



State of Connecticut

FOURTH BIENNIAL REPORT OF THE
COMMISSIONERS

OF THE

State Geological and Natural
History Survey

1909-1910

BULLETIN No. 17

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State of Connecticut.

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State Geological and Natural
History Survey

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BULLETIN No. 17



HARTFORD

Published by the State

1910

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FOURTH BIENNIAL REPORT OF THE
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State Geological and Natural History
Survey of Connecticut

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PUBLICATION
APPROVED BY
THE BOARD OF CONTROL.



HARTFORD, CONN., December 31, 1910.

HIS EXCELLENCY, FRANK B. WEEKS, 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, 1910.

Very respectfully,

FLAVEL S. LUTHER,

Secretary of the Commission.

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY

FOURTH BIENNIAL REPORT

SCOPE AND PLAN OF THE SURVEY

There has been no change in the general scope and plan of the Survey since its first organization. It may, however, be convenient briefly to recapitulate what has been said thereon in former reports. The Survey was established by an act approved June 3, 1903. 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 establishing the Survey proposes definitely 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.

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. This allowance for expenses has been understood to be available for necessary travel, for the employment of stenographic or other clerical assistance, or for the employment of students or scientific men of less experience who could do some part of the work under the direction of the responsible investigator. 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., and Bulletins 6 to 12 as Vol. II. It is expected that Bulletins 13 to 17 will constitute 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 publications 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 three previous biennial reports of the Commissioners are numbered respectively in the series as 1, 9, and 12.

Four bulletins on scientific subjects were published between the dates of publication of the first and the second biennial report. These were the following:—

No. 2. A Preliminary Report on the Protozoa of the Fresh Waters of Connecticut: by Herbert William Conn.

No. 3. A Preliminary Report on the Hymeniales of Connecticut: by Edward Albert White.

No. 4. The Clays and Clay Industries of Connecticut: by Gerald Francis Loughlin.

No. 5. The Ustilagineæ, or Smuts, of Connecticut: by George Perkins Clinton.

Five bulletins were published between the dates of publication of the second and the third biennial report. These were the following:—

No. 6. Manual of the Geology of Connecticut: by William North Rice and Herbert Ernest Gregory.

No. 7. Preliminary Geological Map of Connecticut: by Herbert Ernest Gregory, and Henry Hollister Robinson.

No. 8. Bibliography of Connecticut Geology: by Herbert Ernest Gregory.

No. 10. A Preliminary Report on the Algæ of the Fresh Waters of Connecticut: by Herbert William Conn and Lucia Washburn (Hazen) Webster.

No. 11. The Bryophytes of Connecticut: by Alexander William Evans and George Elwood Nichols.

Two bulletins have been published since the date of publication of the third biennial report. These are the following:—

No. 14. Catalogue of the Flowering Plants and Ferns of Connecticut, growing without cultivation: by Charles Burr Graves, Edwin Hubert Eames, Charles Humphrey Bissell, Luman Andrews, Edgar Burton Harger, and Charles Alfred Weatherby, Committee of the Connecticut Botanical Society.

No. 15. Second Report on the Hymeniales of Connecticut: by Edward Albert White, Professor of Floriculture in Massachusetts Agricultural College.

The Catalogue of the Flowering Plants and Ferns is, particularly from an educational point of view, one of the most

important bulletins the Survey has published. The Connecticut Botanical Society includes about one hundred members, some of them professional botanists, others amateur students of the science. For a number of years the members of this Society have given a great deal of time to the collection and study of the flowering plants and ferns of the state, and the work of the various members has been carefully collated by a Committee whose names are given above in the title of the bulletin. Soon after the organization of the Geological and Natural History Survey, the Superintendent of the Survey learned of the proposed work of the Connecticut Botanical Society, and invited them to offer the Catalogue, when completed, to be published as a bulletin of the Survey. The entire work has been a labor of love on the part of the members of the Committee and many of their associates. The Survey has paid three hundred dollars for incidental expenses, but no compensation has been received by any of the workers. The completed work makes a book of five hundred and sixty-nine pages. It gives a list complete, according to present knowledge, of the flowering plants and ferns (including the closely allied club mosses and scouring rushes) growing without cultivation within the limits of the state. The scientific names adopted for the respective plants, are, in general, the same which are used in the Seventh Edition of Gray's Manual, a book which is widely accepted as a standard in the schools. While no attempt has been made to give a complete record of synonyms, the names which have been in somewhat general use are given as a matter of convenience. English names of the different species are very fully given, including, so far as known, the often whimsical names in use in particular localities or among particular classes of people. Full information is given in regard to the distribution of the plants over the state. In the case of rare species, and species local or peculiar in distribution, particular localities are mentioned with the names of the collectors. Attention is called to all plants having important economic relations, both those which are useful, and those which are injurious. Analytical keys and descriptions are not included in the work, since the Seventh Edition of Gray's Manual is readily accessible and cheap, and will doubtless be in the hands of almost everyone who would wish to use this book. In the introduction is given an interesting history of botanical work in the state from the earliest

days; and in an appendix is included a statistical summary of the plants of Connecticut.

The work of Professor White on the Hymeniales is a supplement to the Preliminary Report on the Hymeniales by the same author, published in 1905, as Bulletin No. 3. The plants treated in these two reports are the fleshy and woody fungi, some of which are edible mushrooms, while others are extremely poisonous. The present bulletin consists of three parts. The first part gives analytical keys for the discrimination of the species of the Agaricaceæ—the most important family of the group, and the one which includes most of the edible species. The second part gives detailed descriptions of some of the edible species of mushrooms. The third part gives a list of all the species of Hymeniales which have been discovered in the state since the publication of the former Bulletin. Both of these bulletins are illustrated with beautiful plates, exhibiting the aspect of many of the species, from original photographs by the author. The study of mushrooms has been very popular in recent years, and Professor White's former bulletin has attracted much attention. Doubtless all who have found the former bulletin useful will want to avail themselves of the present supplementary report.

BULLETINS IN PRESS

Two Bulletins are passing through the press at the date of the present report. These are the following:—

No. 13. The Lithology of Connecticut: by Joseph Barrell, Professor of Structural Geology in Yale University, and Gerald Francis Loughlin, Instructor in Geology in Massachusetts Institute of Technology.

No. 16. Guide to the Insects of Connecticut: prepared under the direction of Wilton Everett Britton, State Entomologist, and Entomologist of the Connecticut Agricultural Experiment Station. Part I. General Introduction: by Wilton Everett Britton. Part II. The Euplexoptera and Orthoptera of Connecticut: by Benjamin Hovey Walden, Assistant in Entomology, Connecticut Agricultural Experiment Station.

The bulletin on the Lithology of Connecticut includes a general introduction to lithology by Professor Barrell, and a special description of forty-one typical rocks from Connecticut localities by Dr. Loughlin. 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. Both in 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 high schools and other institutions in the state will be greatly enhanced by the distribution to those institutions of suites of specimens of rocks from the typical localities described in the special part of the paper. These specimens were for the most part collected in the summers of 1905 and 1906. They will be distributed, as soon as the bulletin is published, to colleges, normal schools, high schools, and academies in the state, on condition that the respective institutions shall pay the cost of transportation. Any suites of specimens remaining in the possession of the Survey after such distribution may be sold and the money paid into the treasury of the state.

The bulletin 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. 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.

BULLETINS ACCEPTED FOR PUBLICATION.

The following Bulletins have been accepted for publication:—

Guide to the Insects of Connecticut: prepared under the direction of Wilton Everett Britton, State Entomologist, and Entomologist of the Connecticut Agricultural Experiment Station. Part III. Hymenoptera of Connecticut: by Henry Lorenz Viereck, of the United States National Museum.

The Triassic Fishes of Connecticut: by Charles Rochester Eastman, Curator of Vertebrate Paleontology in the Museum of Comparative Zoology, Harvard University.

The Echinoderms of Connecticut: by Wesley Roswell Coe, Professor of Biology in Yale University.

Drainage and Glaciation in the Central Housatonic Basin: by Ruth Sawyer Harvey.

The Hymenoptera which are treated in the bulletin by Mr. Viereck, 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 also had the aid of a number of collaborators who are specialists on other groups of this large and varied order. 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.

The bulletin on the Triassic Fishes, by Dr. Eastman, 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 scarcely 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. Dr. 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), but rather with a somewhat lower horizon, near the boundary between the Muschelkalk and the Keuper.

The bulletin by Professor Coe on the Echinoderms of Connecticut will be the first paper which the Survey has published 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.

Miss Harvey's paper on Drainage and Glaciation in the Central Housatonic Basin is a study of the changes in drainage as the result of the events of the Glacial period. It was presented as a thesis for the degree of Doctor of Philosophy in Yale University. It is the first instalment of a series of bulletins bearing on the general subject of the Quaternary geology of the state.

WORK STILL IN PROGRESS

I. Geology

The geological investigations now in progress relate chiefly to surface geology, or the study of the phenomena connected with the work of the great ice sheet of the Glacial period. For more than a generation geologists have recognized that the mantle of heterogeneous and unstratified drift covering most of New England and the adjacent country is essentially the ground moraine of a continental glacier; that the widely scattered smooth, polished, and striated rock surfaces are the result of erosion by such a continental glacier; and that the stratified deposits in the river valleys consist of the débris transported by the glacier, sorted and redistributed by the action of water. But it is within a comparatively few years that a more thorough and detailed study has been given to these glacial phenomena. Of the comparatively small amount of study that has been given to the glacial geology of Connecticut, a considerable part has been vitiated by preconceptions now known to be erroneous, leading to false interpretations of observed facts, and preventing due appreciation of phenomena which might have been observed.

There is need of a large amount of new study before the true history of the glacial and aqueo-glacial formations of the state can be determined.

Dr. F. P. Gulliver of Norwich has been at work for some time on a detailed study of the terraces bordering the estuary of the Thames. These shelves of stratified sand and gravel at a considerable elevation above the present level of the river have been supposed to be remnants of a great plain of sand and gravel which was once substantially continuous across the valley, and which was formed, after the retreat of the ice from the portion of the valley in question, by deposition in the waters of the river, whose velocity was at that time feeble by reason of diminished slope and excessive load of sediment. A number of years ago Dr. Gulliver published a preliminary paper on the terraces of the Thames, in which he gave reasons for the belief that those terraces were formed on the edges of the valley while a tongue of ice still lingered in the central part. Various students have shown reasons for a similar belief as regards the terraces in the lower or estuarine portions of other rivers of the North Atlantic slope. The study of these terraces is therefore of great interest in the endeavor to trace out the detailed history of the later stages of the ice age. Dr. Gulliver has accordingly undertaken to make a more detailed survey of the terraces of the Thames River, and to furnish the result for publication as a bulletin of the State Survey.

Numerous other problems present themselves in the detailed study of the glacial geology of this region. Studies of the glacial formations in the Mississippi Valley, in northern Europe, and in the Alpine region, have clearly revealed the fact that the Glacial period was more complex than was formerly supposed. There were repeated alternations of rigor and mildness in the climate in accordance with which the great ice sheets alternately advanced and retreated. The deposits of earlier ice sheets can be recognized in some regions, emerging from beneath the edge of the later deposits, while in some localities stratified and fossiliferous interglacial deposits can be recognized between the older and the younger glacial formations. In New England the latest advance of the ice sheet extended beyond the shore line, and it has been generally supposed that the latest ice invasion so thoroughly

disturbed all deposits of the earlier ice sheets, as to leave no recognizable remains of them. There is need, however, of thorough study of precisely this question. There is need also of careful examination for the purpose of tracing in more detail the history of successive stages in the final recession of the ice sheet. During the summer of 1907 Professor H. E. Gregory of Yale University devoted considerable time to field work in the study of the Glacial formations of the state. As a preliminary result of this study, a bulletin on the Glacial phenomena of the Naugatuck Valley will be ready at an early date. In the Geological Map of Connecticut, which was published as Bulletin No. 7, surface geology was entirely ignored, the map representing only the bed rocks which lie beneath the mantle of drift. It is expected that Professor Gregory's work will result eventually in the preparation of another general map of the state showing the surface geology, and a volume of text tracing with some approach to completeness the history of the Glacial period in our state.

Dr. Freeman Ward of Yale University has been engaged a part of the time for two summers in special studies of the glacial geology of the New Haven region. It is expected that he will present, at an early date, a paper on that locality, while his work will also contribute material for the general work on the Quaternary geology of the state which is expected from Professor Gregory.

The melting away of the great ice sheet left the surface of Connecticut and of the adjacent country dotted with innumerable lakes and ponds, many of which have already become obliterated. One of the processes which have led to the disappearance of these ponds is the accumulation of the debris of vegetation, converting the ponds into peat bogs. 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 accomplished. 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 Messrs. 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, 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.

In commenting on Dr. Eastman's bulletin on the Triassic Fishes, reference has been made to the numerous tracks of reptiles and amphibians (the so-called bird tracks) which are almost the only other fossils found in the state. Only a very few bones of the creatures that made these tracks have been discovered. Those few finds, however, have thrown much light on the nature of the animals, which was formerly more or less vaguely guessed at from the tracks. Professor R. S. Lull of Yale University, who published some years ago a very valuable study of the fossil footprints of the Connecticut valley, is continuing the study of those interesting fossils, and will present at an early date a bulletin in regard to them, which will undoubtedly be the most authoritative work on the subject that has been issued.

II. Botany

Dr. G. P. Clinton of the Connecticut Agricultural Experiment Station, whose paper on the smuts was published as Bulletin No. 5, has nearly completed a paper on another important group of parasitic fungi, viz., the downy mildews. This group includes a number of parasites destructive to important agricultural products, and the bulletin will be therefore an important contribution to the economic botany of the State.

Professor Conn, whose work on the protozoa and algæ of the fresh waters of Connecticut has been published as Bulletins 2 and 10, is continuing his study of the microscopic life of the fresh waters by an investigation of the bacteria. The relation of bacteria to public health is so well understood as to make it obvious that a study of the distribution of bacteria in the reservoirs and other sources of drinking water must be of great importance from a practical as well as from a purely scientific point of view. A preliminary report on the bacteria will be presented at an early date.

III. Zoölogy

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. John H. Sage and Dr. Louis B. 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 has 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 has been found in W. P. Bliss, M.A., of the State Bacteriological Laboratory. Mr. Bliss is himself an earnest student of the birds, and his general training has given him an excellent fitness for editorial work. He has been giving a good deal of time to collating and getting into shape for publication the notes of Mr. Sage and Dr. Bishop, and it is now hoped that this very valuable bulletin will be able to be published at an early date.

As stated above, two parts of the proposed work on the insects of Connecticut — the general introduction, and the Euplexoptera and Orthoptera — are already in press. The third part, including the Hymenoptera, has been accepted for publication. A fourth part, taking up the Hemiptera, is now in preparation by specialists under the direction of Dr. W. E. Britton. The Hemiptera include the insects popularly called bugs, as well as the cycadas, leaf-hoppers, plant-lice, and the lice infesting man and other mammals. They are mostly to be regarded as injurious insects, some of them being formidable destroyers of agricultural products, while others are troublesome parasites of man and of domestic animals.

As the completion of the Guide to the Insects of Connecticut will undoubtedly occupy many years, it has been thought that it would be desirable to publish at as early a date as practicable a check-list, giving simply the names of the insects of various orders known to occur in Connecticut. Dr. Britton is at work on the preparation of such a check-list, and it will probably be ready at an early date.

A beginning has been made in the preparation of a series of bulletins on the marine zoölogy of the state. A bulletin on the echinoderms, by Professor W. R. Coe, has already been accepted for publication. Professor A. E. Verrill of Yale University is engaged in the preparation of a bulletin on the Stalk-eyed Crustacea (Decapoda, Cumacea, and Stomatopoda). This group includes the highest in rank, the largest and most conspicuous, and the most important economically, of the crustacea. Here belong the crabs, lobsters, and shrimps. While several species of the group on our Connecticut coast are of some degree of economic importance, the common lobster is one of the most valuable of the food resources of the sea. Professor Verrill's paper will deal thoroughly with the scientific relations of the animals in question, and, particularly in the case of the lobster, will treat very fully indeed their economic relations. These large and conspicuous crustacea are exceedingly interesting objects of study, and the work will be of very great value to teachers. It will be profusely illustrated with photographs of entire animals, and drawings of important parts of the anatomy.

Next in importance to the groups of Crustacea treated by Professor Verrill are the amphipods and isopods. Most of these animals are marine, while others, as the wood-lice or sow-bugs, are terrestrial. A bulletin on these forms by Dr. B. W. Kunkel of Yale University is nearly completed. Though less conspicuous than the crabs and lobsters, these animals are large enough to be often collected by visitors to the shore, and a manual of our Connecticut species will be of much use to teachers of zoölogy in our schools.

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, 1907-9	\$400	\$149.56
C. R. Eastman	Triassic Fishes	300	99.45
R. S. Harvey	Glacial Geology, Housatonic Basin	25	72.05
Conn. Botanical Soc.	Flowering Plants and Ferns		299.61
E. A. White	Fungi	100	44.69
W. R. Coe	Echinoderms	75	25.00

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, 1909-11	\$400	\$300
F. P. Gulliver	Thames River Terraces		425
H. E. Gregory	Glacial Geology		825
F. Ward	Glacial Geology		400
C. A. Davis and others	Peat	325	325
R. S. Lull	Fossil Footprints	200	100
G. P. Clinton	Downy Mildews	50	25
H. W. Conn	Fresh-water Bacteria	200	650
J. H. Sage and L. B. Bishop	Birds	200	400
W. E. Britton and others	Insects	625	250
A. E. Verrill	Crustacea	150	250
B. W. Kunkel	Crustacea	100	50

The small expenditure, in comparison with the quantity and quality of the work, is remarkable.

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, and that of Professor Conn and Mrs. Webster on the fresh-water algæ, are 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 accepted for publication, and the papers of Professor Verrill and Dr. Kunkel on the crustacea, which are expected to be finished and presented at an early date. Papers on the 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 in press, 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 the most numerous in species and most important in economic relations.

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

ALTERNATIVE PLANS

The plans outlined in the preceding paragraphs are for work substantially similar in character to the work which has been done in the previous years of the Survey. The value of such work is largely scientific and educational, though the economic side has been by no means ignored. Two projects, however, for work of more decidedly economic character are at present under consideration by the Commissioners, but have not yet been worked out so definitely as to enable the Commissioners to decide whether it is feasible or expedient to undertake either of them in the immediate future or not.

One of these is a soil survey of the state. Such surveys have been prosecuted in many of the states by the Bureau of Soils of the U. S. Department of Agriculture, while in other states such surveys have been conducted by Agricultural Experiment Stations

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

or other local organizations. The Commissioners have not reached a positive conclusion on the question whether a soil survey of great utility to the agriculture of the state can be carried out without greater expenditure than is likely to be practicable in the near future.

The other project under consideration is a study of the water resources of the state, with a view to the practical question, what measures should be taken for the conservation of such resources. The threatened water famine in some of our large and growing cities emphasizes the importance of this question.

If either of these projects should be undertaken, there would be need of a decided increase of the appropriation for the Survey.

THE NEED OF FURTHER APPROPRIATIONS.

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 State Geologist who is Director of the Science Division of the Education Department of the state, and on the staff of that Department are 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.

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 or 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. The experience of our Connecticut Survey illustrates well the economy of this method of procedure. 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 very smallest of those which are made by the states at present maintaining such surveys. North Dakota makes an appropriation somewhat smaller than that of Connecticut. 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. If the work of the next few years is to be of the same general character as that of previous years, we are not disposed to urge strenuously a large increase of the appropriation. If, however, it should be deemed expedient, after further consideration, to undertake either a soil survey or a study of the water resources, there would be need, at least temporarily, of a very considerable increase of the appropriation. In any case we believe that the Survey should be recognized as having passed the experimental stage, and having vindicated its claim to be a permanent establishment. The present demand is for recognition as a permanent institution, and for adequate provision for the publication of the results of its work.

LEGISLATION DESIRED IN REGARD TO PUBLICATION OF BULLETINS

The law establishing the Survey made it the duty of the Commissioners to cause to be prepared a report to the General Assembly before each meeting of the same, and special reports, with necessary illustrations and maps, on the geology and natural history of the state. It also made it the duty of the Commissioners to direct in regard to the sale or distribution of the reports, when printed. It imposed upon the Commissioners no responsibility for the printing. It was the obvious intent of the act that the whole of the small appropriation made for the Survey should be devoted to the scientific work of investigation and preparation of the reports. The cost of publication of the reports

was to come out of the general funds in the treasury of the state. When the first bulletin of the Survey came to be printed, an unexpected difficulty appeared. The general law in regard to the state printing provides for the printing of not more than 1,575 copies of any public document, except certain reports in regard to which the law specifically provides for a larger edition. But an edition of 1,575 copies is utterly inadequate for the bulletins in the Survey. It is desired that these bulletins should be, as is customary in the case of similar publications in other states, widely distributed to colleges, scientific institutions, public libraries, scientific men, teachers, and others. The editions of similar reports published by other states generally range from 3,000 to 8,000. It is obviously useless to prepare elaborate scientific reports, and then print so small an edition as to render it impossible for those reports to reach the persons who would desire to use them. Hence the necessity for some action of the General Assembly to provide for the printing of the bulletins of the Survey.

The editions of bulletins thus far published have ranged between 3,000 and 4,000 copies. The former number seems the minimum number which will permit proper distribution of any of the bulletins likely to be published in the future. Some bulletins are of more popular character than others, and appeal to a wider constituency of readers.

The respective numbers of copies deemed necessary to meet the demand which may be reasonably anticipated in the case of the bulletins already accepted for publication but not yet ordered by the Board of Control to be printed, and of those bulletins which are approaching completion and which may be expected to be ready for publication within a few months, are shown in the following table:—

Author	Subject	No. of Copies
F. P. Gulliver	Thames River Terraces	3000
H. E. Gregory	Glacial Geology of Naugatuck Valley	3500
C. A. Davis and others	Peat	4000
F. Ward	Glacial Geology of New Haven Region	3000
R. S. Harvey	Glacial Geology of Housatonic Basin	3000
R. S. Lull	Fossil Footprints	3500

Author	Subject	No. of Copies
G. P. Clinton	Downy Mildews	3000
H. W. Conn	Fresh-water Bacteria	3500
J. H. Sage and L. B. Bishop	Birds	4500
W. E. Britton and others	Hymenoptera and Hemiptera	3500
W. E. Britton	Check-list of Insects	3500
A. E. Verrill	Stalk-eyed Crustacea	3500
B. W. Kunkel	Amphipods and Isopods	3000

It is needless to remark that the cost of the larger editions, in excess of the number of copies prescribed by the general law, is not great. In ordinary printing, the chief expense is in the composition, and that is the same for a small edition as for a large one. Where there are maps and illustrations, the largest item of cost is the preparation of the plates, and that too is independent of the size of the edition. The first nine of the scientific bulletins published by the Survey cost \$9,570.90. On the basis of figures given by the printers it appears that the excess of cost above the 1,575 copies authorized by the general law was only about \$3,033.

Reference has been made to the fact that the general law limiting the number of copies of public documents to 1,575, specifically provides for larger editions of the reports of certain officers and institutions. For instance, the maximum editions of certain reports, subject in each case to the approval of the Board of Control, are as follows:—state board of education, 6,000; bureau of vital statistics, 3,000; state librarian, 2,500; board of agriculture, 5,000; commissioners of fish and game, 3,000; bureau of labor statistics, 15,000; Connecticut agricultural experiment station, 12,000; state board of health, 3,000; factory inspector, 5,000; Storrs agricultural experiment station, 7,000; highway commissioner, 3,500. In each of these cases the Comptroller is authorized to print 575 additional copies for the bound volumes of public documents. It will be noticed that in general the reports of the scientific bureaus of the state are published in larger editions than the merely administrative reports of state officers, for the obvious reason that they should be read or consulted by a much larger number of people. It is obviously reasonable that the State Survey should be treated in the same manner as the other scientific bureaus.

In 1907 and again in 1909, the General Assembly authorized the printing of editions of the reports of the State Survey exceeding 1,575 copies during the ensuing biennial term, but accompanied that resolution by a resolution appropriating a specific sum for such publication, consequently limiting the amount of material which could be published. In the case of the other scientific bureaus above-mentioned, there is no such limitation. The publication of their reports, with the approval of the Board of Control, is made the duty of the Comptroller, and is paid for from the funds in the treasury without any specific appropriation.

We accordingly earnestly petition the General Assembly to amend the law in regard to the printing of public documents so as to authorize, 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 shall determine, not exceeding 4,500. The Board of Control can surely be trusted to guard against any extravagance. Such amendment would only carry out the intent of the act by which the Survey was established.