Institute of Water Resources

Annual Technical Report

FY 1999

Introduction

Eileen Jokinen, the Associate Director of the Institute, retired in August 1999. Dr. Patricia Bresnahan is the Institute's new Associate Director. Pat will spend half-time with the Institute and half-time as a Research Associate with Dr. David Miller working on the Connecticut Airshed Quality Model and related research. Dr. Hugo Thomas who has been Director of the Institute since October 1994 will retire on June 30, 2000. Dr. Glenn Warner will replace him as the part-time Director of the Institute. The Connecticut Institute received a favorable evaluation by the national panel. The University of Connecticut was notified of the recertification of the Institute's eligibility to receive grants under the provisions of Section 104 of the Water Resources Research Act. In fact the panel indicated that the Connecticut Institute is now among the stronger institutes. In particular, they cited the collaboration with the Connecticut Environmental Research Institute (ERI) and the Connecticut Department of Environmental Protection (DEP) "as worthy of praise". Weaknesses were cited in information transfer with a recommendation to develop a Web site, and direct discretionary State and University funding. In response, the Institute has already established a Web site at: http://www.ctiwr.uconn.edu. The Institute is working with the Connecticut Department of Environmental Protection on a legislative authorization for an Environmental Research Fund. However, this effort was not successful in the current session of the General Assembly, but will be reconsidered next year. The relationship between IWR and ERI remains strong. There is a regular meeting once a week with representatives of IWR, ERI and DEP to review and discuss existing research projects and future research opportunities. A quarterly Council meeting is held with the DEP Commissioners and Bureau Chiefs for longer term overviews. The Director of the Marine Science and Technology Center is also invited to the Council meetings. This relationship ensures continued collaboration among the three dominant water-related research institutions in Connecticut and the State government agency most responsible for implementing water policy and programs. The College of Agriculture and Natural Resources has several thematic research groups. The concept is to bring together faculty from throughout the College that have a common interest and provide a better means of collaboration among themselves and the external University community. The Water Resources Group is chaired by Dr. David Schroeder from the Department of Natural Resources Management and Engineering. IWR participates in this group and recently proposed some new activities for the group to consider. The Institute continues to have a Technical Committee, composed of academic researchers and a State Advisory Board, composed of diverse water resource related organizations. Two joint regular meetings were held during the reporting period. On advice of the State Advisory Board, the Institute focused on more policy relevant research in recent years. Institute supported research on mercury and chlordane in fish tissue has lead to the Connecticut Department of Public Health revision of its fish consumption advisory. Research on the contribution of copper-based architectural material to copper concentrations in surface water runoff has resulted in the Department of Environmental Protection reconsidering its guidance document on Best Management Practices. Research and outreach on the invasive species Lythrum Salicaria (purple loosestrife) has lead to new management techniques around lakes and ponds. The assessment of the applicability of engineering hydrologic models in Connecticut is resulting in major changes in the coefficients and methodologies used in regulations and guidance documents for the engineering design of surface water structures and flood management projects by the Bureau of Water Management in the Connecticut Department of Environmental Protection. The results of current research on internal phosphorous loading in ponds is expected to provide a major contribution to a state-wide problem dealing with the accelerated eutrophication of lakes and ponds in Connecticut. The research supported by the regional grant program on habitat suitability for brown trout has received additional support from the U.S. Park Service for its Wild and Scenic Rivers program in Southern New England, and the results are also being considered for utilization in flow release management from run-of-the river impoundments.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Using a paleolimnological approach as a tool for protecting,restoring and understanding aquatic ecosystems
Project Number	C-01
Start Date	09/01/1996
End Date	08/31/1999
Research Category	Biological Sciences
Focus Category #1	Water Quality
Focus Category #2	Acid Deposition
Focus Category #3	Conservation
Lead Institution	Institute of Water Resources

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Peter Siver	Unknown	Connecticut College	01

Problem and Research Objectives

Problem and Research Objectives: It is rare to find historical data on lakes that span more than 20-30 years (e.g. Eilers et al., 1989; Brenner et al., 1993; Siver et al., 1996). The use of the paleolimnological method in reconstruct-ing previous lakewater conditions has provided scientists and lake managers with a powerful means of compensating for this overwhelming lack of historical data. This multi-disciplinary ap-proach, which incorporates the most current modeling methods, allows the inference of significant relationships between chemical, physical, and biological data within a lake system in the absence of other consistent and reliable data. This approach is an especially useful tool for lake managers and associations in order to find how their lake has responded to possible changes in both the lake and it's surrounding watershed back in time. Without this historical perspective, it is virtually im-possible to make predictions about the future of the waterbody. In recent years paleolimnological methods have provided a means of producing highly significant and quantitative inference models (see Smol, 1995 for a review). Over the recent past the focus of the PI's laboratory has been to develop inference models using either scaled chrysophytes, dia-toms, or both groups that could be utilized to address lake management issues and test scientific hypotheses. Highly significant inference models for pH (Siver and Hamer, 1990), specific con-ductivity (Siver 1993), and trophic status (Siver and Marsicano, 1996) have been developed for scaled chrysophytes based on a calibration set of 60 Connecticut lakes. The major objectives of this research are three-fold: (A) To test the applicability of the Connecti-cut based inference models to three other regions in the New England region (B) To apply the inference models to three different lake management projects in order to provide the groups with invaluable baseline or historical data (C) To increase the statistical viability of the models. In order to accomplish these objectives, three specific projects were focused on. The first main application involved work with the New England Resource Protection Project (NERPP) which represents an effort to identify high priority natural resources and to formulate and implement appropriate strategies for their protection. Several of the criteria for protecting aquatic habitats would include a) resources that are special or unique in nature, b) lakes that have not experienced significant anthropogenic change over the past century, c) those with rare or en-dangered taxa, and d) areas that can be protected the easiest with limited financial resources. An objective of this study would be to utilize the paleolimnological approach to examine four such lakes in Connecticut. The second application was to work with state organizations in Vermont and New Hampshire in order to help determine the reference conditions of their lakes. The agencies are particularly in-terested in determining realistic goals based on baseline data established by using paleolimnologi-cal methods. Therefore we wanted to test our Connecticut models to see if they indeed provided a valid description of the Vermont and New Hampshire lakes. If so, then monies provided to the states could be focused on actual restoration efforts rather than the development of new models, a time consuming and expensive process. The third and final application utilizes the paleolimnological method in order to help elucidate sediment sulfur dynamics of lakes and ponds on Cape Cod, Massachusetts. The PI, in association with Dr. Anne Giblin (The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA) planned to investigate the dynamics of sulfur storage in the sediments of these lakes along a tro-phic gradient. This requires an understanding of both the pH and the trophic structure of these lakes over time.

Methodology

Methodology: Surface sediments and intact cores were collected from all of the study lakes and subsamples of the sediments were extracted for the preparation of permanent slides, scanning electron micros-copy (SEM) preparations, and chemical analyses. A minimum of 300 chrysophyte scales from each sample were enumerated from prepared slides with light microscopy (LM). Prior to enu-meration with LM, taxon identifications of the scaled chrysophytes were verified using SEM. All chemical analyses of the Cape Cod lakes was completed by the PI or by colleagues at the Marine Biological Laboratory using methods outlined in Canavan and Siver (1994).

Principal Findings and Significance

Principal Findings and Significance: 1) A detailed description of the scaled chrysophyte flora from 12 northern New England lakes (paper in press, Nordic Journal of Botany) has been documented. 2) A detailed description of the scaled chrysophyte flora from Cape Cod, Massachusetts (paper in press) has also been documented, including a proposed new species. 3) We were able to describe the limnological conditions of 60 lakes on Cape Cod in relation to distance from the mainland onto the outer peninsula.

One interesting finding is that the majority of very acidic lakes are concentrated on the outer part of the Cape. Another finding is that there is a distinct specific conductivity gradient in waterbodies from the mainland out onto the peninsula (paper in press in Lake and Reservoir Management). The limnological data gathered during this project were added to our searchable data base on the web. 4) It was determined that the paleolimnological inference models for pH, trophic score and spe-cific conductivity developed in Connecticut for scaled chrysophytes are appropriate for use in northern New England (paper in press, Nordic Journal of Botany). Results from our models were compared to existing water chemistry data taken by state agencies in both Vermont and New Hampshire. We believe that the same Connecticut-based inference models will also be useful in historical reconstructions of Cape Cod lakes. 5) Organismal inference models were applied downcore in Uncas, Norwich and Coventry lakes, three Connecticut lakes of interest in Application #1. It was determined that Norwich and Uncas lakes, but not Coventry, have been relatively stable in regards to pH and specific conductivity over the last ca. 150 years despite receiving significant amounts of acid deposition. Coventry has actually significantly increased in pH, trophic condition and specific conductivity over the last century. 6) Through the use of paleolimnological methods it has been determined that Uncas and espe-cially Norwich Pond represent waterbodies that should be considered for conservation efforts re-garding microscopic algal organisms. We had previously determined that Bigelow Pond in Union Connecticut harbors one of the most diverse floras of chrysophyte organisms known in the world. Bigelow Pond is also the site from which several new species were originally described. We strongly suggest that this lake deserves consideration in future conservation efforts. The methods developed, in part from this study, are now being applied by our laboratory to other regions of the country (e.g. the Ocala National Forest in Florida). 7) It was further determined that total sulfur concentrations have significantly increased in most, if not all, sediment cores examined from Connecticut lakes, including Uncas and Norwich lakes. The results of an undergraduate Honor's thesis (Ricard 2000) quantified the amount of alkalinity generation the increased sulfur storage represents relative to the acid deposition levels. It was determined that in-lake alkalinity generation was adequate to neutralize all impinging hydrogen ions from precipitation falling directly onto the lakes. We suspect that such a finding would not apply to lakes known to have acidified and where increases in total sulfur storage did not occur.

Descriptors

Articles in Refereed Scientific Journals

1) Siver, P.A. In press. The scaled chrysophyte flora of Cape Cod, Massachusetts, USA, with special emphasis on lake water chemistry. Proceedings of the Fifth International Chrysophyte Symposium. 2) Ahrens, T.A. and P.A. Siver. In press. Trophic conditions and water chemistry of lakes on Cape Cod, Massachusetts, USA. Lake and Reservoir Management. 3) Siver, P.A. and A.M. Lott. In press. Preliminary investigations on the distribution of scaled chrysophytes in Vermont and New Hampshire, USA, lakes and their utility to infer lake water chemistry. Nordic Journal of Botany. 4) Siver, P.A., Lott, A.M., Cash, E., Moss, J. and L.J. Marsicano. 1999. Century changes in Connecticut, U.S.A., lakes as inferred from siliceous algal remains and their relationships to land-use change. Limnology and Oceanography 44(8): 1928-1935. 5) Siver, P.A. 1999. Morphological observations of Synurophycean algae from some acidic habitats, including the description of a sub-specific taxon. Nordic Journal of Botany 19:121-127.

Book Chapters

Dissertations

1) "Factors controlling the neutralization of acids in three Connecticut lakes". Richard P. Ricard. 2000. Honor's Thesis, Connecticut College, 50 pages. 2) "A paleolimnological examination of acidity trends within two Cape Cod kettle ponds". Arin M. Doherty. 2000. Honor's Thesis, Connecticut College, 60 pages. 3) "A paleolimnological reconstruction of Hamblin Pond, Barnstable, Massachussetts, USA". Ilana B. April. 2000. Honor's Thesis, Connecticut College, 59 pages. 4) "The physical properties, trophic conditions, and water chemistry of 60 lakes on Cape Cod". Toby D. Ahrens. 1999. Honor's Thesis, Connecticut College, 67 pages. 5) "A guide to the Silica Secchi Disk: the structure, use, and maintenance of a searchable web site and database containing lake and organism data. Daniel C. Thompson. 1999. Honor's The-sis, Connecticut College, 30 pages.

Water Resources Research Institute Reports

Conference Proceedings

1) "Century changes in Connecticut lakes: the impact of changing landuse on water quality". Pe-ter A. Siver, New England Chapter of the North American Lake Management Society (NECNALMS), Storrs, Connecticut, 2000. 2) "Alkalinity generation and acidic deposition: why have Connecticut lakes not acidified?" Richard P. Ricard and Peter A. Siver. New England Chapter of the North American Lake Man-agement Society (NECNALMS), Storrs, Connecticut, 2000. 4) "The Silica Secchi Disk: An interactive phycological and limnological tool". Peter A. Siver, Anne-Marie Lott, and Daniel Thompson. Northeast Algal Symposium (NEAS), Rhode Island, 2000. 5) "The paleolimnology of two ponds located on Cape Cod". Ilana April, Arin Doherty and Pe-ter A. Siver. Northeast Algal Symposium (NEAS), Rhode Island, 2000. 6) "Using paleolimnology to understand the effects of changing watershed landscapes on lake water quality." Peter A. Siver, North American Lake Management Society (NALMS), Alberta, Canada, 1998. 7) "Using biological and chemical remains in lake sediment cores to elucidate changes in lake water quality: case studies of Connecticut lakes." Peter A. Siver, Anne-Marie Lott, and Anne Giblin, North American Lake Management Society (NALMS), Alberta, Canada, 1998. 8) "Century changes in Connecticut lakes." Peter A. Siver, New England Association of Environ-mental Biologists (NEAEB), Vermont, March 1999. 9) "The scaled chrysophyte flora of Cape Cod, Massachusetts, USA, with special emphasis on lake water chemistry." Peter A. Siver, Fifth International Chrysophyte Symposium, Edwardsville, IL, August 1999. 10) "Using scaled chrysophytes to help elucidate effects of acidic deposition on softwater lakes: case studies for southern New England." Peter A. Siver, International Botanical Congress, St. Louis, Missouri, August 1999.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A multi-scale study of vernal pools: From Litter to landscape level
Project Number	C-02
Start Date	09/01/1997
End Date	06/30/1999
Research Category	Biological Sciences

Focus Category #1	Wetlands
Focus Category #2	Ecology
Focus Category #3	Hydrogeochemistry
Lead Institution	Institute of Water Resources

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Charlotte Pyle	Assistant Professor	The University of Connecticut	01
Eileen Jokinen	Unknown	The University of Connecticut	02

Problem and Research Objectives

Problem Vernal pools are a type of ephemeral wetland found throughout the world. Vernal pools possess many aspects of independent ecosystems differing from surrounding terrestrial environments, permanent wetlands, or permanent ponds. The pools represent a unique system, which alternates between aquatic and terrestrial within any given year (Wetzel 1983). In addition, the major carbon source for forested pools is not in-pool photosynthesis but leaf litter from the surrounding forest thus creating a detritus based system (such as found in first and second order streams (Allan 1995)). The primary identifying characteristic of vernal pools is that they are dry for some part of the year, usually in summer and early autumn. Therefore, they do not, in our region, harbor fish populations which, in permanent ponds, act as predators. Thus, organisms (or their larvae) which would not survive fish predation are able to survive. In north temperate zones, vernal pools are critical to the survival of several amphibians such as spotted, marbled, and Jefferson salamanders, wood frogs, and eastern spadefoot toads (Klemens 1993). These organisms, some of which are endangered, deposit their eggs in the pools where the larvae develop, metamorphose, and leave the ponds for the surrounding woodlands. Certain invertebrates, the best known of which are fairy shrimp, survive only in vernal pools, probably because of a combination of low predation rates and eggs, which require freezing and/or drying to be viable (Pennak 1989). The pools also serve as habitat for hundreds of organisms which may spend all (e.g. crustaceans, mollusks) or part of their life cycle (e.g. insects with aquatic larvae) as part of the pool ecosystem. Species may survive the drying of the pool by aestivating (Jokinen 1978), by having rapid life cycles, or by leaving the pool when mature. Because southern New England forests are becoming fragmented by suburban and recreational development, there has been an increased interest in the preservation of vernal pools as unique wetlands (Donahue 1996; Kenney 1995; Colburn 1991; Fellman 1998). Legislation defining temporary pools almost always includes the presence/absence of specific amphibians (listed above) and/or fairy shrimp because these organisms are highly visible and often fall into endangered or rare categories. Dearth of real data on the rest (95%) of the pool community the habitat as defined by physical/chemical parameters, and the cyclical trends and patterns is forcing government groups to resort to anecdotal and oversimplified information which may result in eliminating many vernal pools from potential protection. Our observations over the past two years have noted a number of pools which do not have the "proper" amphibians, fairy shrimp, wetland vegetation, wetland soils, nor confined basins. The uniqueness of vernal pools requires comprehensive assessment at all levels: biology, chemistry, hydrology, physical characteristics (e.g. duration of drought and what controls it), and surrounding terrain. With increased forestland development, it is important to be able to locate and protect vernal pools. However, vernal pools can require intensive field reconnaissance to locate, a time consuming element, which will discourage planners, and permitting agencies from locating pools prior to development. If an easier method (model) can be developed to shorten the time required to locate pools, planners and agencies will be encourage to direct development away from vernal pools. Objectives A. Biological/Chemical Aspects: Since February 1997, we have gathered the following field information from 26 vernal pools in southern New England: 1) Diversity data (benthos+plankton): for each sampling period and for total pond season; 2) Dominant species (or taxa) for each pond for each period and the changes in the community structure through a season; 3) Density of organisms as proportional to number of individuals caught in each pond at each sampling period (numbers of animals large enough to be caught by a fine-meshed plankton net and a dip net); 4) Length of time each pool is active (holds water) and patterns of pool filling and drying (ice and water depths); 5)Seasonal temperature changes; 6)Maximal depth and area of each pond; 7) Initial chemistry values as measured in the field (dissolved oxygen, conductivity, pH); 8) Ongoing water analyses for cations (Ca, Mg, Na, k), conductivity, total phosphorus, ammonia/nitrate, sulfur, alkalinity, dissolved inorganic carbon, total organic matter, tannins, and lignins); 9) Whether pools are confined to basins without inlets or whether they are formed by intermittent streams; 10) Soil samples from beneath the pools with no inlets to indicate nature of subsoil and Presence/absence and nature of aquatic vegetation; 12) Nature of surrounding terrestrial vegetation and resultant allochthonous leaf litter; 13) Aerial photos and GPS locations; 14) Groundwater wells in place at two locations. The above data will be used (a) to describe in-pool community dynamics, and (b) to test whether types of taxa (copepods, cladocerans, ostracods, mollusks, et.) total diversity (number of taxa) and community structure of the ponds are determined by a suite of physico-chemical factors. B. GIS-based landscape profiles. The objective of this aspect of the research is to determine whether or not the general areas in which vernal pools are found are significantly different from the average conditions in the larger landscape as assessed by GIS analysis.

Methodology

A. Biological/chemical: The field work on 26 ponds will be competed by February 1999. Field studies on six ponds will continue as part of two graduate degree studies not included in this proposal. Data from all 26 ponds will be used for statistical analyses. Identification manuals used to identify the invertebrates include Belk (1975), Henderson (1990), Jokinen (1983 and 1994), Means (1979) Merritt and Cummins (1996), Peckarsky et al. (1990), Pennak (1989), Smith (1995), Thorp and Covich (1991), Wiggins (1996), and Wood et al. (1979). Water samples were taken from the ponds on each trip (every two weeks in spring, once/month during winter in one liter poly bottles. Additional samples are collected for dissolved inorganic carbon (DIC). Water is being analyzed by standard methods: Cations by atomic absorption and emission with a Perkin Elmer Atomic Absorption Spectrophotometer Model 306; conductivity on a YSI Model 16 conductivity bridge, cell constant-0.1; total phosphorus by the ascorbic acid method; ammonia by the Nesslerization method; nitrate by the cadmium reduction method; sulfide by the methylene blue method; alkalinity by titration to a fixed endpoint (pH=4.5); dissolved inorganic carbon (DIC) by MSA infra-red analyzer; total organics from ash-free dry weight at 550° C; pH by Corning Model 10 pH meter and combination electrode; and tannins and lignins colorimetrically. All equipment necessary for analyses is available at the University of Connecticut. Graphical and statistical analyses: (1). The community structure of each pool for each collection date will be graphed as a percentage of each taxon as part of the whole sample community. This illustrates the community dynamics of each pool (dominant species, changes in dominance through time, predators, etc.). From the diagrams we can compare and contrast pools for community structure. Statistical analyses (arcsine transformation on specific dominant taxa (e.g. harpacticoid copepods, daphniid cladocerans) between ponds (for specific dates) and within ponds (over a series of dates) will test whether the perceived differences are significant. (2). Multivariate and principal components analyses (Harris 1975, Orloci e5t al. 1979) will be run using the software program Statistical Analyses Systems (SAS, SAS Institute 1982). Analyses will determine which factors may be influential in structuring the taxonomic diversity and presence/absence of species. Data to be used in the statistical analyses will include: presence/absence of taxa; mean water chemistry values, maximum depth and area, presence/absence of in-pool vegetation, hydrological status (is pool groundwater controlled or is it part of an ephemeral stream system), and number of months of standing water. (3). The hypothesis that vernal pools will fall into categories defined by basin type, carbon source, water flow, duration of standing water, chemistry, and community dominants will be tested by cluster analysis (Pielou 1984). B. GIS-based landscape profiles. A set of 25 vernal pools documented in the 1997-1998 funded project (U.S. Geological Survey Report No. GR-02661-2, 1998) will be used to develop profiles of general areas in which vernal pools are likely to be found. (These pools are not identical with the set of pools used for the biological/chemical part of this project, although there is some overlap). The study area will be the area covered by the Spring Hill and Coventry, CT, 7 1/2 minute U.S. Geological Survey topographic quadrangles. Global Positioning System (GPS) points have been gathered in Coventry for pools being studied by middle school students (Ken Goodale, personal communication). GPS points for the other pools were gathered in conjunction with analyses of pools from the 1997-98 project. To develop a profile of general areas in which vernal pools are likely to be found, Geographic Information System (GIS) data sets will be amassed an analyzed for the 25 vernal pools using personal computer (PC) ArcInfo and ArcView (Environmental Systems Research Institute 1990-1995, 1996). Variables chosen to be included in the GIS profile will be those for which a significant relationship with the presence of vernal pools is found. Two approaches to analyzing the significance of the variables will be taken. Chi-square goodness of fit analysis will be done for class variables. The proportions of the pools in which the variable is present will be tested against an expected value derived from calculation of the proportion of the study area in which the variable is present. The chi-square goodness of fit analysis will involve the following variables: (1) soil types, (2) surficial geology, and (3) forest cover type. T-tests will be done for continuous variables, the value of which will be measured for the vernal pool locations and for 25 randomly located points in the study area. The t-tests will involve the following variables: (1) mapped slope (calculated from Digital Elevation Model [DEM] data), (2) roughness of topography (calculated from DEM data), (3) distance form any perennial water body, (4) distance from the nearest major (Class III or greater) stream, (4) distance from nearest area of wetland soil, and (5) proportion of the area covered by wetland soils within a circle around the pool or the randomly located point. REFERENCES Allan, J.D. 1995 Stream ecology, structure and function of running waters. Chapman & Hall, London. 388 pp. Belk, D. 1975. Key to the Ahostraca (fairy shrimp) of North America. Southwestern Naturalist 20:91-103. Colburn, E.A. ed. 1991. A citizen's guide to protecting vernal pools. Massachusetts Audubon Society. 107 pp. Donahue, D. 1996. A guide to vernal pool wetland of Connecticut. University of Connecticut Cooperative Extension System Forest Stewardship Program. 18 pp. Fellman, B. ed. 1998. Our hidden wetlands. Proceedings of a symposium on vernal pools in Connecticut 1998. Yale University & Connecticut Department of Environmental Protection, Hartford. 62 pp. Henderson, P.A. 1990. Freshwater ostracods. Synopsis of the British Fauna (New Series), No. 42. Linnean Society of London and The Estuarine and Coastal Sciences Association. Universal Book Services, Oegstgeest, The Netherlands. 228 pp. Jokinen, E.H. 1978. The aestivation pattern of a population of Lymnaea elodes (Say). American Midland Naturalist 100: 43-55. Jokinen, E.H. 1983. The freshwater snails of Connecticut. State Geological and Natural History Survey of Connecticut, Department of Environmental Protection Bulletin 109. 83 pp. Jokinen, E.H. 1994. The freshwater mollusks of the inland waters of the Indiana Dunes National Lakeshore. Indiana Dunes National Lakeshore Research Program Report, Porter, Indiana. 16 pp. Kenney, L.P. 1995. Wicked big puddles. A guide to the study and certification of vernal pools. U.S. Environmental Agency, U.S. Government Printing Office. 58 pp. Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut. Bulletin No. 12:1-318. Means, R.G. 1979. Mosquitoes of New York. part I. The genus Aedes Meigen. New York State Museum Bulletin No. 430a, Albany. 221 pp. Merritt, R.W. and K.W. Cummins, eds. 1996. An introduction to the aquatic insects of North America, 3rd Ed. Kendall/Hunt Publishing Co., Dubuque, Iowa. 862 pp. Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, D.J. Conklin, Jr. 1990. Freshwater macroinvertebrates of Northeastern North America. Cornell University Press, Ithaca. 442 pp. Pennak, R.E. 1989. Fresh-water invertebrates of the United States, 3rd ed. John Wiley & Sons, Inc. New York. 628 pp. Smith, D.G. 1995. Keys to the freshwater macroinvertebrates of Massachusetts, 2nd Ed. Privately printed, D.G. Smith, Sunderland, Massachusetts. 243 pp. Thorp, J.H. and A.P. Covich, eds. 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, Inc. San Diego. 911 pp. Wetzel, R.G. 1983. Limnology, 2nd Ed. Saunders College Publishing, Fort Worth. 767 pp. Wiggins, G.B. 1996. Larvae of the North American caddisfly genera (Trichoptera), 2nd Ed. University of Toronto Press, Toronto. 457 pp. Wood, D.M., P.T. Dang and P.A. Ellis. 1979. The insects and arachnids of Canada, Part 6. The mosquitoes of Canada, Diptera:Culicidae. Biosystematic Research Institute Publication 1686, Ottawa. 390 pp.

Principal Findings and Significance

The principal finding of this work is that vernal pools support a wide array of species assemblages that are not readily characterized by relationships to the physical or environmental parameters associated with the pools. Four pools studied in detail (Jokinen 1998) differed greatly in invertebrate species composition, sequences of species dominance, trophic structure and physical parameters, such as pool size, duration of water, composition of underlying sediments, and water chemistry. The environmental parameters associated with vernal pools were recognized as operating as three spatial scales: within-pool, pool fringe, and the greater landscape scale (Pyle 1998). For the parameters measured in 30 pools, no single factor, nor any suite of factors at a single spatial scale was found to be a reliable predictor of the presence/absence of obligate vernal pool amphibians or fairy shrimp. Our results indicate that it is important to get field data for individual vernal pools. rather than to rely upon physical and environmental factors to predict species composition. This project serves as pilot data for Project B-06 (start date 03/01/1999; end date 02/28/2001).

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Jokinen, Eileen. 1998. Invertebrate communities in vernal pools. Pages 6-8 in Bruce Fellman (editor), Our Hidden Wetlands, Proceedings of a Symposium on Vernal Pools in Connecticut. Published cooperatively by the Center for Coastal and Watershed Systems of the Yale University School of Forestry and Environmental Studies and by the Wetland Management Section of the Connecticut Department of Environmental Protection. Pyle, Charlotte. 1998. Vernal pool ecosystems: similarities and differences at what scale? Pages 9-11 in Bruce Fellman (editor), Our Hidden Wetlands, Proceedings of a Symposium on Vernal Pools in Connecticut. Published cooperatively by the Center

for Coastal and Watershed Systems of the Yale University School of Forestry and Environmental Studies and by the Wetland Management Section of the Connecticut Department of Environmental Protection.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Contribution of copper-based architectural material to runoff copper concentration
Project Number	N-02
Start Date	03/01/1998
End Date	12/31/1999
Research Category	Engineering
Focus Category #1	Hydrology
Focus Category #2	Surface Water
Focus Category #3	Water Quality
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Carley	Unknown	The University of Connecticut	01
Nikolaidis	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A study of mercury in freshwater fish from Connecticut lakes.
Project Number	N-03
Start Date	06/01/1998
End Date	05/01/1999
Research Category	Biological Sciences
Focus Category #1	Toxic Substances
Focus Category #2	Water Quality
Focus Category #3	Management and Planning
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Carley	Unknown	The University of Connecticut	01
Robert Neumann	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A preliminary study of chlordane in largemouth bass from Connecticut lakes.
Project Number	N-04
Start Date	06/01/1998
End Date	05/01/1999
Research Category	Biological Sciences
Focus Category #1	Toxic Substances
Focus Category #2	Management and Planning
Focus Category #3	Non Point Pollution
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Carley	Unknown	The University of Connecticut	01
Robert Neumann	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Banded sunfish study phase 2
Project Number	N-05
Start Date	06/01/1998
End Date	05/31/1999
Research Category	Biological Sciences
Focus Category #1	Conservation
Focus Category #2	Ecology
Focus Category #3	Management and Planning
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Neumann	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	An assessment of the transferability of habitat suitability criteria for brown trout in Southern New England streams.
Project Number	C-03
Start Date	09/30/1998
End Date	09/29/2000
Research Category	Biological Sciences
Focus Category #1	Conservation
Focus Category #2	Ecology
Focus Category #3	Management and Planning
Lead Institution	Institute of Water Resources

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Richard A. Jacobson	Unknown	Connecticut Department of Environmental Protection	01
Robert Neumann	Unknown	The University of Connecticut	01

Problem and Research Objectives

Water allocation and instream flow have risen to the forefront of environmental concerns in New England. Managing water diversions to avoid resource degradations requires access to effective tools to define instream flow needs; the instream flow incremental methodology (IFIM) has generally been recognized as the most useful tool. The physical habitat simulation (PHABSIM), a component of IFIM, uses habitat suitability criteria (HSC) to translate structural and hydraulic characteristics into descriptions of habitat suitability for different fish species and life stages. The HSC describe microhabitat preferences for individual species and life stages as measurable variables (e.g., depth, velocity, substrate, and cover) that change with the quantity of water in a stream. In spite of the widespread acceptance of the IFIM and PHABSIM, concerns have been expressed regarding the transferability of species-specific HSC among streams and regions. The transferability of HSC should be tested before they are used to assess discharge and microhabitat relationships. This has never been done in New England; in each application of PHABSIM, previously developed HSC were used. The objectives of this research are to develop HSC for depth, velocity, substrate, and cover for adult brown trout in one Connecticut stream, and to assess transferability of HSC for adult brown trout in another stream. The HSC will be developed for adult brown trout in the Farmington River. Development of HSC will be based on microhabitat utilization data determined by underwater observation. The HSC developed for brown trout in the Farmington River will be tested for transferability to brown trout in the Westfield River, MA. This study will result in the first set of HSC developed from direct underwater observations in New England. The HSC and transferability test results will be useful to managers throughout New England to improve confidence in future instream flow studies.

Methodology

Development of Habitat Suitability Criteria The source stream for which habitat suitability criteria (HSC) will be developed will be an approximate 6.0-km reach of the west branch of the Farmington River (National Wild and Scenic River). Habitat suitability criteria will developed by observing and measuring the characteristics of microhabitats (e.g., depth, velocity, substrate, and cover) used by many individuals of a target organism. We will use an equal effort sampling design (Thomas and Bovee 1993) to develop HSC in this study. Direct underwater observation (Li 1988; Dolloff et al. 1996) will be used to locate the positions of brown trout at representative sites of each habitat type during midsummer 1999. At each fish location, the following microhabitat measurements will be recorded: water depth, mean water column velocity (measured at 0.6 of the depth), nose velocity (velocity at depth fish was observed), cover type, and substrate composition. Water depths will be measured with a top-setting graduated wading rod. Water velocities (mean column and nose) will be measured with either a Marsh-McBirney or a pygmy-Gurley current velocity meter (McMahon et al. 1986). Cover type and substrate measurements will utilize the same codes used in a previous instream flow assessment on the Farmington River (Normandeau Associates 1992). Habitat suitability criteria for depth, mean column velocity, nose velocity, substrate heterogeneity, substrate particle size, and cover type will be developed for both life stages of brown trout based on the optimum and suitable range approach of Thomas and Bovee (1993). Non-parametric tolerance limits (Bovee 1986) will be used to develop HSC for depth, mean column velocity, nose velocity, substrate heterogeneity, and substrate particle size. Testing Transferability of Habitat Suitability Criteria The destination stream to which HSC are to be applied and tested in the Westfield River, MA. A two-person team will observe fish at each site by snorkeling (Li 1988; McMahon et al. 1986) during early summer 2000 when water temperatures are similar to those in the Farmington River when HSC were developed. Locations occupied by brown trout will be marked with a weighted, numbered tag. At the conclusion of the dive, microhabitat variables at each location will be measured using the same methods outlined for the Farmington River. We intend to achieve microhabitat measurements for at least 100 occupied locations (combined among the four study sites) of each life stage of brown trout. Immediately after microhabitat measurements are taken for all fish locations, microhabitat will be measured at locations where fish were not observed. Microhabitat data from unoccupied locations will be systematically sampled along a series of transects laid perpendicular to the stream flow. Microhabitat measurements of depth, velocity, substrate composition, and cover will be taken at equal increments (preliminary increment = 3 m) along each transect resulting in microhabitat measurements for approximately 200 unoccupied locations sampled systematically throughout each study site. Transferability of depth, velocity, substrate, and cover HSC from the Farmington River to the Westfield will be tested based on a variation of the methods outlined in Thomas and Bovee (1993) and Groshens and Orth (1993); transferability tests will be conducted for both life stages of brown trout. Transferability will be tested for each HSC separately, and for composite suitabilities calculated for each location.

Principal Findings and Significance

During the summer of 1999 habitat suitability criteria (HSC) were developed for adult (>170mm) brown trout (Salmo trutta) on the West Branch of the Farmington River, CT. Snorkeling was used to collect microhabitat observations for 144 brown trout based on equal effort habitat sampling. Suitability criteria for depth, mean velocity, nose velocity, substrate, embeddedness, and cover were developed using non-parametric tolerance limits. Transferability of depth and velocity HSC from other sources to the Farmington River was then assessed. First, the other HSC development techniques were applied to Farmington River observations for comparison. Frequency distributions of SI values between the Farmington River and other sources were compared using the Kolmogorov-Smirnov test. Distributions of SI values from the Farmington River were significantly different than HSC from other sources. Only one of the thirteen tests showed no significant difference. Lack of transferability of other HSC to the Farmington River could be attributable to differences in habitat preference of brown trout between regions. Thus, site specific HSC may be required to accurately assess changes in habitat suitability related to changes in instream flow. Literature Cited Bovee, K. D. 1986. Development and evaluation of habitat suitability criteria for use in the Instream flow incremental methodology. U.S. Fish and Wildlife Service Biological Report 86(7). U.S. Fish and Wildlife Service, Washington, D.C. Dolloff, A., J. Kershner, and R. Thurow. 1996. Underwater observation. Pages 533-554 in B.R. Murphy and D. W. Willis, editors. Fisheries techniques, second edition. American Fisheries Society, Bethesda, Maryland. Groshens, T. P., and D. J. Orth. 1993. An assessment of the transferability of habitat suitability criteria for smallmouth bass. Virginia Water Resources Research Center Bulletin 180. Li, S. K. 1988. Measuring microhabitat in swift water. Pages 392-407 in K. D. Bovee and J. R. Zuboy, editors. Proceedings of a workshop on the development and evaluation of habitat suitability criteria. U.S. Fish and Wildlife Service Biological Report 88(11). U.S. Fish and Wildlife Service, Washington, D.C. McMahon, T. E., A. V. Zale, and D. J. Orth. 1996. Aquatic habitat measurements. Pages 83-120 in B.R. Murphy and D. W. Willis, editors. Fisheries techniques, second edition. American Fisheries Society, Bethesda, Maryland. Thomas, J. A., and K. D. Bovee. 1993. Application and testing of a procedure to evaluate transferability of habitat suitability criteria. Regulated Rivers: Research and Management 8:285-294.

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Strakosh, T, and R. M. Neumann. 2000. Development and assessment of habitat suitability criteria for brown trout in a southern New England river. Southern New England Chapter, American Fisheries Society, Winter Meeting. Strakosh, T, and R. M. Neumann. 2000. Development and assessment of habitat suitability criteria for brown trout in a southern New England river. 56th Annual Northeast Fish and Wildlife Conference. Strakosh, T, and R. M. Neumann. 2000. Development and assessment of habitat suitability criteria for brown trout in a southern New England river. Connecticut Institute of Water Resources Advisory Board and Technical Committee Meeting. April 2000. Strakosh, T, and R. M. Neumann. 2000. Development and assessment of habitat suitability criteria for brown trout in a southern New England river. 130th Annual Meeting of the American Fisheries Society.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Atmospheric mercury and nitrogen deposition network in Connecticut
Project Number	N-06
Start Date	11/01/1998
End Date	02/01/2000
Research Category	Climate and Hydrologic Processes
Focus Category #1	Acid Deposition
Focus Category #2	Toxic Substances
Focus Category #3	Non Point Pollution
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Carley	Unknown	Other	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Airshed/Watershed mercury and nitrogen modeling study
Project Number	N-07
Start Date	11/01/1998
End Date	10/30/2000
Research Category	Climate and Hydrologic Processes
Focus Category #1	Toxic Substances
Focus Category #2	Non Point Pollution
Focus Category #3	Climatological Processes
Lead Institution	The University of Connecticut

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Patricia Bresnahan	Associate Professor	The University of Connecticut	01
David Miller	Professor	The University of Connecticut	01
Xiaohong Xu	Post Doctoral Student	Other	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Leaking underground storage tanks: site locational study II.
Project Number	N-08
Start Date	12/01/1998
End Date	12/31/1999
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Management and Planning
Focus Category #3	Water Quality
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Carley	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Assessment of the applicability of engineering hydrologic models in CT
Project Number	N-01
Start Date	01/01/1999
End Date	12/31/2000
Research Category	Climate and Hydrologic Processes
Focus Category #1	Hydrology
Focus Category #2	Models
Focus Category #3	Management and Planning
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Fred Ogden	Unknown	The University of Connecticut	01
Glenn Warner	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	NEMO (Non-oint Education for Municipal Officials) application in Quinnipiac Watershed.
Project Number	N-09
Start Date	02/15/1999
End Date	07/31/2000
Research Category	Water Quality
Focus Category #1	Management and Planning
Focus Category #2	Non Point Pollution
Focus Category #3	Water Quality
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Chet Arnold	Unknown	The University of Connecticut	01
Laurie Giannotti	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	NEMO (Non-point Education for Municipal Officials) workshops and research
Project Number	N-10
Start Date	02/15/1999
End Date	02/15/2000
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Non Point Pollution
Focus Category #3	Management and Planning
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Chet Arnold	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Internal Phosphorous Loading in Ponds
Project Number	B-05
Start Date	03/01/1999
End Date	02/29/2000
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Non Point Pollution
Focus Category #3	Hydrogeochemistry
Lead Institution	Institute of Water Resources

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Peter Rich	Unknown	The University of Connecticut	01
Tom Torgersen	Unknown	The University of Connecticut	02

Problem and Research Objectives

PROBLEM AND RESEARCH OBJECTIVES Problem Glaciation left deranged drainage patterns and myriad small, shallow basins in much of north temperate America. The resulting ponds and small lakes serve as ice, fish, an fire ponds, stormwater detention and retention, water quality renewal basins, wildlife refuges, ice-skating rinks, and as ornaments in commercial and domestic landscapes. The inevitable result of the appeal and usefulness of ponds has been encroachment upon their drainage basins, excess nutrients, and poor water quality. Ponds can provide primary water quality improvement because dissolved phosphorus (PO4-3) combines with oxidized iron (Fe+3) to create insoluble compounds that can be buried in the sediments. But, in bottom sediments Fe+3 is chemically reduced to soluble Fe+2 , making P mobile once more. In deeper lakes, oxygenated water below the photosynthetic zone recycles P back to the sediments. But in shallow ponds P released by sediments is taken up by photosynthetic algae blooms faster than it can be returned to the sediments. Because residence times for water in ponds are short, a significant fraction of P released by sediments can be discharged downstream, creating poor water quality elsewhere. Research Objectives We correctly hypothesized that several related processes contribute to internal P loading in ponds: 1. Cryptic thermal stratification extends into the sediments of small ponds. 2. Thermal stratification enhances anaerobic decomposition in winter 3. Spring warming destabilizes the sediments resulting in P release 'events' from sediments.

Methodology

METHODS Study Site: Almost half the 2500 developed acres of the University of Connecticut Storrs campus drain into Mirror Lake, a man-made (excavated to 4m) detention/retention and ornamental pond (1.83 ha). A central landscape element of the campus, the pond is in the later stages of eutrophication and succession. Evidence exists of both external nutrient loading from its drainage basin and internal phosphorus loading from its sediments. Episodes of anoxia are implicated in the proliferation of Clostridium (botulism) bacilli, which periodically kill wildfowl on the pond. Outflow from Mirror Lake enters Willow Brook and eventually the Fenton River, a State stocked trout stream. Periodically, attached algae grow in the bottom of Willow Brook to its confluence with the Fenton River and for some distance downstream in the Fenton. The attached algae are associated with high levels of phosphorus in water leaving and immediately downstream of Mirror Lake (J. Clausen pers. comm.). Thus the evidence for high internal P-loading suggests that Mirror represents (what may be) a type locality to study the issue of cryptic thermal stratification, enhanced anaerobic degradation, and thermally driven internal P loading events. Thermal Stratification: Thermal stratification is being determined a) weekly by vertical sampling with an underwater thermistor and b) 96 times a day with two in situ vertical arrays of Onset StowAway® TidbiTs® Temp. transducers/data loggers. These small (0.5 oz.) self-contained units (accuracy 0.2° C) have selectable sampling intervals, 32,522 sample capacity, and are programmed and downloaded by computer. Wind velocity 10m above the water is measured nearby. The thermal sensors are arrayed on two PVC structures used for near-bottom water sampling. Initially, 8 sensors (10 cm in the sediment to 70 cm above the bottom) are deployed at the deepest point, and 4 sensors (10 cm in the sediment to 40 cm above the bottom) at mean depth. Data from the arrays will be reduced to Relative Thermal Resistance to mixing (RTR) values, and later used to calculate heat flux and coefficients of eddy diffusion (Benoit & Hemond 1996). The heat balance may have sufficient sensitivity to identify the influx of heat to the water column from the overturn of sediment and release of sediment porewater. Independent estimates of pore water eddy diffusivity used natural Radium-224 and Radon-222 as tracers (Benoit et al. 1991; Torgersen et al. 1996; Sun & Torgersen 1997b) (see below). More importantly, Ra-224 dynamics in the water column is controlled by the flux of Ra-224 from the sediments. Since Ra follows the (MnO_2) and $Fe(OH)_3$ cycles of the sediments, high concentrations of Ra-224 in the water column are directly attributable to enhanced fluxes from the sediment. Thus, Ra-224 will track destabilization release events (internal P loading events) where temperature and heat budget calculations may not have adequate sensitivity and will track the internal P loading event to a better degree than a time series of P measurements because Ra-224 is not readily involved in the biotic cycles like P. Anoxic Bottom Water: Near-bottom water is sampled (same depths as thermistors) by pumping water from vertical manifolds installed on the two vertical PVC structures (above) anchored to the lake bottom, one at the deepest point and one at mean depth. Dissolved oxygen is measured with both polarography *YSI 59) and Winkler (azide) methods. Anoxia is verified by analyses of bottom [DO], [$Fe^{+2/+3}$], [$Mn^{+2/+4}$], [HS^-], [NH_4^+],[NO_3^-], respiratory quotients ($ÄCO_2$/$ÄO_2$)(IR-CO_2 analysis), alkalinity, pH, and Eh during both summer and winter stratification. All analyses are by standard methods unless noted (ALPHA 1992). P-Release from Sediments: Total P loading is determined weekly from sediment pore water gradients (5 cm intervals), vertical water samples (0.5 m intervals), water going over the spillway, and from water entering Mirror from several large underground culverts. Origins of incoming water will be monitored by AA determinations of [Na], [K], [Ca], & [Mg] (Rich & Murray 1990). Internal P loading and anoxia will be verified by analyses of bottom water [P_{tot}] , [DO], [$Fe^{+2/+3}$], [HS^-], respiratory quotients (CO_2/O_2) (Murray & Rich 1995), and Ra-224 transport as noted above and below. Estimation of Diffusion by Radium-224: Loss of P from highly reduced sediments is controlled by loss of Fe^{+3} (as Fe^{+2}) which removes the possibility of ferric phosphate precipitation. Loss of Fe^{+2} from sediments follows closely the loss of Mn^{+4} (as Mn^{+2}). The flux of dissolved P from sediments is governed by the rates of porewater transport and $FePO_4$ reduction. Ra-224, a naturally occurring radioisotope, is moderately adsorbed to MnO_2 in the sediment, and serves as an analog for PO_4^{-3} reactions with Fe^{+3}. The redox potential at which Fe^{+3} and Mn^{+4} are reduced differs only slightly, and distributions of Mn and Fe in sediments are virtually identical in shallow and productive systems

(Cochran et al. 1997; Sun, 1998). Thus, the effects of micro-stratification and anoxia on the flux of P across the sediment-water interface have been analyzed and corroborated by Ra-224. Ra-224 (half life 3.8 days) is the daughter of naturally occurring Thorium-228 (half life 1.9 years). Th-228 is strongly particulate and Th-228 dissolved in water is negligible (Santschi 1984). Thus, most Th-228 (source of Ra-224) exists in sediments. In contrast to Th-228, however, Ra-224 is moderately soluble and the transport of Ra-224 from sediments to the overlying water column is well documented. Water column Ra-224 has been used to define salt marsh interaction with tidal inputs of seawater (Bollinger & Moore 1984, 1993; Hancock & Murray 1996; Webster et al. 1994), groundwater inputs to the water column (Rama & Moore 1996), as well as bulk transport in the water column (Torgersen et al. 1996). The release of Ra-224 from the sediment is governed by the rate of mixing in the sediment (ranging from molecular diffusion to large scale bioturbation) as well as the adsorption of Ra-224 on MnO2 in the oxidized microzone at the sediment surface. Building on the model of Benoit et al. (1991), Sun, a Ph.D. student in this laboratory, has completed a 1D model of Ra-224 transport and elaborated the interactions of the various controls for Ra-224 transport in sediments (Sun, 1998). Sun & Torgersen (1998a, 1998b) have developed new techniques of measuring Ra-224 dissolved in porewater and adsorbed on particles. Measurements are made directly, and give adsorption coefficients for sediments consistent with laboratory studies (Li & Chan 1979; Webster et al. 1995). The great advantage of the new techniques is their direct measurement of adsorption coefficients for the transport model. The transport coefficient of porewater and the mixing coefficient of sediments are obtained directly for adsorbed materials. To date the method has been used to study the role of MnO2 layer in controlling the flux of trace metals (including Fe+2) and with this study, we have extended its applications to PO4. Application of theRa-224 derived mixing coefficients for sediment to profiles of P will be used to determine the dynamics of P transport in the sediment and flux of P from the sediment. A critical check on the model is provided by measurement of Ra-224 in the overlying water column. Flux of Ra-224 from the sediment must match the flux into the water column, plus loss of Ra-224 from the water column by radiodecay (Loss of Ra-224 over the spillway is small relative to the half life of Ra-224, and will be estimated by direct Ra-224 measurement in the spillway; gain from surface flow and culvert flow into the lake is likely minimal but will be checked by direct sampling). This water column cross check also allows us to construct a Ra-224 balance for the time period over which we expect thermal destabilization of the microstratification layer. Studies before the "event", will show the balance between the Ra-224 in the water column that is supported by a diffusive flux from the sediment and the standing crop present in the pond. Immediately after the "event", we would expect Ra-224 to be very high (since it includes the sediment Ra-224 contribution from a large depth interval) and in fact so high that it cannot be explained by the diffusive flux from the sediment. This is to be considered conclusive evidence for "events" of internal P loading that drive the degradation of these small ponds. After the event, the loss of Ra-224 with time from the pond will be governed by the loss to outflow and the decay in the water column as well as possible re-adsorption on the sediments. A mass balance that indicates re-absorption indicates the reestablishment of the MnO2 and Fe(OH)3 layers which will again begin to precipitate FePO4. The dynamics of Ra-224 and the half-life of Ra-224 are thus optimal for observing the internal P loading dynamics of small ponds and will provide specific quantification of the rates and mechanisms of the processes controlling internal P loading. Estimation of Diffusion by Natural Radon-222: The porewater dynamics and cross checks with water column measures of Ra-224 can also be obtained using Rn-222 (e.g. Benoit 1991, DeAngelo 1993) in a stratified lake, but not in an unstratified pond. For an unstratified pond, the production of Rn-222 in the sediments is balanced by the loss of Rn-222 by decay in the water column and the loss to the atmosphere by gas exchange. Thus, sediment Rn-222 studies and water column measurements can be used to quantify the rate of gas exchange for a small pond and predict the rate of oxygen input. The oxygen input to the lake combined with a measure of the rate of oxygen consumption in the sediment will determine the susceptibility of the lake to sediment anoxia and P release events. That definition of susceptibility and the technique for obtaining it is a potentially valuable management tool. In this pilot project, we are evaluating the potential of Rn-222 as well as Ra-224 as a potential process quantifier for internal P loading in ponds. The sediments of Mirror Lake will be measured seasonally to monthly for profiles of P, Rn-222, and Ra-224 profiles, focussing the bulk of the coring in the spring and summer. We will use methods we have developed over the last decade for use in Long Island Sound. Because of the half-life of these isotopes, their response to changing conditions is attained on approximately the two week timescale. As a result, core samples need only be taken at 2-4 week intervals to define what could/should be. However, water column measurements are taken at shorter time intervals (5-10 days) because that response time is governed by both the tracer half life and the water residence time in the pond an critically by the "event." Box cores are taken and sectioned quickly by 1 cm interval (sufficient to define molecular levels of diffusion). Dissolved porewater concentrations are determined by centrifugation or sediment squeezers and filtration of the water phase. Measruements of dissolved Ra-224 use the concentration method of Moore (1976) and the Rn-220 measurement technique described by Rama et al. (1987), as modified by Sun & Torgersen (1998a). We have measured Ra-224 and Rn-222 in the water column biweekly (weekly to twice weekly in critical periods) including the spillway. REFERENCES Benoit, J., T. Torgersen, & J. O'Donnell. 1991. An advection/diffusion model for Rn-222 transport in near shore sediments inhabited by sedentary polychaetes. Earth Planet Sci. Lett. 105:463-473. Benoit, G. & H.F. Hemond. 1996. Vertical eddy diffusion calculated by the flux gradient method: significance of sediment-water heat exchange. Limnol. Oceanogr. 41:157-68. Bollinger, M.S. & W.S. Moore. 1984. Radium fluxes from a salt marsh. Nature 309:444-446. Bollinger, M.S. & W.S. Moore. 1993. Evaluation of salt marsh hydrology using Ra as a tracer. Geochim. Cosmochim. Acta 57:2203-2212. Cochran, J.K., D. Hirschberg, J. Wang & C. Dere. 1997. Atmospheric deposition of metals to Long Island Sound: evidence from salt marsh deposits. Submitted to Estuarine, Coastal, & Shelf Research. Hancock, J.G. & A.S. Murray, 1996. Source and distribution of dissolved radium in the Bega River Estuary, Southeastern Australia. Earth Planet Sci. Lett. 138:145-155. Li, Y.-H. & L.-H. Chan. 1979. Desorption of Ba and Ra from river borne sediments in the Hudson Estuary. Earth Planet Sci. Lett. 43:343-350. Moore. W.S. 1976. Sampling Ra-228 in the deep ocean. Deep Sea Res. 23:647-651. Murray, T.E. & P.H. Rich. 1995. Respiratory quotients predict increases in reducing products in the hypolimnion of a stratified lake. Can. J. Fish. Aquat. Sci 52:1183-89. Rama, T. Butts, & Moore. 1987. A new method for the rapid measurements of Ra-224 in natural waters. Mar. Chem. 22:43-54. Santschi, 1984. Particle flux and trace metal residence times in natural waters. Limnol. Oceanog. 29:110-1108. Sun, Yin. 1998. Ph.D. thesis. University of Connecticut (draft copy). Sun, Y. and T. Torgersen 1998a. Improved methodology for Ra-224 measurements by Rn-220 emanation: the effects of water content and Mn-fiber surface conditions. Marine Chemistry. Sun, Y. and T. Torgersen. 1998b. Rapid and precise measurement method for adsorbed Ra-224 on sediments. Marine Chemistry. Torgersen, T., K.K. Turekian, V.C. Turekian, N. Tanaka, E. DeAngelo & J. O'Donnell. 1996. Ra-224 distribution in surface and deep water of Long Island Sound: sources and horizontal mixing rates. Cont. Shelf Res. 16:1545-1559.

Principal Findings and Significance

Strong aperiodic fluxes of nutrients to & from sediments. Intense daily thermal stratification Aperiodic anoxia at bottom Blue-Green algae dominant Zooplankton size limited by Blue-Gill predation

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Progress Report

Conference Proceedings

Presentations at New England Nalms Conf. 6/00

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A study of vernal pool ecosystems in southern New England
Project Number	B-06
Start Date	03/01/1999
End Date	02/28/2001
Research Category	Biological Sciences
Focus Category #1	Wetlands
Focus Category #2	Surface Water
Focus Category #3	Ecology
Lead Institution	Institute of Water Resources

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Charlotte Pyle	Assistant Professor	The University of Connecticut	01
Eileen Jokinen	Unknown	The University of Connecticut	02

Problem and Research Objectives

Problem Vernal pools are a type of ephemeral wetland found throughout the world. Vernal pools possess many aspects of independent ecosystems differing from surrounding terrestrial environments, permanent wetlands, or permanent ponds. The pools represent a unique system, which alternates between aquatic and terrestrial within any given year (Wetzel 1983). In addition, the major carbon source for forested pools is not in-pool photosynthesis but leaf litter from the surrounding forest thus creating a detritus based system (such as found in first and second order streams (Allan 1995)). The primary identifying characteristic of vernal pools is that they are dry for some part of the year, usually in summer and early autumn. Therefore, they do not, in our region, harbor fish populations which, in permanent ponds, act as predators. Thus, organisms (or their larvae) which would not survive fish predation are able to survive. In north temperate zones, vernal pools are critical to the survival of several amphibians such as spotted, marbled, and Jefferson salamanders, wood frogs, and eastern spadefoot toads (Klemens 1993). These organisms, some of which are endangered, deposit their eggs in the pools where the larvae develop, metamorphose, and leave the ponds for the surrounding woodlands. Certain invertebrates, the best known of which are fairy shrimp, survive only in vernal pools, probably because of a combination of low predation rates and eggs, which require freezing and/or drying to be viable (Pennak 1989). The pools also serve as habitat for hundreds of organisms which may spend all (e.g. crustaceans, mollusks) or part of their life cycle (e.g. insects with aquatic larvae) as part of the pool ecosystem. Species may survive the drying of the pool by aestivating (Jokinen 1978), by having rapid life cycles, or by leaving the pool when mature. Because southern New England forests are becoming fragmented by suburban and recreational development, there has been an increased interest in the preservation of vernal pools as unique wetlands (Donahue 1996; Kenney 1995; Colburn 1991; Fellman 1998). Legislation defining temporary pools almost always includes the presence/absence of specific amphibians (listed above) and/or fairy shrimp because these organisms are highly visible and often fall into endangered or rare categories. Dearth of real data on the rest (95%) of the pool community the habitat as defined by physical/chemical parameters, and the cyclical trends and patterns is forcing government groups to resort to anecdotal and oversimplified information which may result in eliminating many vernal pools from potential protection. Our observations over the past two years have noted a number of pools which do not have the "proper" amphibians, fairy shrimp, wetland vegetation, wetland soils, nor confined basins. The uniqueness of vernal pools requires comprehensive assessment at all levels: biology, chemistry, hydrology, physical characteristics (e.g. duration of drought and what controls it), and surrounding terrain. With increased forestland development, it is important to be able to locate and protect vernal pools. However, vernal pools can require intensive field reconnaissance to locate, a time consuming element, which will discourage planners, and permitting agencies from locating pools prior to development. If an easier method (model) can be developed to shorten the time required to locate pools, planners and agencies will be encourage to direct development away from vernal pools. Objectives A. Biological/Chemical Aspects: Since February 1997, we have gathered the following field information from 26 vernal pools in southern New England: 1) Diversity data (benthos+plankton): for each sampling period and for total pond season; 2) Dominant species (or taxa) for each pond for each period and the changes in the community structure through a season; 3) Density of organisms as proportional to number of individuals caught in each pond at each sampling period (numbers of animals large enough to be caught by a fine-meshed plankton net and a dip net); 4) Length of time each pool is active (holds water) and patterns of pool filling and drying (ice and water depths); 5)Seasonal temperature changes; 6)Maximal depth and area of each pond; 7) Initial chemistry values as measured in the field (dissolved oxygen, conductivity, pH); 8) Ongoing water analyses for cations (Ca, Mg, Na, k), conductivity, total phosphorus, ammonia/nitrate, sulfur, alkalinity, dissolved inorganic carbon, total organic matter, tannins, and lignins); 9) Whether pools are confined to basins without inlets or whether they are formed by intermittent streams; 10) Soil samples from beneath the pools with no inlets to indicate nature of subsoil and Presence/absence and nature of aquatic vegetation; 12) Nature of surrounding terrestrial vegetation and resultant allochthonous leaf litter; 13) Aerial photos and GPS locations; 14) Groundwater wells in place at two locations. The above data will be used (a) to describe in-pool community dynamics, and (b) to test whether types of taxa (copepods, cladocerans, ostracods, mollusks, et.) total diversity (number of taxa) and community structure of the ponds are determined by a suite of physico-chemical factors. B. GIS-based landscape profiles. The objective of this aspect of the research is to determine whether or not the general areas in which vernal pools are found are significantly different from the average conditions in the larger landscape as assessed by GIS analysis.

Methodology

A. Biological/chemical: The field work on 26 ponds will be competed by February 1999. Field studies on six ponds will continue as part of two graduate degree studies not included in this proposal. Data from all 26 ponds will be used for statistical analyses. Identification manuals used to identify the invertebrates include Belk (1975), Henderson (1990), Jokinen (1983 and 1994), Means (1979) Merritt and Cummins (1996), Peckarsky et al. (1990), Pennak (1989), Smith (1995), Thorp and Covich (1991), Wiggins (1996), and Wood et al. (1979). Water samples were taken from the ponds on each trip (every two weeks in spring, once/month during winter in one liter poly bottles. Additional samples are collected for dissolved inorganic carbon (DIC). Water is being analyzed by standard methods: Cations by atomic absorption and emission with a Perkin Elmer Atomic Absorption Spectrophotometer Model 306; conductivity on a YSI Model 16 conductivity bridge, cell constant-0.1; total phosphorus by the ascorbic acid method; ammonia by the Nesslerization method; nitrate by the cadmium reduction method; sulfide by the methylene blue method; alkalinity by titration to a fixed endpoint (pH=4.5); dissolved inorganic carbon (DIC) by MSA infra-red analyzer; total organics from ash-free dry weight at 550° C; pH by Corning Model 10 pH meter and combination electrode; and tannins and lignins colorimetrically. All equipment necessary for analyses is available at the University of Connecticut. Graphical and statistical analyses: (1). The community structure of each pool for each collection date will be graphed as a percentage of each taxon as part of the whole sample community. This illustrates the community dynamics of each pool (dominant species, changes in dominance through time, predators, etc.). From the diagrams we can compare and contrast pools for community structure. Statistical analyses (arcsine transformation on specific dominant taxa (e.g. harpacticoid copepods, daphniid cladocerans) between ponds (for specific dates) and within ponds (over a series of dates) will test whether the perceived differences are significant. (2). Multivariate and principal components analyses (Harris 1975, Orloci e5t al. 1979) will be run using the software program Statistical Analyses Systems (SAS, SAS Institute 1982). Analyses will determine which factors may be influential in structuring the taxonomic diversity and presence/absence of species. Data to be used in the statistical analyses will include: presence/absence of taxa; mean water chemistry values, maximum depth and area, presence/absence of in-pool vegetation, hydrological status (is pool groundwater controlled or is it part of an ephemeral stream system), and number of months of standing water. (3). The hypothesis that vernal pools will fall into categories defined by basin type, carbon source, water flow, duration of standing water, chemistry, and community dominants will be tested by cluster analysis (Pielou 1984). B. GIS-based landscape profiles. A set of 25 vernal pools documented in the 1997-1998 funded project (U.S. Geological Survey Report No. GR-02661-2, 1998) will be used to develop profiles of general areas in which vernal pools are likely to be found. (These pools are not identical with the set of pools used for the biological/chemical part of this project, although there is some overlap). The study area will be the area covered by the Spring Hill and Coventry, CT, 7 1/2 minute U.S. Geological Survey topographic quadrangles. Global Positioning System (GPS) points have been gathered in Coventry for pools being studied by middle school students (Ken Goodale, personal communication). GPS points for the other pools were gathered in conjunction with analyses of pools from the 1997-98 project. To develop a profile of general areas in which vernal pools are likely to be found, Geographic Information System (GIS) data sets will be amassed an analyzed for the 25 vernal pools using personal computer (PC) ArcInfo and ArcView (Environmental Systems Research Institute 1990-1995, 1996). Variables chosen to be included in the GIS profile will be those for which a significant relationship with the presence of vernal pools is found. Two approaches to analyzing the significance of the variables will be taken. Chi-square goodness of fit analysis will be done for class variables. The proportions of the pools in which the variable is present will be tested against an expected value derived from calculation of the proportion of the study area in which the variable is present. The chi-square goodness of fit analysis will involve the following variables: (1) soil types, (2) surficial geology, and (3) forest cover type. T-tests will be done for continuous variables, the value of which will be measured for the vernal pool locations and for 25 randomly located points in the study area. The t-tests will involve the following variables: (1) mapped slope (calculated from Digital Elevation Model [DEM] data), (2) roughness of topography (calculated from DEM data), (3) distance form any perennial water body, (4) distance from the nearest major (Class III or greater) stream, (4) distance from nearest area of wetland soil, and (5) proportion of the area covered by wetland soils within a circle around the pool or the randomly located point. REFERENCES Allan, J.D. 1995 Stream ecology, structure and function of running waters. Chapman & Hall, London. 388 pp. Belk, D. 1975. Key to the Ahostraca (fairy shrimp) of North America. Southwestern Naturalist 20:91-103. Colburn, E.A. ed. 1991. A citizen's guide to protecting vernal pools. Massachusetts Audubon Society. 107 pp. Donahue, D. 1996. A guide to vernal pool wetland of Connecticut. University of Connecticut Cooperative Extension System Forest Stewardship Program. 18 pp. Fellman, B. ed. 1998. Our hidden wetlands. Proceedings of a symposium on vernal pools in Connecticut 1998. Yale University & Connecticut Department of Environmental Protection, Hartford. 62 pp. Henderson, P.A. 1990. Freshwater ostracods. Synopsis of the British Fauna (New Series), No. 42. Linnean Society of London and The Estuarine and Coastal Sciences Association. Universal Book Services, Oegstgeest, The Netherlands. 228 pp. Jokinen, E.H. 1978. The aestivation pattern of a population of Lymnaea elodes (Say). American Midland Naturalist 100: 43-55. Jokinen, E.H. 1983. The freshwater snails of Connecticut. State Geological and Natural History Survey of Connecticut, Department of Environmental Protection Bulletin 109. 83 pp. Jokinen, E.H. 1994. The freshwater mollusks of the inland waters of the Indiana Dunes National Lakeshore. Indiana Dunes National Lakeshore Research Program Report, Porter, Indiana. 16 pp. Kenney, L.P. 1995. Wicked big puddles. A guide to the study and certification of vernal pools. U.S. Environmental Agency, U.S. Government Printing Office. 58 pp. Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut. Bulletin No. 12:1-318. Means, R.G. 1979. Mosquitoes of New York. part I. The genus Aedes Meigen. New York State Museum Bulletin No. 430a, Albany. 221 pp. Merritt, R.W. and K.W. Cummins, eds. 1996. An introduction to the aquatic insects of North America, 3rd Ed. Kendall/Hunt Publishing Co., Dubuque, Iowa. 862 pp. Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, D.J. Conklin, Jr. 1990. Freshwater macroinvertebrates of Northeastern North America. Cornell University Press, Ithaca. 442 pp. Pennak, R.E. 1989. Fresh-water invertebrates of the United States, 3rd ed. John Wiley & Sons, Inc. New York. 628 pp. Smith, D.G. 1995. Keys to the freshwater macroinvertebrates of Massachusetts, 2nd Ed. Privately printed, D.G. Smith, Sunderland, Massachusetts. 243 pp. Thorp, J.H. and A.P. Covich, eds. 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, Inc. San Diego. 911 pp. Wetzel, R.G. 1983. Limnology, 2nd Ed. Saunders College Publishing, Fort Worth. 767 pp. Wiggins, G.B. 1996. Larvae of the North American caddisfly genera (Trichoptera), 2nd Ed. University of Toronto Press, Toronto. 457 pp. Wood, D.M., P.T. Dang and P.A. Ellis. 1979. The insects and arachnids of Canada, Part 6. The mosquitoes of Canada, Diptera:Culicidae. Biosystematic Research Institute Publication 1686, Ottawa. 390 pp.

Principal Findings and Significance

PROGRESS REPORT A pilot project (Pyle and Jokinen) indicated great variability in vernal pool species assemblages and associated physical and environmental parameters. In the present study, vernal pool invertebrates were sampled repeatedly across the seasons at ponds additional to those sampled in the pilot project. Analysis is underway to determine the extent to which physico-chemical factors are related to the presence of different types of invertebrates, total diversity of invertebrate groups, and community structure of vernal pool invertebrates. To aid in the characterization of the landscape-scale location of vernal pools, GIS-based landscape profiles of vernal pools in the town of Mansfield, CT will be compared to profiles for an equal number of randomly-located points. The analysis will be repeated in the town of Washington, CT. The reason for the augmentation of the project to include Washington is to provide the opportunity for a Master's student to make a comparison of vernal pool profiles from two CT eco-regions. A set of pools in Washington has been located with Global Positioning System equipment, and the location of additional pools in Mansfield is underway. GIS data management and statistical analysis of the soils, surficial geology, land cover types, slope, distance from water, and prevalence of wetland soils in the pool vicinity for the pools in each town and the corresponding random points will follow. Additional findings related to the invertebrate portion of the study will appear in the Technical Completion Report. This project was a continuation of a regional grant, R-02. Please also see the results section for that project.

Descriptors

Wetlands, Geographic Information Systems, Invertebrates

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Management of purple loosestrife (Lythrum salicaria) in Connecticut watersheds.
Project Number	B-07
Start Date	03/01/1999
End Date	02/29/2000
Research Category	Biological Sciences
Focus Category #1	Wetlands
Focus Category #2	Conservation
Focus Category #3	Ecology
Lead Institution	Institute of Water Resources

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Richard A. Ashley	Unknown	The University of Connecticut	01
David Askew	Unknown	The University of Connecticut	01
Donna Ellis	Unknown	The University of Connecticut	01

Problem and Research Objectives

Problem Purple loosestrife [Lythrum salicaria L. (Lythraceae)] is an invasive non-native plant from Eurasia that was introduced into North America almost 200 years ago. The largest occurrences of this species are found in wetlands in the northeastern U.S., and include all major river watersheds. Recent surveys in Connecticut have documented purple loosestrife in many wetland habitats, including rivers, lakes, streams, ponds, tidal areas and wet meadows. Purple loosestrife aggressively outcompetes and displaces native wetland vegetation such as cattail, sedge, and bullrush. Accompanied by this significant loss of native plant diversity, few species of wildlife are supported, a reduction in stopover sites along bird migratory pathways occurs, and valuable natural resources in wetland ecosystems are destroyed. The rapid spread of purple loosestrife may encroach on croplands, hay meadows and forage pastures, thus having a measured impact on agriculture. Purple loosestrife quickly overtakes and dominates disturbed areas, which may impede or prevent successful wetland creation, enhancement and restoration. Desirable food plants for waterfowl and other wildlife are eliminated when purple loosestrife dominates waterways. These waterways become clogged and water flow is impeded in irrigation systems where purple loosestrife infestations become established. Purple loosestrife is officially recognized as a noxious weed in 21 states, where its importation and distribution are prohibited. Physical and chemical methods to manage purple loosestrife infestations are often cost prohibitive and labor intensive, providing temporary relief at best to curb the spread of this invasive species. Biological control is recommended as a long-term management strategy to reduce populations of purple loosestrife. Watershed and natural resource managers, park supervisors, wetland property owners, and agencies or individuals seeking methods to reduce purple loosestrife infestations in wetlands are interested in obtaining strategies they may implement to conserve wetland resources, improve water quality and restore vegetative diversity in these ecosystems. Objectives A demonstration project is proposed to field test a hypothesis on changes in the occurrence and distribution of purple loosestrife in Connecticut watersheds through biological control and other management strategies. Field studies will continue to build on purple loosestrife control methods currently being developed in the state, in conjunction with national program efforts. Research results obtained through the study will be disseminated to state cooperators, local end-users and the general public. Methods will be applied to pilot programs for volunteer citizens in soil and water conservation districts, watershed associations and municipalities to more effectively control the spread of purple loosestrife. Purple loosestrife biological control awareness will increase for cooperators and the general public as a result of the proposed activities. Through this process, changes in the occurrence and distribution of purple loosestrife and associated plant species will be documented through judicious monitoring and evaluation of new and established wetland study sites. Description of work to be accomplished. 1. Conduct field studies to test a hypothesis on changes that occur to purple loosestrife populations when biological control or other management methods are implemented (please see Research Methods section below). 2. Provide a one-year summer training-employment program for advanced college undergraduate or graduate students through their involvement with program activities. 3. Identify state and local cooperators with an interest in purple loosestrife management. Cooperators may include volunteer citizens and high school students from soil and water conservation districts, watershed associations and municipalities where purple loosestrife infestations occur. 4. Conduct field demonstrations and training sessions for volunteer citizens and students in local wetlands so that they may become more knowledgeable about purple loosestrife management and participate in program activities. Field demonstrations will be held in wetlands where purple loosestrife biological control is in progress or where management of purple loosestrife is desired. 5. If sufficient populations of Galerucella beetles develop, provide "starter kits" of biological control agents and site monitoring documentation to end-users so they may establish new sites of introduction. 6. Prepare and distribute educational materials on purple loosestrife biological control to soil and water conservation district, watershed associations, municipalities and the general public. The educational materials, developed from ongoing research results, will include a color brochure on purple loosestrife awareness and management, summary reports on Connecticut biological control program activities and other reference materials. 7. Provide information on purple loosestrife biological control activities in Connecticut to the news media, nursery growers and garden center managers to increase awareness. This information will also be made available on Interned web sites (note: purple loosestrife is not regulated in Connecticut and continues to be sold in many nurseries and garden centers).

Methodology

Site monitoring. The protocol for purple loosestrife site monitoring in Connecticut will be adapted from the Purple Loosestrife Monitoring Guide (Blossey 1997), comprising all elements described in the next five paragraphs: Baseline ecological sampling data were initially gathered at each site in newly established locations prior to introduction of the biological control agents. Ecological sampling will continue at selected sites where Galerucella beetles were introduced from 1996 to 1998 and will be initiated in several new wetland locations in 1999, pending availability of the biological control agents. The study sites are located on state, municipal and private properties. The number of new sites to be established will be dependent on the availability of biological control agents and available resources. If sufficient biological control agents are available, two new sites will be established in 1999. Up to six site visits per location will occur between May and September to coincide with purple loosestrife phenology and insect developmental stages. New study sites will be selected according to the following criteria: 1) purple loosestrife populations of approximately 0.25 to 2.0 acres, 2) a mixed plant community present at the site consisting of purple loosestrife and other wetland plants, with preference for locations with maximum vegetative diversity and 3) locations that are not permanently flooded; occasional spring flooding is acceptable. One-square-meter permanent quadrats (plots) will be placed along a linear transect at each new study site for the collection of replicated data during the monitoring period. The transect will be a minimum of 30 meters in length and a maximum of 150 meters, depending on the extent of the purple loosestrife population at each location. Quadrats will be set at designated intervals of 5 to 15 meters at each site, with up to eleven quadrats established per location. The center quadrat within each transect will be designated as the 'release' quadrat, where the biological control agents will be introduced. All other quadrats will be assigned as 'control' quadrats, where beetles will not be released. Galerucella populations and feeding damage assessments on purple loosestrife will be documented, including life stages of the biological control agents observed and degree of insect feeding injury to purple loosestrife. Purple loosestrife development will be assessed through measurements of plant height, percent plant cover, number of stems, degree of flowering, inflorescence number and number of flower buds with seed on the inflorescence. If sufficient resources are available for this project, the number of seeds per flower bud will also be determined to indicate purple loosestrife reproductive potential and fitness. Herbivores and predators, such as other insects or spiders, observed feeding on purple loosestrife or on Galerucella beetles will be noted. Non-target plants within the quadrats and in areas adjacent to the quadrats will be monitored for any adverse effects by the biological control agents. Field insectaries may be established at selected study sites for subsequent redistribution of the biological control agents at additional wetland locations in the state. Vegetative data, including percent plant cover, will be collected for plant species most frequently associated with purple loosestrife. An inventory of associated plant species will be conducted for all plant species within all quadrats along the transect at each site where the biological control agents are introduced to monitor changes in vegetative diversity. Inventories of plant species in the area adjacent to the transect will also be conducted. All inventories will continue for a minimum of five years Introduction of biological control agents. State and federal permits to introduce Galerucella calmariensis and Galerucella pusilla into Connecticut were obtained in 1996 and are valid through 2007. Permission to establish release sites on state property was granted in 1996 through a Special Use License. Signed consent forms from towns or private landowners were obtained for release sites on municipal or private properties. A Special Use License or signed consent form will be obtained for new locations initiated during the proposed project duration. All sites are also approved by the Connecticut Deputy State Entomologist on a site-by-site basis prior to the introduction of the biological control agents. USDA APHIS Plant Protection and Quarantine (PPQ) will provide Galerucella beetles in 1999. Documentation of project results. Information on methods described above will be collected during each site visit using field data forms adapted from the national Purple Loosestrife Monitoring Guide. Statistical analysis will be performed on data collected from all sites. Project results will be summarized in a technical report and submitted to a peer-reviewed journal. Additional Information. Purple loosestrife biological control is a relative newcomer to Connecticut, beginning just a few years ago in 1996. As purple loosestrife biological control agents are introduced into additional wetlands each year, there exists a need to concurrently increase site monitoring activities to carefully document impacts on purple loosestrife by the biological control agents and to provide information to the general public to increase their awareness of biological control and other management strategies. One solution to this challenge is to enlist the support of volunteer citizens so they may learn about biological control of purple loosestrife by gaining hands-on experience through participation in a local monitoring program that is part of their town or watershed. To further meet this challenge, a combined training-employment program can be offered to college students to provide them with both educational opportunities and personal experience in the purple loosestrife management project. USDA APHIS plant Protection and Quarantine (PPQ) will provide Galerucella beetles to Connecticut in 1999. Beyond 1999, however, additional shipments of purple loosestrife biological control agents may not be available from outside sources but may need to be collected from within Connecticut. It is recommended that Galerucella beetles introduced into a new wetland be allowed to build in population at that site for three or more years before they are collected and redistributed into new wetlands where management of purple loosestrife is also desired. Small populations of beetles would then be provided to cooperators as "starter kits," accompanied by field training sessions and evaluation materials to continue long-term site monitoring in local wetlands. In the interim, until starter kits become available for distribution, field demonstrations and involvement by the general public would occur at established sites of introduction or in wetlands where management of purple loosestrife is desired to increase awareness in the biological control community. Procedures developed and results obtained from ongoing purple loosestrife biological control studies in Connecticut will be provided to state and local end-users. The end-users will include citizens in soil and water conservation districts, watershed associations and municipalities where purple loosestrife is problematic in wetlands. Throughout this process, changes in the occurrence and distribution of purple loosestrife and associated plant species will be documented through monitoring and evaluation of wetland study sites. Additionally, and increase in purple loosestrife biological control awareness will occur as end-users and the general public gain first-hand experience in local wetlands. Alternative strategies for management of purple loosestrife in watersheds will be considered as needed, particularly during the first few years of the program when the supply of Galerucella beetles is limited.

Principal Findings and Significance

Purple loosestrife biological control program efforts in Connecticut continue to expand each year. Three new biological control study sites were initiated during 1999. More than 100,000 purple loosestrife biological control agents have now been released in the state. The Connecticut purple loosestrife program has expanded to include 16 locations in the following 13 towns where biological control agents have been introduced: Bloomfield Hamden New Canaan Southbury Wethersfield Chester Manchester Redding South Windsor Haddam Meriden Salisbury Storrs In Connecticut, more than 67,000 Galerucella beetles and 3,900 Nanophyes weevils were introduced into 16 wetlands in 13 towns in the state between 1996 and 1999. An additional 30,000 Galerucella beetles were produced at the University of Connecticut this summer in a preliminary field rearing trial. These field-reared beetles were released at established biological control study sites to supplement initial introductions from previous years. A small colony of root feeding weevils, Hylobius transversovittatus [Coleoptera: Curculionidae] provided by the Mission Plant Protection Center was introduced into a wetland in Manchester in the Hockanum River watershed during 1999. The Hockanum River feeds into the Connecticut River in Hartford County. The Hylobius release was the first time this biological control agent was introduced in the state. This particular wetland now contains all four species of biological control agents. Purple loosestrife biological control agent release sites are located in the Chester Creek watershed and the Connecticut, Hockanum, Housatonic, Mill, Noroton, Norwalk, Park (North Branch), Pomperaug and Quinnipiac River watersheds. In the Connecticut River watershed, study sites include Special Focus Areas of the Silvio O. Conte National Wildlife Refuge. Selected wetland sites in Connecticut will continue to be monitored for several years after release to document interactions occurring between the biological control agents and the target host plant, purple loosestrife. Field surveys continued during the 1999 summer to identify purple loosestrife infestations in the state. Distributional surveys for purple loosestrife conducted in Connecticut from 1995 through 1999 documented more than 250 wetland locations in every county statewide, with plant densities of more than 1,000 stems per location observed in the majority of these habitats. The field reports are reviewed each year to prioritize locations as potential biological control study sites or where other types of management for this invasive species may occur. The Connecticut Invasive Plant Working Group was founded in 1997 to promote awareness of invasive plants in Connecticut and throughout the region (the Lead Principal Investigator serves as Co-Chair of the Working Group). Information on purple loosestrife and other invasive plant species can be found on the new web site for the Connecticut Invasive Plant Working Group at http://www.eeb.uconn.edu/invasives. Educational outreach for this program continued during 1999, with numerous training sessions, field demonstrations, workshops and other presentations conducted by the Principal Investigator. A color pamphlet on purple loosestrife, including management options and alternatives to plant in the home garden or natural areas, was mailed to more than 1,000 nurseries and garden centers in Connecticut. A student internship was provided to an advanced undergraduate student. The student was trained in all aspects of the program, including principals of biological control and Integrated Pest Management.

Descriptors

Articles in Refereed Scientific Journals

Blossey, B., R. Casagrande, L. Tewksbury, D.A. Landis, R. Wiedenmann and D.R. Ellis. 2000. Non-target feeding of leaf-beetles introduced to control purple loosestrife (Lythrum salicaria). (Submitted to Natural Areas Journal April 2000.)

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Inhibition of biological nitrogen removal.
Project Number	N-11
Start Date	03/15/1999
End Date	03/14/2000
Research Category	Biological Sciences
Focus Category #1	Nitrate Contamination
Focus Category #2	Nutrients
Focus Category #3	Non Point Pollution
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Grasso	Unknown	Other	01
Smets	Unknown	Other	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Total Petroleum Hydrocarbon (TPH) method validation and development for drinking water.
Project Number	N-12
Start Date	07/01/1999
End Date	12/30/1999
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Methods
Focus Category #3	Toxic Substances
Lead Institution	Other

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert Carley	Unknown	The University of Connecticut	01

Problem and Research Objectives

Methodology

Principal Findings and Significance

Descriptors

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Information Transfer Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Seminar Series
Description	Held October, November, February, March and April
Start Date	03/01/1999
End Date	02/29/2000
Type	Conferences
Lead Institution	Institute of Water Resources

Principal Investigators

Problem and Research Objectives

February 10, 1999. Vernal Pools: Our Hidden Wetlands. A discussion on the science and regulation of vernal pools. Speakers: Eileen Jokinen, Institute of Water Resources, and Douglas Hoskins, Environmental Analyst III, Land & Water Resources Division, Bureau of Water Management, CT DEP. March 10, 1999 Analyses of Precipitation and Runoff in Connecticut. A review of over 100 years of precipitation records and the relationship of precipitation to runoff in selected small streams in Connecticut. Speakers: Glenn Warner, Department of Natural Resources Management and Engineering, and Fred Ogden, Department of Civil and Environmental Engineering, University of Connecticut. April 14, 1999 Connecticut’s Source Water Assessment Program (SWAP). A plan to evaluate the susceptibility of all of Connecticut’s public drinking water supply sources. Speakers: Lori Mathieu, Water Supply Section of CT Dept. of Public Health & Rob Hust, Bureau of Water Management of CT Dept. of Environmental Protection.

Methodology

Principal Findings and Significance

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	7	4	N/A	12
Masters	3	3	N/A	N/A	6
Ph.D.	N/A	N/A	N/A	N/A	N/A
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	4	10	4	N/A	18

Awards & Achievements

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications