STATE GEOLOGICAL AND NATURAL HISTORY SURVEY OF CONNECTICUT

NATURAL RESOURCES CENTER
DEPARTMENT OF ENVIRONMENTAL PROTECTION

A HISTORY OF THE STATE GEOLOGICAL AND NATURAL HISTORY SURVEY OF CONNECTICUT

By Robert J. Altamura

Reprint from

THE STATE GEOLOGICAL SURVEYS - A HISTORY

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Directors of the State Geological and
Natural History Survey of Connecticut (established in 1903)

William North Rice, *Superintendent*, 1903-1916
Herbert Ernest Gregory, *Superintendent*, 1916-1921
Henry Hollister Robinson, *Superintendent*, 1921-1925
Wilton Everett Britton, *Superintendent*, 1925-1939
Edward Leffinwell Troxell, *Director*, 1939-1954
John Becker Lucke, *Director*, 1954-1960
Joe Webb Peoples, *Director*, 1960-1974
Hugo Frederick Thomas, *State Geologist*, 1974-

Early Official Geological Surveys of the State

James Gates Percival (Geological survey of Connecticut with map) 1835-1842
Charles Upham Shepard (Mineralogical survey of Connecticut) 1835-1837

NOTE FOR THE READER

This history of the State Geological and Natural History Survey of Connecticut is a reprint of an article that was prepared for a volume containing the history of each of the fifty state geological surveys. Space limitations for this volume necessitated that this history of the Connecticut Survey be somewhat abbreviated, and greater detail is provided on geologic topics than on natural history (biology) topics.

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THE STATE GEOLOGICAL SURVEYS - A HISTORY [1]
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A HISTORY OF THE STATE GEOLOGICAL AND NATURAL HISTORY SURVEY

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FOUNDATIONS OF THE SURVEY

There was a growing interest in geology in the early part of the 19th century, not only in Connecticut, but elsewhere. By that time, James Hutton, the founder of modern geology, had presented his epoch-making *Theory of the Earth* to the Royal Society of Edinburgh in 1785. Europeans, who had studied the natural sciences for some time, continued to pursue the subject of geology. Here in the United States, foreign literature stimulated interest in natural science, including geology and biology, and people were becoming increasingly aware of the natural world.

In 1802, the President of Yale College in New Haven, Connecticut, hired Benjamin Silliman, who just had completed his training in law, to head a department and offer courses in science. Before he began teaching, Silliman attended lectures in chemistry at a medical school in Philadelphia and had studied natural science in Europe. By 1806, Silliman had published a sketch of the mineralogy of New Haven and in 1818 he founded *The American Journal of Science*. The early volumes of *Silliman's Journal*, as it was then known, contained a number of papers on Connecticut mineralogy and geology, many by Silliman himself.

Silliman's students carried their knowledge to other parts of the country. In 1824, Denison Olmsted went to head the North Carolina Survey. Edward Hitchcock went to Amherst College in Massachusetts and conducted the geological survey of that state beginning in 1830, which inspired and stimulated other states to get surveys under way. Amos Eaton went to Williams College in Massachusetts and later to Rensselaer Polytechnic Institute in Troy, New York, where he worked on a geological survey in eastern New York, and James Gates Percival stayed in Connecticut to lead the state's first systematic geological survey.

In the United States, the period from 1830-80 has been referred to as the "Era of the State Surveys" (Merrill, 1924). William W. Mather, who taught at Wesleyan University in Middletown, Connecticut from 1833-34, was one of four state geologists who mapped New

[1] *This paper was written for inclusion in The State Geological Surveys - A History, a 500-page volume including papers on the histories of state geological surveys of the fifty states. This project was edited by Arthur A. Socolow and published by the Association of American State Geologists (AASG) in 1988. The Connecticut chapter is reproduced here with the permission of the AASG as a Connecticut Geological & Natural History Survey reprint.*

York State from 1836-42, and in 1841 Edward Hitchcock completed the geological survey of Massachusetts.

The first systematic study of the geology of Connecticut was made when a survey of the state was authorized by the Legislature on June 15, 1835. James Gates Percival was placed in charge of the geology and Charles Upham Shepard, the mineralogy. A passage from the Annual Message of 1835 from Governor Henry Edwards may provide insight into the thinking of the times, which led to the birth of that first geological survey of the state.

> The mineralogical treasures which have been developed within a few years and which are constantly coming to light in different parts of our country, give us reason to believe, that we have not as yet availed ourselves to the extent that we might of this source of wealth, and suggests the expediency of a more systematic examination than has hitherto taken place . . . (from Shepard, 1837).

Shepard's *A Report of the Geological Survey of Connecticut* was published in 1837, but it wasn't until 1842 that Percival published his *Report on the Geology of the State of Connecticut*, which was a comprehensive geological investigation. By 1841, Percival (fig. 1) had surveyed the entire state in E-W traverses at 2-mile intervals, which means that he touched every square mile of the state. By the time Percival accomplished this task, the Legislature and new governor William Ellsworth became impatient for a final report. Requests for further appropriations were denied, and Percival was forced to report his work in "a hasty outline" of 495 pages with a map (the first state geological map, scale 1:250,000).

Percival's report on the geology of Connecticut delineates all the major rock types with particular attention to detail. His observations are descriptive with little interpretative bias. Geologic boundaries key to some of the modern interpretations as shown on the most recent state map were delineated on Percival's 1842 map. As an example of the value of Percival's observations, in preparing the 1985 *Bedrock Geological Map of Connecticut*, John Rodgers of Yale used Percival's map to help resolve conflicts.

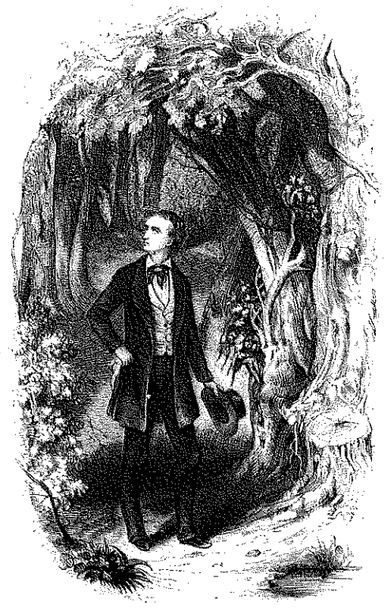

Figure 1.--James Gates Percival--student of Benjamin Silliman and author of the first geological map of Connecticut, which was published in 1842.

From 1842 to 1903, the State initiated no new geological investigations. However, studies were conducted by various university and federal geologists. In the last half of the 19th century, instruction and investigations in geology were conducted primarily at three Connecticut universities. At Yale, Benjamin Silliman, James Dwight Dana, his son Edward S. Dana, and George Brush, made early contributions to the geology and mineralogy of the state. At the Peabody Museum of Yale, Othniel C. Marsh made collections of dinosaur bones from the western United States, competing with Edward Drinkwater Cope of the Academy of Natural Sciences in Philadelphia. Also at this time, geological instruction and investigations were under way by John Johnston and William North Rice at Wesleyan. Rice had received a Ph.D. from Yale in 1867. This was the first Ph.D. in geology given by an American university. The title of his dissertation was *The Darwinian Theory of the Origin of Species*. Rice, a graduate of Wesleyan in 1865, returned to become professor of geology and in 1903 became the first Superintendent of the State Geological and Natural History Survey of Connecticut. Rice was also an ordained minister. Charles Upham Shepard taught and conducted numerous investigations at Washington College (later to become Trinity College) in Hartford during this time. Key contributions to Connecticut geology and mineralogy appeared in *The American Journal of Science*.

Shortly after its formation in 1879, the U.S. Geological Survey (USGS) began work in Connecticut. William Morris Davis, who was a professor at Harvard and also worked for the USGS, studied and mapped the Mesozoic rocks of Connecticut. Davis accomplished part of this work by leading the Harvard College summer geology school to the Meriden area for geological mapping. Later, Davis worked with S. Ward Loper, a farmer who later became curator of the geology museum at Wesleyan. Loper helped confirm Davis' structural models for block faulting in the Connecticut valley by locating specific fossil fish and fossil plant marker horizons.

One of Davis' geological assistants was William North Rice (fig. 2). Another was Lewis Gardner Westgate, also a graduate of Wesleyan, who did considerable mapping in the crystalline rocks near Middletown.

In 1891, W. F. Hillebrand, a chemist with the USGS, studied uraninite (essentially UO_2) from Portland, Connecticut, and noticed during the preparation for analysis that a gas was being emitted. Several years later, helium was isolated as a stable decay product of uranium. In 1904, Ernest Rutherford of McGill University presented ideas on how progressive accumulation of daughter products might be used to measure geologic time. Those ideas were put to use by Bertram B. Boltwood of Yale, who, in 1906, following a suggestion made by Rutherford, looked at analyses of uranium minerals, including Hillebrand's uraninite analyses, and made the first radiometric age determinations. Radiometric age dating indicated that the expanse of geologic time was much greater than geologists previously thought.

Around the turn of the century, William H. Hobbs of the USGS conducted pioneering lineament studies in Connecticut, a field that today receives a significant amount of attention.

During the 19th century, people in Connecticut also turned their attention to biology. For example, around the time of Percival and Shepard, Eli Ives of Yale, a professor of botany and medicine, published three papers on plants in *Silliman's Journal*. Ives later made a list that included the names of more than a thousand plants growing near New Haven (Troxell, unpub. ms.). Troxell also reports that Amos Eaton and John Pierce Brace pursued similar interests. Brace later studied plant life in the Litchfield, Connecticut, region, and his herbarium was donated to Williams College.

About 1856, professor Daniel Cady Eaton and other members of the Sheffield Scientific School of Yale produced a catalog of the higher plants found in the vicinity of New Haven, listing about 1,230 species (Troxell, unpub. ms.). In 1885, James W. Bishop presented a catalog of plants for all of Connecticut which included contributions from many naturalists throughout the state.

Figure 2.--William North Rice (first Superintendent of the Connecticut Geological and Natural History Survey) (left) and William Morris Davis of the U.S. Geological Survey (right) "toast" in the field. (Department of Earth and Environmental Sciences, Wesleyan University.)

In 1903, the Connecticut Botanical Society was founded, and a goal was to catalog all the higher plants growing naturally in the state. That same year the State Geological and Natural History Survey of Connecticut (also referred to as the Connecticut Geological and Natural History Survey) was founded.

FORMATION OF THE CONNECTICUT GEOLOGICAL AND NATURAL HISTORY SURVEY

The Act establishing the State Geological and Natural History Survey was approved by the Legislature on June 3, 1903. The Commissioners, under whose direction the Survey was placed by the terms of the Act, appointed William North Rice (fig. 3), Professor of Geology at Wesleyan, to be Superintendent of the Survey.

The first Biennial Report of the Commissioners states that equal attention be paid "both to the rocky framework of the state and to its vegetable and animal life--both to the Geology of the state and to its Botany and Zoology." The report also states that the Survey has three distinct aims. These are:

> First the advancement of our knowledge of the geology, botany, and zoology of the state as a matter of pure science; second, the acquisition and publication of such knowledge of the resources and products of the state as will serve its industrial and economic interest; third, the presentation of the results of investigation in such form as to be useful in the educational work carried on in the various schools of the state. These three aims, the purely scientific, the economic, and the educational, we have endeavored constantly to keep in mind in all plans which have been made.

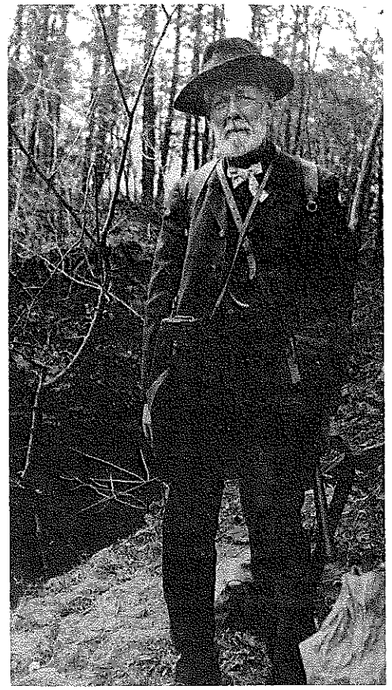

Figure 3.--William North Rice--First Superintendent of the Connecticut Geological and Natural History Survey and Professor of Geology at Wesleyan. (Wesleyan University Archives.)

It may have been Professor Herbert Ernest Gregory of Yale and also of the U.S. Geological Survey who eventually brought the elements together to form the Survey. Troxell (unpub. ms.) implies that Gregory, who took many trips back and forth to Hartford, was the main organizer. Gregory met frequently with other scientists, with administrative officers, and with politicians whose final consent needed to be won.

On the occasion of the 25th anniversary of the Connecticut Survey, Gregory wrote a letter, dated December 30, 1927, in which he states that his deep and continuing interests made him feel that the time he gave to the Survey's organization, along with its administration and scientific studies, was profitably spent. He further states, "My reason for urging the establishment of the Survey was the belief that such an organization would fill a useful place in the educational system of the state." Education may have been Gregory's primary incentive.

Practical Organization

The Connecticut Survey consisted of a board of commissioners, who were made up of the presidents of the state's principal colleges. These institutions were the Connecticut Agricultural College (later to become the University of Connecticut) in Storrs, Trinity College in Hartford, Wesleyan University in Middletown, and Yale University in New Haven. Later Connecticut College in New London was represented on the Commission. The Governor was an *ex officio* member of the board. A Superintendent, who was a scientist and not necessarily a college president, was appointed by the Commission to direct the work of the Survey.

The organization of the Survey was intended to be simple and, following this reasoning, the Commissioners decided that no promises of position or support would be implied beyond the current biennial term. The exception to this rule was the Superintendent, who was appointed by the Commission to serve until removed for valid reason. The Survey's office was based at the institution where the Superintendent was employed.

The initial biennial appropriation for the Connecticut Survey was $3,000. "Scientific men" employed to investigate specific subjects and to prepare reports were paid a sum when their report was

accepted. The Commission, in addition, would allocate funds for travel expenses, services of stenographers and other assistants, and to purchase materials as needed. Only the Superintendent was paid a regular salary, and this was provided in quarterly installments. In the early years, the Superintendent's annual salary was $400.

Once under way, the Survey quickly undertook several studies in the fields of geology, botany, and zoology.

Publication

Each report was published as a separate bulletin in paper cover. When several bulletins were completed, bound volumes were then prepared. The distribution and exchange of publications was conducted by the State Librarian, a function now provided by the Natural Resources Center. Publications received from other geological surveys "and from various learned societies and scientific institutions" were deposited in the State Library.

From the beginning, the Survey had to deal with inadequate means for publishing. At the time the Connecticut Survey was founded, the general law of the State limited the editions of printed matter to 1,375 copies. The Survey immediately saw the need to acquire agreement for larger printing runs of 3,000 to 8,000 copies. At the recommendation of the Survey, the General Assembly adopted a resolution authorizing the printing of the necessary number of copies.

Every 2 years, Biennial Reports dutifully cited work undertaken, accomplished, and proposed for the future. Superintendent Rice suggested that these reports include proposed future work, so that members of the General Assembly would be "better prepared to reach wise conclusions in regard to the continuation of appropriation for the Survey." The Legislature appropriated funds on a biennial basis.

ERA OF COLLEGE PRESIDENTS AS COMMISSIONERS: 1903-45

During the first 42 years of the Geological and Natural History Survey, scientific research in the geological and biological sciences was undertaken and reports written at a remarkable pace and quality.

Generally, the Survey encouraged work on the geology and biology of the state through the support and/or publication of work conducted by university faculty and graduate students. Where need was determined to exist, selected studies were strongly urged and researchers sought for those projects. Appropriations were applied to projects where the need was judged to be greatest and where there was the likelihood of the greatest success.

Geology

The first geological work undertaken included a manual on the geology of the state. Since the publication of Percival's *Report on the Geology of the State of Connecticut* in 1842, a good deal of geological work was done partly by the U.S. Geological Survey, and partly by those working at universities. The results of these studies were scattered in various publications. Rice (1904) recognizing this wrote,

> In this condition they are almost inaccessible to the great number of teachers in our high schools and other intelligent people in the state, who are not geologists by profession, but who desire to know something of the geological structure and history of the state.

Superintendent Rice and Professor Gregory (second Superintendent of the Connecticut Survey) undertook the responsibility for the *Manual of the Geology of Connecticut* which was published as Bulletin No. 6 in 1906. In additional work, Professors Gregory and Henry Hollister Robinson (also of Yale and third Superintendent of the Survey) prepared the second state geological map, which was in color and at the scale of 1:250,000. An investigation called *The Clays and Clay Industries of Connecticut* by Gerald Francis Loughlin was published in 1905. Joseph Barrell and Loughlin wrote *The Lithology of Connecticut* (1910), and Barrell prepared *Central Connecticut in the Geologic Past* (1915) (fig. 4).

Aside from Rice and Gregory's manual of geology, which rapidly went out of print, one of the most widely read geologic reports was published in 1929--Bulletin No. 47, *The Glacial Geology of Connecticut* by Richard Foster Flint. This comprehensive and popular bulletin includes many landscape photographs plus the first glacial geologic map of the state, which is in color at 1:125,000 scale. Flint, in putting together the report and map, synthesized much information about the glacial geology of the state and developed many of his ideas about glacial processes.

In addition, the Survey's *List of Publications* for this period includes reports on fossil fishes and other Mesozoic life, a physical history of Connecticut's shoreline, the mineralogy of the state, an investigation on the marbles of Connecticut, and various other studies of both regional and local nature.

Natural History

One of the first botanical works undertaken by the Connecticut Survey was an annotated list of the state's

STRUCTURE SECTIONS of CENTRAL CONNECTICUT

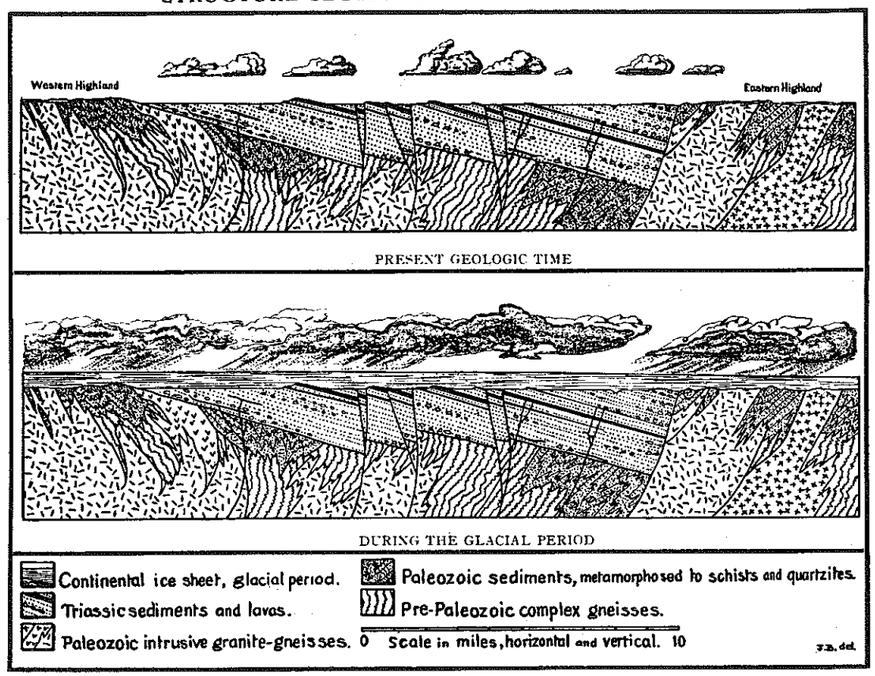

Figure 4.--Structural sections across central Connecticut showing the Mesozoic age Hartford basin (Newark Supergroup). These and other sections appeared in Survey Bulletin No. 23, *Central Connecticut in the Geologic Past* by Joseph Barrell (1915).

vascular flora. The Commissioners believed that having such a list was in the interest of pure science. One of the criteria for the report was to give attention to the economic relation of plants "valued for their beauty or for their useful products, and to those which are troublesome weeds, or which possess poisonous or other injurious properties." Such a work already was begun by the Connecticut Botanical Society, which responded "most cordially" to a suggestion that the Survey act as the vehicle to publish the work (Rice, 1904). Subsequently, this list was published as Bulletin No. 14, *Catologue of the Flowering Plants and Ferns of Connecticut, Growing Without Cultivation* by C.B. Graves, E.H. Eames, C.H. Bissel, L. Andrews, E.B. Harger, and C.A. Weatherby (see fig. 5) in 1910 and added to in 1926 as Bulletin No. 48, *Additions to the Flora of Connecticut.*

Concurrently, reports on certain groups of fungi in Connecticut were undertaken by Professor E. A. White of the Connecticut Agricultural College and G. P. Clinton of the Connecticut Agricultural Experiment Station. Clinton's report on smuts had economic importance, because among them are many plant diseases caused by fungi that destroy agricultural crops.

During this era, botanical reports also were published concerning freshwater algae, bryophytes (mosses and liverworts), and lichens.

In the field of vertebrate zoology, the Survey's first undertaking was a list of Connecticut's birds. "Their migration, their food, and other matters bearing on their economic relations" were of interest to the Survey. John S. Sage, a banker and early member of the American Ornithologists' Union and Dr. L. B. Bishop of New Haven were the investigators, and in 1913, they published *The Birds of Connecticut* as Bulletin No. 20.

Planned in the first Biennial Report was a systematic study of the microscopic life of the fresh waters of the state. The study satisfied all the scientific, educational, and economic aims of the Survey. Considered economically important, the study explored the possibility of contamination of reservoirs by "injurious or disagreeable organisms." The investigation was undertaken by Professor Henry William Conn of Wesleyan and published as Bulletin No. 2, *A Preliminary Report on the Protozoa of the Fresh Waters of Connecticut.* It marked the first scientific investigation published by the Survey.

Other zoological work during this period included initiation of an entire series (9 fascicles) on insects, publication of reports on shrimp- and sowbug-like invertebrates, fish, amphibians, reptiles, and mammals.

Of the zoological work, perhaps the publication *The Birds of Connecticut* by Sage and Bishop is significant enough to be singled out. The information included in this long-awaited document was carefully collected. Sage and Bishop, using a method common for ornithologists of that time, shot the specimens to make a "bird in hand" identification.

In addition, the series of guides to the insects of the state, which has continued to the present, has been particularly responsive to people's needs. For example, after World War I, a study of mosquitoes was done with attention to diseases that might be transmitted by returning soldiers.

The Survey's *List of Publications* grew rapidly, and by 1945, more than 68 bulletins had been published.

Early U.S. Geological Survey Cooperatives

In the 1890's, prior to the founding of the Connecticut Geological and Natural History Survey, the State of Connecticut cooperated with the relatively newly formed USGS to create a 15-minute series of topographic maps of the state. In 1893, the first state topographic map

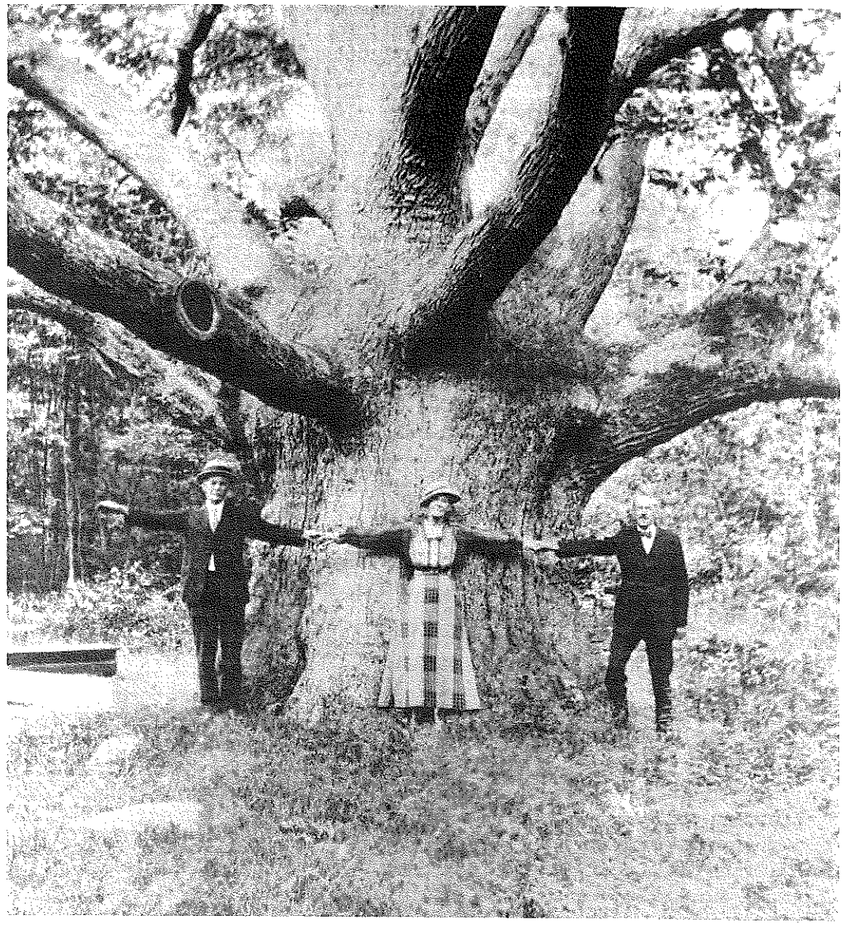

Figure 5.--Charles Burr Graves, Una F. Weatherby, and Charles Alfred Weatherby pose in front of a large oak tree in Ledyard, Connecticut. C. Weatherby and Graves collaborated with others in the publication of Bulletin 14, *Catalogue of the Flowering Plants and Ferns of Connecticut, Growing Without Cultivation* in 1910.

was compiled at a scale of 1:125,000. The popular topographical atlas of the state (a book made from the 1:62,500 scale 15-minute quadrangle sheets) was out of print by 1908, and the State Legislature ruled that the Survey was responsible for supplying bound copies of the atlas. This was an early example of the State Legislature relying on the Survey to provide map information.

The Biennial Report for 1927-28 (Bulletin No. 45) states that the Survey had proposed new topographical surveys for funding by the State Legislature as the obsolescence of the 1890's map series had been recognized for some time. A revised 1:125,000 scale map was needed

for the glacial geology by Flint, who finally had to use the 1893 map. The proposal for new mapping was submitted biennium after biennium without receiving favorable action. New surveys were indeed needed, but it wasn't until the late 1940's that new 7.5-minute topographic mapping at a scale of 1:31,680 (later changed to 1:24,000) began under a USGS cooperative agreement.

During the Survey's early years scientific investigation proceeded in many directions. In 1911, the State Geological and Natural History Survey entered into a cooperative agreement with the USGS to study the water resources of Connecticut under the direction of George Otis Smith, Director of the USGS and William North Rice, Superintendent of the State Survey. Professor Gregory was placed in charge of the USGS effort. The agreement, made and entered on May 31, 1911, is reported to be the first cooperative agreement between the USGS and a state geological survey. The project was successful and produced a number of USGS Water-Supply Papers that focused on ground water and included the occurrence of water in crystalline rocks and the study of coastal ground water.

Some fundamental ideas concerning salt water intrusion came from the coastal ground-water work by John S. Brown of the USGS, who was assisted by Harold T. Stearns, a former student of Rice, and Wilber G. Foye at Wesleyan.

Another type of cooperation occurred in 1911-12 when T. Nelson Dale of the USGS was assisted by Gregory in writing a chapter for a book on granites in Connecticut. Gregory wrote about the geology of the state and Dale focused on the more utilitarian aspects of quarry rock, operations, and products. The report was published as USGS Bulletin No. 484 in 1911. Dale prepared a report on the commercial granites of New England some years later.

This era of the Connecticut Survey experienced two world wars. From 1917-18, the Survey assisted the Council on National Defense through the National Research Council by taking the responsibility of providing reliable information regarding earth materials for road making and fortification construction along the Atlantic seaboard. During World War II, work was directed along three lines: forest study, search for strategic minerals (primarily mica and some beryl), and areal geology and field work in southern Connecticut. General Survey work was hampered by very limited appropriations during the Depression and World War II.

Following World War II, a change was made to switch the appointment of Commissioners of the Survey from college presidents to scientists who were on the faculties of the respective colleges. The Survey's character changed, and its activities evolved to move forward into a new era.

ERA OF SCIENTISTS AS COMMISSIONERS: 1945-71

During this period, the Commission was composed of members selected from the science faculties by their college presidents, together with the Superintendent, and Governor, who served *ex officio*.

Troxell (unpub. ms.), Superintendent of the Survey from 1939-54, wrote that the spirit and attitude of the Survey changed with the transition from college presidents to scientists as Commissioners--a move that inspired and invigorated. One example of the change is that individual members of the Commission frequently visited investigators in the field, not merely to check on progress, but to lend assistance in solving difficult problems.

Troxell lists the personnel of the Survey at that time (circa 1953) as: the Commissioners; the Director (the title Superintendent had been changed to Director--apparently by Troxell's usage);

the professional specialists or researchers; the State Librarian; and an editor, a new position at the time.

Natural History

During the era of scientists as Commissioners, publications in natural history included 5 fascicles (primarily on flies) in the series *Guide to the Insects of Connecticut*; a bulletin on *The Flora of Windham County: A Check List*; bulletins on the fresh water and salt water fishes of the state, and the first publication with color photographic plates--*Connecticut's Venomous Snakes*.

In addition, *Spiders of Connecticut* by Benjamin J. Kastin was published in 1948 (see fig. 6) and a revised edition published in 1981. This 1,020 page monograph is considered one of the most authoritative references on spiders of eastern North America. *The Climate of Connecticut*, (Bulletin No. 99) written by Joseph J. Brumbach and published in 1965, shows the diversity of publications in natural history.

In 1962, William Niering and Commissioner Richard Goodwin of Connecticut College, conducted and published pioneering studies on natural areas which stimulated public interest. Later, in 1965, a new series, *The Vegetation of Connecticut Natural Areas*, published reports by Frank E. Egler and William Niering documenting the results of vegetation studies of selected habitats in the state. This series has been expanded to include a greater diversity of habitats such as trap rock ridges.

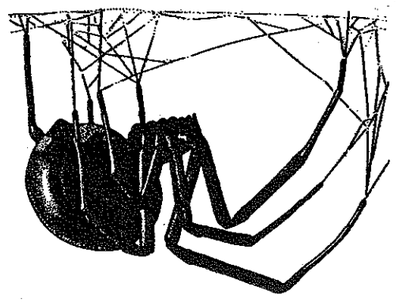

Figure 6.--*Latrodectus mactans* (Fabricius) [black widow spider]. This figure is part of a plate from Benjamin J. Kastin's *Spiders of Connecticut* (Connecticut Geological and Natural History Survey Bulletin No. 70) published in 1948 and revised in 1981.

Geology

Around 1948, it became apparent that a long-range, statewide program for mapping geology was needed. At the urging of Commissioner Goodwin, the Connecticut Survey and the Yale University Department of Geology sponsored a conference in New Haven on May 8, 1948. All who were "apt to have a real interest in the geology of Connecticut were invited to review the geology of the state; to clarify ideas on outstanding problems and discuss how to attack them; and to lay the groundwork for a program which would result in a revised modern bulletin of the geology of the state." This was an important meeting, which provided new direction for geologic mapping in the state. The resolutions developed at the meeting had far-reaching effects in future geological work.

The meeting had 54 registered delegates and passed the following resolutions: that geological mapping of the state on 7.5-minute quadrangles should be conducted; that publishing

these maps and reports was important and the necessary publication funds should be sought; and that southwestern Connecticut should have new topographic maps prepared. Earlier maps of southwestern Connecticut, which were made during World War II by private contractors, were inaccurate and below the high standards of the USGS.

Because of his strong interest in Connecticut geology and in the proposed mapping program, Professor John Rodgers of Yale was regularly invited to attend the meetings of the Survey, although he was not a Commissioner at that time. In the early 1960's, Rodgers was made a Commissioner. Another interested party was Robert Gates of the University of Wisconsin, who, along with his students, began mapping geology in western Connecticut as early as 1948.

Delays, unfortunately, forced a landmark piece of work in sedimentology to be published later than it might have been. *Petrology, Stratigraphy, and Origin of the Triassic Sedimentary Rocks of Connecticut* by Paul D. Krynine was printed by the Survey in 1950, nearly 14 years after the study had been completed as a dissertation for a Ph.D. at Yale. This paper remains a classic in the field of sedimentary petrography, in paleoclimatology, and in redbed studies. The work shows careful assembly of data (often from diverse sources), drawn together in an exciting, forceful style, and directed toward support of his argument on a controversial issue, the origin of redbeds.

At this time, the Connecticut Survey also published posthumously a report by Wilber G. Foye of Wesleyan, *The Geology of Eastern Connecticut*. This, like Krynine's paper, had been delayed. In addition, the catalog of minerals of Connecticut was updated, and Richard Swann Lull of the Yale Peabody Museum revised his classic work, *Triassic Life of the Connecticut Valley* nearly 36 years after its initial publication (Lull cites Krynine's ideas on Mesozoic climate as an impetus for the revision).

The 50th anniversary of the Connecticut Geological and Natural History Survey (1953) occurred during this period. To celebrate, the American Association of State Geologists (AASG) held a special meeting at Trinity College in Hartford. This was also to honor Dr. Troxell, who had been President of the AASG. The meeting was marked by a number of geological field trips throughout the state. Also, a biological symposium was held at Connecticut College in New London in recognition of the anniversary.

Publication formats other than the State Survey Bulletin were developed to allow for more varied types of reports and maps. The new formats included a Report of Investigation series, which covered less comprehensive studies than Bulletins; Guidebooks; a series on the Vegetation of Connecticut Natural Areas; and a Miscellaneous Series.

Shortly after the Connecticut Survey marked its 50th year, systematic geologic mapping on 7.5-minute quadrangles was initiated with the help of the USGS. Robert Gates was the author of the first quadrangle geologic map, which carried forward the thrust of the Yale meeting of 1948. This work, *The Bedrock Geology of the Litchfield Quadrangle* was published in 1951 under the Miscellaneous Series. Five years later, a preliminary state geologic map (1:253,440 scale) and text were prepared by Rodgers, Gates, and others, which helped to focus the statewide quadrangle mapping. Also in 1956, under a cooperative agreement, the USGS began systematic geologic quadrangle mapping.

The Connecticut Geological and Natural History Survey at first published quadrangle maps with reports under the Miscellaneous Series, and later under a new specialized series--the Quadrangle Report (QR). Maps were published by the USGS under the

Geologic Quadrangle Map (GQ) series. For the most part, two maps were prepared for each quadrangle--one delineating the bedrock geology and the other the surficial geology. In some cases, both bedrock and surficial geology are shown on the same map. During this era of scientists as Commissioners, more than 100 7.5-minute geologic quadrangle maps were published and mapping was started on many others.

By 1968, both Rodgers and Flint had state compilations at the scale of 1:125,000 under way. These compilations used a 1:125,000 scale topographic base map. This base map had been prepared by the USGS as a result of efforts by Director Peoples, who successfully gained appropriations for its preparation from the State Legislature. The base map has been used to present a variety of information (e.g. regional geology and ground-water availability) published under the Natural Resources Atlas Series. In 1988, there are ten maps in this series.

In addition to the bedrock and surficial maps, other geological products prepared during this time were aeromagnetic maps (1:24,000; 1:125,000 scales), a gravity map (1:125,000), along with an aeroradioactivity map (1:250,000), and one of the first examples of side-looking airborne radar imagery (1:500,000). Some of these products were developed using advances in geophysical technology developed during World War II.

In 1959, reorganization of State agencies placed the Survey within the newly organized Department of Agriculture and Natural Resources. The administrative structure of the Survey remained essentially the same, but now came under the authority of a new department. A representative from the Department of Agriculture and Natural Resources would frequently attend the Survey Commissioners' meetings.

During the 1960's and 1970's, when geologic quadrangle mapping was particularly active, important changes were taking place in geologic science that would profoundly affect the later quadrangle mapping and especially the state bedrock and surficial map compilations. In bedrock geology, the development of the theory of plate tectonics brought new significance to the structure and stratigraphy of Connecticut, as it lies in the center of the Appalachian orogen. The state bedrock map, published in 1985, used a plate tectonics conceptual model.

In surficial geology, work in New England that was led in part by USGS geologists resulted in a new conceptual model for regional deglaciation. The new model, termed "stagnation zone retreat," differed significantly from Flint's model of "regional stagnation." Flint's compilation work of the state surficial map was halted by his death in 1976. Subsequent work by USGS personnel on a new state surficial compilation is based on the new model of glacial retreat.

During this period of increased activity, Joe Webb Peoples was Director of the Survey (1960-74). He conducted annual summer field conferences in Middletown to allow geologists to meet to discuss common issues and future plans, and to resolve correlation problems (especially at quadrangle boundaries). At the conferences, reports and compilations were presented informally. These events, which were well-established by the mid-1960's, are fondly remembered by those who participated in both the technical conference and the evening comradery that followed at Director Peoples' home overlooking the Connecticut River in Middle Haddam.

In time, the summer conferences were attended by other interested people, including planners, water resource managers, soil scientists and topographic mappers. As a result, participants recognized the need for interdisciplinary cooperation in the earth sciences, and in 1969 with the help of Harold Bannerman, a consultant for the Survey who was retired from the

USGS, the Connecticut Geology-Soils Task Force was developed. Bannerman convened the Geology-Soils Task Force to bring the appropriate branches of science together to address how geoscience information could best be applied in land- and water-use planning. The Task Force included John Baker of the Water Resources Division of the USGS, David Hill of the Connecticut Agricultural Experiment Station, and Hugo Thomas of the University of Connecticut.

A major result of the work of the Task Force was the publication of a report by Hill and Thomas: *Use of Natural Resource Data in Land and Water Planning*. The report discusses how separately mapped resource parameters (e.g. surficial geology; bedrock geology; slope; drainage; soils; depth to ground water, . . . or what they called "single factor maps") could be used to improve land and water use analysis and decision making.

They presented, as an example, plans for a hypothetical solid waste disposal site in a trial map area. The need for the standardization of map scales and map units was clearly identified. Their suggested land- and water-use analysis process began to identify which were the most important pieces of geologic resource information for modern society.

Also during the later part of this era, the State Survey acquired its first full-time geologist. Until that time, work had been conducted for the Survey through part-time employment and volunteer efforts. The appointment came after an unusual set of circumstances which increased the responsibilities of the Survey and necessitated the creation of the position.

In 1966, during excavation for the foundation and basement of a Highway Department testing laboratory on a site in the central lowlands, a bulldozer operator recognized dinosaur tracks in rocks several feet below the natural surface of the ground. Because of the extent and number of tracks, Governor John Dempsey announced that the site would be set aside as a state park. Investigations by scientists from the Peabody Museum (Yale), the Survey, the University of Connecticut, and Willimantic State College (now Eastern Connecticut State University) had established the significance of the area. Dinosaur State Park today is a very popular educational site for natural sciences.

The government agencies responded quickly to a situation requiring rapid decision-making. They delayed and ultimately halted the construction of the Highway Department building and dedicated the area as an educational site. Much of the credit for this was due to the skill and determination of Director Peoples (fig. 7). Sidney Quarrier was completing a master's degree in earth science education at Wesleyan, when he was assigned to work at the Park. As the Survey's first full-time employee, Quarrier helped to initiate a new direction for the agency, and this included entering public education, increasing public awareness of the geology of the state, and maintaining contact with other State departments. The Park was extensively used by schools in the area, and programs were designed as such. By 1970, the Survey hired current Park manager Richard Krueger as geologist. Krueger ran the Park, relieving Quarrier to perform other Survey work. In 1971, the Parks and Forests division of the State took over all Park operations.

The 34th Biennial Report (1969-71) (Bulletin No. 104) outlined a cooperative agreement with the U.S. Geological Survey in which the Connecticut valley is chosen for an interdisciplinary study to develop new ways to present geoscience data to be used by planners, engineers, and the general public. The concept of the project must, with little doubt, have been influenced by the

Figure 7.--Joe Webb Peoples, Professor of Geology at Wesleyan University and seventh Director of the Connecticut Geological and Natural History Survey, shows colleagues the extent of the dinosaur footprint track-way near the town of Rocky Hill at the site that is now Dinosaur State Park. Tracks of the dinosaur *Eubrontes* appear in the foreground. (From left to right: Joe Webb Peoples, Lawrence Frankel of the University of Connecticut, Elwyn Simons of the Peabody Museum of Yale University, and Hugo F. Thomas of the University of Connecticut and current State Geologist.) (Photo by John Howard.)

summer conferences and the Geology-Soils Task Force. This project, directed by Frederick Pessl of the USGS, came under the heading of the Connecticut Valley Urban Area Project (CVUAP). Members of the Geology-Soils Task Force and CVUAP worked closely as a cooperative spirit existed between the various groups of geologists and hydrologists.

The project began developing and producing applied geologic quadrangle scale products for a one hundred quadrangle area of Connecticut and Massachusetts. Among the innovative products created by this project were individual maps at the scale of 1:125,000, showing textures of unconsolidated materials, thickness of fine-grained deposits, slopes, and ground-

water availability. A surficial materials map (a derivative from the glacial geological map), a depth to bedrock map and a standardized quadrangle drainage area map were produced for many 7.5-minute quadrangles in the project area.

Economic Geology

As shown over the Connecticut Survey's 85-year existence, economics played an important role in many aspects of the scientific investigations. Loughlin reported on clays and clay industries in Bulletin No. 4 in 1905, a work still prized by one of the two remaining clay-mining operations in the state. Also, Gregory and Nelson reported on *The Granites of Connecticut*, while Fred Holmsley Moore, a graduate student at Yale, investigated *Marbles and Limestones of Connecticut*, which was published as Bulletin No. 56 in 1935.

Although Connecticut is not thought of as a mining state, it ranked number eight in the country in 1986 for dollar value of nonfuel mineral production per square mile. The State Survey has given attention to economic geology in quadrangle reports and GQs, which typically discuss or note mines or quarries of both historic and current interest, especially on surficial maps.

In some cases, papers on Connecticut economic geology published elsewhere have been outgrowths of work conducted for the Survey. For example, Crawford Fritts reported on the barite deposits that occur near the town of Cheshire within the Mount Carmel quadrangle, which he had mapped as part of the quadrangle mapping project.

As part of a strategic minerals investigation of the nation during World War II, State and Federal surveys investigated the occurrence of mica and beryl within some of the granitic pegmatites in Connecticut, particularly within the Middletown Pegmatite District. Connecticut investigations are reported in USGS Professional Paper No. 255.

Today, the Connecticut Survey under the Natural Resources Center regularly cooperates with the U.S. Bureau of Mines (USBM) to prepare *The Mineral Industry of Connecticut*, which is published in the USBM Minerals Yearbook. Recently, as part of its Atlas Series, the Natural Resources Center published a map, *Bedrock Mines and Quarries of Connecticut*, which locates and identifies the more than 600 historic and active mines and quarries. The Center also keeps records of active operations and regularly responds to inquiries concerning the mining industry in the state.

The era of the scientists as Commissioners is brought to a close by another change for the State Survey. As part of a State agency reorganization, the Survey joined the newly formed Department of Environmental Protection (DEP).

DEP AND THE NATURAL RESOURCES CENTER YEARS: 1971-PRESENT

During the 1960's, as a result of concern about the environment, a number of state governments reorganized their offices to more efficiently manage land, water, and air resources. Many states created departments of environmental conservation and environmental protection and the federal government formed the Environmental Protection Agency. The State Legislature passed the Act creating Connecticut's Department of Environmental Protection in 1971, and in 1972, the new department began setting up shop.

DEP absorbed about 15 different boards and commissions. The State Geological and Natural History Survey, which had been part of the former Department of Agriculture and Natural Resources, was included in the new DEP. Survey Director Peoples became an employee of the DEP, and the other

Commissioners of the Survey were asked to serve in an advisory capacity.

DEP's first Commissioner, Daniel Lufkin, was responsible for developing the new department and coordinating the many separate elements from which his agency was formed. He was particularly interested in the Geological and Natural History Survey's record of collecting and publishing natural science information. He and his staff recognized that geology, hydrology, and biology had a vital role in environmental management.

The State Survey had been involved in two projects that were significant at this point, the Connecticut Geology-Soils Task Force and the Connecticut Valley Urban Area Project (CVUAP). Both projects used resource information. The CVUAP developed new, more usable formats for geological and hydrological information, and the Geology-Soils Task Force developed the methodology to use resource information for environmental decision-making. The Task Force publication, *Use of Natural Resource Data in Land and Water Planning*, had provided new direction for methods of environmental management (fig. 8).

Commissioner Lufkin saw the value of, and need for, such resource information in his new Department. He arranged to have Hugo Thomas, a member of the Geology-Soils Task Force, develop a central office within DEP to coordinate collection, interpretation and publication of natural resources information. This central office, called the Natural Resources Center, started with a staff of several geologists and hydrologists.

The Natural Resources Center began to function as a repository and clearing house for information on earth sciences and biology. Early on, the Center's staff became involved in the DEP's environmental management activities, providing technical advice to the DEP and to local town governments.

The Survey provided much of the basic information for the thrust of the Natural Resources Center. Work in DEP soon became a focus of the Survey's activities. In 1974, the State Geological and Natural History Survey and the Natural Resources Center were officially merged. The State Survey office at Wesleyan was moved to the DEP offices in Hartford and Survey staff was transferred to the Natural Resources Center. The State Geological and Natural History Survey became the technical resources investigation arm of the Center. At this time, Dr. Peoples retired and Dr. Thomas, Director of the Center, became the State Geologist.

As the Natural Resources Center began to function, several goals were developed, and these included managing comprehensive basic data collection programs in earth sciences and biology; establishing a working reference library serving users of resource maps and information; developing methods of applying resource information to land- and water-use planning and environmental management decisions; and providing technical assistance to DEP and local governments in the use of resources information in their planning and decision-making.

The Natural Resources Center expanded its programs and staff to more uniformly address topics in geology, hydrology, and biology as well as to develop applied methodologies for use of resource data for planning and management. A major effort was made to centralize the management of USGS cooperative programs for topographic mapping, water resources, and geology. In the related area of soils mapping, the Legislature approved a 6-year appropriation for DEP to support completion of detailed soils mapping of the state by the U.S. Department of Agriculture, Soil Conservation Service. Among other things, this provided maps for the DEP's inland wetlands program. In biology, a program was initiated to

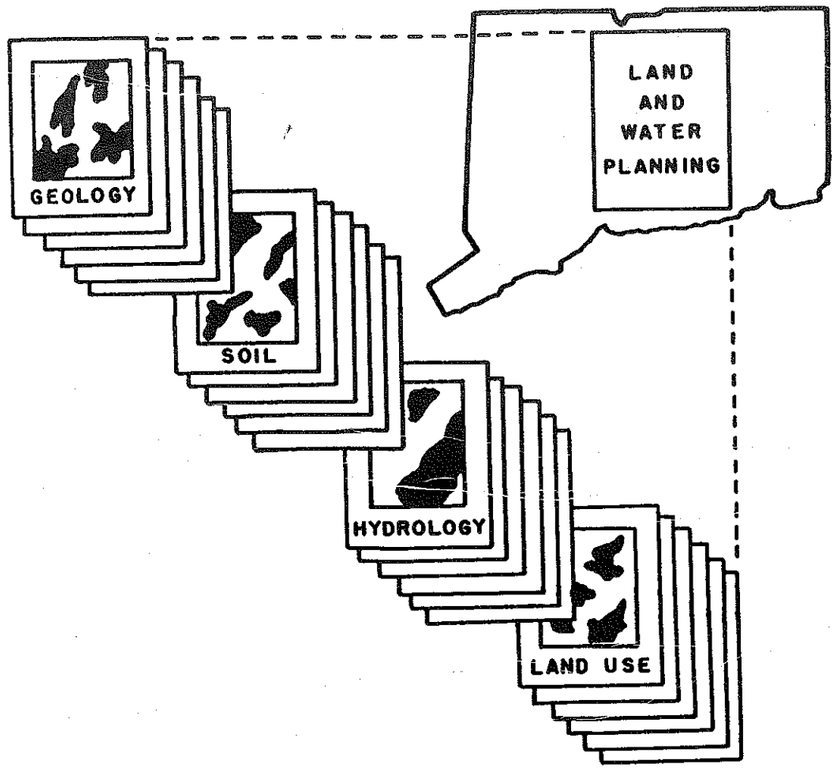

Figure 8.--Separately mapped resource parameters or "single factor maps" for land- and water-use analysis became a theme for the Natural Resources Center. Figure is from *Use of Natural Resources Data in Land and Water Planning* by Hill and Thomas, which was published in 1972 as Connecticut Agricultural Experiment Station Bulletin 733.

collect information on rare and endangered species. The state low-altitude air photo flights were conducted by the Center on a regular 5-year basis. An important step was to standardize map scales at 1:24,000, 1:50,000 and 1:125,000 for all types of mapped resource information.

Eventually, the Center added a sales office. This function formerly was carried out at the State Library. At this new sales office, anyone could buy maps and publications and get information and technical assistance about the meaning and use of the resource information.

The Center began to provide technical assistance to regulatory and management units of DEP on topics such as water resources, waste disposal, ecological habitats, and earth materials. These units of DEP became increasingly aware of their need for trained technical staff. They rapidly began to hire technical staff, some of whom were initially trainees at the Center. DEP units began to use more natural resources information, and the demand for additional coverage and new

information mounted, driving forward the Center's data collection program. The Natural Resources Center quickly brought the value of resource information, concepts, and resource staff out of the academic institutions and into the forefront of the decision-making process of a state government department.

Through the late 1970's, environmental management in Connecticut passed from merely using resource information, to basing long-term environmental management on "resource system concepts." For example, DEP's water management programs changed from the previous method of simply using hydrologic information as one technical element of water management, to newly designed programs managing ground and surface water of each drainage basin. This more comprehensive and integrated approach to resource management was based on sound hydrologic principles and on understanding of the water resource system for each basin.

Interaction between the Center's staff and scientists and planners continued at the federal, state, and local levels. The emphasis was on interdisciplinary involvement. This was the theme of the Geology-Soils Task Force and CVUAP. The Natural Resources Center played a leadership role in coordinating the collection, dissemination, and use of the resource information.

The period since 1974, when the Geological and Natural History Survey was combined with the Natural Resources Center, has been especially productive. Programs of longstanding interest to the Survey have been pursued, and a number of new programs have been initiated. The following selection gives highlights for this period and gives an overview of the Survey's current program.

Earth Sciences

Statewide low-altitude aerial photo surveys are conducted on a regular 5-year schedule, and an air photo lending library that contains all 5-year flights has been established.

The Natural Resources Center manages a USGS cooperative to produce revised 7.5-minute topographic quadrangle maps and to routinely update regional and state base maps. Recently acquired digital 1:24,000 scale quadrangle data will be used for a statewide geographic information system (GIS).

The Center also has been cooperating with the U.S. Department of Agriculture's Soil Conservation Service to complete detailed statewide soil mapping. A project has been initiated to rectify and digitize detailed soils maps for inclusion in the DEP's geographic information system (GIS).

In the field of geology, several projects continued during this period including management of the cooperative geologic mapping program with the USGS. This included the quadrangle mapping that started in the 1950's and completion of the compilations of the state bedrock and surficial maps. The state bedrock compilation by John Rodgers (fig. 9) was published in 1985 at a scale of 1:125,000. Both Rodgers' map and *The Face of Connecticut: People, Geology, and the Land*, a general introduction to the geology of the state by Michael Bell, were prepared for the 77th annual meeting (1985) of the American Association of State Geologists in Mystic, Connecticut. Compilation for the state bedrock and surficial maps has produced a complete set of 7.5-minute bedrock and surficial quadrangle sheets with consistent map units. This quadrangle scale geologic information is being entered in the GIS. In addition, a 10-year program to study the marine geology of Long Island Sound is under way.

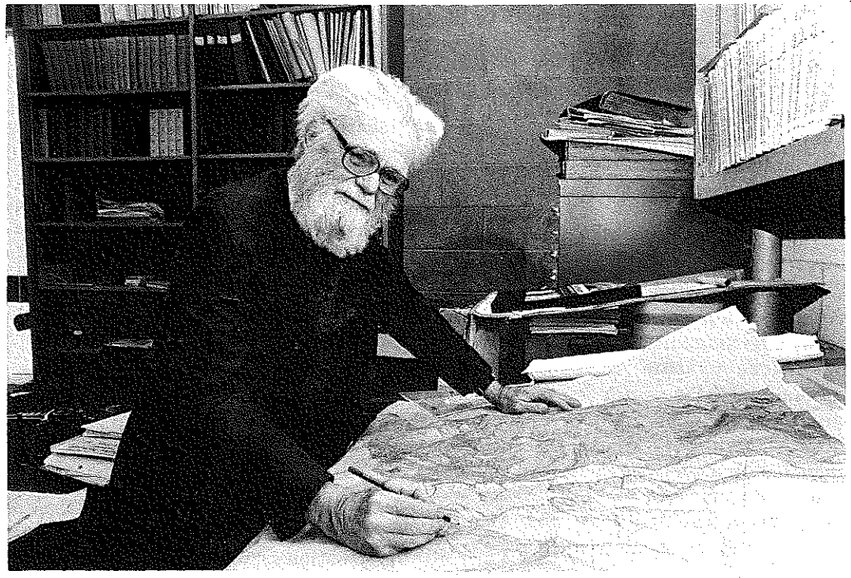

Figure 9.--John Rodgers, Professor of Geology at Yale University and former Commissioner of the Survey, working on a draft of the state bedrock geological map of Connecticut. The published map was first presented to the geological community at the annual meeting of the American Association of State Geologists in 1985 at Mystic, Connecticut. (Photo by T. Charles Erikson.)

In the field of hydrology, a cooperative water resources investigation program with the USGS Water Resources Division continues. As a result, inventories of the state's surface and ground-water inventories have been completed. The Center continues to operate an integrated ground- and surface-water quality monitoring network. A statewide map showing stratified drift aquifers, compiled by Daniel Meade, was published in 1978. In addition, detailed mapping of drainage basins has been completed delineating basins with drainage areas greater than one square mile. This information has been published on a state map, and entered in the GIS. The data has allowed DEP to develop a statewide water quality classification and management system.

Biology

A major part of the biology program is the Natural Diversity Data Base, a computer inventory of the occurrence and distribution of critical biological resources, including both species and habitats. The Data Base is used to guide biological protection programs and to evaluate potential negative impacts to biota during land-use change or development. Systematic mapping of critical habitat information is being prepared for the GIS. Bulletin No. 70, *Spiders of Connecticut* has been revised and reprinted.

Geographic Information System (GIS)

A statewide computer mapping system for natural resources and related data is being completed. The interactive system will permit spatial analysis of resource data bases. Data sets being compiled at 1:24,000 include: USGS quadrangle bases, surficial and bedrock geology, drainage basins, public water supply sources and distribution systems, waste water discharges and water pollution sources, soils, land use and land cover, zoning, open space lands and selected biological information. The DEP uses the GIS for environmental planning and management.

Publications and Outreach

All in-print maps and other publications can be bought at the Center's sales office. This office serves as a resources center where the Center's staff is available to assist people in understanding and using the information. Regular educational workshops are run for local town officials to train them to use the information.

GEOLOGICAL AND NATURAL HISTORY SURVEY AND NATURAL RESOURCES CENTER

85 Years of Natural Science Service to the State of Connecticut

The Natural Resources Center serves as a central office for collecting and distributing information about the state's physical and biological resources. The Center also develops methods of using resource information for environmental management. These activities compare favorably with the three goals set out for the State Geological and Natural History Survey in the first Biennial Report (1904)--to advance knowledge for pure science; to serve economic needs, and to educate.

The data collection movement of Percival and Shepard (1835-42) has grown into something larger and more directly functional to the State than perhaps could have been imagined by the Survey founders. The State Geological and Natural History Survey of 1903 to 1974 became part of a natural resources center for an environmental protection department.

In 1903, there was only one regular employee of the Survey--Superintendent Rice--who worked only part-time along with the voluntary Commissioners. Eighty-five years later, in 1988, the Natural Resources Center employs about 30 people in all fields of natural resources investigations and applications.

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