State of Connecticut

FIFTH BIENNIAL REPORT OF THE COMMISSIONERS

OF THE

State Geological and Natural History Survey

1911-1912

BULLETIN No. 21

State of Connecticut

PUBLIC DOCUMENT No. 47

State Geological and Natural History Survey

COMMISSIONERS

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SUPERINTENDENT

WILLIAM NORTH RICE

BULLETIN No. 21

HARTFORD
Published by the State
1912

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THE BOARD OF CONTROL

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FIFTH BIENNIAL REPORT OF THE COMMISSIONERS

OF THE

State Geological and Natural History Survey of Connecticut

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HARTFORD, CONN., December 31, 1912.

HIS EXCELLENCY, SIMEON E. BALDWIN, Governor of Connecticut,
Hartford, Connecticut.

Sir: — I have the honor to transmit to you herewith, in behalf of the Connecticut Geological and Natural History Survey Commission, the report of the Superintendent of the work, covering the period of two years ending December 31, 1912.

Very respectfully,
FLAVEL S. LUTHER,
Secretary of the Commission.

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY

FIFTH BIENNIAL REPORT

Coöperation with United States Geological Survey in Study of Water Resources

In the Report of the Commissioners of the State Geological and Natural History Survey to the General Assembly in 1911, it was intimated that two plans were under consideration for the inauguration of a kind of work different from that in which the Survey had been engaged in previous years and having a somewhat more direct economic bearing. The two projects under consideration were a survey of the soils of Connecticut, and a survey of the water resources of Connecticut. After thorough investigation, it was decided that the latter project was the more desirable of the two. Accordingly, in the past two years the bulk of the appropriation of the State Geological and Natural History Survey has been applied to an investigation of the water resources of the state.

One consideration making it desirable to enter upon the investigation of the water resources of the state at this time, was that the United States Geological Survey was ready to coöperate in such investigation, appropriating from the United States Treasury an amount equal to that which was appropriated from the State Treasury. It was therefore practicable for us, by the use of $2,000 of the appropriation made by the State of Connecticut, to secure for the work on the water resources the expenditure of a total amount of $4,000.

Investigation of the water resources of the state seemed to the Commissioners of the State Survey especially timely, in view of the fact that most of the large towns of Connecticut have, in recent years, been on the verge of suffering from water famine. The consumption of water, both for domestic and manufacturing purposes, is rapidly increasing with the growth of our population and the increased development of manufactures. In addition to other uses of water, it is evident that in the near future increased attention must be given to the development of water power. The exploitation of the national supply of coal is going on with increasing rapidity, and in the consumption of coal we are using not our income but our capital. The available supply of coal

tends to exhaustion, and the diminished supply must mean in the near future a considerable increase in the cost. It is evident, then, that in the near future our manufacturing industries must depend more largely than in the past upon some cheaper form of power than that which is afforded by the combustion of coal.

It is believed, also, that irrigation is destined to play a large part in the future development of the agriculture of Connecticut. There is, of course, no such necessity for irrigation in Connecticut as exists in the arid region of the country. The average rainfall for Connecticut is sufficient for agricultural use; but our rainfall is more or less irregular, and our farmers often suffer heavy losses from occasional long periods of drouth. It is practicable, by means of irrigation, not only to carry on agriculture in localities where the rainfall is always insufficient, but to avoid the heavy losses to agriculture from occasional periods of drouth in districts ordinarily well watered.

In view of the growing demands upon our water supply, it is evidently fitting that there should be a thorough study of our water resources. The streams should be gaged, that we may know their rates of flow in different seasons of the year and their fluctuation in different years. The gaging of the streams must, therefore, be carried on not for one year but for a term of several years, in order that the necessary data may be obtained. Profiles of the streams should be constructed so as to indicate suitable sites for storage reservoirs and for the development of water power.

The underground waters of the state should also be studied. Already our population is coming to rely largely upon deep wells for manufacturing and other purposes. The geological structure of Connecticut is not such as to make it possible to say with approximate certainty, as can be done in some parts of the country, at what depth an abundant supply of water can be encountered. But it is believed that a careful study of wells and springs throughout the state will render it possible to map the distribution of ground water in such a way that the search for an underground supply of water will not be so completely a lottery as it is at present.

In view of these considerations, it was determined by the Commissioners to apply $2,000 of our appropriation to coöperative work with the United States Geological Survey on the water resources of the state. The following contract was accordingly signed by the Director of the United States Geological Survey and the Superintendent of the State Geological and Natural History Survey of Connecticut.

"THIS AGREEMENT, made and entered upon this 31st day of May, 1911, by and between GEORGE OTIS SMITH, DIRECTOR, for and on behalf of the UNITED STATES GEOLOGICAL SURVEY, the first party, and WILLIAM N. RICE, SUPERINTENDENT, for and on behalf of the CONNECTICUT STATE GEOLOGICAL AND NATURAL HISTORY SURVEY, the second party, WITNESSETH:

"1. That there shall be maintained within the State of Connecticut a coöperative survey of water resources, which shall consist of such studies of the occurrence, amount, and availability of underground waters, and of the sources, capacity, and availability for economic use of the rivers and streams, as shall be necessary to enable the people of the State of Connecticut to make the most comprehensive development thereof.

"2. That the investigations shall be under the supervision of the first party, who shall be represented in all work, negotiations, and disbursements involved in the performance of this agreement by a duly accredited representative, whose agency shall be formally certified to for the information and guidance of the second party; that the methods of investigation shall be those usually followed by the first party, and they shall be subject to such modification or improvement as may be suggested by the second party and approved by the first party.

"3. That the location of the investigations and the character thereof shall be from time to time determined upon by the parties hereto or their duly accredited representatives; and, during the progress of the work, all notes, maps, measurements, gagings, and other material shall be open to the inspection of the second party, and, if the work is not being carried on in a manner satisfactory to said party, he may on formal notice terminate this agreement.

"4. That the first party shall contribute toward the maintenance of the work herein provided the sum of one thousand dollars ($1,000) to be expended during the fiscal year ending June 30, 1912, and a further sum of one thousand dollars ($1,000) to be expended during the fiscal year ending June 30, 1913; PROVIDED, That, should the Congress of the United States fail to make provision for the water resources investigations of the first party in suitable amount to enable said party, under an equitable distribution of its appropriation for this purpose, to continue the work herein provided during the year ending June 30, 1913, this agreement shall lapse on June 30, 1912; that the second party shall allot for the investigations herein provided the sum of two thousand dollars ($2,000), which shall be expended on or before June 30, 1913; that the accounts for the work herein provided shall, except as above specified, be rendered against the allotments of either party, the same to be determined upon by said parties or their respective representatives, according to convenience, or to the balance remaining in the respective allotments; PROVIDED, That all expenses shall eventually be divided

between the two agreeing parties in such a way that they shall be equal on June 30, 1913.

"5. That the results of the investigations, surveys, observations, measurements, and computations, and all other matters acquired in the due performance of this agreement, shall become the property of the first party, certified copies thereof to be delivered to the second party on demand.

"6. That the results of the work contemplated in this agreement, together with the interpretations thereof, will be published by the first party, said publications to contain full and complete statements of the relation thereto of each party as set forth in this agreement; that these publications shall be made as soon as possible after completion of each unit piece of work which may be determined upon by said parties as of suitable scope for a separate publication, and the cost of such publications shall not be included in the allotments made by either party; PROVIDED, That nothing herein shall act to prevent the second party from compiling and arranging for independent publication any of the results collected under the terms of this agreement; PROVIDED FURTHER, That in such independent publication the relation of the first party thereto shall be clearly stated.

"IN WITNESS WHEREOF, We have hereunto set our hands and seals the day and year first herein written.

GEO. OTIS SMITH,
Director, United States Geological Survey, The First Party.

WM. NORTH RICE,
Superintendent, Connecticut State Geological and Natural History Survey, The Second Party."

From the foregoing contract it will be seen that the work has been carried on under the direction of the United States Geological Survey. It has been placed under the charge of Professor Herbert E. Gregory, of Yale University. Professor Gregory has given very much attention to the study of water resources, and his paper on Underground Water Resources of Connecticut, published in 1909 as Water-Supply Paper 232 of the United States Geological Survey, is the best statement extant of our present knowledge in regard to that subject. It is certain that no man could have been selected better qualified to take charge of this investigation.

It will be seen from the contract that the results of the work, when ready for publication, are to be published by the United States Geological Survey in the usual form of their publications, and at the expense of the United States. The contract, however, gives to us the right to republish any part of these results in the series of Bulletins of the State Geological and Natural History Survey; provided, only, that, in any form of publication of a special Connecticut edition, credit shall be given to the United States Geological Survey for their share in the work.

WORK ON WATER RESOURCES DURING THE PAST TWO YEARS

The total appropriation of four thousand dollars (two thousand from the United States and two thousand from the State of Connecticut) has of course sufficed only for a very modest beginning of the survey of our water resources. It has been deemed best to use the whole amount in a study of underground waters in certain selected areas. The field work has been done, under the direction of Professor Gregory, by Arthur J. Ellis, M.A., Junior Geologist, U. S. Geological Survey. The following account of his work is quoted from a letter of Mr. Ellis to the Superintendent of the State Survey.

"Under the direction of Prof. H. E. Gregory, I have studied the water supplies, with especial attention to underground waters, in selected areas in Connecticut, which represent the typical geologic conditions of the state. These areas are:

"1. The Hartford area, including the towns of Hartford, West Hartford, Newington, Wethersfield, Manchester, East Hartford, South Windsor, East Windsor, Windsor, and Bloomfield.

"2. The Stamford area, including Stamford and Greenwich.

"3. The Canaan-Salisbury area, including Canaan, North Canaan, and Salisbury.

"4. The Willimantic area, including Windham and Franklin.

"5. The Saybrook area, including Saybrook, Essex, Westbrook, and Old Lyme.

"In each of these areas the towns have been studied as units, and the results are to be given on the same basis, but grouped with reference to the areas. A map of each town has been prepared, upon which are shown data relating to underground waters, and contour lines representing the position of ground water with reference to the land surface. In the Hartford area the rock surface is also shown by contour lines. In all except the Hartford area, these maps will show the distribution of timber and tillage, and of rock outcrops and Glacial drift.

"Field assays have been made of several hundred samples of water taken from springs, dug wells, drilled wells, and brooks.

An effort has been made to obtain data concerning all the drilled wells in the areas studied, and as many dug wells have been examined as were deemed necessary to locate the position of the water-table throughout the areas, and to supply a general knowledge of the condition of dug wells, and the amount and quality of water obtained from them."

Coöperation with United States Geological Survey in other Work

It is proper here to mention the fact that the work on the water resources of the state is not the only work in which there has been coöperation between the United States Geological Survey and the State Survey of Connecticut. In the study of the peat deposits of the state, a work of great importance, both scientific and economic, in regard to which a bulletin is soon to be published, the State Survey was greatly aided by the generous coöperation of the United States Geological Survey, as is stated more fully on page 19 of this report. In another instance, we were able to render some service to the United States Geological Survey. When Professor T. M. Dale was working on a bulletin on the Granites of Connecticut for the United States Geological Survey, he requested the Superintendent of the State Survey to furnish an introductory chapter on the general geological relations of the granites of the state. Such a chapter was accordingly prepared by Professor H. E. Gregory, author of the chapter relating to the crystalline rocks in Rice and Gregory's Manual of the Geology of Connecticut (Bulletin 6 of the State Survey). Bulletin 484 of the United States Geological Survey, on the Granites of Connecticut, accordingly bears on its title-page the words, "Prepared in coöperation with the Geological and Natural History Survey of Connecticut."

General Scope and Plan of the State Survey

While it has been deemed best to devote the bulk of the appropriation for the past two years to the coöperative work on the water resources of the state, and to undertake no other new work, it is not forgotten that the scope of the Survey, as defined in the act of 1903 by which the Survey was established, is much broader. That act proposed for the Survey two subjects for investigation; viz., the geology of the state, and the natural history, or botany and zoölogy, of the state. It has been presumed to be the intent of the law that the appropriation should be divided with some approach to equality between geology and biology. The law further specifies three aims with reference to which the work should be prosecuted: — first, the purely scientific

aim of advancing our knowledge of the geology and natural history of the state; second, the economic aim of leading to the most effective conservation and utilization of the resources of the state; third, the educational aim of promoting the work of the schools of the state by the publication of the results of investigation in a form adapted for the use of teachers.

It will be appropriate to outline briefly the plans adopted for the carrying out of these objects, and the work which has been already accomplished, or which is in progress.

The plan of organization which was outlined in the first report has been retained. Only one salaried officer has been appointed by the Commissioners; viz., the Superintendent. Other scientific men have been engaged to investigate particular subjects and prepare reports or bulletins thereon. In the great majority of cases, the terms of contract with these scientific men have been that the investigator should receive a certain sum as compensation when the bulletin presented was accepted by the Superintendent, and that a certain allowance should also be made for the expenses of the work, the allotment for expenses to be drawn upon from time to time as the expenses were actually incurred. In some cases, however, this form of contract has been impracticable, as investigations have been commenced and prosecuted in regard to which it could not be foreseen how soon they would result in conclusions definite enough for publication. In such cases the agreement has been to pay the investigator a small sum per diem, a maximum limit being prescribed in every such case.

Each report prepared is published as a separate bulletin, the bulletins being numbered consecutively, generally in the order in which they are received. Each bulletin bears the name of the author or the names of the authors, and each author is responsible for his own work. The bulletins are issued in paper covers, but a part of the edition is reserved for binding. Bulletins 1 to 5 have been bound as Vol. I., Bulletins 6 to 12 as Vol. II., and Bulletins 13 to 15 as Vol III. The bound volumes are especially desirable for public libraries and similar institutions, in which complete sets of our publications are to be preserved. The pamphlet form, in which each bulletin is complete in itself, is convenient for the large number of students, teachers, and others who have use for some particular bulletin. The publications of the Survey are distributed by the State Librarian. They are given liberally to colleges, public libraries, geological surveys, and other scientific institutions, and to scientific men of repute in the branches of science with which the respective bulletins are concerned. In many cases books and papers of great value are received in exchange for the publications of the Survey. All

books and papers thus received are deposited in the State Library. The publications of the Survey are also distributed liberally to citizens of our own state, particularly to teachers who can make use of them in their work. In the case of persons in other states who are not known as scientific men, and who appear to have no special claim for the donation of the publications of the Survey, the bulletins are sold at prices sufficient to cover the cost of printing and transportation.

Bulletins already Published

The following is the list of the bulletins already published: —

1. First Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1903-1904.
2. A Preliminary Report on the Protozoa of the Fresh Waters of Connecticut: by Herbert William Conn.
3. A preliminary Report on the Hymeniales of Connecticut: by Edward Albert White.
4. The Clays and Clay Industries of Connecticut: by Gerald Francis Loughlin.
5. The Ustilagineæ, or Smuts, of Connecticut: by George Perkins Clinton.
6. Manual of the Geology of Connecticut: by William North Rice and Herbert Ernest Gregory.
7. Preliminary Geological Map of Connecticut: by Herbert Ernest Gregory and Henry Hollister Robinson.
8. Bibliography of Connecticut Geology: by Herbert Ernest Gregory.
9. Second Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1905-1906.
10. A preliminary Report on the Algæ of the Fresh Waters of Connecticut: by Herbert William Conn and Lucia Washburn (Hazen) Webster.
11. The Bryophytes of Connecticut: by Alexander William Evans and George Elwood Nichols.
12. Third Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1907-1908.
13. The Lithology of Connecticut: by Joseph Barrell and Gerald Francis Loughlin.
14. Catalogue of the Flowering Plants and Ferns of Connecticut growing without cultivation: by a Committee of the Connecticut Botanical Society.
15. Second Report on the Hymeniales of Connecticut: by Edward Albert White.
16. Guide to the Insects of Connecticut: prepared under the direction of Wilton Everett Britton. Part I. General Introduction: by Wilton Everett Britton. Part II. The Euplexoptera and Orthoptera of Connecticut: by Benjamin Hovey Walden.
17. Fourth Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1909-1910.
18. Triassic Fishes of Connecticut: by Charles Rochester Eastman.
19. Echinoderms of Connecticut: by Wesley Roscoe Coe.

Four of these, viz., Bulletins 13, 16, 18, and 19, have been published since the last biennial report.

Bulletin 13, on the Lithology of Connecticut, includes a general introduction to lithology by Professor Barrell, of Yale University, and a special description of forty-one typical rocks from Connecticut localities by Dr. Loughlin, of Massachusetts Institute of Technology. In the general part of the work, lithology is treated in relation to mineralogy and dynamical geology, so that the student may learn somewhat of the agencies by which the different types of rocks are produced, as well as their composition and characteristic aspect. In both the general and the special part of the work attention is given chiefly to those characteristics of rocks which can be recognized by the naked eye or by the simple microscope, with comparatively little reference to the phenomena which can be observed only by the examination of thin sections under the compound polarizing microscope. This limitation in the treatment of the subject renders the work adapted to the use of comparatively elementary students. The usefulness of the work in the educational institutions of the state will be greatly enhanced by suites of specimens of rocks from the typical localities described in the special part of the paper, which have been distributed to colleges, normal schools, high schools, and academies in the state, on condition that the respective institutions should pay the cost of transportation. Any suites of specimens remaining in the possession of the Survey after such distribution will be sold and the money paid into the treasury of the state.

Bulletin 16, on the Insects of Connecticut, forms the beginning of a series of papers on that class of animals, whose publication may be distributed through a considerable number of years. It is needless to comment on the economic importance of the class of insects, many insects being among the worst enemies of the agriculturist, while others, insectivorous or parasitic in habit, tend to hold in check the destroyers of agricultural products. The various parts of the work will be written by specialists on various groups, under the general direction of Doctor Britton, Entomologist of the Connecticut Agricultural Experiment Station. The present bulletin includes two parts of the proposed work. Part I. gives a brief outline of the general characters of insects and their relations to other allied groups of animals, the

classification of the group, and their economic relations. In Part II., Mr. Walden gives a catalogue, with analytical keys, of the two orders, Euplexoptera and Orthoptera. The former order is a small and comparatively insignificant one, including the insects commonly called earwigs. By many entomologists the Euplexoptera have been regarded as merely a subdivision of the Orthoptera. The Orthoptera constitute a larger and more important order, including, besides some less familiar forms, the cockroaches, the locusts and grasshoppers, the katydids, and the crickets. The mere mention of the names, locust and grasshopper, is enough to suggest the importance of the economic relations of the Orthoptera. Part I. of this bulletin is illustrated by a series of plates, representing typical examples of all the principal orders of insects. Part II. is illustrated by a number of plates from photographs of entire insects representing different groups of Orthoptera, and by numerous figures in the text from drawings of diagnostic parts of the anatomy of various families and genera.

Bulletin 18, on the Triassic Fishes, by Professor Eastman, of the University of Pittsburgh, is a very important contribution to the paleontology of the state. The area of Connecticut is by no means rich in fossils. The crystalline rocks of the eastern and western highlands have proved as yet utterly barren of fossils. Whatever fossils some of these rocks may have once contained have been entirely obliterated by the processes of metamorphism. The Triassic formation of the Connecticut Valley has afforded scarely any fossils, excepting tracks of reptiles and amphibians on some of the beds, and remains of fishes and a few species of plants in two or three thin strata of black shale intercalated among the red shales and sandstones. The scantiness of fossils in this formation has made difficult the determination of its geological age. Professor Eastman has made a very careful study of all the important collections of the fossil fishes of this formation. He has been able thus to make a more exact determination of some features of the anatomy of the animals than has been made before. He has also made comparisons of the fish fauna of our Connecticut beds with the fish faunas of other Triassic formations in various parts of the world. This comparison leads him to the opinion that the age of our Connecticut formation corresponds most nearly, not with the uppermost European Trias (Keuper or Rhætic), as has been of late generally supposed, but rather with a somewhat lower horizon, near the boundary between the Muschelkalk and the Keuper.

Bulletin 19, by Professor Coe, of Yale University, on the Echinoderms of Connecticut, will be the first paper published by the Survey on the marine zoölogy of the state. The

Echinoderms include the creatures commonly called sea-urchins and starfishes. Though not a large class as regards the number of species, the Echinoderms are an interesting group. They are among the marine animals which are large and conspicuous, and most of them have skeletons which are readily preserved. They are accordingly among the forms which attract the attention of visitors to the shore. Professor Coe's full descriptions of our species will be useful to teachers, particularly in the towns along the coast, where the pupils may easily become acquainted with these animals. One genus of the Echinoderms, the common starfish, is of great economic interest, since it is one of the most destructive enemies of the oyster. Professor Coe has given much attention to the relation of the starfish to the oyster industry. The work is beautifully illustrated with plates showing the aspect of the living animals, and others showing their anatomical structure.

Bulletins in Press or Approved for Publication by the Board of Control

One bulletin is now in press; and two others have been approved for publication by the Board of Control, but have not yet gone to press on account of an unexpected delay in the revision of the manuscript. These are the following:—

20. The Birds of Connecticut: by John Hall Sage and Louis Bennett Bishop, assisted by Walter Parks Bliss.

22. Guide to the Insects of Connecticut: prepared under the direction of Wilton Everett Britton. Part III. Hymenoptera of Connecticut: by Henry Lorenz Viereck.

23. The Peat Deposits of Connecticut: by Charles Albert Davis.

Probably no work which the Survey has announced as in preparation has been awaited by so many people, in the state, and out of it, with eager expectation, as the work of Mr. Sage and Dr. Bishop on the Birds of Connecticut. In their careful studies, continued for many years, a vast amount of information has been recorded in regard to the dates of arrival and departure of our migratory birds, the localities of rare birds, and the food and habits of the birds. This bulletin will be of interest not only to ornithologists, but also to teachers and farmers, and to the multitude of people who have learned to love the birds. The publication of this bulletin will help to correct some erroneous impressions, widely prevalent among farmers, in regard to some of our birds. Many of the birds of prey, for instance, which are commonly regarded as the farmer's foes, are really his friends. In fact, the sharp-shinned hawk, Cooper's hawk, and

the great horned owl, are probably the only birds of prey that are in any considerable degree injurious to agriculture in Connecticut. It is matter of regret that the publication of this bulletin has been so long delayed, owing to the pressure of other duties and cares which made it impossible for the authors to give the amount of time necessary for the completion of the work. Happily a very competent editorial assistant was found in W. P. Bliss, M.A., of Columbia University. Mr. Bliss is himself an earnest student of the birds, and his general training has given him an excellent fitness for editorial work. By his work in the collation of the notes of Mr. Sage and Dr. Bishop, it has been made possible to bring this valuable bulletin to completion.

Bulletin 22, by Mr. Viereck, of the United States National Museum, forms the second instalment of the work on the Insects of Connecticut, under the general direction of Dr. Britton, of the Connecticut Agricultural Experiment Station. It deals with the Hymenoptera, which form one of the largest and most important of the orders of insects. The marvelous instincts and habits of bees, wasps, and ants have always attracted the interest of thoughtful observers. Many of the Hymenoptera are of very great economic interest. The bees, by their transportation of pollen from flower to flower, are indispensable for the fertilization and consequent propagation of a great many plants. Many of the smaller Hymenoptera, as the ichneumon flies, are parasitic upon other insects, and thus serve to keep in check insects which would otherwise be destructive pests to the agriculturalist. Some of the Hymenoptera, on the other hand, as the saw-flies, are themselves prominent among the destroyers of agricultural products. Mr. Viereck is himself a specialist on some of the groups of Hymenoptera, and he has had the aid of a number of collaborators who are specialists on other groups of this large and varied order. Among the writers who have contributed chapters to the work, are the following:—Alexander Dyer MacGillivray, Assistant Professor of Entomology and Invertebrate Zoölogy in Cornell University; Charles Thomas Brues, Curator of Invertebrate Zoölogy, Public Museum, Milwaukee, Wis.; William Morton Wheeler, Professor of Economic Entomology in Harvard University.

Bulletin 23 treats of the Peat Deposits of Connecticut. Like other regions covered by the great ice sheets of the Glacial period, the surface of Connecticut was left dotted with innumerable lakes and ponds, many of which have been converted into peat bogs by the accumulation of the débris of vegetation. The peat is not only of great scientific interest, both to the geologist and to the botanist, but possesses considerable economic importance, having

uses as a fuel and as a fertilizer, and being capable also incidentally of employment for various other purposes. Attention has recently been called to the economic value of peat by the investigations of the United States Geological Survey, which have shown its special fitness for use in the gas-producer. It was, therefore, deemed desirable to make a special investigation of the peat deposits of Connecticut, and this was rendered practicable by the generous coöperation of the United States Geological Survey. During the summer of 1907 the field work of the investigation was substantially finished. The localities of all the important peat bogs of the state were visited; the area of those bogs was noted, their depth was determined by a sounding apparatus, and samples for analysis were collected from various depths. This work was accomplished by E. C. Miller, A.B., and T. T. Giffen, A.B., of Yale University. Professor C. A. Davis, of the United States Bureau of Mines, who was employed by the United States Geological Survey in the summer of 1907 for a reconnoissance of the peat deposits of the Atlantic border of the country from Maine to Florida, was permitted by the courtesy of the United States Geological Survey to spend a few days in Connecticut at the beginning of the season of field work. He was able, therefore, to give Messrs. Miller and Giffen the necessary instruction in regard to methods of work. The bulletin which is now nearly ready for publication, will contain a general paper on the scientific and economic relations of peat, by Professor Davis, who has made himself eminently an authority on the subject. It will also contain a digest of the notes of Messrs. Miller and Giffen in regard to their field work. A selection of samples collected by Messrs. Miller and Giffen have been analyzed in the laboratory of the United States Geological Survey, and reports of those analyses will be included in the bulletin. The State Survey is very greatly indebted to the liberality of the United States Geological Survey for the all-important assistance of Professor Davis at the beginning of the investigation, and for the analyses made in the laboratory of the United States Geological Survey. The attention which has recently been given to the scientific and economic relations of peat has brought into notice the valuable work on peat from the chemical standpoint done many years ago by Professor S. W. Johnson, of Yale University, the pioneer in agricultural chemistry in this country. Professor Johnson's book is out of print, and his work on peat had been almost forgotten. The forthcoming bulletin will render his important work once more accessible by the republication of the important parts of his book, edited and revised by his friend and pupil, Dr. E. H. Jenkins, Director of the Connecticut Agricultural Experiment Station.

Bulletins Accepted for Publication

The following bulletins have been accepted for publication by the Superintendent, but the appropriations hitherto available for printing have sufficed only for the bulletins in the previous lists.

Drainage and Glaciation in the Central Housatonic Basin: by Ruth Sawyer Harvey. This paper is an interesting study of some changes in drainage resulting from the events of the Glacial period.

The Amphipods and Isopods of Connecticut: by Beverly Waugh Kunkel. These are interesting groups of Crustacea, chiefly marine. This paper will be the second instalment of the series on the marine zoölogy of the state, inaugurated by Professor Coe's bulletin on the Echinoderms.

Triassic Life of the Connecticut Valley: by Richard Swann Lull. Professor Lull has made himself eminently an authority on the Dinosaurs, a remarkable group of extinct reptiles whose presence in the Connecticut Valley is attested by a few skeletons and numerous footprints. This paper presents not merely a catalogue of fossil species, but a vivid picture of the life of Triassic times.

Central Connecticut in Geologic Time: by Joseph Barrell. This paper will be of special value to teachers, by reason of its realistic representation of the geographical changes which this region has undergone in the course of geological time.

Check-list of the Insects of Connecticut: by Wilton Everett Britton. As it must be many years before the Guide to the Insects of Connecticut can be finished, it is believed that a check-list will be useful in the meantime.

Glacial Geology of the New Haven Region: by Freeman Ward. A detailed study of the Glacial Geology of a single district. Valuable in itself, and valuable as a contribution to the investigations which are expected eventually to afford material for a general map of the Glacial geology of the state.

The Bacteria of the Fresh Waters of Connecticut: by Herbert William Conn and Lena Raye Potter. This is of great value, being the result of work prosecuted in the laboratory of Wesleyan University continuously for a number of years.

Unfinished Work

Professor H. E. Gregory and his assistants have done a large amount of field work on the Glacial geology of the state. It is hoped that some of the results of this work will appear at an early date in a bulletin on the Glacial geology of the Naugatuck Valley, and that later the material will be accumulated for a general report with map of the Quaternary of the state. Dr. F. P. Gulliver's studies of the terraces of the Thames River have added much to our knowledge of some phases of Quaternary history, but are not yet ready for publication. Dr. G. P. Clinton has a bulletin on the Downy Mildews, a group of Fungi very pernicious to agricultural interests, well advanced towards completion. Professor A. E. Verrill has done much work on a bulletin on the Stalk-eyed Crustacea (including a full discussion of the economic relations of the lobster). Dr. W. E. Britton has in hand a third instalment of the Guide to the Insects of Connecticut, relating to the Hemiptera, or bugs and their allies.

Distribution of the Appropriations

The expenditures for work which has been completed and for which full payment has been made since the last biennial report, have been as follows:—

Name	Work	Compensation	Expenses
W. N. Rice	Superintendence, 1909-11	$400.00	$300.00
F. Ward	Glacial Geology	192.50	54.63
R. S. Lull	Triassic Life of Connecticut Valley	200.00	101.97
H. W. Conn	Bacteria of Fresh Waters	200.00	570.88
B. W. Kunkel	Amphipods and Isopods	100.00	48.00
W. E. Britton	Check-list of Insects	100.00	16.50

The allotments for work which is still in progress, or for which full payment has not been made, are as follows:—

Name	Work	Compensation	Expenses
W. N. Rice	Superintendence, 1911-13	$400	$500
F. P. Gulliver	Terraces of Thames River	425	
H. E. Gregory	Glacial Geology	828	
C. A. Davis and others	Peat Deposits	659	
G. P. Clinton	Downy Mildews	50	25
J. H. Sage and L. B. Bishop	Birds	200	400
W. E. Britton and others	Guide to Insects	525	325
A. E. Verrill	Stalk-eyed Crustacea	150	250

Plans for Future Work

I. Geology

It may be said in general that there is need of more detailed study in most parts of the state than has yet been accomplished. The area of the state most thoroughly studied as regards the bed rocks is that of the Triassic formation. The area where detailed work is most lacking as yet is that of the eastern crystallines. The geological work which has been done in much of eastern

Connecticut amounts to little more than a reconnoissance. The Manual of Geology, and the Geological Map by which it is supplemented, bear most eminently the character, not of final reports, but of reports of progress. Their publication was amply justified by the need, on the part of teachers and others, for publications which would set forth in convenient and intelligible form our present knowledge of the geology of the state. But they certainly will require very much of correction in detail. It is, moreover, not unlikely that more detailed study will bring to light facts which will lead to very important changes in the general conception of the geological history which is recorded in our rocks.

The necessity for more detailed study in various parts of the state is even greater in regard to surface geology than in regard to the geology of the underlying rocks. Professor Gregory and Drs. Gulliver, Ward, and Harvey have made a beginning of such investigation; but a vast amount of careful work must be done before we can reach the true history of the Quaternary era in our territory.

A class of geological papers which would be of great educational value would be a series of geological guide-books to various regions of the state. In these guide-books directions sufficiently detailed to be practical should be given for excursions to localities where the most characteristic and instructive geological phenomena could be seen. Professor James D. Dana prepared years ago a book fitted to serve this purpose for the vicinity of New Haven; but even for that region there is need of a guide-book brought down to date, as regards both the scientific interpretation of phenomena and the arrangement of the itinerary. A series of such books for various districts of the state would make the study of geology in the high schools more real and genuine than it can otherwise be.

A report on the mineralogy of our state would be very useful. Lists of American localities of minerals have been published in a number of editions of the works of J. D. and E. S. Dana on mineralogy, the latest being in the sixth edition of the System of Mineralogy, published in 1892. A list of Connecticut minerals by Hattie E. Cochrane, dated 1894, is contained in the Report of the State Board of Education for 1896. Neither of these lists is by any means complete. Moreover, a report of the mineralogy of the state should be much more than a mere list of minerals occurring in the respective towns. Such a report should give more detailed information in regard to localities of interesting and important minerals, and should enter into some discussion of the geological relations of the minerals.

In the introductory chapter of the Manual of Connecticut Geology is found a brief discussion of the physical geography of the state in relation to geological structure. A subject whose treatment in a bulletin or in a series of bulletins would be of great educational value, would be the physical geography of various parts of the state, particularly in relation to human life and history. In such publications, the influence of geographic conditions in the location of towns, in the determination of routes of travel, and in the control of the industries of the state, should be discussed. Such bulletin or bulletins on the physical geography of the state would be of great interest to all intelligent citizens, and particularly to the teachers in our schools.

II. Botany

The labors of the Connecticut Botanical Society have given to us a list of the flowering plants of the state, and of the ferns and their allies. This paper affords much information in regard to the geographical and topographical distribution of particular species of plants. An appropriate line of investigation, and one in regard to which it may be hoped that the Survey may be able to publish important papers in the future, would be the more extended study of the distribution of plants with reference to altitude, geological formation, distance from the sea, temperature, and rainfall, and the grouping of plants into plant societies in different areas — in short, the study of what is now called the ecology of plants.

The systematic botany of the flowering plants has been comparatively well worked out for this region of country. Much less has been done in regard to the flowerless plants, and particularly in regard to the lower classes of flowerless plants. The paper of Professor Evans and Mr. Nichols on the mosses and liverworts, those of Professor White on the larger fungi, those of Dr. Clinton on the microscopic fungi, that of Professor Conn and Mrs. Webster on the fresh-water algæ, and that of Professor Conn on the bacteria, make a good beginning in this direction. But there are a number of groups of the lower flowerless plants for whose study very little material is accessible to students or even to teachers in Connecticut. Interesting groups which should be treated in future bulletins of the Survey are the lichens and the marine algæ.

III. Zoölogy

Professor Conn's paper on the protozoa makes a good beginning of the study of the life of our fresh waters. In future years attention should be given to other groups of fresh-water organisms; for instance, the mollusks, worms, crustacea, and fishes.

No general work dealing with the marine fauna of the Connecticut coast has been published since the very valuable paper by Verrill and Smith on the Invertebrate Animals of Vineyard Sound, published in the Report of the United States Commissioner of Fish and Fisheries for 1871-2.* The State Survey has made a beginning of a series of papers on our marine fauna, in the paper of Professor Coe on the echinoderms, already published, and the papers of Professor Verrill and Dr. Kunkel on the crustacea, of which the former is well advanced towards completion, and the latter has been accepted for publication. Papers on other groups of marine organisms should follow. Some of these papers would be of very great educational value, while some of them would be important from an economic point of view, since our marine fauna includes some species which are among the important resources of the state, and other species which are destructive of important resources.

Of the principal orders of insects, the orthoptera are treated in a bulletin already published, and the hymenoptera in one which has been accepted for publication. A bulletin on the hemiptera is in preparation. Other orders remain to be treated, among which are several of those most numerous in species and most important in economic relations.

A bulletin on the birds of Connecticut is now in press; but the mammals, reptiles, amphibia, and various groups of terrestrial invertebrates await consideration in future years.

The Continuance of the Survey

What has already been said in regard to the work accomplished or in progress and the plans for future work, makes it obvious that the business of the State Geological and Natural History Survey is not rapidly approaching completion. In fact, the State Survey should be recognized as a permanent institution. The Geological Survey of the state of New York was commenced in 1836. There is at present no organization in the state of New York bearing the title of Geological Survey, but there is a Science Division of the Educational Department of the state, whose staff includes a State Geologist, a State Botanist, a State Entomologist, and a number of other scientific workers. Under one form of organization or another, the work of investigation of the geology and natural history of New York under the auspices of the state has already been substantially continuous for more than two generations. There is no prospect that it will ever be finished.

*Most of the animals living in Long Island Sound and Fisher's Island Sound are included in the fauna of Vineyard Sound.

In a number of states, indeed, Geological Surveys have been organized, prosecuted for a few years, and concluded by the publication of so-called final reports. But there can be no final report on the geology, the botany, or the zoölogy of any district of country. In those states whose Geological Surveys have published what have been called final reports, enlightened citizens and legislators have sooner or later come to see the necessity for organizing a second, and in some cases a third, Survey, and doing the work over again. The sciences of nature are progressive; new discoveries from time to time put old facts in new relations, and raise new questions whose answer requires new methods of investigation. There are changes also in the arts which depend upon the application of the sciences, as well as in the sciences themselves. New forms of raw material become valuable, new modes of utilizing well-known materials become practicable. On the economic side, as well as on the purely scientific side, arises a necessity that the work of a Survey which had been supposed to be completed should be done over again.

If a State Survey is recognized as a permanent bureau, it can publish, from time to time, supplementary reports correcting and amplifying its previous work as may be necessary. It can be ready also to give attention to particular investigations which may have a special importance, for economic or other reasons, at some particular time. Moreover, the work of a Geological and Natural History Survey can be carried on much more economically by the plan of small appropriations maintaining a permanent organization, than by the plan of attempting to complete the work in a few years and then doing it over again a generation later. Field work can be done in the summer vacations by college professors, teachers, and others who are willing to do a certain amount of such work for very small compensation. Investigations can be made and bulletins can be written in large degree in odds and ends of time, by men who receive salaries for work in the colleges and schools or in museums and other scientific institutions. Under such conditions men of a high grade of ability and attainment are willing to offer for publication the result of their investigations for merely nominal compensation. The amount of valuable material already published, and the amount which is ready or nearly ready for publication, by our Survey, in comparison with the very small cost, is a striking illustration of the economy of this method of procedure. If, on the other hand, the work of a Survey is to be completed, and final reports presented, in a few years, it is generally necessary that a number of competent men should be employed to give practically their whole time to the work. They must be paid salaries which will justify them in resigning any official positions which they may hold and

taking their chances of securing other employment when the work of the Survey is finished.

The appropriation for the Connecticut Geological and Natural History Survey is one of the smallest of those which are made by the states at present maintaining such surveys. Six states make annual appropriations for geology alone ranging from ten thousand to twenty-eight thousand dollars, exclusive of cost of publication, and five others make annual appropriations ranging from ten thousand to fifteen thousand dollars, inclusive of cost of publication. In comparison with an appropriation of ten thousand dollars for geology alone, our appropriation of fifteen hundred dollars for geology, botany, and zoölogy seems rather small. It is fair, however, to consider that Connecticut is not a large state, and that there is no probability that further geological exploration will develop great mineral wealth or create a great mining industry. While a moderate permanent increase of the appropriation would be desirable, the experience of our Survey has shown that creditable and useful work can be done with a small appropriation. The Survey should be recognized as having passed the experimental stage and having vindicated its claim to be a permanent institution.

Plans for the Next Two Years and Appropriations Desired

However useful the kinds of work outlined above, in Geology, Botany, and Zoölogy, may be, it is the judgment of the Commissioners that they should be postponed for the present, in order that the investigation of the water resources may be pushed forward as rapidly as possible. It is obvious that the sooner the work of surveying the water resources can be completed the greater will be its utility. The United States Geological Survey is willing to continue the same sort of coöperative agreement which has been in force for the past two years. The amount of money which they are willing to allot to the work in Connecticut will depend upon the amount of the appropriation made by Congress in its present session. It is almost certain, however, that the United States Geological Survey will be able to make at least as large an appropriation for the next two years as for the past two years. Two years ago the officers of the United States Geological Survey would have been willing to make a considerably larger appropriation for work in the state of Connecticut if we had been able to duplicate it. Whether they will be able, in view of present demands in other parts of the country, to increase the allotment to Connecticut, cannot be known till the appropriations have been made. The Commissioners of the State Survey are of the opinion that we ought to offer for the ensuing biennial term a larger appropriation than the former one, on condition that the United States Survey be able to duplicate it.

We accordingly earnestly petition the General Assembly to appropriate, for the ensuing biennial term, $1,000 for administrative and miscellaneous expenses, and $3,500, or such part of that sum as the United States Geological Survey may be able to duplicate, for coöperative work in the investigation of water resources.

In accordance with this plan, it is proposed that no new work on the general lines of geology, botany, or zoölogy be commenced during the ensuing biennial term. Work which has been commenced will be pushed forward towards completion as rapidly as possible, and bulletins which have been or which may be completed will be published as speedily as practicable. The appropriation of $1,000 for administrative and miscellaneous expenses will pay the salary of the Superintendent, and necessary traveling and incidental expenses; and will also allow, in some cases in which it may be necessary, small additional payments for work which has been undertaken, for which the allotment originally made proves to be inadequate.

The General Assembly of 1911 granted the petition of the Commissioners of the State Survey for an amendment to the law in regard to the printing of public documents, authorizing, in the case of the general and special reports of the State Survey, the printing of such numbers of copies as the Board of Control may determine, not exceeding 4500. This amendment to the law in regard to public printing carries out the intent of the act by which the Survey was established; which obviously contemplated the printing of the general and special reports of the State Survey, from the funds available for the printing of public documents in general. We, therefore, ask for no special appropriation for publication for the ensuing biennial term.