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Connecticut Wildlife: Biodiversity and Conservation Status of Our Vertebrate Populations

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Introduction

Biodiversity is broadly defined as the "full array of life on Earth" and is considered to include genetic, species, ecological, and landscape components. Biodiversity thus includes concepts of species richness, ecosystem complexity, and genetic variation (Allaby. 1994.), and it addresses "both the variety of these things and the variability found within and among them (The Nature Conservancy and Association for Biodiversity Information. 2000.). This curriculum unit addresses contemporary issues of biodiversity and conservation biology. It develops ecological concepts relating to the meaning and value of biodiversity, the extent of biodiversity (local, regional, national, and global), present and past threats to biodiversity, and efforts to maintain or restore biodiversity to habitats or communities at regional, national, or global scales. I refer to the vertebrate wildlife of Connecticut for the examples or case studies that are developed, including our herpetofauna (amphibians and reptiles), avifauna (birds), and mammalian fauna. I do not discuss the freshwater and salt water fishes of the state, instead giving emphasis to the tetrapods or quadrupeds of Connecticut. The unit has been developed through my participation as a fellow in the "Ecology and Biodiversity Conservation" seminar of the 2005 Yale-New Haven Teachers Institute (Oswald Schmitz, Seminar Leader).

The unit is intended for students in Advanced Placement Environmental Science (APES) a course that I have been teaching for the past five years. This is an upper level science elective which is a part of the College Board/AP Program course offerings at Wilbur Cross High School in New Haven, Connecticut. Students taking the course are high school juniors and seniors who have shown previous aptitude and interest in physical and life sciences and who seek a head start on college level course work and possible college credit. Future development of the unit will provide some applications for the Macy Honors Anatomy & Physiology course that I teach, as well as college and general physiology courses. While the target student population is advanced high school science students, there are a number of aspects of the unit, including subject matter and laboratory and field activities, which can be applied to middle school and elementary science education.

My teaching over the years has included courses in the physical and the life sciences, including physical science, chemistry, geology, biology, botany, physiology, ecology, environmental science, and laboratory techniques. My particular interests in science have ranged from general biology to ecology and evolutionary

biology to the environmental sciences, with a secondary interest in chemistry, geology, and paleontology. My 2005-06 teaching schedule includes one section of AP Environmental Science, two sections of Macy Honors Anatomy and Physiology, and two sections of Honors Biology (for high school sophomores), and I anticipate that this schedule will provide me a good blend of these various fields of interest. I have developed this curriculum unit because it addresses a number of major concepts in the fields of ecology and environmental science, both in terms of subject matter and laboratory and field investigations. Portions of the unit can be used in the study of comparative vertebrate anatomy and physiology, which is one of the primary approaches that I use in teaching about the structure and functioning of the human body.

Unit Objectives

This unit has the following content objectives:

1. Recognizing the meaning and value of biodiversity
2. Developing an appreciation for the extent of biodiversity on a local, regional, national, and global basis
3. Identifying and analyzing various threats to biodiversity
4. Developing familiarity with the global impacts of habitat degradation and destruction and introduction of exotic, invasive species
5. Relating current and future problems of global warming to the loss of biodiversity
6. Considering aspects of the population dynamics of selected vertebrate species

The Advanced Placement Environmental Science (APES) Curriculum.

In this section, I provide an overview of the APES course, as this curriculum unit necessarily must fit into an established national curriculum. As with any curriculum, it is the responsibility of the teacher to follow designated content standards and performance objectives. This is best done when drawing on the teacher's personal creativity and background strengths, and it is an approach that I aspire to use in this unit. The APES course is a highly interdisciplinary study of physical and life science and the various social sciences. According to the College Board/Advanced Placement Program Course Description, or Acorn Book, the APES course is "designed to be the equivalent of a one-semester, introductory college course in environmental science." It continues,

> "the goal of the . . . course is to provide students with the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them" (CEEB/AP. 2001.).

Six themes are identified as providing the foundation of the APES course, and they pertain to science as a process, energy conversions, the interconnectedness of Earth, human alteration of natural systems, environmental problems from a cultural and social context, and the development of sustainable systems to ensure human survival (CEEB/AP. 2001.) The Acorn Book stipulates six major topics for study in the course, as listed here:

I. Interdependence of Earth's Systems: Fundamental Principles and Concepts
II. Human Population Dynamics
III. Renewable and Nonrenewable Resources: Distribution, Ownership, Use, Degradation
IV. Environmental Quality
V. Global Changes and Their Consequences
VI. Environment and Society: Trade-Offs and Decision-Making

The curriculum unit that I present here has students conduct work on the following topics: the biosphere, including organisms, populations, and communities (Topic I); population dynamics of selected vertebrate species (Topic II); global changes such as habitat degradation and destruction, and also higher-order interactions including loss of biodiversity and (potentially) global warming (Topic V).

My science teaching invariably involves the extensive use of laboratory and field activities, regardless of the course being taught. It also is the expectation of the College Board/AP Program that a strong component of laboratory and field work is central to the teaching of environmental science. This hands-on and minds-on work supports the understanding of concepts and principles of environmental science, provides opportunity for in-depth study of selected subjects, and makes clear to the student that environmental problems faced by humankind are complex, not easily solved, and often involve making choices from among a number of potential solutions. Lab and field investigations that are a part of the APES course teach students about diverse methods of collection and analysis, the value of long-term ecological and environmental studies, and the interpretation of sets of data. Students are taken on trips to representative natural and human-altered habitats (studying communities or ecosystems), and they visit such facilities as a water-treatment plant.

The College Board is very specific in identifying the significance of such laboratory and field work (for example, linkage with major concepts and development of communication skills), and it discusses the performance objectives for such lab experiences (including designing experiments, using instrumentation, thinking analytically, and evaluating results). Finally, I will note that AP students take a national examination in mid-May that includes multiple-choice and free-response questions and requires that the student use both depth and breadth of understanding to recall facts and concepts and apply these to present-day environmental problems. The free-response questions, in particular, are structured to test the student on the analysis of a data set, the interpretation and evaluation of a document, and the ability to synthesize and evaluate environmental issues.

The Biodiversity of Connecticut's Vertebrates.

Biodiversity indices have been developed to measure the full array of life in terms of species richness, the commonness or rarity of species, and the evenness of distribution of species in communities or habitats. Thus, alpha diversity is a measure of "species richness within a community," beta-diversity is a measure of "species diversity between communities or habitats," and gamma diversity is "species diversity among communities over a [large] geographical area" (Smith and Smith. 1998.) Applied to the wildlife of Connecticut, alpha diversity would pertain to all the different species of vertebrates found within state boundaries, if the state is defined as the community under consideration. Beta-diversity would consider a comparison between the diversity of vertebrates in Connecticut and that of other (perhaps neighboring) states (including species turnover). Gamma-diversity would be a measure of biodiversity of the United States, or of North America, or perhaps global biodiversity.

The State of Connecticut has fairly high species diversity for a northern temperate climate, including freshwater and salt water fishes, amphibians, reptiles, birds, and mammals. This unit does not address the diversity of Connecticut's freshwater and salt water fishes, although for many researchers the piscines have been a subject of considerable interest and ecological and evolutionary significance. I focus instead on some of the tetrapods found in the state. Current check-lists of the vertebrates of Connecticut identify 22 amphibians, 28 reptiles, 409 birds, and approximately 100 species of mammals.

Amphibians and reptiles often are studied by the same researchers and are grouped as the herpetofauna of a region. The amphibians of Connecticut include twelve species of salamanders and ten species of frogs. The salamanders are classified in four families, consisting of ambystomatids (4), plethodontids (6), proteids (1), and salamandrids (1). Representative species are the Spotted Salamander, the Red-backed Salamander, the Mudpuppy, and the Eastern Newt or Red-spotted Newt, respectively. I have never seen Mudpuppies in Connecticut. Klemens (1993.) states that this species "has been collected in the Connecticut River, from the Massachusetts border (Hartford County) south to Middletown (Middlesex County.)." The mudpuppy has been reported in the 1950s and again in the 1980s, and its small populations may derive from intentional introductions earlier in the 20th century. I see Spotted Salamanders on an annual basis in West Rock vernal pools – they are obligate species in these temporary or ephemeral pools of shallow water - during their early spring breeding aggregations and during fall migrations to nearby underground hibernating sites. The Eastern Newt is found in the Lake Wintergreen site at West Rock Ridge State Park, in its aquatic stages, and on the ridge top and slopes in its terrestrial red eft stage. Red-backed Salamanders are ubiquitous under rocks and fallen trees in the forested regions of Connecticut. They are believed to be the species of greatest total biomass of all vertebrates in Connecticut.

The frogs of Connecticut are grouped in four families, and they include bufids or toads (2 species), hylids or treefrogs (2), pelobatids or spadefoots (1), and ranids or true frogs (5). Representative frogs and toads are the Eastern American Toad, the Northern Spring Peeper, the Eastern Spadefoot (limited to a half-dozen or so known populations in Connecticut and classified as state-endangered), and the Bullfrog and Wood Frog, respectively. The American Toad, Spring Peeper, and Bullfrog are common and widespread in Connecticut in appropriate terrestrial or aquatic habitats (deciduous forests, talus slopes, wet meadows, fields, lakes and ponds, and floodplain swamps). Wood Frogs have more restricted habitat requirements for breeding and are found in vernal pools, wooded swamps, and flooded meadows (Klemens. 1993.). I have never seen the state-endangered Eastern Spadefoot in Connecticut, but I am familiar with and have photographed two populations

in the town of Wellfleet, Massachusetts (on sandy Cape Cod) where these rarely observed burrowing amphibians come out to traditional breeding pools following very occasional violent thunderstorms. The Eastern Spadefoot is another obligate vernal pool breeder.

Connecticut's reptiles include thirteen turtles, one lizard, and fourteen snakes. The turtles include five sea turtles grouped in two families, the dermochelyids and the cheloniids, and eight freshwater, brackish water, or terrestrial turtles, including chelydrids (1) emydids (6), and kinosternids (1). Sea Turtles are federally and state-endangered. Non-marine turtles include the Common Snapping Turtle (a chelydrid), the Painted Turtle, Wood Turtle, and Eastern Box Turtle (emydids), and the Common Musk Turtle (a kinosternid). The one lizard species found in Connecticut is the Eastern Five-lined Skink (Family Scincidae), which I have observed in forested parklands of Alabama but never in Connecticut. The New England states have next to no diversity in lizards, which are far more abundant and diverse in the species-rich southern and western portions of the United States. Connecticut's snakes include colubrids (12) and viperids (2). Common colubrid species include the Northern Black Racer, the Eastern Milksnake, and the Eastern Garter Snake. All three of these species are widely distributed at West Rock Ridge. The two viperids present in our state are the Northern Copperhead and the Timber Rattlesnake. Copperheads are fairly common in appropriate habitat; I have made so many as twenty separate observations of copperheads at West Rock in a given year, having observed them at two annually used hibernacula (hibernating places) and during their dispersal in spring from upland to lowland habitats. In most instances, I have found copperheads basking under dead leaves along the edges of rock jumbles on the ridge top. One site on the ridge top serves as an inter-species hibernaculum for copperheads, black racers, and eastern hognose snakes. Timber Rattlesnakes are highly endangered in Connecticut, and I have not made the effort, yet, to see any of them at their den sites.

Common Snapping Turtles grow to very large sizes in the quiet, shallow waters of Konold's Pond. I have photographed one snapping turtle found in Konold's Pond (just west of the old quarry site in the town of Woodbridge) which had a carapace (upper shell) measuring seventeen inches. An acquaintance who is a regular mountain biker at this state park found and photographed a snapping turtle on the ridge top that equaled or exceeded the 17.5 inch carapace of the largest specimen measured in Connecticut. (Snapping Turtles, incidentally, are potentially among the most dangerous of Connecticut vertebrates, as their powerful jaws can easily remove a carelessly placed finger or hand. Painted Turtles are very common in the lakes and ponds surrounding West Rock Ridge, particularly in Konold's Pond. Box Turtles are found on the ridge top, slopes, and lowlands of West Rock, and they are particularly likely to be seen following rain storms as they move about the ridge. The trail that runs alongside Wintergreen Brook on the east side of the ridge is another good area for finding box turtles. Wood Turtles are far less frequently encountered but may also be found in the Wintergreen Brook floodplain. Both box turtles and wood turtles are listed as Special Concern Species in Connecticut.

The birds of Connecticut include 409 species classified in sixty families. The most species diverse of these birds are the anatids (ducks, geese, and swans – 41 species), the parulids (wood warblers – 39 species), the scolopacids (sandpipers – 37 species), the larids (gulls, terns, jaegers, and skimmers – 32 species), and the emberizids (sparrows and relatives – 29 species). Additional species-diverse families include the tyrannids (tyrant flycatchers – 17 species), the accipitrids (hawks, eagles, and kites – 14 species), the turdids (thrushes – 12 species), the icterids (blackbirds, orioles, and relatives – 12 species), the ardeids (herons, bitterns, and relatives – 11 species), the strigids (true owls – 11 species), the fringillids (finches, grosbeaks, crossbills, and relatives – 11 species), and the rallids (rails, coots, and gallinules – 10 species). During nearly twenty-five years of field work at West Rock Ridge, I have documented more than 230 species of birds in its uplands, slopes, floodplain, and lake habitats, and I have determined that approximately one hundred species of birds

breed at West Rock, based on my having located nests with eggs or young and recently fledged birds being attended by adults. West Rock Ridge is one of a small number of breeding bird "hot spots" in Connecticut and is exceeded in its diversity of breeding birds by no more than five regions of northwestern and west-central Connecticut. My analysis of the results of the 1982-1986 Breeding Bird Survey of the State of Connecticut and my subsequent field work at West Rock Ridge indicate that the most significant breeding hotspots are: (1) Nepaug State Forest and Nepaug Reservoir (Collinsville Quadrangle/town of New Hartford); (2) Bantam Lake (Litchfield Quadrangle/town of Litchfield); (3) Housatonic State Forest and the Housatonic River (Sharon and Ellsworth Quadrangles/towns of Sharon, Warren, and Cornwall); (4) Tunxis State Forest, Peoples State Forest, Barkhamsted Reservoir, and Ragged Mountain (West Granville and New Hartford Quadrangles/towns of Hartland and Barkhamsted); (5) the Housatonic, Shepaug, and Pomeraug Rivers (Woodbury and Newtown Quadrangles/towns of Woodbury, Southbury, Newtown, Bridgewater, and Brookfield); (6) West Rock Ridge State Park (New Haven and Mount Carmel Quadrangles/towns of Woodbridge, Bethany, Hamden, and New Haven). Unusual or rare breeding bird species at West Rock include Pied-billed Grebe (a state-endangered species and a probable breeder in lakes around the ridge), Sharp-shinned Hawk (probable breeder and state-endangered), Cooper's Hawk (a confirmed breeder in a pine plantation at the Lake Wintergreen site), Peregrine Falcon (state-endangered; confirmed as a breeding species by me in 2000 and each year since), Whip-poor-will (special concern species; known for many years to breed at the Lake Wintergreen site), Common Raven (special concern species; breeding in its southernmost location at West Rock since at least 2002, when I discovered adults attending recently fledged young), Winter Wren (a very rare breeding species outside Litchfield County), Brown Thrasher (special concern species), and Yellow-breasted Chat (at the Lake Wintergreen parcel, one of only two confirmed breeding sites during the five year breeding bird atlas project). In addition, Black Vulture has given some indications of seeking a breeding site at West Rock Ridge in recent years, as it expands its range into southern New England from more southern populations.

The mammals of Connecticut include opossums, shrews and moles, bats, rabbits, rodents (squirrels, beavers, rats and mice, and porcupines), carnivores (coyotes, bears, raccoons, weasels and allies, skunks, and cats), and artiodactyls (deer and moose). West Rock is home to many of these state species, including numerous small mammals (shrews, moles, and rodents), coyotes (confirmed as breeders when I observed two recently born coyotes on the ridge top several years ago), gray fox and red fox, weasels, river otters (seen in Wintergreen Brook and Konold's Pond), the Red Bat (a Special Concern Species), and not surprisingly, the White-tailed Deer. On March 29, 2005 I observed an adult Fisher (Order Carnivora, Family Mustelidae) as it walked and loped down the paved Baldwin Drive on the east slopes of West Rock Ridge, thereby confirming that this recently reintroduced (1989 and 1990) member of the weasel family has extended its range from northwestern and northeastern Connecticut into south-central Connecticut in the last year or two.

The complete check-lists of the vertebrates of Connecticut are too lengthy to publish here, but I have developed computer files listing all recognized species in each taxonomic category. The check-lists also are available through the website of the State of Connecticut, Department of Environmental Protection and from websites of such organizations as the Connecticut Ornithological Association.

Biodiversity of East Rock Park (New Haven) and West Rock Ridge (New Haven, Hamden, Woodbridge, Bethany).

My school is located on City of New Haven parklands and is in effect an extension of East Rock Park, a city park that was established in the nineteenth century and continues to fall under the management of the New Haven Department of Parks, Recreation, and Trees. The school and the park are located at the base of East Rock, a trap rock ridge which is the southernmost in a series of north-south trending ridges that are found in the central valley lowlands of Connecticut and Massachusetts. Hamden's Sleeping Giant (Mount Carmel), the Hanging Hills of Meriden, Ragged Mountain in Berlin and Kensington, Talcott Mountain in Avon, Simsbury, and Farmington, and the Barndoor Hills of northern Connecticut are additional components of the series of trap rock ridges trending north-south through the state. The bedrock of East Rock is basalt, or more properly, West Rock diorite, a common form of igneous rock in this part of New England.

East Rock has a park ranger station and environmental center immediately opposite the school. The Mill River flows through the park and behind the high school, and it joins with the substantially larger and longer Quinnipiac River to flow into New Haven Harbor and, ultimately, Long Island Sound. East Rock Park is enjoyed by such diverse individuals as hikers, runners, nature enthusiasts, canoeists, historians, researchers, and science educators. It is justifiably famous to Connecticut and New England birders for the impressive diversity of migrant and breeding birds found here. The flycatchers, vireos, thrushes, orioles, tanagers, and especially the wood warblers invariably attract a great deal of human interest during the spring migration. East Rock has a broad diversity of habitats within a limited area, including lowland, west-facing talus slopes, east-facing gentle slopes, and upland that serve as habitat for a substantial portion of the birds and other vertebrates found in southern New England. My students are able to carry out field research in nearby portions of East Rock Park during a standard 45-minute period, and we can reach further into the park during eighty-minute block periods designated for laboratory or field work.

West Rock Ridge is the western counterpoint to East Rock Park and along with New Haven Harbor provides geographic definition to the City of New Haven. West Rock is a trap rock ridge formed at the same geological instant as were the other ridges of the central valley lowlands of Connecticut and Massachusetts. West Rock is significantly larger than East Rock, as it extends seven miles from the southern terminus to the northern part of the ridge, just to the south of High Rock in Hamden and Bethany. Its ridge top forms the boundaries separating the more eastern towns of Hamden and New Haven from the more western towns of Woodbridge and Bethany. West Rock has been the focal point of my field research for the past twenty-two years, and I have extensive familiarity with the ridge top and slopes, rocky outcrops and cliff faces, vernal pools, and associated red maple swamps and lacustrine environments. I serve on the DEP's West Rock Ridge State Park Advisory Council (as a member-at-large), and I am a member of the board of the West Rock Ridge Park Association. My advisory board contributions to the state park and my field research have led to my obtaining authorized motor vehicle access to the ridge top.

With some field observations contributed by Anthony Bledsoe and Noble Proctor, I have developed a list of more than 230 species of birds that are found annually at West Rock, including approximately 120 species that are confirmed or probable breeders. This represents an unusually high percentage of the total number of breeding species occurring in Connecticut. My field work at West Rock includes observations of plants, invertebrates, and vertebrates, including amphibians, reptiles, birds, and mammals. West Rock has been studied heavily during the past century, and it has been shown to be the location of the second highest

concentration of rare and endangered plants in Connecticut. It is one of the hot spots for breeding birds in the state, and I have confirmed the breeding of endangered or threatened species in Connecticut including Peregrine Falcon and species of high conservation priority such as American Black Duck, Broad-winged Hawk, American Woodcock, Black-billed Cuckoo, Whip-poor-will, Eastern Wood-Pewee, Great Crested Flycatcher, Eastern Kingbird, Wood Thrush, Brown Thrasher, Blue-winged Warbler, Prairie Warbler, Black-and-white Warbler, Worm-eating Warbler, Louisiana Waterthrush, Scarlet Tanager, Rose-breasted Grosbeak, Eastern Towhee, Field Sparrow, and Baltimore Oriole.

Presently, I am preparing a report nominating West Rock Ridge for consideration as an "important bird area in Connecticut." My students will assist in this application process. West Rock has its fair share of mammals, also. I have made observations on red foxes, gray foxes, coyotes, fishers, river otters, flying squirrels, red bats and brown bats, white-tailed deer, and numerous small mammals over the course of the past two decades.

Classroom Activities/Sample Lesson Plans

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(1) Biodiversity Worksheet Using the Nature Conservancy/Association for Biodiversity Information Publication, Precious Heritage: The Status of Biodiversity in the United States.

This introductory laboratory activity serves as the introduction to our study of biodiversity. I give my students a reading assignment taken from the publication, *Precious Heritage* . This well-illustrated book provides a comprehensive overview of a full range of topics in the study of biodiversity. It could easily serve as the basis for a study of biodiversity in the AP Environmental Science curriculum. I have selected one of the introductory chapters in the book to introduce my students to these following aspects of biological diversity: the geography and phytogeography of the United States; the total presently-known number of species on Earth; scientific nomenclature and taxonomic classification; U.S. biologists who pioneered the study of biodiversity; endemic species and non-native species; biogeography; definitions of biodiversity; exceptional species richness in regions of the U.S.; taxonomic groups, including plants, mammals, birds, reptiles, amphibians, fishes, insects, and other invertebrates. I run the activity the same way I conduct many laboratory classes, with information drawn from the assigned reading distributed among twelve stations set up on classroom tables or counters. Students work in pairs to visit each station for a period of time, review materials such as tables, graphs, photographs, and text, and answer the questions provided.

Instructions for the student. Read *Precious Heritage* , Chapter 3 A Remarkable Array: Species Diversity in the United States (pages 55-91), and answer the following questions.

1. The phytogeography of eastern North America is most similar to that of what other part of the world? [Answer. Eastern Asia (forests)]
2. Why is the snail darter (*Percina tanasi*) well known in the annals of North American endangered species? [Ans. It held up construction of the Tellico Dam on the Little Tennessee River; a single species conservation problem and political hot potato.]
3. Describe the geography of the United States in terms of square miles of land, miles of coastline, overall size of the country, latitude and longitude, elevation, and diversity of

ecosystems. [Ans. 3.5 million square miles of land, 12,000 miles of coastline, fourth largest country, 120 degrees longitude and 50 degrees latitude, 282 feet below sea level to 20,320 feet above sea level, wide array of ecosystems.]
4. (a.) Why is Quaking Aspen (*Populus tremuloides*) considered by some to be the largest living organism? [Ans. 47,000 tree trunks may be connected underground through a common root system. They are genetically identical clones.]
(b) Why is the creosote bush (*Larrea tridentata*) considered by some to be the oldest living tree or shrub? [Ans. Estimated age of 11,700 years, based on "fairy rings" of the shrub stems.]
5. How many species inhabit the world? (Give the high and low estimates, and the "working estimate". What percentage of these species has been given a formal Latin (scientific) name? [Ans. 3 million to 100 million (estimated 14 million). A total of 1.5 million have formal Latin names.]
6. Which taxa have been studied the most for their biological diversity? Which geographic region of the world has been most heavily studied for biological diversity? [Ans. Vertebrate animals and vascular plants. Economically developed countries of the Northern Hemisphere.]
7. There are 250,000 vascular plants catalogued worldwide. What are the vascular plants? [Ans. These are plants that have vascular tissues, xylem and phloem, through which water and nutrients are transported. They include horsetails, club mosses, ferns, gymnosperms (cone-bearing plants), and angiosperms (flowering plants).]
8. Identify some of the most poorly known organisms. Identify two major environments that are very poorly studied. [Ans. The most poorly known organisms are microorganisms, algae, fungi, and many groups of invertebrate animals. Deep-sea environments and soil horizons are poorly studied.]
9. Write scientific names for each of the following species:
American Burying Beetle – [Ans. *Nicrophorus americanus*]
Shasta snow-wreath – [Ans. *Neviusia cliftonii*]
Furbish lousewort – [Ans. *Pedicularis furbishiae*]
Giant coreopsis – [Ans. *Coreopsis gigantean*]
Desert shrub ocotillo –[Ans. *Fouquieria splendens*]
American bison – [Ans. *Bos bison*]
Pronghorn – [Ans. *Antilocapra americana*]
10. Examine Figure 3.1. Estimated number of species in major groups (text page 59). Identify the four largest groups of organisms. Identify the four smallest groups of organisms. [Ans. Four largest groups = insects, other invertebrates, fungi, and bacteria. Four smallest groups = vertebrates, protozoa, plants, and algae.]
11. What are symbiotic and parasitic organisms? [Ans. Symbiotic organisms are dissimilar organisms that live together in close association. Symbiosis is usually restricted to mutually beneficial species interactions. Parasitism is an interaction of species populations in which one (typically small) organism (the parasite) lives in or on another (the host), from which it obtains food, shelter, or other requirements. Parasitism usually implies that some harm is done to the host.]
12. Approximately how many native vertebrate species are found in the United States? [Ans. More than 4,900 vertebrate species.]
13. Examine Table 3.1. Number of native species known from the United States. Extract the following information from this table:

Common Name | Phylum | Number of U.S. Species [Ans.]

Nonlichenized fungi (not shown) more than 34,000

Lichens (not shown) 3,800

Mosses Bryophyta 1,400

Clubmosses Lycophyta 100

Horsetails Sphenophyta 10

Ferns Filicinophyta 444

Conifers Coniferophyta 104

Flowering plants Anthophyta 15,320

Jellyfish, corals, relatives Cnidaria 1,620

Flatworms Platyhelminthes 6,000

Roundworms Nematoda more than 5,300

Arachnids and relatives Chelicerata 9,557

Insects Mandibulata 96,406

Crustaceans Crustacea 9,675

Segmented worms (annelids) Annelida 3,360

Mollusks Mollusca 7,500

Echinoderms Echinodermata 1,110

Vertebrates Craniata more than 4,900

14. Briefly identify each of the following nineteenth and early twentieth century biologists, and state which organisms they did research on:
Spencer Fullerton Baird – [Ans. Assistant Secretary, then Secretary of the Smithsonian Institution; he conducted research on vertebrates.]
David Starr Jordan – [Ans. Stanford University researcher; he did research on fishes.]
C. Hart Merriam – [Ans. director of the Bureau of Biological Survey; he did research on mammals.]
15. How many species have been formally described in the United States? What is the estimated number of species that inhabit the U.S.? [Ans. More than 200,000 species are known in the United States. Total numbers of U.S. species range from an estimated 300,000 to 600,000 species.]
Alien Species
16. How many alien plant and animal species (also called exotics, introduced, or non-native

species) inhabit the United States? Why are alien species considered a threat to (U.S.) biodiversity? [Ans. Perhaps 3,500 introduced plants and 2,300 introduced animals are found in the U.S..]
17. List all the species of exotic birds inhabiting Connecticut today. (Consult with Mr. Broker for this answer.) [Ans. The introduced or exotic birds found in the state of Connecticut are: Mute Swan, Ring-necked Pheasant, Rock Pigeon, Monk Parakeet, European Starling, House Finch, and House Sparrow.]
18. List six species of exotic plants found in East Rock Park. [Ans. Six introduced plants in East Rock Park are: Japanese Knotweed, Japanese Barberry, Asiatic Bittersweet, Phragmites (Common Reed), Norway Maple, and Ailanthus (Tree-of-Heaven).]
U.S. Species in a Global Context
19. What are "biological boundaries", and how do they form? What is "one of the crucial facts of biogeography"? [Ans. Biological boundaries are barriers to the exchange of living organisms, such as oceans, mountains, deserts, gradations in rainfall or temperature. From the study of biological boundaries and of life on Earth, we know that species are not distributed evenly across the planet.]
20. Define "species richness". [Ans. Species richness is the number of species present in a given area.]
Quantifying Diversity
21. The American ecologist Robert Whittaker proposed three separate types or measures of species richness. Define each of these following according to Whittaker's system. [Ans. Alpha diversity – the number of species in some small, homogeneous area, such as a study plot or a naturally defined ecological community. Beta diversity – the rate of change (or turnover) in species across adjacent habitats. Gamma diversity – the number of species in a large geographic region.]
22. Define "endemism". [Ans. The restriction of a species or other taxonomic group to a particular geographic region.]
23. Explain the following statement: "the presence of unique families or orders is particularly noteworthy from an evolutionary perspective". See page 66. [Ans. These higher taxonomic levels may include a number of fairly closely related species. Many regions of the world have endemic species. Regions that have endemic genera, families, or orders are particularly noteworthy.]
National Patterns of Diversity
24. What is the broad relation between biological diversity and latitude? [Ans. Biological diversity (alpha and gamma) increases with decreasing latitude. That is, there is greater biological diversity closer to the Equator and lesser diversity closer to the poles.]
25. Examine Table 3.2. Global significance of selected U.S. plant and animal groups. Identify the five species groups that have the greatest significance (high levels of diversity) in the United States. List the U.S. percentage of global species represented by the top three groups. [Ans. The species groups with greatest significance in the U.S. are crayfishes, freshwater mussels, freshwater snails, gymnosperms, and freshwater fishes. U.S./global percentages are: Crayfishes – 61% Freshwater mussels – 29% Freshwater snails – 17%]
26. List some of the species groups from among the freshwater organisms that are exceptionally diverse in the United States. Why is there such great species diversity and endemism in the nation's freshwater biota? [Ans. Again, they include freshwater mussels, freshwater snails, crayfishes, and several freshwater insect orders. There has been tremendous evolution through adaptive radiation and speciation in the nation's rivers and streams, lakes and ponds.]

Plants
27. List the flowering plant families that are particularly species rich in the United States. [Ans. The species rich flowering plants include members of the composite family (asters, sunflowers, goldenrods), peas, and grasses.]
28. List six broad categories of coniferous trees found in the United States. [Ans. These include pines, firs, spruce, hemlocks, cedars, and cypresses.]
29. How many plant species are endemic to the United States (north of Mexico)? [Ans. About 4,000 plant species are endemic to the U.S..]
30. How many vascular plants are endemic to the Hawaiian Islands? [Ans. About 1.050 vascular plants are endemic to the Hawaiian Islands.]
31. How many U.S. gymnosperms are endemic? [Ans. Some 45 gymnosperms (39% of the gymnosperm flora) are endemic to the U.S..]
Mammals
32. Where does the United States rank worldwide in terms of mammal diversity? Identify the order of mammals that constitutes half of all U.S. mammal species. Name some of these mammals. [Ans. The U.S. ranks 6th in mammalian diversity among the nations of the world. The order Rodentia constitutes almost half of all U.S. mammal species. The rodents include squirrels, gophers, and lemmings, chipmunks, beavers, etc.]
33. List three mammals endemic to the United States. [Ans. The U.S. endemics include the giant kangaroo rat (*Dipodomys ingens*), the Mt. Lyell shrew (*Sorex lyelli*), and the black-footed ferret (*Mustela nigripes)* .]
33. Complete the following table:
Species | Mammalian Order [Ans.]
Opossum Marsupialia
Nine-banded armadillo Xenarthra
Caribbean manatee Sirenia
What do these three species have in common? [Ans. These three species are the only representatives of their orders found in the U.S..]
Birds
34. Approximately how many bird species breed in the United States? How many bird species are known to breed in Connecticut? [Ans. About 720 bird species breed in the United States. Some 173 species of birds were confirmed breeding in Connecticut during the 1982-1986 breeding bird survey. Several additional species have been confirmed breeding in Connecticut since then.]
35. Briefly describe the level of endemism of birds in Hawaii. Then, list three birds endemic to the mainland United States. [Ans. Hawaii has 52 endemic bird species, a very high percentage of its total avifauna. Three mainland U.S. endemic birds are Yellow-billed Magpie, Lesser Prairie-Chicken, and Bachman's Sparrow.]
36. The Whooping Crane (*Grus americana*) is a highly endangered species of bird in the United States and Canada. Name the most important nesting location of this species. What caused the severe decline in numbers of this bird? [Ans. Whooping Crane nests in central Canada's Wood Buffalo National Park. Hunting (direct exploitation) and agricultural conversion (habitat loss) brought the species to the brink of extinction.]
Reptiles
37. How many reptile species are endemic to the U.S.? [Ans. The U.S. has 90 endemic reptiles (32% of the U.S. total of 280 reptile species).]
38. Give the common name and the Latin name for each of the venomous lizards found in the

United States. [Ans. Gila Monster *Heloderma suspectum* and Mexican Beaded Lizard *Heloderma horridum.*]

Amphibians

39. With regard to one particular group of amphibians, the United States is the richest country on Earth. Name this amphibian group, and state how many species have been described and what percentage of the world total they represent. [Ans. The U.S. is the richest country for salamanders. There are 140 described species of salamanders. This comprises 40% of the world's total.]

40. Which amphibian group is the most species-rich worldwide? [Ans. Frogs are the most species-rich amphibian group worldwide (90% of described species).]

41. Allopatric speciation is "the origin of a new species through the acquisition of effective isolating mechanisms by a geographically isolated portion of the parental species." The process of allopatric speciation can result in great adaptive radiations and species-richness. What accounts for the great species-richness of plethodontid salamanders? [Ans. There is a large number of narrowly distributed species, due to their occurrence in the highly dissected Appalachian Mountains. Examples include the Shenandoah Salamander, the Tellico Salamander, Valley and Ridge Salamander, Peaks of Otter Salamander, Jordan's Salamander, Cumberland Plateau Salamander, Cheat Mountain Salamander, Southern Appalachian Salamander, Pigeon Mountain Salamander, White-spotted Salamander, Ravine Salamander, Southern Zigzag Salamander, Wehrle's Salamander, Weller's Salamander, and Yonahlossee Salamander. Geographic isolation led to numerous speciation events.]

Freshwater Fishes

42. Identify the top seven nations for diversity of freshwater fishes. Which freshwater fish family has high levels of endemism in the United States? [Ans. The countries with the greatest diversity of freshwater fishes are: Brazil, Venezuela, Indonesia, China, Democratic Republic of Congo, Peru, and United States of America. The minnow family (Cyprinidae) has great species diversity in the U.S..]

43. Identify three species of so-called "ancient fishes." (These fishes are classified in taxa with evolutionary histories of many millions of years.) [Ans. Ancient fishes (showing little evolutionary change over millions of years) include the bowfin (*Amia calva*), gars (Family Lepisosteidae), and the paddlefish (*Polyodon spathula*).]

Insects

44. Identify the four largest insect orders in the United States. [Ans. The four largest insect orders in the U.S. are: Coleoptera (beetles, 25,030 species); Diptera (flies, 20,627 species); Hymenoptera (bees and relatives, 18,107 species); Lepidoptera (butterflies and moths, 12,261 species).]

45. The U.S. is extremely rich in bee species, particularly in the arid southwest. What are some of the evolutionary adaptations of these U.S. bees? [Ans. Most of our native bees are solitary. Many burrow into the ground to nest. Many U.S. species coevolved with flowering plants, as there are many wildflowers specialized for bee pollination.]

46. Explain the term "coevolutionary arms race" as it is applied to insects and flowering plants. [Ans. This term refers to plants evolving specific chemical defenses to ward off foraging caterpillars, and to insect larvae evolving the ability to overcome these chemical toxins.]

47. Larry Gall of Yale University did his doctoral research in ecology and evolutionary biology on the *Catocala* moths of West Rock Ridge. What are these moths, and why are they significant in the eastern United States? [Ans. The Catocala moths are underwing moths. They consist of about

105 U.S. species. The eastern U.S. is their global center.]
48. Briefly discuss the species richness of Hawaii's picture-wing fruitflies. [Ans. There are perhaps 100 species of picture-wing flies in Hawaii. They exhibit complex courtship rituals, including defense of mating territories (leks).]
49. Describe the species richness of freshwater insects in the United States. [Ans. The United States is species-rich in freshwater invertebrates, including caddisflies, mayflies, and stoneflies. More of these species are found in the U.S. than in any other country.]
50. Dragonflies and damselflies are indicators of environmental health. Explain this statement for the odonates, and describe the species diversity of U.S. dragonflies and damselflies. [Ans. Odonate larvae are fully aquatic and sensitive to the health of their rivers, streams, ponds, and other wetlands. There are 450 species of odonates in the U.S., approximately 8% of worldwide species.]
Other Invertebrates
51. Three groups of invertebrates show great species richness in the United States. Identify these three groups. [Ans. The U.S. is particularly species-rich in freshwater mussels, freshwater snails (including tree snails), crayfishes, and subterranean invertebrates (found in caves and other underground habitats).]
52. How are the tree snails of the Hawaiian Islands similar ecologically to the terrestrial snails of the western U.S. mountain ranges? [Ans. Both the Hawaiian Islands and the western mountain ranges of the U.S. serve as isolated habitats for the speciation of snails over time.]

(2) West Rock Ridge Bio-Blitz

My students will conduct a series of bio-blitzes to study the diversity of West Rock Ridge through fall, winter, and spring seasons. We will survey a series of sites on the ridge top, the eastern slopes, and the surrounding lowlands to learn about preferred habitats of West Rock's indigenous vertebrates. For example, the Wintergreen site has a red maple swamp that serves as a lekking area for the migratory American Woodcock. The rocky outcrops on the ridge top hold hibernacula for Northern Black Racers and Eastern Hognose Snakes (also Northern Copperheads). There is considerable zonation of canopy and subcanopy trees along transects from lowlands to uplands. We also will develop species lists for all plants and animals observed at the ridge during our series of field trips there. These lists will be measured against those lists that I have assembled over my years of field work at West Rock Ridge. Our field trips to East Rock Park, West Rock Ridge, and elsewhere in Connecticut focus on the geology, soils, topography, representative plants and animals, forms of natural and human-induced disturbance, land use practices, and management issues of such diverse habitats as forested uplands, freshwater wetlands, agricultural and pasture lands, and urban environments. In past years, my science students have been able to observe live animals in the classroom, including fishes, salamanders, frogs and toads, snakes, turtles, birds, and small mammals. (All wild animals brought in for educational purposes are treated with respect and care and are returned unharmed to the exact locations where they were captured.)

(3) Case Study: Common Raven (Corvus corax)

This lesson is designed to be used over a period of days, as my students work with and extract important information from a comprehensive set of published and unpublished biology field notes. I have studied the feeding, territorial, and breeding biology of the Common Raven (*Corvus corax*) at West Rock Ridge during 2002, 2003, 2004, and 2005 breeding seasons, and I have produced written and audio-recorded notes on many aspects of the life history of this large corvid species. The Common Raven is believed to have been part of the Connecticut avifauna prior to 1700. It was extirpated from the state as the result of direct persecution, habitat loss, and loss of food sources (carcasses of large mammals). This species has undergone a natural range expansion back into the northwestern and northeastern portions of the State of Connecticut since 1988, and it is rapidly expanding its range southward through many regions of the state. Ravens have been sighted on occasion at West Rock since the mid- to late-1980s, but they are not known to have bred there prior to 2002. For the past four years, the same pair of adult ravens has occupied territory at West Rock Ridge near the quarry cliffs overlooking Konold's Pond, performing courtship rituals, building and rebuilding a large stick nest, defending territory against vultures, hawks, and falcons, obtaining and storing food sources, laying eggs, and hatching and raising young. The July 2004 issue of *The Connecticut Warbler* (the state journal of ornithology) carried an article that I wrote on the 2003 nesting season. I have made additional, unpublished field notes from the two most recent breeding seasons. By working with my field notes, my students will develop observational skills that can be used in the study of territoriality, pair bond formation, nest construction, mating, egg-laying, incubation, nestling and fledgling stages, feeding, food caching, and agonistic behaviors for this avian species. I anticipate that we will be developing tables and charts of information that document the various behaviors of the ravens. Following is an annotated sampling of field notes from the 2004 winter and spring breeding seasons. The notes contain references to a series of cliff face landmarks that define the locations of the observed behaviors of the ravens under study.

Sunday, January 4, 2004 (1340-1440 hour; 39o F, steady light rain) – Two Common Ravens seen from the Quarry Site, center column, flying in the vicinity of the 2003 nest crevice and further north. One raven then seen to fly south low, along the east edge of Konold's Pond, disappearing beyond the South Prom cliff. The

second raven is seen and heard in the north cove area, just south of the north point. Relocating to the nest site, this raven is heard further to the north, beyond the north point. Then, the first raven returned from the south, flying out past me and disappearing beyond the north point.

Tuesday, February 3 (0930-1000) – At 0941, the cliff top deer carcasses are checked. A raven is pushed off the most recently deposited deer carcass. It circles between the nest crevice and the north point for a period of four minutes, then flies out beyond the northwest corner of Konold's Pond and loops south. Its calls were heard from 0941 until 0947, as it was in flight. During the circling, the raven's "kronk" calls often were grouped in fours. At one point, the bird nearly hovered in position. It flew close to the cliff on four or five occasions, circling. The newest, non-dissected, deer carcass showed exposed red meat for the first time. Nest-building has not yet begun. One small, foot-long branch, previously noted, is present on the nest ledge, along with a few small twigs.

Thursday, February 5 (1500-1525, 34o F, gray, cloudy, slight breeze) – No Common Raven observed. Foot-long branch is no longer on the nest ledge. The ledge is fairly cleaned of, or devoid of, nest material.

Thursday, February 12 (1416-1449, 36-37o F) – Arriving at the center column, one raven is seen and heard, and it dive-bombs an immature Red-tailed Hawk over the quarry space. A second raven is observed shortly thereafter (1425), from the nest crag area. At 1431, both ravens are observed, trading dives with the Red-tailed Hawk. A new audibilization is heard from the ravens, a castinette-like sound, followed by a low grunting sound. This is being given when the ravens are in pursuit of the hawk. No nest-building has begun, but these birds appear highly territorial. I depart as the ravens' pursuit of the red-tail continues. [School vacation interrupts observations for a week.]

Sunday, February 22 (1200-1340, 41-43o F) – No Common Ravens are observed, but nest-building has begun! The 2003 nest ledge has no branches on it, but a foot or so to the north, a number of broken-off branches have been placed at the base of the sapling that emerges here from the cliff and stretches outward (west) from the cliff face. At 1302, both ravens are seen in flight, each doing dives with barrel rolls. One raven (the male?) departs across Konold's Pond, flying over open water, then to the island, where I lose track of him at 1309. Reexamining the nest from the more southern vantage point, I see that nest-building is progressing with some large branches having been put in place. More whitewash is evident on the cliff above the nest crag.

Tuesday, February 24 (1519-1535, 35o F) – Two Common Ravens fly into the quarry space opposite the center column, coming from the north. The second raven is carrying a large branch, which it drops as it flies ca. 100 feet above the quarry floor. The two ravens circle for a minute in the quarry, doing barrel roll dives. They then fly into the nest recess, circling there for about a minute, and they both depart north beyond the north point. After the ravens have departed, the nest is examined. It is found to have had a small amount of nest material added to it. Future nest observations should be made from the more southern vantage point.

Wednesday, February 25 (1510-1540, 37o F) – During the period 1519-1522 hours, both ravens are in the quarry space. They flew in at eye level, coming in from the north, perhaps from the nest recess. After circling for three minutes, they disappeared to the south over Baldwin Drive and the center of West Rock Ridge. Checking the nest, it is found to have additional material added, but this appears to be a slow process of addition. One large branch has been added, and it projects outward to the west, some 2 to 3 feet beyond the present, rough nest dimensions. A smaller branch is below the large one, also projecting outward. The rock surface of the nest ledge appears to be unchanged. Two of the deer carcasses appear to show some work on them by mammalian predators.

Friday, February 27 (1501, 45o F, beautiful clear sky, bright sun, 0-15 mph gusts of wind from the WSW or SW) – On arrival, I approached the top of the cliff and heard raven kronking before I came into view. Two ravens lift up in the air at the carcass site, and then an immature Red-tailed Hawk lifted up directly from the deer carcass. Moments later, as the two ravens and the red-tail circled, I realized that two additional immature Red-tailed Hawks were up in the air. The ravens circled west and south of me to the quarry space, then headed south out of sight. On inspection of the nest from directly above and from the more southern vantage point, it was apparent that substantial nest-building had taken place in the last two days, with five to eight large sticks now lying over the flat rock surface. There was additional nest-building work at the base of the cliff tree where the nest building had initially begun. The long branch jutting out to the west is no longer there, or no longer so prominent. The deer carcasses are being consumed down to the bone. They should be moved by the next weekend in order to remove the hawks from the area of the raven nest.

Saturday, February 28 (1650-1730, 51o F.) – At the raven nest site, no birds are seen on the deer carcasses. Looking down on the nest crevice, I see one raven, and a moment later the second, flying below me. The second raven is carrying three small sticks. One of the ravens made three low or soft kronk calls, not expressing a lot of objection to seeing me. Both birds flew low to the north and perched on a rock ledge just out of sight, on this side of the north point. I did a quick inspection of the nest from the southern sloping rock ledge. There are now about ten sticks on the bare rock nest shelf, all parallel to each other and bundled up, running parallel to the ridge line. The nest is also taking shape around the base of the cliff sapling. The second raven was carrying the sticks in its bill and did not drop them when it flew north and perched. At 1723, I heard two cries, then three more, seemingly from a raven to the west over Konold's Pond, but I did not see the bird.

Monday, March 1 (1532 arrival at the south prom, 60o F, with hazy white clouds on the horizon and a bright sun. The cliff face is fully illuminated by the sun.) – No ravens are observed. At 1547, I relocate to the raven nest site. At 1556, I check the raven nest and find that an incredible rounded stick nest is taking shape. Viewing is from directly above and from the more southern ledge vantage point. Flies are observed on the deer carcasses for the first time. At 1607, I may have caught a glimpse of one raven, disappearing low behind the north point. Two minutes later I conclude that the bird seen was probably a crow. Departure from the ridge top at ca. 1615.

Wednesday, March 3 (0915) – Three adult peregrine falcons are observed from the quarry site, center column. The peregrines dive-bombed a Red-tailed Hawk near the quarry. One of the females departed the area shortly thereafter. The other female and the male gave several passes by me on the quarry cliff and then continued soaring out over Konold's Pond and to the distant north. Observations of the peregrines were made discontinuously over the period 0915-0940. At 1245 (50o F), one male and one female peregrine are observed in the air above the quarry. Then, they dive bomb a Red-tailed Hawk to the north. They are observed in the air for about 4 minutes. They disappear high to the south. At 1315, the raven nest is checked. New nest-building seems to have taken place, but no ravens are seen. At 1658 from the south prom outer ledge, I observe one Common Raven for several seconds, gliding out from the nest recess. It then disappears from sight. At this time of day, it is a cold, windy, very overcast day. The sun is visible in the cloud break to the west. At 1701, a raven flies north to the north point, moves to the center of the ridge, and then disappears to the north. At 1708, both ravens are seen flying in from the north. First assuming perch sites to the north, the two birds then fly into the nest recess. One raven has a mouth-full of what appears to be an excelsior-like material, light tan in color. At 1713, one raven does a quick loop flight out from the cliff and then back in and out of sight. At 1716, both ravens come out from the nest recess. One enters the quarry, flying right in front of me, and then lands on a column at the south end of the quarry. Between 1718 and 1719, a raven gathers branches from live trees north of and upslope of the nest recess, breaking the branches off from the tree and then flying in to

the nest. At 1720, the second raven flies in to the nest. Two minutes later, a raven comes out from the nest, carrying nest material, loops around once, and then returns to the nest. Over the course of the next minute or so, a raven either goes in to the nest or leaves it. At 1725, both ravens are upslope on the cliff gathering sticks. One flies to the nest. The other raven is seen to be stripping bark from the lower trunk of an Eastern Redcedar tree. At 1728, both ravens are perched on the upper north edge of the quarry. At 1729, one raven goes in to the nest carrying sticks. It is followed a minute later by the second raven carrying bark strips. During the next five minutes, both ravens gather bark strips from the redcedars growing along the upper slopes of the ridge. At 1738, both ravens fly into the quarry and glide just below me. They circle once, one of the birds gives three "kwarks", and they then disappear to the south at 1739. At 1752, I examine the redcedar tree where the ravens had been concentrating their nest gathering efforts. The ravens have definitely been pulling off strips of cedar bark; the tree trunk is all frayed. A sample of loose bark is collected from the tree. 53o F.

Thursday, March 4 (1448 arrival at West Rock) – A female Peregrine Falcon is seen up in the air at the quarry site. As I move out to the outer ledge observation shelf, a raven flies in to the quarry from the south, carrying nest material in its bill. The Peregrine Falcon immediately attacks, in the direction of the center column. The raven drops the nest material and retreats from view, seeking shelter in the trees in front of the nest site. At 1455, the female peregrine is still circling overhead. At 1456, the peregrine defecates in the air, and at 1500, it perches on the high sentinel. At 1515, the peregrine jumps off its perch site, and in another minute and a half she disappears to the south over the centerline of the ridge. During the last period of time, there have been several raven "kronks" coming form the north. At 1524, both ravens are circling in the space between the nest site and the north point. 1531, both ravens have been gathering branches along the lower north edge of the quarry (well below my line of sight toward the nest). Both now fly to the nest, one carrying nest material and the other without. At 1533, both land at the base of the cedar tree I examined yesterday. Each bird gets a large mouthful of cedar bark shavings, and each flies to the nest, dropping down into the crevice from above. At 1536, another trip is made to the nest with cedar bark. At 1537.30, both ravens are back to the cedar tree. At 1540, one raven flies to the nest with bark shavings. At 1541, the second raven flies to the nest, without nest material. At 1545, both ravens come out from the nest and fly to the vicinity of the north point, wing tip to wing tip. One lands out of sight on the cliff slope. At 1551, one raven is observed stripping bark from a thin grape vine on the talus slope below the nest site. The vine is suspended from a small tree or shrub. The bird wrestles with the vine while balanced on it. At 1554, this raven flies off the talus slope carrying one or two sticks, and it goes to the nest. At 1555, a raven flies in low to the nest. At 1556, both ravens are out in the air, then both fly in to the nest. At 1559, one raven comes out "kronking", agitated by a low-flying Turkey Vulture (one of four flying by). Kronking, the raven then lands on the top of the quarry and begins digging at grass and tree roots. The raven then lands upslope of the rock overhang and digs up three clumps of green moss and flies with the moss to the nest. 1604 departure from West Rock. [Continuation of notes is not published here.]

(3) Case Study - Peregrine Falcon (Falco peregrinus)

The Peregrine Falcon (Falco peregrinus) is known to have bred or attempted to breed in Connecticut during the period 1850-1948. All peregrine breeding from this historical period took place on trap rock ridges in the central valley lowlands of Connecticut, The four known nest sites consist of Talcott Mountain in the Avon-Farmington area, Ragged Mountain in Kensington/Berlin, the Hanging Hills of Meriden (West Peak), and Sleeping Giant (Mount Carmel) in Hamden/North Haven. In addition, Peregrine Falcon is known to have nested on the Travelers Tower (Travelers Insurance Company) in downtown Hartford during the period 1943-1948. It was extirpated as a breeding bird in the United States east of the Rocky Mountains by the mid-1960s due to

pesticide poisoning of peregrines. Additional higher order consumers whose populations were decimated by the bioaccumulation of DDT pesticide included Bald Eagles, Ospreys, and Brown Pelicans. The eastern race of the Peregrine Falcon, *Falco peregrinus anatum* , was driven to extinction. As the result of an extensive program of reintroduction of the peregrine since the 1960s, this species has recovered as a breeding bird throughout the eastern United States, and it was recently removed from the federal list of endangered species. In recent years, it has occurred in Connecticut as a fall and spring migrant. It has returned to Connecticut as a breeding bird only since the mid-1990s, and it is currently listed as a state-endangered species.

For the past seven years, I have carried out extensive field work on peregrines attempting to breed at West Rock Ridge in the Greater New Haven area. I first discovered a pair of peregrines at West Rock on Sunday, June 10, 1999 during my participation in the New Haven, Connecticut Summer Bird Count, an annual survey of birds that follows the guidelines of the early winter National Audubon Society sponsored Christmas Bird Counts (see below). That discovery has led to more than five hundred hours of field observations on Peregrine Falcon behavior. The unbanded male occupied his West Rock breeding site during the years 1999 through 2004. His mate that year was a US Fish & Wildlife Service-banded and color-banded female. The band information enabled me to trace the origins of this female. She was hatched out on Riverside Church in New York City in 1998 and was banded by a New York Department of Conservation biologist on June 4 of that year. Too young to lay eggs in 1999, this female returned to West Rock in 2000 as a mature falcon with the same mate, and on March 29 at 2:30 P.M. she laid an egg in her cliff nest – the first peregrine falcon egg to be laid on a Connecticut cliff since 1940. I witnessed the egg emerging from her body and being deposited in the nest scrape. The full details of this nesting effort and two subsequent years in which eggs have been laid at the West Rock cliff site (2001 and 2005) will be published in The Connecticut Warbler journal in future years.

My field notes record data on four additional females and one additional male peregrine that have occupied the West Rock site during the period 2001-2005. The females have included a bird that was banded in the 1999 fall migration at Assateague National Wildlife Refuge on the Eastern Shore of Virginia, two additional color-banded females whose origins have not yet been determined, and most recently, a female banded in the nest by a Connecticut State Department of Environmental Protection biologist, on a bridge in Middletown, Connecticut. The second male peregrine observed at West Rock was the partner of this Middletown bird during the 2005 breeding season.

My students will use a variety of materials from the scientific and popular literature to learn about the captive breeding program that is successfully restoring peregrines to their former range in the eastern United States, and they will apply their knowledge to the specific case of the West Rock Peregrines. As with the study of Common Ravens at West Rock Ridge, I have made written and audio-recorded field notes of my peregrine observations. I presently have assembled more than sixty microcassettes of field notes on the West Rock peregrines, each containing ninety minutes of recorded information. Some of these recorded notes are transcribed, but many have not yet been converted to computer files. To date, none of the information has been published. My students will assist in many aspects of the compilation and interpretation of these data.

(4) Connecticut Christmas Bird Count Data.

In 1900, Frank Chapman of the American Museum of Natural History in New York and a group of similarly dedicated birders initiated a census of birds during early winter that more than a century later is still held every year and is recognized as the longest running wildlife census in the world. The Christmas Bird Count, as it was initially proposed, was a one-day (December 25) effort to go out in the field and locate and count all the

birds in a defined area. The Christmas Bird Count was established in direct response to the late Victorian tradition in America, known as the side hunt, of going out on Christmas Day and shooting birds and other wildlife for the dinner table and for sport. In the era of the millinery trade, birds were being shot by the hundreds of thousands by professional market hunters to satisfy the style fashions of women and men who considered themselves best dressed when wearing the feathers or wings or whole bodies of birds on their hats, coats, and gowns. Conservation-minded citizens, including these ornithologists, reached the conclusion that we were devastating our wildlife through such wanton consumptive use and that a different relation with the natural world had to be developed. Today, the National Audubon Society and local Audubon chapters or birding organizations conduct several thousand bird counts throughout the United States and the Americas. These counts, which are held on designated days during the period December 14 through January 5, take place in defined fifteen-mile count circles, and they begin at 12 Midnight and proceed until the following 12 Midnight. Birders with experience ranging from beginners to highly skilled field observers have the task of checking all suitable habitat for anything that has feathered wings (caged or domesticated birds excluded). For many of us, the Christmas Bird Count is one of the highlights of the birding year.

For nearly twenty years, I served as the compiler of the New Haven Christmas Bird Count, and I continue to serve as compiler for the statewide Connecticut Christmas Bird Counts, a task that I have assumed for the past eighteen years. Each year, I tabulate the results of all Christmas Bird Counts held wholly or partially in the state, comparing the results with the previous thirty years of count data. I then write a review article that is published in *The Connecticut Warbler* (Connecticut's journal of ornithology) on the results of the year's bird counts. There are six bird counts conducted in the northern regions of Connecticut (Hartford and Storrs CBCs are examples), five mid-state counts (including Woodbury-Roxbury and Quinnipiac Valley), and seven coastal counts (among them, Greenwich-Stamford, New Haven, and New London). The spreadsheets of birding data that I have produced and that I add to each year now cover the period 1960-2004 in Connecticut. These CBC data offer rich material for studying the population trends for 250 species of birds that occur in the state during early winter. They lend themselves to potential science classroom study and also to science fair projects. My students will use these data to determine trends in winter bird populations over the last several decades.

For example, a number of bird species have increased in numbers dramatically in recent years, including such "southern species" as Turkey Vulture, Black Vulture, Red-bellied Woodpecker, Tufted Titmouse, Carolina Wren, and Northern Cardinal. Other species, including many grassland and deep forest birds, have gone through significant declines in numbers during the same years. These species include American Black Duck, Ring-necked Pheasant (an introduced species), Ruffed Grouse, Sharp-shinned Hawk, American Kestrel, American Woodcock, Loggerhead Shrike, Brown Thrasher, European Starling (another introduced species), Eastern Meadowlark, and Evening Grosbeak. I envision my students working with this large database of information to develop projects on such topics as arrivals and losses of bird populations, causes of population fluctuations, habitat loss in Connecticut, successful conservation measures to restore birds to the region, and the occurrence of rare, vagrant species.

Annotated Teacher Bibliography

Cracraft, Joel, and Francesca T. Grifo. 1999. The living planet in crisis: biodiversity science and policy. New York: Columbia University Press, 311pp. A significant contribution to the literature on biodiversity from American Museum of Natural History researchers.

Daily, Gretchen C. 1997. Nature's services: societal dependence on natural ecosystems. Washington, D.C.: Island Press, 392pp. A five part edited volume, addressing economic issues of valuation, overarching services, services supplied by major biomes, case studies, and conclusions.

Grifo, Francesca, and Joshua Rosenthal, eds. 1997. Biodiversity and human health. Washington, D.C.: Island Press, 379pp. In recent years, biodiversity has been linked with human health, national defense, and other global issues.

Knight, Richard L., and Suzanne Riedel, eds. 2002. Aldo Leopold and the Ecological Conscience. New York: Oxford University Press, 190pp. Thirteen essays on [Aldo] "Leopold's relevance to today's social and environmental changes," including one by Stephen R. Kellert of the Yale School of Forestry and Environmental Studies.

Levin, Simon. 1999. Fragile dominion: complexity and the commons. Reading, Massachusetts: Helix Books/Perseus Books, 250pp. Two chapters were used as readings in the seminar. The complete book is challenging and enlightening. A merging of ecology, evolutionary biology, complex systems theory, and biodiversity to address key questions about patterns in nature, historical considerations, ecosystem assembly, structure and function, and ecosystem resiliency.

Reaka-Kudla, Marjorie L., Don E. Wilson, and Edward O. Wilson, eds. 1997. Biodiversity II: understanding and protecting our biological resources. Washington, D.C.: Joseph Henry Press, 551pp. The follow-up volume on biodiversity from the National Academy of Sciences.

Soule, Michael E., and Gordon H. Orians, eds. 2001. Conservation biology: research priorities for the next decade. Washington, D.C.: Island Press, 307pp. Described by ecologist David Wilcove as "an informed synopsis of today's accomplishments in the field of conservation biology, and a guide to tomorrow's breakthroughs."

Wilson, Edward O. 2002. The future of life. New York: Alfred A. Knopf, 229pp. An up-to-date account of the value of biodiversity by the leading figure in the field.

Wilson, Edward O. 1992. The diversity of life. New York: W.W. Norton & Company, 424pp. An earlier work by this Pulitzer Prize winning author.

Wilson, E.O., ed. 1988. BioDiversity. Washington, D.C.: National Academy Press, 521pp. This National Academy of Sciences publication laid the groundwork for all subsequent works on biodiversity.

Worster, Donald. 1994. Nature's economy: a history of ecological ideas (Second edition). New York: Cambridge University Press, 507pp. Read during the course of the seminar, this classic work will (along with works by such authors as Roderick Nash) lead to further refinement of this curriculum unit to include a section on the environmental ethic.

Additional References - Vertebrates of Connecticut

Amphibians and Reptiles

Babbitt, Lewis Hall. 1937. The amphibia of Connecticut. Hartford: State Geological and Natural History Survey, Bulletin 57, 50pp+plates. Early but important check-list of the amphibians of the state.

Klemens, Michael W. 1993. Amphibians and Reptiles of Connecticut and Adjacent Regions. Hartford, Connecticut: State Geological and Natural History Survey of Connecticut, Department of Environmental Protection, Bulletin No. 112, 318pp. The essential work on Connecticut's herpetofauna. Includes some of my early field notes on copperheads at West Rock Ridge.

Lamson, George Herbert. 1935. The reptiles of Connecticut. Hartford: State Geological and Natural History Survey, Bulletin 54, 35pp+plates. Counterpart to the state natural history survey publication on amphibians.

Birds

Askins, Robert A. 2000. Restoring North American birds: lessons from landscape ecology. New Haven, Connecticut: Yale University Press, 320pp. Highlights the changing landscape in Connecticut and the United States and the resultant population declines in deep forest, grassland, and other groups of birds. Written by a Connecticut College biologist, a leader in the study of songbird declines.

Bagg, Aaron Clark, and Samuel Atkins Eliot, Jr. 1937. Birds of the Connecticut Valley in Massachusetts. Northampton, Massachusetts: The Hampshire Bookshop, 813pp. Important nineteenth and early twentieth century field data on bird species occurrences and distributions in Massachusetts and neighboring Connecticut.

Merriam, C. Hart. 1877. A review of the birds of Connecticut, with remarks on their habits. Transactions of the Connecticut Academy of Arts and Sciences, Volume IV, Part 1. Pages 1-150. The state's second check-list of birds.

Sage, John Hall, Louis Bennet Bishop, and Walter Parks Bliss. 1913. The birds of Connecticut. Hartford: State Geological and Natural History Survey, Bulletin No. 20, 370pp. The state's third check-list of birds.

Zeranski, Joseph D., and Thomas R. Baptist. 1990. Connecticut Birds. Hanover, New Hampshire: University Press of New England, 328pp. The most current descriptive check-list of the birds of Connecticut, by two active state birders.

Mammals

Goodwin, George Gilbert. 1935. The mammals of Connecticut. Hartford: State of Connecticut, State Geological and Natural History Survey, Bulletin No. 53, 221pp+33 plates. Published during the same time period as the amphibians and reptiles check-lists.

Whitaker, John O., Jr., and William J. Hamilton, Jr. 1998. Mammals of the Eastern United States (Third Edition). Ithaca, New York: Cornell University Press, 583pp. Good reference material.

Student Reading List (Including Reference Materials).

Allaby, Michael. The concise Oxford dictionary of ecology. New York: Oxford University Press, 415pp. A useful source of definitions for ecological terms.

College Entrance Examination Board. 2001. Environmental science: course description (the "Acorn Book"). New York: College Entrance Examination Board/Advanced Placement Program, 45pp. The AP Environmental Science course is "designed for highly motivated students in secondary schools."

Groombridge, Brian, and Martin D. Jenkins. 2002. World atlas of biodiversity: Earth's living resources in the 21st century. Berkeley, California: University of California Press, 340pp. An important source of information on global biodiversity, prepared by the United Nations Environment Programme, World Conservation Monitoring Centre. Outstanding maps and charts.

Hammerson, Geoffrey A. 2004. Connecticut Wildlife: Biodiversity, Natural History, and Conservation. Hanover, New Hampshire: University Press of New England, 465pp. The most significant recent contribution to the literature on Connecticut's natural history and ecology, written by a friend and colleague.

H. John Heinz III Center for Science, Economics and the Environment. 2002. The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. Washington, D.C.: Cambridge University Press, 270pp. Chapters deal with core national indicators of the condition and use of U.S. ecosystems, followed by analysis of coasts and oceans, farmlands, forests, fresh waters, grasslands and shrublands, urban and suburban lands.

Miller, G. Tyler, Jr. 2002. Living in the Environment: Principles, Connections, and Solutions (Twelfth Edition). Belmont, California: Brooks/Cole – Thomson Learning, 758pp+appendices. The text book used in my AP Environmental Science course. It is updated every two years.

Novacek, Michael J., ed. 2001. The biodiversity crisis: losing what counts. New York: American Museum of Natural History/The New Press, 224pp. Highly adaptable to pre-college science teaching.

Raven, Peter H., and Linda R. Berg. 2001. Environment (Third Edition). Fort Worth, Texas: Harcourt College Publishers, 612pp+appendices. Used as a supplemental text for the APES course. I consider this the best environmental science text available today.

Ricketts, Taylor H., Eric Dinerstein, David M. Olson, Colby J. Loucks, et al. 1999. Terrestrial Ecoregions of North America: A Conservation Assessment. Washington, D.C.: Island Press, 485pp. This publishing house is a leader in releasing timely books on the fields of ecology, environmental science, and conservation biology.

Smith, Robert Leo, and Thomas M. Smith. 1998. Elements of ecology (fourth edition). San Francisco: Benjamin Cummings/Addison Wesley Longman, Inc., 567pp. The ecology text I have used in teaching graduate level ecology courses.

Stein, Bruce A., Lynn S. Kutner, and Jonathan S. Adams, eds. 2000. Precious heritage: the status of biodiversity in the United States. New York: Oxford University Press, 399pp. (A joint project of The Nature Conservancy & Association for Biodiversity Information.) An extremely important, well-illustrated review of biodiversity in the United States. One chapter provides the background material for one of this unit's sample lesson plans.

Classroom Materials.

A comprehensive slide set on representative vertebrates of West Rock Ridge, including many of the species mentioned in this curriculum unit. Also, representative plant associations, habitat types, and ecosystems of southern New England. These slides are presently being scanned for use in PowerPoint presentations in support of the unit.