State of Connecticut

SIXTH BIENNIAL REPORT OF THE COMMISSIONERS

OF THE

State Geological and Natural History Survey

1913-1914

BULLETIN No. 25

State of Connecticut

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State Geological and Natural History Survey

BULLETIN No. 25

HARTFORD
Published by the State
1915

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HARTFORD, CONN., December 31, 1914.

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, 1914.

Very respectfully,

FLAVEL S. LUTHER,
Secretary of the Commission.

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY

SIXTH BIENNIAL REPORT

Coöperation with United States Geological Survey in Study of Water Resources

During the years 1913-14, as during the previous biennial term, the major part of the appropriation of the State Geological and Natural History Survey has been devoted to an investigation of the water resources of the State, in coöperation with the United States Geological Survey. The reasons which led the Commissioners to that course were stated in the last Biennial Report, but it may be well to repeat the statement in the present Report.

Such an investigation has 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 in many seasons we have very much less than the average rainfall, 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.

It is the policy of the United States Geological Survey to promote the study of the water resources of the various states by coöperation with State Surveys, the expense of the work (exclusive of cost of publication) being equally divided between the national and the state treasury. It is on this plan that the work is being done in Connecticut. The State Survey contributes to the work two thousand dollars of the biennial appropriation, or one thousand dollars per year; and our expenditure of one thousand dollars per year secures in addition one thousand dollars per year from the national treasury.

The contract under which the investigation of the water resources of Connecticut is prosecuted during the two years ending June 30, 1915, is as follows: —

"THIS AGREEMENT made June 14, 1913, by and between the UNITED STATES GEOLOGICAL SURVEY by George Otis Smith, Director, party of the first part, and the STATE OF CONNECTICUT by Wm. North Rice, Superintendent, Connecticut State Geological and Natural History Survey, party of the second part, WITNESSETH:

"1. The parties hereto covenant and agree that, in accordance with their respective statutory authorities, copies of which are attached hereto, there shall be maintained in coöperation an

investigation of the water resources of the State of Connecticut.

"2. That the parties hereto shall contribute for the purpose of carrying on these investigations and for preparing the results thereof for publication, the following amounts: (*a*) the party of the first part Two Thousand Dollars ($2,000) to be expended before the close of the fiscal year ending June 30, 1915; (*b*) the party of the second part Two Thousand Dollars ($2,000) to be expended within the same period; it being understood that the contribution of the United States Geological Survey is dependent upon Congressional appropriations for carrying on these investigations, and that the contribution of the State of Connecticut is to be expended only in accordance with the conditions of the appropriation made by the General Assembly for this purpose.

"3. The areas to be investigated and the scope of the investigations shall be determined by mutual agreement between the parties hereto and their respective representatives.

"4. The areas to be investigated and the nature of the investigations having been determined, the field and office work necessary therefor shall be under the direction of the party of the first part, who shall by a duly accredited representative supervise the expenditure of the funds contributed by both parties and shall approve vouchers for all such expenditures. The methods of investigation and the regulations governing them shall be those usually followed by the party of the first part, provided that they may be subject to such modification as is suggested by the party of the second part and approved by the party of the first part.

"5. During the progress of the work all records pertaining thereto shall be open to the inspection of the party of the second part, and, if the work is not being carried on in a manner satisfactory to the party of the second part, he may, on formal notice, terminate this agreement.

"6. Accounts and expenses incurred in the performance of the work herein provided shall be rendered monthly in the manner required by the laws and regulations of the parties hereto and shall be paid in accordance therewith.

"7. Certified copies of all results of investigations shall be furnished to the party of the second part on demand. The original records should ultimately be deposited in the office of the party of the first part and shall become part of the records of said office.

"8. The results of the work contemplated in this agreement shall be published by and in the regular reports of the party of the first part, and said publications shall contain a statement of the coöperative relation between the parties hereto. The cost of publication shall not be included in the contribution herein provided by the parties to this agreement. The party of the second part reserves the right to publish all results of said investigation,

it being understood that at least sixty (60) days shall be given the party of the first part for the proper assembling and compiling of any data desired for such State reports.

"IN WITNESS WHEREOF, We have hereunto set our hands and seals this fourteenth day of June in the year one thousand nine hundred and thirteen.

GEO. OTIS SMITH,
Director, for and on behalf of the
UNITED STATES GEOLOGICAL SURVEY,
Party of the First Part.

WM. NORTH RICE,
Supt., State Geol. & Nat. Hist. Survey,
STATE OF CONNECTICUT,
Party of the Second Part.

From the foregoing contract it will be seen that the work is 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 knowledge in regard to that subject at the date of the inception of the present investigation. 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 their regular reports, and that the United States Treasury bears the entire expense of publication. All such reports are to contain a statement of the coöperative relation of the United States Survey and the State Survey. The contract reserves to the State Survey the right to republish any part of these results in its own series of bulletins. Moreover, in case it is not deemed advisable to avail ourselves of that right, the Director of the United States Geological Survey has courteously offered to furnish the State Librarian a supply of the publications containing the results of the coöperative investigation for distribution to citizens of Connecticut.

WORK ON WATER RESOURCES ALREADY ACCOMPLISHED

During the years 1911-1912 field work was done in the towns of Hartford, West Hartford, Newington, Wethersfield, Manchester, East Hartford, South Windsor, East Windsor, Windsor, Bloomfield, Stamford, Greenwich, Canaan, North Canaan, Salisbury, Windham, Franklin, Saybrook, Essex, Westbrook, and Old Lyme.

Maps were prepared showing by contour lines the depth of the surface of ground waters in the areas examined. Numerous field assays of water from springs, wells, and brooks were made. It was the intention to obtain records of all drilled wells and of as many dug wells as were necessary to show the form of the ground water surface.

Professor Gregory has furnished the following statement in regard to the work done in the years 1913-1914:—

"The report on the Hartford, Stamford, Salisbury, Willimantic, and Saybrook areas was transmitted to the Director of the United States Geological Survey in April, 1913, and approved for publication, and is now in the hands of the editorial force. The report on the Waterbury area, including the towns of Ansonia, Seymour, Oxford, Beacon Falls, Naugatuck, Watertown, Waterbury, and Thomaston, was sent to the Director in September, 1914, and approved, and is also in the hands of the editorial division. In the study of the towns along the Naugatuck Valley, special attention was paid to municipal water supply and to the possibility of utilizing the ground water stored in the gravel by the installation of infiltration plants.

"The report on the towns of Southbury, Woodbury, Middlebury, and Bethlehem, on which work was begun in May, 1913, is finished so far as the general and areal studies are concerned. This report is, however, being held up because it is desirable to get several years' record of rainfall, ground water levels, and run-off, before issuing the bulletin. Observations are being continuously taken in the Pomperaug Valley by Mr. Ernest W. Parkin, who is acting as a field assistant. It is believed that these studies, covering a period of several years, will give us significant data for the entire state with special reference to the relation between the supply of water in the ground and the rainfall.

"The field work to July 1st, 1914, was in charge of Mr. Arthur J. Ellis, A. M., under my supervision. Beginning with the present fiscal year (that is, after July 1st), Mr. Ellis was assigned to work in the West, and Harold S. Palmer, A. B., was appointed to carry on the field work in Connecticut under the joint auspices of the State and the Federal Survey, reporting to me. Mr. Palmer's work has been on the group of towns centering at Plainville, and includes the towns of Plainville, Farmington, Bristol, Southington, and New Britain. Plainville, most of Bristol, New Britain, and Farmington, had been covered when field work closed on the first of November. In the spring it is planned to continue work in the same area.

"As yet no systematic studies of run-off have been made other than those which are being carried on in the Pomperaug Valley. However, data obtained by the Hartford Water Company on the water-shed of the Farmington are of such character that they may be directly utilized for our purposes.

"All this work is in pursuance of our original plan of determining the ultimate amount of water to be obtained from the ground and surface in the various parts of the state; and the work is of such detailed character that, for any given place, and almost for any particular farm, data will be available. A large number of maps are being prepared, showing the depth to water in various localities, and studies have been made of the type of well to be constructed for different areas. It is going to cost the U. S. Geological Survey a large amount of money to get out these maps, and Connecticut will profit accordingly."

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., Bulletins 13 to 15 as Vol. III, and Bulletins 16 to 21 as Vol. IV. 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 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.
20. The Birds of Connecticut: by John Hall Sage and Louis Bennett Bishop, assisted by Walter Parks Bliss.
21. Fifth Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1911-1912.

One of these, Bulletin 20, has been published since the last Biennial Report.

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 is 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. This bulletin was announced as in preparation in the Report of ten years ago, but the pressure of other duties and cares made it impossible for the authors to bring the work to completion. Happily a very competent editorial assistant was found in Walter P. Bliss, M. A., an earnest student of birds, and a man well trained for editorial work. His efficient help made possible the completion of this valuable work.

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

Three bulletins are now in press. These are the following: —

22. Guide to the Insects of Connecticut: prepared under the direction of Wilton Everett Britton. Part III. Hymenoptera of Connecticut: by Henry Lorenz Viereck, with the collaboration of Alexander Dyer MacGillivray, Charles Thomas Brues, William Morton Wheeler, and Sievert Allen Rohwer.
23. Central Connecticut in Geologic Time: by Joseph Barrell.
24. Triassic Life of the Connecticut Valley: by Richard Swann Lull.

Bulletin 22, by Mr. Viereck, of the California Horticultural Commission, 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 agriculturist. 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.

Bulletin 23, by Professor Barrell of Yale University, will be, from an educational point of view, one of the most valuable bulletins the Survey has published. The series of events in geological history by which the Connecticut area has been brought to its present condition, is illustrated by a series of structure sections representing the conditions at successive epochs. It is safe to say that no previous publication has given so luminous an exposition of the geological history of the region in question.

Bulletin 24, on the Triassic Life of the Connecticut Valley, by Professor Lull, of Yale University (in connection with Bulletin 18, by Professor Eastman, on the Triassic Fishes), affords by far the most complete account of the fossils of our Triassic formation and their significance. 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 very numerous footprints. To this group, in fact, probably belong a very large majority of the so-called "bird tracks" of the Connecticut Valley. Professor Lull's bulletin gives a complete list of the fossils which have been found in our Triassic formation, and discusses with great fullness the zoölogical affinities of the reptilian groups represented, and presents a vivid picture of Triassic life in relation to its environment. The work offers much material of interest to geologists and paleontologists, and will be especially helpful to the teachers of Connecticut.

A bulletin on the Peat Deposits of Connecticut has been approved for publication by the Board of Control, but the pressure of other work has thus far made it impossible for the author to complete the revision of the manuscript which was deemed necessary. The melting of the great ice sheet of the Glacial period left the surface of Connecticut dotted with innumerable lakes and ponds, many of which have been converted into peat bogs by the accumulation of the debris of vegetation. This peat is of considerable economic importance, its chief uses being as a fuel and as a fertilizer. Recent investigations of the United States Geological Survey have shown that peat is especially fitted for use in the gas-producer. The most of the field work in the study of our peat bogs was accomplished in the summer of 1907. The work was done by E. C. Miller, A. B., and T. T. Giffen, A. B., of Yale University, under the direction of Professor Charles A. Davis, now of the United States Bureau of Mines. Professor Davis was at that time in the employ of the United States Geological Survey, and was engaged in a reconnoissance of the peat deposits of the Atlantic border of the

United States. By the courtesy of the United States Geological Survey, he was permitted to spend a few days in Connecticut to direct the work of Messrs. Miller and Giffen. The main part of the bulletin is written by Professor Davis, who has made himself eminently an authority on both the scientific and the economic relations of peat. We are also indebted to the liberality of the United States Geological Survey for analyses of samples of peat collected by Messrs. Miller and Giffen. The value of the bulletin will be increased by including in it a republication of important parts of a work (now out of print) on the chemistry of peat, by Professor S. W. Johnson, of Yale University, the pioneer in the study of agricultural chemistry in America, edited and revised by his friend and pupil, Doctor 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, and should be published as soon as the necessary editorial revision can be accomplished.

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.

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) Hedenburg. 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 a 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.

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.

A number of the State Geological Surveys have devoted much labor and expense to the investigation of the distribution of different kinds of soils and the construction of soil maps of the respective areas. In some states this work has been done in coöperation with the Bureau of Soils of the United States Department of Agriculture. Other State Surveys have proceeded with this sort of investigation on methods of their own, differing more or less from those of the Bureau of Soils. Four years ago the project of starting on a general soil survey of the state was seriously considered by the Commissioners. It appeared, however, that there was much difference of opinion among experts as to the methods on which such a survey should be conducted. It also appeared doubtful whether such a survey would be of any great utility unless conducted on such a scale as to be very ex-

pensive. For these reasons it was then decided to postpone the project of a soil survey, and to devote the major part of the appropriation for the next few years to the survey of water resources. At some future time the project of a soil survey should be again considered, and it may be found practicable to undertake the work. The experiments in progress in various parts of the country may lead to a more general agreement of authorities as to the best methods.

A scheme has been organized for a co-operative investigation, by the United States Geological Survey, the Bureau of Mines, the Bureau of Standards, and the Office of Public Roads, on the rocks of the United States, with reference to their fitness for use in building, in road construction, and in manufacture of concrete. There will doubtless be arrangements which will make it possible for State Surveys to secure the advantage of such co-operative work. It may be desirable for our State Survey in future years to take up that line of work.

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 and Mrs. Hedenburg 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 intsance, 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 toward 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 is now in press. 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 has been published; 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, a Survey of that kind should be regarded 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.

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

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.

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 results 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 have made in recent years annual appropriations for geology alone ranging from ten thousand to twenty-eight thousand dollars, exclusive of cost of publication, and eight others have made annual appropriations ranging from ten thousand to thirty 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. Moreover, the topographic map of Connecticut has been completed (though some of the sheets are in need of revision), while in some of the states a considerable part of the appropriation is expended for topographic work. 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

It is the judgment of the Commissioners that in the next two years, as in the last two, the bulk of the appropriation should be devoted to work in coöperation with the United States Geological Survey on the water resources of the State. It is obvious that the sooner that investigation can be completed the greater will be its utility. While the action of the United States Geological Survey is dependent upon the appropriations to be made by Congress, there is no reasonable doubt that the United States Geological Survey will be able and willing to appropriate at least two thousand dollars for the water investigation on condition that the State Survey can give an equal amount.

Under normal conditions we should petition the General Assembly to make a moderate increase in the appropriation in order that the important investigation of our water resources may be prosecuted somewhat more rapidly. In view of the financial disturbance and industrial distress resulting from the

European war, we ask only for the continuation of the same small appropriation which has been made in each biennial term since 1903.

We accordingly petition the General Assembly to appropriate, for the ensuing biennial term, one thousand dollars for administrative and miscellaneous expenses, and two thousand dollars, 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; will provide for the employment of assistance in editorial work on the bulletins; 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.