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Inland Wetlands

Curriculum Unit 85.07.09
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ABSTRACT

A classification system based on vegetative cover for inland wetlands is explained. Calcium oxalate crystals in a wetland plant, *Nymphaea odorata,* the fragrant waterlily, are investigated. The importance of inland wetlands and laws pertaining to them are explored. A curricula unit designed as a biological profile of an inland wetland using vegetative cover as a classification system is provided in this unit and a biological profile of a local inland wetland, Cedar Swamp, can be found on file at the Teacher's Institute along with an accompanying slide show.

INTRODUCTION

Freshwater inland wetlands are areas of great ecological importance and play a vital role in: hydrological stability and the control of flooding, surface and ground water supply, the recharge and purification of ground water, and in providing a habitat for many forms of animal and plant life.

Through my job as an environmental educator, I have become increasingly interested in inland wetlands, but know little about them. I developed this unit to educate myself so that I could add inland wetland field trips to my already existing ones on coastal and Long Island Sound ecology and also to give other teachers background information so that they can: 1) lead their students in identifying inland wetlands; 2) discuss an inland wetland plant of particular interest, the waterlily, and discuss the formation of calcium oxalate crystals in its leaves; and 3) impress upon students the vital importance of inland wetlands and how they can, as citizens, contact a regulatory agency should a wetland area be threatened. This unit is best used as part of an ecology section in a senior high school biology class.

BACKGROUND

Useful background information for teachers using this unit on the geological formation of Connecticut, topography of Connecticut and the formation of wetlands can be found in the Teacher's Institute Guide developed in 1984, *Geology and Industrial History of Connecticut.* A unit found in that Guide, *Know Your Watershed,* will be of particular interest to those teachers that will use this unit. The following is the abstract from that unit:

> The objective of this unit is to teach students the importance of knowing the watershed in which they live. The unit is divided into four parts; watershed, hydrologic cycle, surface water and ground water. The strategy for each section is to provide teachers with background information and then to suggest in-the-classroom, in-the-playground, and in-the-field curricula units to enhance classroom lectures. [1]

There are two main categories of wetlands, saltwater coastal wetlands and freshwater inland wetlands. The focus of this unit is inland wetlands. A saltwater coastal wetland, the salt marsh, is shown in Figure 1 merely for comparison.

Bogs, marshes, and swamps have been known for centuries, but only recently, due to the recognition of their importance, have there been attempts to group them under one term, "wetlands." There is still much confusion concerning the definition of various types of wetlands due to their diversity and because demarcation between wet and relatively dry environments lies on a continuum. Interesting further complications arise depending whether one is dealing with a local, state or federal classification system.

Over fifty percent of our Connecticut wetlands have been destroyed by filling and other construction activities. Although they are now protected by law, it is important for citizens to be able to identify a wetland area should it be threatened by a proposed construction site so that they can contact the proper authorities. If the area in question is a lake or pond, this determination is rather easy. However, if the area is a marsh during the dry month of August, which may not show visible signs of water, how can you determine whether you are in a wetland? It seems important to me that a classification system should allow a lay person to identify wetlands so that it can be determined whether a wetland is involved in a particular project and to tell what statutes apply, where to get information on each regulatory program, and under what conditions permits can and can not be issued. Some classification systems make this determination easier than others.

In Connecticut, the following is the State Department of Environmental Protection's definition of inland wetlands: "Freshwater wetlands are areas such as banks, bogs, swamps, meadows and submerged land. Soil types designated as poorly drained, very poorly drained alluvial and flood plain by the National Cooperative Soils Survey define inland (freshwater) for regulatory purposes." [2]

The soil categories are as follows:

> *Poorly drained soils* occur on land areas where the water table either interrupts or lies near the surface from late fall to early spring. This land is nearly level or gently sloping.
>
> *Very poorly drained soils* occur in either level or depressed land areas. The water table lies at or above the surface at almost all times during the year.
>
> *Alluvial and flood plain soils* occur along stream belts occupying nearly all level areas subject to stream flooding.

Alluvium (water-transported sediments) is the inorganic component of these soils. Some of these soils may be well drained.

Tidal Wetlands (or marshes) consist of very poorly drained *organic* soils which are subject to regular tidal inundation. They are typically found in protected areas along the shore and estuaries of Long Island Sound. [3]

The main reason for using soils as a determining diagnostic factor, and not plants, is that all of Connecticut's soils had been mapped by 1980. Soil maps can be obtained from the Hartford DEP office listed in the Teacher's Resource list. However, using this system often requires that a soil scientist make wetland determinations since it is difficult to identify soil types. In response to this problem, the EPA decided that a more workable classification system should point to a vegetative cover as a means of identification of a wetland and its boundaries, since plants are an easier, more visible marker and since there are many picture guides to identify plants available. EPA and The Peterson Field Guide series which use pictures to aid in plant identification are listed in the Teacher and Student Bibliography.

IDENTIFICATION OF INLAND WETLANDS BY VEGETATIVE COVER

The EPA describes a wetland as "an area where naturally occurring water is at or near the surface for a significant portion of the growing season, and that, under normal conditions, supports a prevalence of vegetation typically adapted for growth in saturated soil conditions." [4] The EPA Guide, *New England Wetlands,* is an excellent guide to inland wetlands and provides identifying characteristics of the more important commonly found wetland plant species. It is the plant grouping that is the true indication of the characteristic soil conditions.

The two types of inland wetlands are bogs and marshes. After the last glacier receded some 15,000 years ago, inland wetlands formed. Marshes, typified by an absence of trees and shrubs, developed in low-lying areas which had a high water table. Bogs were formed when the retreating glacier left blocks of ice surrounded by glacial debris. As the ice melted, it left depressions called kettle-holes in the land. These depressions were later filled with meltwaters. The bog formed as sphagnum plants grew, floating upon the surface. As the floating mat became more dense, a greater variety of plants were supported and islands formed.

Figure 2 depicts a cross-section of a typical freshwater marsh. Plants in the marsh can be grouped into three categories based on degree of tolerance of wet conditions. Species which are termed tolerant are species of trees, shrubs and herbs which can grow under saturated conditions for a limited time during their growth season but do not require saturated soils for normal growth. These species can equally be found in upland dry conditions. An example of a tolerant tree in the freshwater marsh is the red maple; a tolerant woody shrub is the laurel; and a tolerant herbaceous plant is purple loosestrife. Table 1 shows tolerant, phreatophytic and hydrophilic trees, shrubs and herbaceous plants of the Connecticut area.

TABLE 1 FRESH WATER INLAND PLANTS

(figure available in print form)

A phreatophyte is defined by Webster's Dictionary as "a deep-rooted plant that obtains its water from the water table or the layer of soil just above it." [5] An example of a phreatophyte freshwater marsh tree is the Atlantic white cedar; a phreatophytic woody shrub is the alder; and a phreatophytic herbaceous plant is the cattail.

A hydrophyte is defined by Webster's Dictionary as "a vascular plant growing wholly or partially in water, requiring an abundance of water, growing in places too waterlogged for most other plants." [6] Hydrophilic species include burden grasses, emergents, floating-leaf plants and submerged plants. All of these plants are herbaceous, meaning they are a nonwoody plant. Examples of hydrophilic freshwater marsh species are rushes, pickerel weed, and waterlilies. [7]

Figure 3 depicts a cross-section of a bog. The same three categories of plants, based on their degree of tolerance of wet conditions, are also found in the freshwater bog. An example of a tolerant tree is the hemlock; a tolerant woody shrub is the highbush blueberry; and a tolerant herbaceous plant is the purple loosestrife. Phreatophytic trees are the tamarack and black spruce; phreatophytic woody shrubs are buttonbush and sweet pepperbush; and phreatophytic herbaceous plants are pitcher plants and sundews. Hydrophilic freshwater bog plants are spatterdock and bladderwort.

If the area in question exhibits some of the characteristics shown in Figures 2 or 3, the flora should be examined to determine whether there is a predominance of wetland species.

The Curriculum Unit, *Inland Wetland Area Exploration* , provides guidelines and a survey form for teachers to use when taking their students on a field trip. Parameters included on the survey form are flora, fauna, water chemistry, physical characteristics of the wetland area, and land use. Background on water chemistry, physical characteristics of the wetland area and land use can be found in the unit, *Know Your Watershed,* 1984, Teacher's Institute. A good reference book to identify fauna is *A Guide to the Study of Fresh Water Biology* and the Peterson Field Guide Series in the Teacher and Student Bibliography *.*

After it has been determined that a wetland is involved, the individual can then notify the regulatory agency. The section of this paper, *Importance of Inland Wetlands and Connecticut Wetland Laws* describes how and who to contact should you suspect an inland wetland is being threatened. [8]

A PLANT OF THE HYDROPHILIC ZONE IN THE BOG OR MARSH, Nymphaea odorata OF THE Nymphaeaceae FAMILY, THE FRAGRANT WATERLILY

An inland wetland plant of particular beauty is the waterlily. Its distribution is worldwide and it occurs in colors ranging from white to blue, yellow and red. We enjoy waterlilies for their beauty and they also have become one of the plant indicators for inland wetlands. Biologists are particularly interested in the waterlilies because they form large crystals in their leaves. The following is a discussion of the waterlily, its adaptations to its aquatic environment and of the crystal structures that form in its leaves.

Man has used the seeds and tuberous roots of waterlilies as food for centuries. We find mention of them as far back as Egyptian times where, besides being an important food, they were used in social and religious instances. The waterlily, or lotus, was placed upon the bodies of the dead. It was also the emblem of the Nile god, being an evident product of the river. An historian tells us, "When the Egyptians approached the place of divine worship, they held the flower of the lotus in their hand, indicating that that man had proceeded from a well-watered or marshy land, and that he required a moist rather than a dry ailment." [9]

Waterlilies are found in the shallows of slow streams and still waters all around the world. They, like their fellow freshwater seed plants, are derived from terrestrial ancestors. They have become modified in various ways to their new habitat—development of buoyant stems or floaters, adaptations in the shape of the leaves, and in some, underwater pollination. [10]

Although some have rhizomes, a mass of roots, the greater number have a tuberous stem from which many fibrous roots pass downward and anchor the plant in place. The stems of the waterlily branch infrequently; however, they have bunches of tubers growing from the sides. The tubers can float and are easily detached from the plant. Thus the tubers serve to distribute the plant widely. Figure 4 shows the tuber of a waterlily.

Few genera of flowering plants show such variety in size and color as the waterlilies. Shades of white, yellow, red and even royal blue do occur. The opening of the flower occurs at a particular time of day for each species. The process of opening and closing takes nearly an hour. Most open during the day, but some open at night. The flowers are pollinated by insects and on the last day of opening, the fertile flower sinks into the water and disintegrates. The fruit, technically a berry, forms underwater near the bottom.

The waterlily leaf, or lily-pad, is familiar to many of us. The leaves of waterlilies can be submerged. floating or aerial. Aerial leaves are rare, but do occur in conditions of overcrowding.

The submerged leaves are narrower in shape, more like a deltoid, than are the floating leaves. It is surmised from the richness of their chlorophyll that they play a major role in photosynthesis. Figure 5 illustrates a typical waterlily and the slide show that accompanies the unit also shows the waterlily's anatomy, especially of the leaves, along with pictures of the plant community of Cedar Swamp.

The stalks of the leaves, or petioles, may range in length from a few centimeters to six meters, depending on the depth of the water. They grow to a length that allows the leaf some freedom in floating. The floating leaves are especially adapted so that the stomata, openings through which gases pass, occur only on the top of the leaf. In nonhydrophytes, the stomatas occur on both sides. This is of course a necessary modification, since only the top of the leaf has contact with the atmosphere.

The floating leaves are very round in shape, thus maximizing their potential for surface area and thus their photosynthetic potential. The leaves also provide the outlet for transpiration (the loss of water vapor). [11]

Cellular Biology and Calcium Oxalate Crystal Formation

In special cells of the waterlily, a phenomenon occurs that has fascinated scientists for ages, the formation of crystals. The deposition of inorganic material in living plants and animals is a common occurrence.

It culminates in the beautiful home of the corals, spiral shells of snails, and the complex bones of vertebrates, including humankind. And we find deposits of calcium oxalate (CaC2O4) in the stems, roots and leaves of many plants. The mode of deposition of these crystals in the waterlily is not known. However, much speculation exists as to why these crystals are formed, and how. The following will be a discussion of this speculation.

There are two components that are of importance to our discussion; one is oxalic acid, and the other calcium.

Oxalic acid is an interesting organic compound, since except for carbon dioxide, it has the highest proportion of oxygen to carbon and thus is a frequent end-product of oxidation (an important reaction of energy transfer in all living things). So it is not surprising that we find oxalic acid extensively in nature, sometimes as the free acid, but more commonly as the potassium or calcium salt. It is believed by many that oxalic acid is a useless end-product of metabolism. This view is supported by the fact that many plants cannot utilize the acid, or its salt. Those who believe this theory regard oxalic acid to be toxic, and feel that it is rendered harmless by precipitating it as the calcium salt. However, some believe that oxalic acid is produced to rid the plant of excess calcium ions. The fact that some plants, such as begonias, can store large amounts of oxalic acid without any harmful effects, and that several reports show that oxalate formation is related to the supply of calcium, support this view. [12]

Calcium is essential to the growth of all plants and most plants must take in substantial amounts for normal growth. Figure 6 shows the calcium cycle in plants. Calcium is taken up in the soil by the roots. The movements of calcium through the plant is believed to be through the transpiration stream. Calcium is lost from pithy tissues through decay, abscission (the dropping off of plant parts), gustation (the exudation of liquid from leaves) and leaching (the downward movement and drainage of minerals through the soil by percolating water). [13]

The principal forms of calcium oxalate occurring in nature are the monohydrate whewellite (CaC2O4.H2O) and the dihydrate, weddelite [CaC2O4.(2 + x) H2O, where 0.5]. Whewellite is more stable, and is the most common form [14]

Calcium oxalate crystals are bound generally intracellularly, often in cells called idioblasts, a`specialized cell entirely different from its neighbors. The crystals may occur as single and massive (styloids); as large single prisms or pyramids (prismatic); as needles shaped in packets of as many as 2,000 crystals per cell (raphides), multiple star-shaped (druse), or in fine crystals (crystal sand).

The crystals are produced and contained within a vacuole, a membrane bound structure that is found within the cell's cytoplasm, a watery fluid in which the organelles of the cell float. Crystals are formed in crystal chambers formed by membranes. The crystal vacuole is surrounded by a membrane called the tonoplast.

The mechanism that brings the calcium and oxylate together is unknown. It has been suggested that a calcium pump may be present and that it transports calcium from the cytoplasm to the chamber which is already loaded with oxalate. [15]

The genus Nymphaea is somewhat different from other plants observed. The crystals are associated with the cell wall; the mode of the crystal formation is still unknown. Figure 7 shows a cell with crystals. This is a scleroid cell (a cell which is part of the plant's structural support system, which is variable in form and often branched). It is somewhat difficult to illustrate, but under polarized light, the crystals in these cells reflect the light, seen in Figure 7 as the light areas.

Figure 8 illustrates an electron micrograph showing a transverse section through an arm of the crystaliferous scleroid of the waterlily. This cell has a secondary cell wall, the innermost layer of the cell wall (labeled SW) formed in certain cells after cell elongation has ceased. Three calcium oxalate crystals are embedded in the secondary cell wall. A primary cell wall (PW), the wall deposited during the period of cell growth, separates the exterior of the cell from an intracellular airspace (IS) and a small area of cytoplasm (CY) can be seen towards the bottom of the picture. [16]

The Role of Calcium Oxalate Crystals In Plants

Other species of plants have calcium oxalate crystals; the reason for crystal formation varies with the species and with the environmental conditions. [17] In some plants, such as the Jack-in-the-Pulpit, the crystals may be formed to discourage predation from insects, snails, and other animals. One bite of the stalk will prove it to you by the burning sensation caused by its raphides. [18]

The lupin plant shows us another possible reason for the role of calcium oxalate production in plants. In most species, once the crystals are formed they remain unchanged. In this plant, however, when the seeds germinated, the crystals dissolved, then disappeared. [19] Hence, the crystals may provide a valuable source of calcium and oxalic acid.

And, supported by many, is the theory that calcium oxalate is a useless and possibly adventitious product of metabolism. [20]

Not much has been written on its possible structural or skeletal significance. It is interesting to note that in the case of Nymphaea, the crystals are associated with the cell wall of a structural cell of the leaves. The particular conditions of life have impressed themselves strongly upon the forms and functions of the waterlilies, as previously discussed. Once spread out upon the water surface, the leaves are subjected to the stress of currents in air and water. Perhaps the presence of these crystals may have something to do with the plant's particular adaptations—an interesting question for further investigation.

IMPORTANCE OF INLAND WETLANDS AND CONNECTICUT PROTECTION LAWS

Historically, wetlands have been considered to be wastelands of little value to society and have been subject to filling, dumping and draining with little thought given to the consequences. Only recently has the role of wetlands in maintaining and improving water quality been more fully understood.

Inland wetlands make up some twenty-five percent of Connecticut's acreage and play an essential role in holding surface and underground waters.

Wetlands also provide habitat for wildlife. To some animals it is their sole habitat. To others, it is their breeding refuge, or feeding ground.

Wetlands act as a storage basin for large amounts of water and can detain dangerous flood waters. Also, they can trap sediments and so help stop erosion.

And finally, wetlands act as a natural filter for many pollutants and can trap them from runoff prior to discharge to a waterway.

In 1972, due to the increased public awareness of the vital role that wetlands play, the Connecticut Inland Wetlands and Water Courses Act was formed. This act defines wetlands and also makes guidelines for the DEP to help local agencies regulate the activities which:

1. Remove material from
2. Deposit material in
3. Construct
4. Obstruct
5. Alter or . . .
6 Pollute . . . inland wetlands or watercourses. [21]

In Connecticut, the state has delegated regulatory authority to 143 towns. Usually a town establishes an inland wetland agency. Towns that do not have their own wetlands agency are regulated by the State Inland Wetlands Unit. New Haven does not have its own agency so information can be obtained from: Inland Wetlands Unit, Department of Environmental Protection, State Office Building, Hartford, CT 06115, 566-7280. If you are not in New Haven, you can call 566-7280 to see if your town has its own agency. For questions on soil categories in the New Haven area, contact: Agricultural Center, Wallingford 06492, 269-7509. [22]

In conclusion, inland wetlands are areas of importance and beauty. It is essential that individuals understand the vital role their wetlands play, be able to identify a wetland area should it be in potential danger of destruction, and know how and who to contact. These areas contain many species of plants and animals that require the type of saturated situation that only a wetland can afford. The waterlily, one such plant, is of considerable interest due to the crystals that form in its leaves. The preservation of these areas insures that for generations to come, wildlife can breed, naturalists can explore, and scientists can investigate questions of interest in our nation’s wetlands.

INLAND WETLAND AREA EXPLORATION

OBJECTIVES

To identify an inland wetland by its vegetative community. to note fauna.

land use patterns, and test for water quality.

MATERIALS

-Personal equipment, including boots or waders

-Fish and plankton nets
-White-bottomed pans (refrigerator trays, bleach bottle bottoms)
-Hand lenses. collection jars or plastic bags
-Field guides as noted in attached Teacher/Student Bibliography
-LaMotte or Hach chemistry kits for oxygen, carbon dioxide, pH, and a thermometer
-Surficial geology map of area (see Teacher's Resource section), compass

WETLAND SURVEY FORM

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1. Date __________ River system __________
    State __________
    Name of bog or marsh __________

Notes: sketches (show stations, plant types, tributary streams, outlet, roads and trails)

2. FLORA AND FAUNA
    A. *Flora* : Note species, size, color, abundance, growth, habits, etc.
        1. Hydrophilic
        2. Phreatophytic
        3. Tolerant
    B. Fauna: Note species, size, abundance, feeding habits, stages or ages found, special adaptations or activities
        1. Invertebrates and vertebrates
            Free-swimming
            Walking on surface or swimming on surface
            Sessile on vegetation
            Sessile on stones, logs, rocks, bottoms
            Flying
            Burrowers
            Tube dwellers

3. WATER CHEMISTRY AND WEATHER CONDITIONS

oxygen __________	air temperature __________
carbon dioxide __________	cloud cover __________
pH __________	time __________
temperature __________	precipitation __________

other __________ wind velocity __________

4. PHYSICAL CHARACTERISTICS OF THE WETLAND AREA

widths

depths

area

Note: See Needham, *A Guide to the Study of Freshwater Biology*

bottom type: mud, silt, sand, clay, peat, marl, detritus, gravel, bedrock character of watershed: mountainous, hilly, flat, swampy, wooded, open, cultivated, uncultivated, etc.

Land use noted

(figure available in print form)

FIGURE 1. *SALT MARSH*

(figure available in print form)

FIGURE 2. *FRESH WATER MARSH*

(figure available in print form)

FIGURE 3. *FRESH WATER BOG*

(figure available in print form)

FIGURE 4. *TUBER*

(figure available in print form)

FIGURE 5. *TYPICAL WATERLILY*

(figure available in print form)

FIGURE 6. *CALCIUM CYCLE IN PLANTS*

Calcium is taken up in the soil by the roots. Calcium is lost from tissues through decay, abscission (the dropping off of plant parts), gustation (the exudation of liquid from leaves) and leaching (the downward movement and drainage of minerals through the soil by percolating water). Adapted from drawing in Zipkin, *Biological Mineralization.*

(figure available in print form)

FIGURE 7. *SCLEREID CELL WITH CALCIUM OXALATE CRYSTALS*

Drawing of a scleroid cell from the leaf of *Nymphaea odorata* seen in polarized light. Numerous small calcium oxalate crystals can be seen as the white areas. Adapted from *Raven, Biology of Plants.*

(figure available in print form)

FIGURE 8. *TRANSVERSE SECTION THROUGH A SCLEREID CELL*

Drawing of an electron micrograph showing a transverse section through the arm of a scleroid cell. Three calcium oxalate crystals (C) are embedded in the secondary cell wall (W). (CY) is the cytoplasm, (PW) is the primary cell wall and a thin layer of internal cutin separates the exterior of the cell from an intracellular airspace (IS). Adapted from Watabe, *The Mechanisms of Mineralization in the Invertebrates and Plants* .

FOOTNOTES/REFERENCES

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22. Ibid.

TEACHER AND STUDENT BIBLIOGRAPHY

Conard, Henry S. *The Waterlilies* , The Carnegie Institution of Washington, 1905. A beautifully illustrated book on waterlilies including their anatomy, physiology, and uses by mankind. Suitable reading for teachers and advanced high school.

DEP State of Connecticut. *Wetland Protection In Connecticut* , Water Resources Unit, Hartford, CT, 1985. A good introduction to wetlands biology and Connecticut's protection laws. Available from the DEP. Easily read by teachers and junior and senior high school students.

EPA. *New England Wetlands* , U.S. Government Printing Office, Washington, D.C., 1980. An excellent guide to inland wetland and coastal wetland biology, plant species, and protection laws. Beautiful photographs. I used it to identify most of the wetland plants at Cedar Swamp. Easily read by teachers and junior and senior high school students.

EPA. *Wetland Protection in Connecticut* , Water Resources Unit, Hartford, CT, 1984. Free pamphlet from the EPA on wetland classification and protection in Connecticut. Good introduction for teachers and junior and senior high school students.

Hodgkinson, A. *Oxalic Acid in Biology and Medicine* , Academic Press, London, 1977. Good background reading for teachers on oxalix acid, its molecular structure, and biochemical associations.

Needham, James G. *A Guide to the Study of Fresh Water Biology* , Holden-Day, Inc., San Francisco, CA, 1962. An excellent guide to the identification of fresh water algae, invertebrates, and fishes and to methods of sampling and analyzing aquatic organisms and their environment. The glossary aids in its potential use by teachers and senior high school level students.

Raven et al. *Biology of Plants* , Worth Publishers, Inc., NY, 1976. Good background on the biology of plants to help teachers when they are reading the other technical literature. Also suitable reading for senior level high school students.

The Peterson Field Guide Series , sponsored by The National Audubon Society. Available at most bookstores in hard and soft cover. A visual approach to a variety of subjects, including animal tracks, trees, flowers, insects, and many more. Useful for field identification by junior and senior high school students as well as teachers.

Watabe, N. *The Mechanisms of Mineralization In The Invertebrates and Plants* , University of South Carolina Press, SC, 1976. Good treating of mineralization in higher plants, including micrographs of *Nymphaea odorata* . Good for teacher background.

Zipkin, Isadore. *Biological Mineralization* , John Wiley & Sons, NY, 1973. Good teacher background on the mechanisms of mineralization plus good treating of the calcium cycle.

Teacher Resources

Area Cooperative Educational Systems (ACES)
205 Skiff Street
Hamden, Connecticut 06517
248-9119
Good resource library for films, books and curricula on water related subjects, flora, conservation, fauna, and geology.
Connecticut Audubon Society
314 Unguowa Road
Fairfield, Connecticut
259-6305

Good source for field trip books and for seasonal field trips to familiarize teachers with upland and coastal habitats or interest.

Macalaster Bicknell Company
169-181 Henry Street
New Haven, Connecticut 06510
624-4191

Distributors of scientific instruments such as microscopes, glassware, hydrometers and thermometers needed to test salinity, and chemical kits for water quality testing.

Hach Chemical Company
PO Box 389
Loveland, Colorado 80537
303-669-3050

LaMotte Chemical Company
Chestertown, Maryland 21620
301-778-3100

Distributors of the chemical kits to do water testing. Also, their service department is very helpful in giving advice as to the appropriate kits to use.

New Haven Water Company
90 Sargent Drive
New Haven. Connecticut 06511
624-6671

Good resource for maps of local watersheds. Also open for small tours through the facility's laboratories.

Schooner, Incorporated
60 South Water Street
New Haven, Connecticut 06519
865-1737

Provides adjunct marine and upland water field trip services to students, teachers and public membership. Field classes take place aboard the J. N. CARTER, Schooner's 66-foot sailing research vessel and at various sites of biological interest along Long Island Sound. Hands-on marine life programs available for elementary aged students. Also, college accredited teacher workshops available.

Teacher's Center, Incorporated
425 College Street
New Haven, Connecticut 06510
776-5987

Good resource library for films and curricula categorized by subject matter and rented in self-contained boxes (much like the Teacher's Box that accompanies this unit).

The State of Connecticut
Department of Environmental Protection
Natural Resources Center
Room 553
165 Capitol Avenue
Hartford, Connecticut 06106
566-5599

Resource books and maps on water resource, water quality, conservation, soils, surficial geology

and bedrock geology of Connecticut.
Virginia Institute of Marine Science
Glouster Point, Virginia 23062
Attn: MEMS
804-642-2111
A computerized bibliography of all marine and water related curricula in the United States by subject and grade level. A $5.00 search fee is required. Microfiche can be purchased or borrowed free of charge.
Yale/New Haven Teacher's Institute
53 Wall Street
New Haven, Connecticut 06510
436-3316
Curricula units developed by New Haven teachers are available on a free lending basis to teachers from schools which have participated in the Institute. Very useful units on the environment, and the geology unit noted in this paper, *Know Your Watershed,* can be found here.