond region) are not far from the average for the whole area.

No. 2 has less of all soluble and volatile constituents than any other in the table, except that it exceeds in humus and the components thereof No. 4, which is a subsoil, and No. 6, which is soil and subsoil mixed, and has a little more lime than No. 4. It is not surprising therefore that it is uncultivated.

The greatest surprise was in the case of Nos. 3 and 4, the soil and subsoil so carefully selected from near Crawfordville, on a special trip made for the purpose. By all accepted physical and chemical standards this should be a rather poor soil; but the vegetation and crops indicate decidedly otherwise. Perhaps the main source of fertility lies in some constituent not considered in these analyses; or perhaps the soil has some peculiarity that enables plant roots (especially in the case of trees, which have a life-time to do it in) to get more out of it than the chemists' reagents do in a few days.* Another possibility is that there is a more fertile stratum below the depth sounded (three feet),

*Possibly a different method of analysis would give results more consistent with the surface indications. Hilgard (Soils 343, 375) states that the A. O. A. C. methods for soils extract less of some constituents, particularly potash, than his acid-digestion method; and Mr. Heimburger used the A. O. A. C. methods for fertilizers, which may differ in still other ways. And yet all of his analyses having been made by the same method, ought to be strictly comparable with each other, if not with those made by other methods; unless there is some significant difference in the rate of reaction of soils of different texture to the same reagents.

which is reached by the roots of trees but not by those of herbs. For strange to say, the native herbs of region 13 are nearly all species characteristic of high pine land and sandy hammocks, the red oak and dogwood forests being almost devoid of herbaceous vegetation. In this particular this region is much like No. 11, but a good deal different from Nos. 4 and 5, and very, very different from Nos. 1 and 3; although the arborescent flora of these six hardwood regions (which are shaded on the map) has much in common. But the fact that there is more potash, lime, phosphorus, iron and alumina in the soil than in the subsoil would not be easy to explain on the last hypothesis, nor would the productivity of the soil; for it is not likely that the roots of annual crops go as deep as three feet. (The soil is indeed loose and easily penetrated for considerable depths, but so is that of regions 12 and 17, which are much less fertile.) This soil problem thus adds one more to the several mysteries or curiosities for which Wakulla County is already noted.*

No. 5 contains more lime than any of the others in this lot ,as was expected, and also more humus, which is often correlated with lime. (This was the only one of the last six soils in which earthworms were noticed.) It contains considerably less lime, though, than the clayey soils previously analyzed, and whether the amount of lime in it completely explains the peculiarity of its vegetation or not cannot be said to be definitely settled.

No. 6 is the poorest of the six in humus, but the richest in phosphorus, which might have been expected, as it comes from the phosphate country. It contains less phosphorus than the (more clayey) soils of regions 1 and 11, however, if we may judge from the analyses.

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*The name of the county is said to be an Indian word meaning mystery. (See Norton's Handbook of Florida, 3d edition, 1892, pp. 98, 347.)

LIST OF TREES

The following list comprises all the native trees (including many small trees) mentioned in the foregoing pages (and a few additional ones too rare to appear in any of the regional lists), with their percentages of abundance for northern Florida as a whole, their technical and common names, and a few words about their distribution and habitat. The percentages are given only to the nearest tenth of one per cent, and therefore those less than .05% are represented by 0. In the case of the small trees, which have been estimated on a smaller scale than the large ones, as explained on pages 178 and 186, the percentages are not given, but are replaced by interrogation points. None of them would exceed 1% even if they were given. Evergreens are indicated by heavy type, as before. The sequence is very nearly the same as in Small's Trees of Florida (1913), in which can be found the names of several species which are not mentioned here because they are confined to the southern parts of the state, or are not native, or have not been identified by the writer, or are too small to be regarded as trees.

41.7 **Pinus palustris** Mill. LONG-LEAF PINE.
Sandier soils, in every region except the last.

0.2 **Pinus Caribaea** Morelet?
Mostly near Gulf coast. Not well understood as yet.

9.2 **Pinus Elliottii** Engelm. (SLASH PINE.)
Ponds, bays, non-alluvial swamps, etc., nearly throughout.

4.7 **Pinus Taeda** L. SHORT-LEAF PINE. (Also called loblolly pine and black pine.)
Hammocks, bottoms, and other moderately rich soils, nearly throughout.

2.9 **Pinus serotina** Mx. (BLACK PINE.)
Bays, flatwoods, etc., rare westward, common eastward.

1.8 **Pinus echinata** Mill. SHORT-LEAF PINE. (Also called rosemary pine.)
Mostly on clayey uplands. West and Middle Florida.

0.7 **Pinus glabra** Walt. SPRUCE PINE.
Hammocks, etc., common westward, rare eastward.

0.5 **Pinus clausa** (Engelm.) Vasey. SPRUCE PINE.
Old dunes near coast, and scrub of peninsular lake region.

0.9 Taxodium distichum (L.) Richard. CYPRESS.
Mostly in marly or alluvial swamps; common but not abundant.

8.8 Taxodium imbricarium (Nutt.) Harper. (*T. ascendens* Brong.) (POND) CYPRESS.
Ponds, bays, non-alluvial swamps, etc., nearly throughout. Trees apparently intermediate between this and the preceding occur in the Gulf hammock region.

0.2 **Chamaecyparis thyoides** (L.) BSP. JUNIPER.
Non-alluvial and estuarine swamps, in West Florida pine hills.

0.3 **Juniperus Virginiana** L. (RED) CEDAR.
Rock outcrops, low hammocks, etc., mostly in calcareous regions.

0.1 **Tumion taxifolium** (Arn.) Greene. STINKING CEDAR, or SAVIN.
Apalachicola River bluffs, in shade of other trees. Not known elsewhere.*

*See Bull. Torrey Bot. Club 32:149. 1905.

o **Taxus Floridana** Nutt.
Alum Bluff, and reported from farther up the same river. Confined to region 3, like the preceding.

0.5 **Sabal Palmetto** (Walt.) R. & S. CABBAGE PALMETTO.
Mostly in low hammocks and near coast. Not known west of St. Andrew's Bay.

? **Yucca aloifolia** L. SPANISH BAYONET.
Dunes of east coast.

o Juglans nigra L. (BLACK) WALNUT.
Richest soils in regions 1 and 3.

o Hicoria aquatica (Mx.f) Britton. (SWAMP) HICKORY.
Mostly in alluvial swamps, but not confined to muddy streams.

0.3 Hicoria alba (L.) Britton? HICKORY.
Moderately rich uplands, widely distributed.

0.1 Hicoria glabra (Mill.) Britton? HICKORY.
Mostly in hammocks, with poorer soil than the preceding requires.
(There are probably two or three other hickories in our area, but they are difficult to distinguish from the two preceding.)

? **Myrica cerifera** L. MYRTLE. (Usually only a shrub.)
Low hammocks, etc., rather common.

? **Myrica inodora** Bartr.
Non-alluvial swamps in Middle and West Florida. Occasionally arborescent in region 7.

0.1 Populus deltoides Marsh. COTTONWOOD.
Banks of Apalachicola River mostly.

o Populus heterophylla L. (COTTONWOOD.)
Banks of lower Apalachicola River, in region 9.

0.3 Salix nigra Marsh. WILLOW.
Banks of streams, etc., mostly westward.

? Salix longipes Anders.? WILLOW.
Mostly in marly swamps and low hammocks, particularly in region 15.

? Salix Floridana Chapm.
Somewhat calcareous swamps in regions 1 and 2; rare.

0.3 Carpinus Caroliniana Walt. (IRONWOOD.)
Bottoms, low hammocks, etc., mostly northward.

0.2 Ostrya Virginiana (Mill.) Willd.
Rich woods and hammocks, mostly westward.

0.2 Betula nigra L. BIRCH.
Banks of creeks and rivers, mostly northward.
(Several current botanical manuals credit *Betula lenta* L. to West Florida, but that seems to be wholly unfounded, for that species is not known south of the mountains of Georgia and Alabama, and it is very stunted even there.)

0.4 Fagus grandifolia Ehrh. (*F. Americana* Sweet.) (Our tree has been separated from the northern one as var. *Caroliniana*, but the differences are not very marked.) BEECH.
Rich woods and hammocks; common westward, rare or absent eastward.

o Castanea pumila (L.) Mill. CHINQUAPIN.
A small to medium-sized tree in regions 4 and 14; rare and usually only a shrub elsewhere.

0.2 Quercus alba L. White oak.
Rich woods, mostly westward. Not seen east of region 10.

0.1 Quercus Margaretta Ashe. Post oak. (Sometimes called black-jack oak.)
Sandy uplands, nearly throughout.

0.2 Quercus stellata Wang. Post oak.
Clayey uplands, west of Suwannee River.

0.1 Quercus lyrata Walt. (Swamp post oak. Overcup oak.)
Bottoms of Chipola, Apalachicola and Suwannee Rivers mostly.

? Quercus **Chapmani** Sarg.
Sandy hammocks in peninsular lake region.

0.2 Quercus Michauxii Nutt. (Swamp chestnut oak. Chestnut white oak.)
Low hammocks, bottoms, etc.; rather widely distributed.

0 Quercus Muhlenbergii Engelm.
Rich calcareous uplands in regions 1 and 3.

0.5 **Quercus Virginiana** Mill. Live oak.
Hammocks, lake shores, etc., apparently preferring phosphatic soils.

0.3 **Quercus geminata** Small. (Smaller, or scrub) live oak.
In poorest dry sandy soils, such as old dunes, and scrub, also in sandy hammocks. Often scarcely more than a shrub.

? **Quercus myrtifolia** Willd.
Often with the preceding, but confined to still poorer soils if anything, and only rarely arborescent.

0.5 **Quercus laurifolia** Mx. (Evergreen willow oak?)
Sandy hammocks, etc., pretty widely distributed.

0 Quercus Phellos L. Willow oak.
In clayey soil around small ponds in region 1. Very rare farther south.

0.1 **Quercus hybrida** (Chapm.) Small?
Common in low hammocks in the Gulf hammock region, and occasionally in similar situations elsewhere.

0.7 Quercus **nigra** L. Water oak.
Bottoms and other low grounds, common except near coast.

1.7 Quercus cinerea Mx. Turkey oak. (Sometimes called upland willow oak or narrow-leaf black-jack.)
Dry sandy uplands; apparently with a slight preference for phosphatic soils.

3.4 Quercus Catesbaei Mx. Black-jack oak. (Also called turkey oak or forked-leaf black-jack.)
Dry sandy uplands, in every region except nos. 11 and 20.

0.3 Quercus Marylandica Muench. Black-jack oak. (Sometimes called round-leaf black-jack or dollar-leaf oak to distinguish it from the preceding.)
Mostly on driest red clay uplands, from Leon County westward.

1.3 Quercus falcata Mx. (*Q. digitata* Sudw.) Red oak. ("Spanish oak" of the books.)
Rich dry uplands, west of Trail Ridge.

0 Quercus pagodaefolia (Ell.) Ashe. (Red oak.)
Bottoms of Apalachicola River.

0 Quercus velutina Lam. (Black oak.)
Dry red clay uplands, mostly in Tallahassee red hills.

0 Quercus Schneckii Britton? (Red oak?)
Rich woods and hammocks, mostly in regions 1 and 3. (*Q. rubra* L., the northern red oak, which resembles it considerably, may possibly occur with it.)

0.1 Morus rubra L. MULBERRY.
Rich woods and low hammocks in calcareous regions.

0 Ulmus alata Mx. ELM.
Rich woods, especially in calcareous soils; rare.

0.1 Ulmus Floridana Chapm. ELM.
Calcareous bottoms, low hammocks, etc., especially in Gulf hammock region.

0 Ulmus Americana L.? ELM.
Along Chipola and Apalachicola Rivers.

0 Ulmus fulva Mx. SLIPPERY ELM.
Rich calcareous woods in regions 1 and 3; very rare.

0.1 Planera aquatica (Walt.) Gmel.
Along Apalachicola and Suwannee Rivers, and in a few other places where the water fluctuates several feet during the year

0.1 Celtis occidentalis L.? HACKBERRY. (Perhaps more than one species.)
River-bottoms, rich hammocks, etc.

1.8 Magnolia grandiflora L. MAGNOLIA. (Occasionally called loblolly.)
A characteristic tree of hammocks, in every region.

3.0 Magnolia glauca L. (WHITE) BAY.
Bays and non-alluvial swamps, in every region except the last.

? Magnolia macrophylla Mx. CUCUMBER TREE.
Rich woods in Knox Hill country and Holmes Valley.

? Magnolia pyramidata Pursh. CUCUMBER TREE.
With the preceding, but rarer.

0.5 Liriodendron Tulipifera L. POPLAR.
Branch-swamps and wet woods, mostly northward.*

2.4 Liquidambar Styraciflua L. SWEET GUM. (Red gum of the lumber trade.)
In various situations, nearly throughout; apparently preferring somewhat phosphatic soils.

0.1 Platanus occidentalis L. SYCAMORE.
Banks of Apalachicola River, in regions 2, 3 and 9.

0.1 Malus angustifolia (Ait.) Mx. CRAB-APPLE.
Moderately rich uplands, west of Suwannee River.

? Amelanchier Canadensis (L.) Med.?
Rich woods in West Florida; rare.

? Crataegus apiifolia (Marsh.) Mx. (PARSLEY HAW.)
Bottoms, low hammocks, etc.; not common.

? Crataegus spathulata Mx.
Bluffs of upper Apalachicola River.

? Crataegus aestivalis (Walt.) T. & G. MAY HAW.
Suwannee River bottoms, and shallow ponds in clayey soil westward.

0.1 Crataegus viridis L. HAW.
Bottoms and sloughs, mostly in regions 2 and 15. (This is the largest of our haws, but it is never more than a medium-sized tree.)

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*About two years ago Prof. P. H. Rolfs found this tree being cut for lumber in the southwestern part of Putnam County, which was farther south than it had previously been known to grow. (See Torreya 13:69. 1913.) On July 9, 1914, the writer passed through the same section on the Ocala Northern R. R. and saw enough of this tree to warrant its inclusion in the list of plants for the peninsular lake region (page 322).

? Crataegus Michauxii Pers.? HAW.
Moderately rich sandy uplands, particularly in old fields.

? Crataegus lacrimata Small. HAW.
Sandy ridge in central part of Walton Co.

? Crataegus Crus-Galli L.? HAW.
Calcareous flatwoods in Gulf hammock region.
Several other species of this difficult genus, which have not been identified, occur in regions 11, 13, 15, and elsewhere. (See index.) In Small's Trees of Florida 48 alleged species of *Crataegus* are enumerated, most of them from the area covered by this report.

? Prunus umbellata Ell. HOG PLUM.
Dry woods, etc., mostly northward.
(There is another species, apparently undescribed, which differs from this in having red and more edible fruit. It grows mostly along roads in regions 10, 11 and 13, and may not be native.)

o Prunus Americana Marsh. WILD (GOOSE) PLUM.
Rich calcareous woods in regions 1 and 3.

o **Prunus Caroliniana** (Mill.) Ait. MOCK ORANGE.
Bluffs of Apalachicola River, etc. Very rare in the wild state.

0.1 Cercis Canadensis L. REDBUD.
Rich, especially calcareous, upland woods.

o Gleditschia triacanthos L.? (HONEY LOCUST.)
Calcareous sloughs, etc., in Gulf hammock region, and perhaps elsewhere.

o Gleditschia aquatica Marsh?
Banks of Suwannee River, etc.

? Xanthoxylum Clava-Herculis L.
Phosphatic (?) sandy hammocks in Alachua County and along east coast.

? Cyrilla **racemiflora L.** TYTY. (Also spelled tietie, tighteye and titi.)
Branch and creek swamps, etc.; common in most of the regions.

? **Cyrilla parvifolia** Raf. TYTY. (Usually only a shrub.)
Bays, etc.; almost confined to Middle Florida.

? **Cliftonia monophylla** (Lam.) Sarg. TYTY.
Bays and sour swamps, from Jefferson County westward.

? Ilex decidua Walt.
Alluvial bottoms of Apalachicola River, etc.

? **Ilex myrtifolia** Walt. YAUPON.
Shallow ponds, in most of the counties north of latitude 30.

? **Ilex Cassine** L. (*I. Dahoon* Walt.)
Non-alluvial swamps, mostly southeastward.

? **Ilex vomitoria** Ait. (*I. Cassine* Walt.)
Sandy hammocks, especially along east coast.

0.4 **Ilex opaca** Ait. HOLLY.
In hammocks, commonest westward.

? Aesculus Pavia L. BUCKEYE.
Bluffs and moderately rich uplands; usually only a shrub.

o Acer saccharinum L. (*A. dasycarpum* Ehrh.) (SILVER) MAPLE.
Banks of Apalachicola River, in regions 2, 3 and 9.

0.8 Acer rubrum L. (RED) MAPLE.
Mostly in non-alluvial swamps, in nearly every region.
The var. *tridens* (or *A. Carolinianum* Walt.) is difficult to distinguish from this. It seems to prefer richer soils.

0.1 Acer Floridanum (Chapm.) Pax. SUGAR-MAPLE.
Rich calcareous woods, mostly in regions 1 and 3.

0 Acer Negundo L. BOX-ELDER.
Along Apalachicola River, and in hammocks in central Florida. (As these two habitats are quite different, and also pretty widely separated, there may be two species involved, but botanists have not yet distinguished them.)

0 Sapindus marginatus Willd.
Phosphatic (?) hammocks around Alachua Sink.

0 Tilia Floridana Small. (LIN, or BASSWOOD.)
Rich woods and bluffs near Apalachicola River, Jackson and Gadsden Cos.

0.1 Tilia pubescens Ait.
Mostly in low or phosphatic hammocks, in regions 10, 13, etc.

0.2 **Gordonia Lasianthus** (L.) Ellis. (RED, TAN, or LOBLOLLY BAY.)
Bays and non-alluvial swamps; rare west of Suwannee River, common east of Trail Ridge.

0.1 **Persea Borbonia** (L.) Sarg. (RED BAY.)
Hammocks; commonest eastward.

0 **Persea pubescens** (Pursh) Sarg. (RED BAY.)
Non-alluvial swamps, etc.; widely distributed but rather scarce.

? **Persea humilis** Nash.
Scrub in the peninsular lake region.

0.1 Sassafras variifolium (Sal.) Kuntze. SASSAFRAS.
Arborescent in the Wakulla hammock country. Elsewhere usually a shrub in old fields. Rare in East and West Florida.

0 Nyssa sylvatica Marsh. BLACK GUM.
Clayey uplands, mostly northward.

2.0 Nyssa biflora Walt. BLACK GUM.
Non-alluvial and estuarine swamps and shallow ponds.

0.2 Nyssa uniflora Wang. (*N. aquatica* L.?) TUPELO GUM.
Swamps and sloughs, from Choctawhatchee River to Wakulla Co.

0.2 Nyssa Ogeche Marsh. TUPELO GUM. (Ogeechee Lime.)
Swamps and sloughs, especially of lower Apalachicola River.

0.9 Cornus florida L. DOGWOOD.
On loamy uplands, in shade of other trees.

? **Cholisma** (originally misspelled **Xolisma) ferruginea** (Walt.) Heller.
Sandy hammocks and scrub, Middle and East Florida; usually no more than a shrub.

0.1 Oxydendrum arboreum (L.) DC. SOURWOOD.
Loamy uplands, north of lat. 30° and west of Suwannee River.

? Batodendron arboreum (Marsh.) Nutt. SPARKLEBERRY.
Sandy hammocks and other dry places protected from fire.

? Diospyros Virginiana L. PERSIMMON.
Old fields, etc.; common, but perhaps not native, and often little more than a shrub. In the vicinity of Tallahassee its fruit begins to ripen about the last week in August, notwithstanding the old tradition about persimmons and frost (which probably originated in Virginia, and may be true there).

0 Bumelia **lycioides** (L.) Gaert.
Calcareous bluffs of Apalachicola River, Gadsden Co.

? Bumelia **lanuginosa** (Mx.) Pers.
Sandy hammocks mostly.

? Symplocos tinctoria (L.) L'Her.
Hammocks and bluffs, west of Suwannee River.

o Halesia Carolina L.
Rich woods near Chipola and Suwannee Rivers, etc.

o Halesia diptera Ellis.
Apalachicola River bluffs, etc.

o Fraxinus Americana L. ASH.
Rich woods, mostly in regions 1 and 13.

0.2 Fraxinus Caroliniana Mill. ASH.
Swamps of various kinds, especially alluvial and calcareous.
Two or three other species of *Fraxinus,* difficult to distinguish without fruit, grow in situations similar to the last.

? Adelia acuminata Mx.
Banks of Apalachicola and Suwannee Rivers.

? Chionanthus Virginica L. GRAYBEARD.
Hammocks and rich woods, mostly in Middle Florida.

? Osmanthus Americana (L.) B & H.
Hammocks.

o Catalpa bignonioides Walt. CATALPA.
Banks of smaller rivers; possibly not native.

? Viburnum rufidulum Raf. BLACK HAW.
Rich upland woods, mostly northward and westward.

This list contains about 126 species (or nearly the same number as in either of the two adjoining states), about 40 of which (12 gymnosperms and 28 angiosperms, together making up about 70% of the forest) are evergreen. The only ones which seem to make up more than 1% of the forest (13 in number) may be arranged in order of abundance as follows: *Pinus palustris, P. Elliottii, Taxodium imbricarium, Pinus Taeda, Quercus Catesbaei, Magnolia glauca, Pinus serotina, Liquidambar, Nyssa biflora, Magnolia grandiflora, Pinus echinata, Quercus cinerea, Q. falcata.*

The eight pines make up about 62% of the forests, or 60% of the total vegetation, and 21 arborescent oaks between 9 and 10%. (Alabama has the same number of pines and of oaks, but in that state each makes up about 20% of the forests, and not over 40% of the trees are evergreen.)

LIST OF ERICACEAE AND LEGUMINOSAE.

In each regional description some statistics of the quantity of Ericaceous and leguminous plants have been given, but it would be difficult if not impossible for a non-botanical reader to verify the figures from the regional lists alone. A list of the plants belonging to these families is therefore appended here. With the Ericaceae are included two closely related families now generally regarded as distinct, namely, Clethraceae and Vacciniaceae; and with the Leguminosae are included two smaller families formerly (and still by some botanists) united therewith, namely, Mimosaceae and Caesalpiniaceae. As these other families are believed to have essentially the same soil preferences as the Ericaceae and Leguminosae proper, they have been counted into the statistics in every case.

Of the Ericaceae and related families, *Oxydendrum* is a tree, *Batodendron* a small tree or large shrub. *Cholisma ferruginea* occasionally arborescent, *Pieris phillyreifolia* usually a vine (something very exceptional in this family*) and the rest shrubs, ranging in size from *Kalmia latifolia*, which is mentioned in some books on trees, to *Gaylussacia dumosa*, which is smaller than many herbs. Of the Leguminosae *Cercis* and *Gleditschia* are trees, *Wistaria* a woody vine, *Amorpha fruticosa* a shrub, and the rest ordinary herbs or herbaceous vines.

The following list does not include all the plants of these families that are known in northern Florida, or even all seen by the writer, but only those seen often enough to be mentioned in one or more of the foregoing regional lists. The names of a few additional Ericaceae can be found in Small's Shrubs of Florida (New York, 1913), and of several additional species of both families in the Flora of the Southeastern United States by the same author (1903 and 1913).

In this list, as in the regional lists, evergreens are indicated by heavy type and weeds by (X). Common names are given when known. Instead of stating the habitat and distribution, as in the foregoing list of trees, the names of the species are here followed by the numbers of the regions from which they have been listed; and the interested reader can turn back to the proper pages for additional information. These numbers of course do not indicate all the regions in which the species have been seen, but only those in which they are abundant enough to be listed.

CLETHRACEAE.

Clethra alnifolia L. (including *C. tomentosa* Lam.) 2, 7, 9, 10, 12, 14, 16.

ERICACEAE.

Bejaria racemosa Vent. 18, 19.
Azalea nudiflora L. HONEYSUCKLE. 3, 4, 10, 11.
Azalea viscosa L. HONEYSUCKLE. 7, 19.
Kalmia latifolia L. IVY. 2, 3, 4, 7.
Kalmia hirsuta Walt. 9, 15, 16, 18, 19.
Leucothoe axillaris (Lam.) Don. 3, 10.
Leucothoe racemosa (L.) Gray (including *L. elongata* Small) 2, 9, 12, 16.
Pieris phillyreifolia (Hock.) DC. 2, 7, 10, 14, 16.
Pieris nitida (Bartr.) B. & H. (HURRAH BUSH.) 2, 7, 8, 10, 12, 14, 15, 16, 17, 18, 19.

*See Torreya 3:21-22. 1903.

Pieris Mariana (L.) B. & H. 12.
Cholisma ferruginea (Walt.)) Heller. 8, 10, 12, 13, 15, 18, 19, 20.
Cholisma fruticosa (Mx.) Nash. (Poor grub.) 9, 10, 13, 15, 16, 18, 19.
Cholisma ligustrina (L) Britton. 9, 10.
Oxydendrum arboreum (L.) DC. Sourwood. 3, 4, 5, 7, 8, 10, 11.

VACCINIACEAE.

Gaylussacia **dumosa** (Andr.) T. & G. 2, 4, 6, 7, 9, 12, 13, 14, 15, 19.
Gaylussacia hirtella (Ait.) Klotzsch. 7.
Gaylussacia frondosa (L.) T. & G. (Including the varieties *nana* and *tomentosa,* sometimes treated as distinct species.) Huckleberry. 2, 7, 9, 10, 13, 14, 18, 19.
Batodendron **arboreum** (Marsh.) Nutt. Sparkleberry. 1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13, 15, 17, 18, 20.
Polycodium (probably two or three species). Gooseberry. 4, 11, 12, 13, 17, 20.
Vaccinium nitidum Andr. *(V. Myrsinites* Lam?) 2, 6, 7, 9, 10, 12, 13, 14, 15, 18, 19, 20.
Vaccinium virgatum Ait. (and probably a few other species). Huckleberry. 2, 4, 10, 15.

MIMOSACEAE.

Morongia uncinata (Willd.) Britton. 1, 2, 11, 12, 14.

CAESALPINIACEAE (or Cassiaceae).

Cercis Canadensis L. Redbud. 1, 2, 3, 4, 10, 11, 13, 15, 17.
Cassia Tora L. (X) Coffee-weed. 10, 11, 13, 17.
Chamaecrista fasciculata (Mx.) Greene (and a few other species) Partridge pea. 7, 11, 12, 13, 14, 15, 17, 20.
Gleditschia (perhaps both *G. triacanthos* L. and *G. aquatica* Marsh.) Honey locust. 15, 17.

LEGUMINOSAE (or Fabaceae.)

Baptisia simplicifolia Croom. 14.
Baptisia LeContei T. & G.? 8, 9, 13, 14, 17.
Baptisia hirsuta Small. 7.
Baptisia lanceolata Walt. 2, 6, 7, 14.
Baptisia alba (L.) R. Br. 1.
Baptisia leucantha T. & G. 10, 11.
Crotalaria rotundifolia (Walt.) Poir. 12, 14.
Lupinus perennis L. Lupine. 14.
Lupinus villosus Willd. 12, 14.
Medicago Arabica All. (X) Bur-clover. 11.
Trifolium Carolinianum Mx. (X) Clover. 11.
Indigofera Caroliniana Walt. 12, 14, 17, 18.
Cracca Virginiana L. Devil's shoestring. 7.
Cracca spicata (Walt.) Kuntze? 13.
Cracca chrysophylla (Pursh) Kuntze. 2, 7, 12, 14.
Wistaria frutescens (L.) Poir. Wisteria. 9, 17.
Glottidium vesicarium (Jacq.) Mohr. (X) 10, 17, 19.
Psoralea Lupinellus Mx. 12.

Psoralea canescens Mx. 2, 7, 10, 12, 13, 14, 17, 18, 19.
Amorpha fruticosa L. 1, 2, 9, 15, 17, 19.
Petalostemon albidus (T. & G.) Small. 12, 13, 15.
Kuhnistera pinnata (Walt.) Kuntze. (SUMMER FAREWELL.) 2, 7, 9, 10, 12, 13, 14, 15, 17, 18.
Aeschynomene Virginica (L.) B.S.P. (X) 11.
Aeschynomene viscidula Mx. 14.
Stylosanthes biflora (L.) B.S.P. 2, 12, 13, 14.
Chapmania Floridana T. & G. 18.
Meibomia nudiflora (L.) Kuntze. (This and other species of the same genus are often called BEGGAR-LICE.) 1.
Meibomia laevigata (Nutt.) Kuntze. 1.
Meibomia rigida (Ell.) Kuntze. 13.
Meibomia purpurea (Mill.) Vail. (X) BEGGAR-WEED. 11, 13.
Lespedeza striata (Thunb.) H. & A. (X) JAPANESE CLOVER. 11, 13.
Lespedeza hirta (L.) Ell. 11, 14, 17.
Pitcheria galactioides Nutt. 2, 6, 7, 8, 14.
Dolicholus simplicifolius (Walt.) Vail. DOLLAR-WEED. 2, 7, 12, 13, 14, 17.
Erythrina herbacea L. 11.
Galactia erecta (Walt.) Vail. 2.
Galactia regularis (L.) B.S.P. 12.
Galactia mollis Mx. 13.
Galactia Elliottii Nutt. 19, 20.
Phaseolus polystachyus (L.) B.S.P. 11.
Vicia acutifolia Ell. 15.

It appears from the foregoing that the sparkleberry (*Batodendron*) is the commonest Ericaceous plant in northern Florida, and that three others grow in ten or more of the twenty regions. *Kuhnistera pinnata* is the only leguminous plant listed from as many as ten regions, and nearly half the Leguminosae are listed from only one region each.*

It has already been shown in the statistical summary that regions 12 and 14 contain the largest quantity of Ericaceae, proportionately, and regions 14 and 17 the most Leguminosae. But statistics based on number of species, regardless of relative abundance, naturally do not give exactly the same results. Regions 7 and 10 seem to contain the most species of Ericaceae, and 12, 13 and 14 the most species of Leguminosae.

It is interesting to note that none of the Ericaceae are weeds, and none of the Leguminosae are evergreen.

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*In the Altamaha Grit region of South Georgia, which corresponds to region 7 of this report, it has been estimated that the average Ericaceous plant grows in 2.87 different habitats, and the average leguminous plant in 1.56. (See Ann. N. Y. Acad. Sci. 17:326. 1906.)

BIBLIOGRAPHY.

This list aims to include only works in which the geography or vegetation of some part of northern Florida is described, and therefore excludes purely geological papers and mere lists of plants, except a few of the latter which deal with some particular small area. Some pertinent titles which were given in the First or Third Annual Report are omitted here to avoid undue repetition, as are most papers in which some general features of the state are described without locating them definitely enough to be cited in the foregoing regional descriptions.

The names of authors are arranged alphabetically and the writings of each one chronologically, if there is more than one.

Adams, J. S. (Commissioner of Immigration).

Florida: its climate, soil and productions, with a sketch of its history, natural features and social condition A manual of reliable information concerning the resources of the state and the inducements which it offers to those seeking new homes.—8vo. pamphlet, 69 pp., a few illustrations, and folded map. New York, 1870.

A 64-page pamphlet with very nearly the same title, apparently official or semi-official, but with no author indicated, was published by L. F. Dewey & Co. of Jacksonville in 1868.

Barbour, G. M.

Florida—for tourists, invalids and settlers; containing practical information regarding climate, soil, and productions; cities, towns, and people; the culture of the orange and other tropical fruits; farming and gardening; scenery and resorts; sport; routes of travel, etc., etc.—310 pp., 39 figs., folded map. D. Appleton & Co., New York, 1882.

Bartram, William.

Travels through North & South Carolina, Georgia, East & West Florida, the Cherokee country, the extensive territories of the Muscogulges, or Creek Confederacy, and the country of the Chactaws; containing an account of the soil and natural productions of those regions, together with observations on the manners of the Indians.—522 pp. and a few plates. 12mo. James & Johnson, Philadelphia, 1791. (Soon afterwards reprinted in London and Dublin, and also translated into French and German.)

The author's travels in Florida (described on pages 70-254, 303-306, 413-417 of the first edition) extended south to what is now Volusia County, and west to the Suwannee River, with a brief visit to Pensacola by way of Mobile. His descriptions of the country in Florida seem less accurate than in the case of the other southern states (see 3d Ann. Rep., p. 242), and it is difficult to trace his route in this state with any degree of accuracy.

Burnett, W. I. (M. D.)

(Notes on Florida, extracted from a letter to Prof. J. D. Dana.)—Am. Jour. Sci. 67:407-412. 1854.

Bush, B. F.

Notes on the botany of some southern swamps.—Garden & Forest 10:514-516. Dec. 29, 1897.

Contains a few notes on the river-swamps near Apalachicola.

Carse, G. B.

Florida: its climate, soil, productions and agricultural capabilities. (With chapters by *A. W. Chapman* and *J. H. Foss*.)—U. S. Dept. Agric. [Report 21] 98 pp. 1882.

Chapman, A. W. (M. D.)

Torreya taxifolia, Arnott. A reminiscence.—Bot. Gaz. 10:251-254. pl. 5 (map). April, 1885.

Contains a list of plants characteristic of the Apalachicola bluff region (no. 3); the only one published up to the present time.

Croom, H. B.

Botanical communications.—Am. Jour. Sci. 25:69-78; 26:313-320; 28:165-168. 1833-1835.

These papers contain valuable information about the flora of Middle Florida, particularly around Tallahassee and Aspalaga. (See 3d Ann. Rep., p. 333, footnote.)

Curtiss, A. H.

A visit to the shell islands of Florida.—Bot. Gaz. 4:117-119, 132-137, 154-158. 1879.

These islands are near the mouth of the St. John's River.

Dall, W. H., & Stanley-Brown, J.

Cenozoic geology along the Apalachicola River.—Bull. Geol. Soc. Am. 5:147-170. 1894.

Eagan, Dennis. (Commissioner of Lands and Immigration.)

The Florida settler, or immigrants' guide; a complete manual of information concerning the climate, soil, products and resources of the state.—8vo pamphlet, 160 pp. Tallahassee, 1873.

A copy of this rare pamphlet has been seen in the library of Dr. Eugene A. Smith, who made good use of it in writing his description of Florida for the Tenth Census. It has no index or table of contents. The first 54 pages are devoted to the general features of the state, and the remainder mostly to county descriptions, which are somewhat optimistically exaggerated, as is often the case. The following statement about malaria, on page 11, is of interest, and probably true: "St. Augustine has long enjoyed a total exemption from all kinds of fever; Jacksonville is equally favored. In Pensacola the treatment of malarial fever is not a part of the practice of the city physicians."

Garber, A. P. (M. D.)

1. Botanical rambles in East Florida.—Bot. Gaz. 2:70-72, 82-83. Jan. and Feb. 1877.

2. Botanical rambles in Middle Florida.—Bot. Gaz. 2:102-103. May, 1877.

(This deals with the country around Gainesville, and not with Middle Florida, which the author seems never to have visited.)

Gillmore. (Gen.) Q. A.

Survey for a ship-canal from St. Mary's River, Florida, to the Gulf of Mexico.—Ann. Rep. Chief of Engineers (U. S. Army) 1880:973-1010, with folded map. 1880.

Contains valuable information about the topography of parts of Middle and East Florida.

Gray, Asa (M. D.)

A pilgrimage to Torreya.—Am. Agriculturist 34:266-267. July, 1875. (Reprinted with some alterations in Scientific Papers of Asa Gray, 1:188-196. 1889.)

Describes a visit to River Junction in the spring of 1875, to find *Tumion taxifolium* (then known as *Torreya taxifolia*, named in honor of his colleague Dr. John Torrey) and *Croomia pauciflora*, both of which were discovered a few miles farther down the river about 40 years before by H. B. Croom. (See pages 214-215 of this report for notes on the relative abundance of these two plants at the present time.)

Harper, R. M.

1. Preliminary report on the peat deposits of Florida.—Fla. Geol. Surv., 3d Ann. Rep., 201-375 (including figs. 17-30), pl. 16-28. Jan. 1911.

Plate 16 is a folded map showing the geographical divisions of the state.

2. Chondrophora virgata in West Florida.—Torreya 11:92-98, fig. 1. April, 1911.

Describes the geology and vegetation of Rock Hill, Washington Co.

3. Early spring aspects of the coastal plain vegetation of South Carolina, Georgia, and northeastern Florida.—Bull. Torrey Bot. Club 38:223-236. "May" [June], 1911.

Describes the vegetation seen from a fast train on March 4, 1910, arranged by regions and in order of abundance.

4. A quest for the Wakulla volcano.—Florida Review 6:215-224, with 3 half-tones. Sept., 1911.

Describes parts of the Gulf hammock region and Middle Florida flatwoods, in Wakulla and Jefferson Counties.

5. The river-bank vegetation of the lower Apalachicola, and a new principle illustrated thereby.—Torreya 11:225-234, fig. 1. Nov., 1911.

6 Notes on the distribution of the southeastern salamanders (Geomys Tuza and allies).—Science 11:35:115-119. Jan. 19, 1912.

Mostly about Florida. (Even at this writing the writer has never seen a salamander.)

7. The coniferous forests of eastern North America.—Pop. Sci. Monthly 85:338-361, with 16 half-tones not numbered. Oct., 1914.

Two illustrations are from northern Florida.

8. (Topography, streams and springs, lakes and ponds, coast and harbors, climate, vegetation, flora, fauna, and forest products of Florida.)—New International Encyclopaedia, Second Edition, 7:706-709, 713. Dodd, Mead & Co., New York, Dec. 1914. (Also about ½ column on Hammocks in vol. 9.)

Harshberger, John W.

The vegetation of South Florida, south of 27° 30′ north, exclusive of the Florida Keys.—Trans. Wagner Free Inst. Sci. (Philadelphia) 7:49-189, with map, 2 text-figures and 10 plates. Dec. 1914.

On pages 64, 69 and 71 are descriptions of the vegetation of Anastasia Island, St. John's Co., introduced by way of comparison.

Johnson, L. C.

1. The structure of Florida.—Am. Jour. Sci. 136:230-236. 1888.

2. The Chattahoochee embayment.—Bull. Geol. Soc. Ann. 3:128-132. 1891.

Jones, Barton D.
On the Gulf coast [of Florida].—Lippincott's Mag. 29:113-122, 217-229, with 11 wood-cuts. February and March, 1882.

Not restricted to the coast, but describes most of the counties in Middle and West Florida.

Lanier, Sidney.
Florida: its scenery, climate and history. With an account of Charleston, Savannah, Augusta, and Aiken, and a chapter for consumptives; being a complete hand-book and guide.—226 pp. and numerous wood-cuts. J. B. Lippincott & Co., Philadelphia, 1875 (and later editions).

Leeds, B. F.
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Long, (Mrs.) **Ellen Call.**
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Claims that long-leaf pine forests would gradually be converted into hammocks if fully protected from fire. One of the first papers in which this theory is proposed.

Matson, G. C., & Clapp, F. G. (of U. S. Geol. Surv.)
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Matson, G. C., & Sanford, Samuel.
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McAtee, W. L.
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The timber pines of the southern United States.—U. S. Dept. Agriculture, Div. Forestry, Bull. 13. Quarto, 160 pp., 27 plates. 1896. (Second edition, 176 pp., 1897.)

See also under *Sargent,* below.

Nash, George V.
Notes on some Florida plants. II.—Bull. Torrey Bot. Club. 23:95-108. March, 1896.

Relates mostly to northern Florida.

Neal, J. C. (M. D.)
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Pierce, James.

Notices of the agriculture, scenery, geology, and animal, vegetable and mineral productions of the Floridas and of the Indian tribes.—Am. Jour. Sci. 9:119-136. 1825.

Reynolds, (Miss) **Mary C.**

Notes from St. Augustine, Fla.—Bot. Gaz. 4:227-230. Nov., 1879.

Sargent, C. S.

(Forests of) Florida. (Including notes on Middle and East Florida by *A. H. Curtiss* and on West Florida by *Charles Mohr.*)—Tenth Census U. S. 9:520-523, with map. 1884.

Some of Dr. Mohr's observations have been quoted on pages 239-240 of this report. Mr. Curtiss expressed somewhat different views about the future of our pine forests, as follows: "One of the most important facts in regard to the pine forests of Florida is their permanence. Owing to the sterility of soil and the liability to inundation of most of the state, it is certain that but a very small portion of Florida will ever be cleared of its forest covering. Taking into consideration the great area covered with valuable pine forests, and the fact that there will be a continuous new growth if the spread of forest fires can be checked, only trees of the largest size being cut, it is evident that Florida will furnish a perpetual supply of the most valuable pine lumber." The truth doubtless lay somewhere between these statements and Dr. Mohr's.

Sellards, E. H.

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2. The soils and other surface residual materials of Florida.—Fla. Geol. Surv., 4th Ann. Rep., 1-79, figs. 1-3, pl. 1-12, and map. 1912.

3. Classification of the soils of Florida.—12th Bien. Rep. Dept. Agr. Fla., 249-299, 4 text-figs., and single-page outline map. 1913. (Also issued separately, with corresponding pages numbered 3-53.)

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Sellards, E. H., & Gunter, H.

1. The fuller's earth deposits of Gadsden County, Florida, with notes on similar deposits found elsewhere in the state.—Fla. Geol. Surv., 2nd Ann. Rep., 253-291, pl. 16, 17, 19, and 3 line-drawings in the text (one of which is a map of Gadsden Co. and some contiguous territory). Jan., 1910.

2. The artesian water supply of eastern Florida.—Fla. Geol. Surv., 3d Ann. Rep., 77-195, figs. 6-16, pl. 10-15 (one of which is a map of the state). Jan., 1911.

Deals with the counties east of Trail Ridge.

3. The water supply of west-central and West Florida.—Fla. Geol. Surv., 4th Ann. Rep., 81-155, figs. 4-15 (including map and 7 half-tones), pl. 13-16. 1912.

Treats all the counties of Middle and West Florida except Hamilton.

4. The artesian water supply of eastern and southern Florida.—Fla. Geol. Surv., 5th Ann. Rep., 103-290, figs. 1-17, pl. 10-14. 1913.

As far as northern Florida is concerned this covers the same ground as no. 2.

Smith, Eugene A.

1. On the geology of Florida.—Am. Jour. Sci. 121:292-309 (including map). April, 1881.

2. Report on the cotton production of the state of Florida, with an account of the general agricultural features of the state.—Tenth Census U. S. 6:175-257, with 3 single-page (quarto) maps, two of which are colored and inserted. 1884.

For an appreciation of this report see 3d Ann. Rep., p. 365, and p. 172 of the present volume.

Smith, J. D. (of Marianna)

About unknown Florida.—Fla. Review 2:33-39 (including 3 full-page half-tones). July, 1909.

Mostly about the caves of Jackson County.

Stickney, L. D.

Florida Soil, climate and productions.—Rep. U. S. Com. Agr. 1862:52-65. 1863.

(This was published at a time when Florida and other southern states were temporarily out of the Union, a fact which is mildly commented upon in the report.)

Thompson, Maurice.

A Tallahassee Girl.—16-mo., 355 pp. Houghton, Mifflin & Co., Boston, 1881.

Although this is a novel, it contains valuable information about geographical and social conditions in and around Tallahassee at that time. (The author was state geologist of Indiana from about 1885 to 1888.)

Torrey, Bradford.

A Florida Sketch-book.—Houghton, Mifflin & Co., Boston, 1894.

This contains many interesting notes on the plants, birds, people, etc., around Tallahassee, St. Augustine, and some places farther south, by a well-known naturalist. Most if not all of the chapters were previously published in the Atlantic Monthly.

U. S. Army Engineers.

The annual reports of the Chief of Engineers of the U. S. Army contain a great deal of detailed geographical information about Florida rivers which is not found elsewhere. Many reports on particular rivers and harbors by the Army Engineers have also been transmitted to Congress by the Secretary of War and published as Congressional documents. Such reports are so numerous that it would be out of the question to refer to them individually here.

U. S. Department of Agriculture, Bureau (formerly **Division) of Soils.**

Soil surveys of various counties and similar areas, in annual reports of Field Operations.

The following areas in northern Florida have been reported on by this organization up to the present time. (The dates given are the years in which the field work was completed, and the reports are found in the volume for that year. But the separate reports usually appear the following year, and the complete volumes about two years after the field work. The latest complete volume on hand is that for 1911.) Gadsden Co., 1903; "Gainesville area," 1904; Leon Co., 1905; Escambia Co., 1906; Jefferson Co., 1907; "Marianna area," 1909; "Jacksonville area," 1910; Bradford Co., 1913. A survey of Payne's Prairie.

in Alachua Co., was published in 1912 as Circular 72 of the Bureau. In the last few years the State Geological Survey has co-operated in this work to some extent.

Vignoles, Charles.

Observations upon the Floridas.—190 pp. and map. New York, 1823

See Third Annual Report, p 365, for comments on this rare work.

Whiting, Henry.

Cursory remarks upon East Florida, in 1838.—Am. Jour. Sci. 35:47-64. 1838.

Williams, (Col.) **John Lee.**

1. A view of West Florida, embracing its geography, topography, etc., with an appendix, treating of its antiquities, land titles, and canals, and containing a map, exhibiting a chart of the coast, a plan of Pensacola, and the entrance of the harbour.—178 pp. and folded colored map. Philadelphia, 1827.

"West Florida" at that time included also what was later called Middle Florida.

2. The territory of Florida: or sketches of the topography, civil and natural history of the country, the climate, and the Indian tribes, from the first discovery to the present time, with a map, views, etc. 304 pp. A. T. Goodrich, New York, 1837.

These two extremely interesting and valuable books by Col. Williams have been seen only in the New York Public Library, and could not very well be cited by page in the foregoing regional descriptions. They furnished Dr. Eugene A. Smith much accurate information about the parts of Florida which he was unable to visit in 1880.

INDEX OF PLANT NAMES

This index includes both technical and common names of the plants mentioned in the report on northern Florida, and also many synonyms, with cross-references, which are inserted for the benefit of persons who may know some of the species better by other names than those used in the body of this report. Common names are enclosed in quotations, so that the non-botanical reader can pick them out readily.

Where the name of a genus is not followed by any specific name it means either that only one species of that genus has been seen by the writer in northern Florida and the specific name is omitted to save space, or that the identity of the species is doubtful, or that some statement is made in the text at the page indicated that applies to several or all of the species of that genus.

As there are many places in the text where species are referred to by only the technical name or only the common name, especially in the case of trees, the reader who wants to be sure to find everything that is said about a given species should bear both names in mind. In this index numbers in parentheses refer to pages where the plant in question is referred to indirectly or under a different name; and this device is used in most of the cases referred to in the preceding sentence, but not in all of them.

Numbers in heavy type refer to pages belonging to the regional list in which the species named stands highest, or is most abundant. They do not correspond exactly with the double + marks in the plant lists, because it was not possible to make careful comparisons between all the lists before they were printed (especially in the case of the herbs whose percentage numbers are not given), owing to the fact that the first parts of the manuscript were sent to the printers before the last parts were finished, and many of the + and — marks were therefore located by guess. The necessary comparisons have been made in the paged proof, however, resulting in the discovery of several inconsistencies and many places where the double + marks should have been used and were not; all of which are now rectified in the index as far as possible. There are over twice as many numbers in heavy type in this index as there are double + marks in the plant lists, partly on account of the more careful comparisons just mentioned, and partly because they are given here for technical and common names separately and also for families.

The object of making these numbers conspicuous in the index, as stated on pages 186-187, is to enable any one who desires a supply of any particular tree or other plant to tell in two or three glances in which part of northern Florida it is most abundant.

Where the references to any plant do not include any number in heavy type either the name is a synonym, or an extra-limital species mentioned incidentally, or else it is difficult to decide in which of several regions the species is most abundant. And where there are two or more such numbers in the same line either it is a name (generic or common) which belongs to two or more species, or else the species in question seems to be equally abundant in two or more regions and perceptibly less so in the rest.

The number of species listed is about 750 (including nearly 100 weeds, which probably did not grow in this area before the discovery of America), which is probably not over half the total number of vascular plants in northern Florida. But those omitted, together with all the cellular cryptogams (which may be still more numerous) probably do not make up more than one or two per cent of the total bulk of vegetation, and would hardly be noticed by any one traveling by rail. As the 19 regional lists together contain about 2600 lines of plant names, it is evident that the average species here listed grows in about 3½ regions. (But if the lists had been made more complete this ratio would be smaller, for the rarer species are naturally less widely distributed.)

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General Index

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