Using Lake Ontario Biocomplexity Research Sites for Coastal Environmental Indicator Testing

Project Proposal by

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for the

Lake Ontario Biocomplexity Research Team

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Robert Johnson, Ecology & Evolutionary Biology, Cornell University
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To

Julie Wagemakers
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4 September 2001

Applicant Background

We propose to address needs of the Great Lakes Wetlands Consortium in developing long-term basin-wide monitoring plan for the Great Lakes coasts by making modest changes in our current Lake Ontario Biocomplexity Project (http://Ontario.cfe.Cornell.edu/). This large, multi-university, interdisciplinary program is analyzing ecosystem structure and function for a series of Lake Ontario coastal bays and lagoons. The principal theme organizing the program is that open ecosystems like our coastal wetlands differ in ecosystem structure formation in relation to the average time water takes to move through them. We believe that our study systems will be shaped by internal biological processes (e.g., competition for space in plant communities) under stable water environments, and driven by outside forces when water retention is low. We set the stage for efficient and effective testing of environmental indicators by selecting a set of eight co-located, wetland-rich study waters having very different hydrologic settings. Indicators that are sensitive to changes in wetland conditions should show different values across our study waters. Also, because our program is an interdisciplinary research effort, we will be measuring and quantifying many of the Consortium's indicator attributes simultaneously. Finally, our extensive data will be made available for other Consortium indicator tests and evaluations in the context of well characterized wetland systems.

The Lake Ontario Biocomplexity research team spans topics as diverse as water turbulence and human settlement patterns. The team is organized at two levels; space-time interdisciplinary groups and whole study integration. Three Cornell investigators will measure and model external processes working at the watershed scale to determine water quality and quantity entering the study systems. They are developing watershed hydrologic simulators, modeling land use and land cover, and developing a hydrodynamic simulator to model water exchange between Lake Ontario and the bay systems. Investigators at Cornell and Syracuse University will study internal ecosystem processes that rapidly change (weekly-monthly) in the study waters: plankton, fishes, water quality, and water mixing. Investigators at Cornell and the SUNY College of Environmental Science and Forestry (Syracuse) will study the ecosystem properties that change seasonally: benthic invertebrates, aquatic plants, and wetland flora. SUNY and Cornell investigators will also study internal system properties that change over long-time scales using historical patterns of human settlements and vegetation distributions. Finally, all data and model simulations will be integrated mathematically to determine the conditions that allow ecosystem self organization or ecosystem property forcing by external factors.

Study Waters

We have identified eight study ecosystems that combine extremes of three main physical factors that will determine water residence time: bay volume, watershed size, and connectedness to Lake Ontario. These study water bodies are located in far eastern Lake Ontario and along the southeast coast of the lake. The eastern set of four study waters (Figure 1) all have extensive wetlands and are mostly separated from open Lake Ontario by a barrier composed mainly of sand. For the purposes of this proposed study, we will add some data collections along the Lake Ontario shallow sloping beach zone. The western set of four study waters (Figure 2) have varying amounts of wetlands and are separated from Lake Ontario by gravel and cobble barriers with some being reinforced and roaded. As with the other set, we will add the open shoreline zone of Lake Ontario for this proposed study.

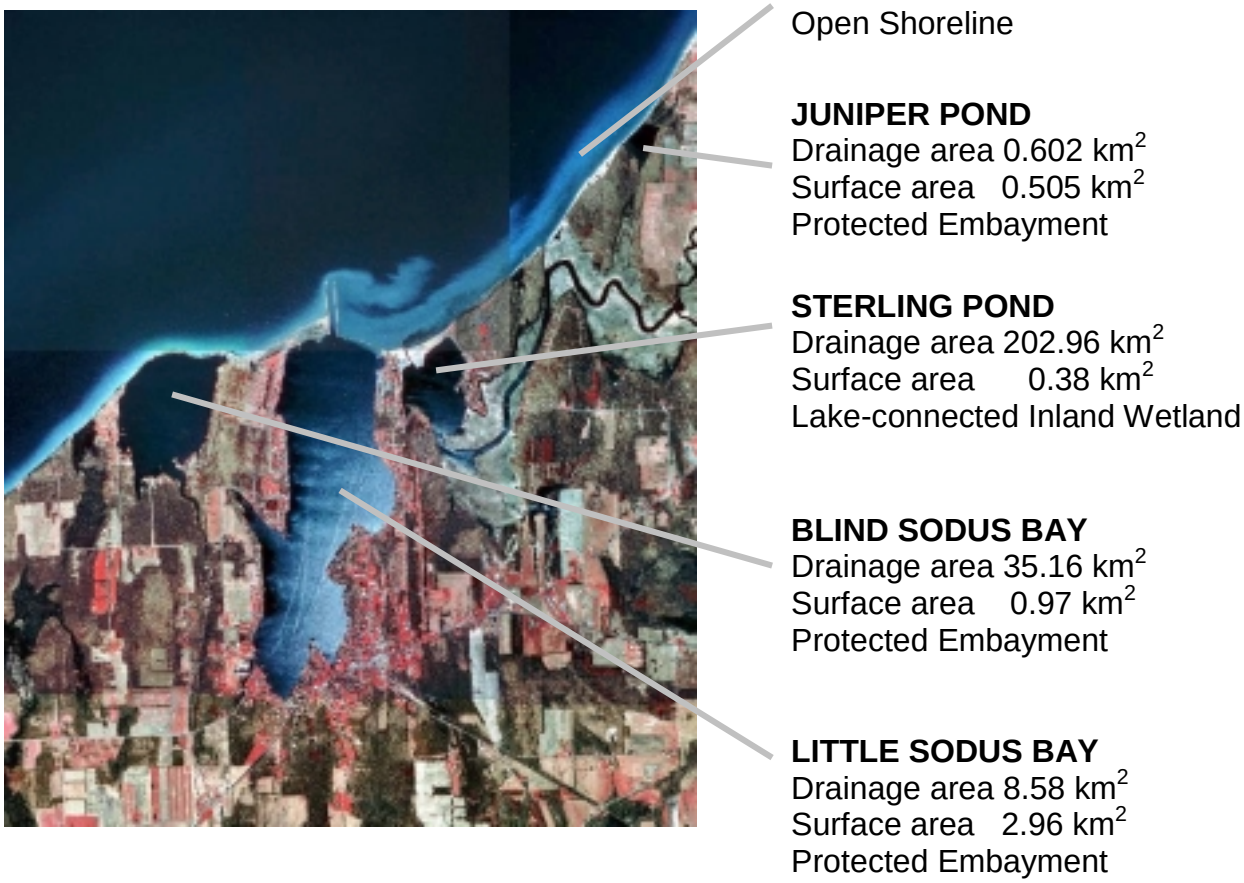

Figure 1. Western set of biocomplexity study sites along the southeastern shore of Lake Ontario.

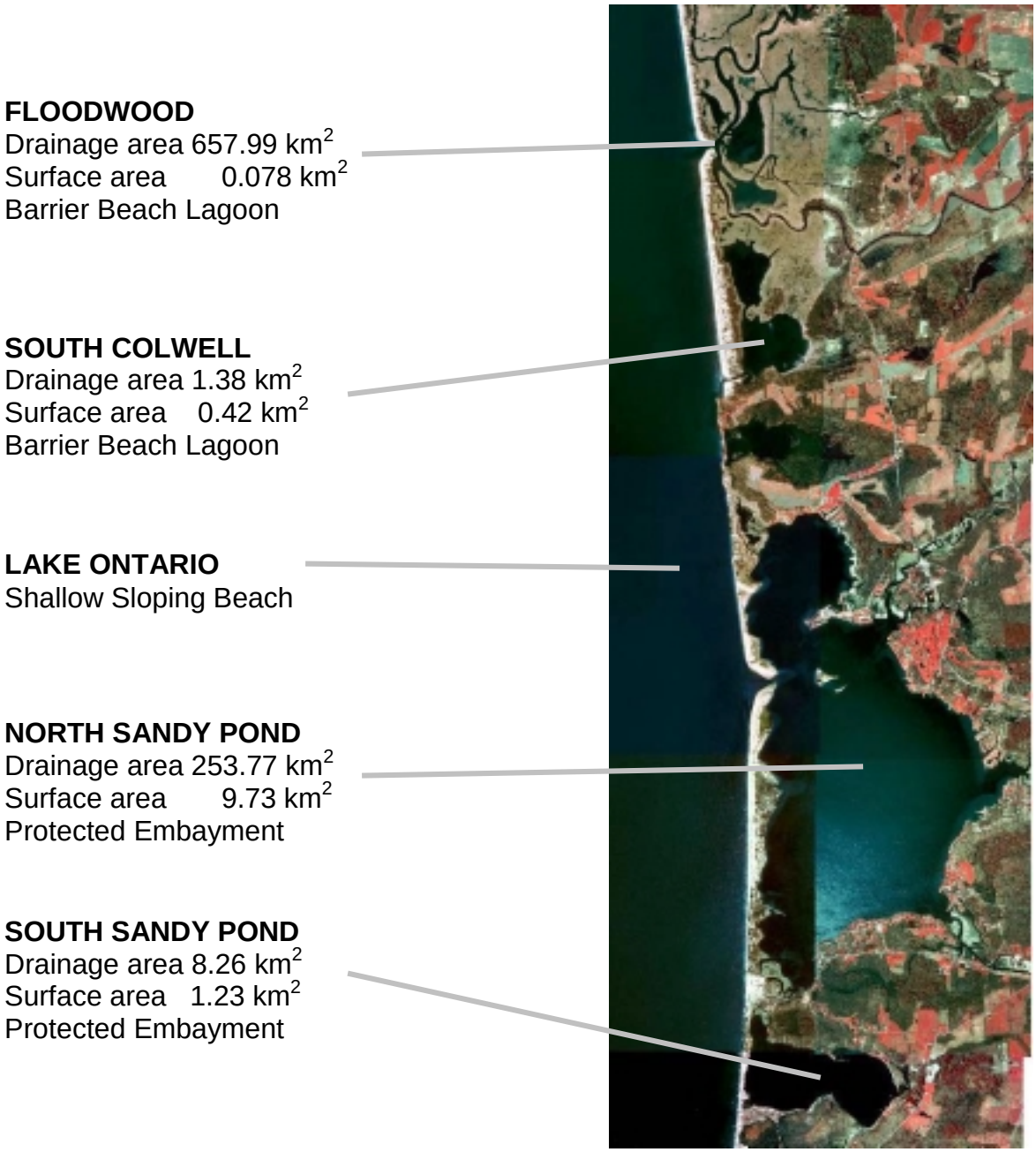

Figure 2. Eastern set of biocomplexity study sites along the eastern shore of Lake Ontario.

Project Narrative/Workplan

Our field investigations at the Lake Ontario Biocomplexity sites began in 2001 and were limited to assembling basic information on the sites and establishing protocols for an integrated sampling effort to begin in 2002. Several dimensions of our work will provide data of direct use in comparing indicator performance among our sites, and some additional tasks will substantially expand the comparability of our efforts with Consortium indicator evaluation goals. Our objectives in this proposed project are:

1. To test the feasibility of applying indicators in a monitoring plan, and

2. To test the comparability and usefulness of indicators across the wetland geomorphic classes named in Figures 1 and 2.

By making our data and findings available to the Consortium and other project proponents identified below, we will work to advance the following objectives:

3. Working with others to identify how data collection and analytical methods can be coordinated, and

4. Testing the variability of indicators across the Great Lakes

Below we list a selection of Consortium specified indicators where our current and proposed efforts would provide the most data and application experience.

Invertebrate Community Health

We are currently collecting macroinvertebrates at randomly located coordinates in all study waters using a petite ponar grab. This gear was selected as a powerful grab capable of pulling up most bottom materials including plants. Samples are field sorted in trays following the common USEPA stream bioassessment approach of counting 100 organisms on random tray cells. Identifications will be done to the lowest commonly used taxonomic level (mostly genus) for biomonitoring. Common habitat data are collected such as water depth, substrate type, and relative macrophyte abundance. We propose here to add Hester-Dendy samplers deployed at random coordinates and retrieved at four week intervals two times in 2002. Unlike our current grad samples, all organisms would be counted and identified to the lowest commonly used taxonomic level for biomonitoring. Community measures such as diversity, dominant taxa, proportion of sensitive taxa (mayflies, caddisflies), and modified biotic indices would be reported with raw data files. Field data on invertebrates will be collected in open lake shoreline and beach habitats.

Fish Community Health

Currently we are conducting standardized (15 minutes) electrofishing around randomly selected coordinates in water less than 4 m deep. We have been using gill nets in deeper water but this may be discontinued in 2002. Most waters being studied are shallower than our deep water criteria, and most deep waters are anoxic in the summer. Hence we have little room left for gill nets, and the catch has not been greatly different than the more productive electrofishing samples. All captured fish are identified and measured with basic habitat attributes recorded for all samples. Initially we electrofished on randomly located transacts but this designed was judged impractical because of crossing numerous habitats and running out of room in some water bodies. For the purposes of Consortium specified indicator testing, we will add fyke nets set for two consecutive nights in multiple random locations per water body at about 2 of 3 meters depths and oriented parallel to shore or structure. Counts of deformities, eroded fins, lesions, and tumors (DELT data as in Sanders et al. 1999) will also be added to our recording protocol for all sampling. While our sites do not vary greatly in human stresses, the DELT data can be compared to wetlands with heavy physical and chemical stresses in other studies (see collaborations below). Field data on fish will be collected in open lake shoreline and beach habitats as practical (i.e., no electrofishing in rough open lake waters).

Plant Community Health

In 2001 we collected field data on all wetlands associated with our study waters and aquatic macrophytes in five of our waters. Plant species identified at sampling points on transects arranged across wetlands, and by raking three times at coordinates of 100 m or 50 m grids imposed on aquatic habitats. In August, the International Joint Commission study of water management in Lake Ontario and the St. Lawrence River commissioned color-infrared aerial photography at a scale of 1:10,000 covering all our study waters plus others. We also developed a methodology using our GIS data layers for depicting water body morphology from a dense field survey of water depths. The final GIS will allow three dimensional representations of our waters and their plant communities. Taken together then, we now have the ability to estimate several of your plant community metrics such as percent dominant vegetation types, percent invasive types, percent wetland obligate species, percent native taxa, and others. To make the most of these data, we propose to integrate the aerial photographs with our field data to depict plant communities in our study waters with our GIS. Our current Biocomplexity study does not include this exacting and time consuming step, but we will complete this full level of analysis for this proposed project.

Water Levels

At present we rely on NOAA lake stage data for mean water surface elevations in our study waters. Use of local stage recorder data by others is being investigated now, and we are seeking additional National Science Foundation funding for detailed water level recording instruments. However, we completed one survey of 12 tributary discharges (23 measurement sites) during summer base flow, and this will be repeated at higher fall streamflows. Additional stream discharge surveys in 2002 will allow prediction of stream volumes for all inflows calibrated to USGS gages on nearby streams. Predicted hydrologic data for all sites will be provided from these efforts. In 2001 we completed a detailed field survey of water body bathymetry, and the International Joint Commission obtained both topographic LIDAR and SHOALS bathymetric aerial surveys in May 2001. Our study areas GIS exists now and in 2002 it will be expanded in data layers to allow accurate projections of water exchange rates between our study waters and lake Ontario associated with changes in lake stage and streamflow. Thus we will soon have the capability to estimate daily changes in water body volume from both change in lake Ontario levels and streamflow inputs. We anticipate being able distribute a programmed spreadsheet keyed to a few web linked NOAA and USGS hydrologic stations to allow anyone to simulate water exchange in our bays and lagoons.

Sediment Flow, Phosphorus and Total Nitrates

Concurrent with our stream discharge surveys we collected water quality samples, and repeated sampling was done in our study bays and lagoons and adjacent Lake Ontario shoreline waters. These samples have been analyzed for a wide range of physicochemical parameters including base cations, NH4, dissolved SiO2, NO3, SO4, Cl, total nitrogen, DIC, DOC, total phosphorus, soluble reactive phosphorus, particulate organic carbon, and total suspended solids. When combined with predicted streamflow volumes, we would be able to accurately project the requested suspended sediment unit area yield (tonnes/km2 of upstream watershed) for each study water. All physicochemical data will be made available for the Consortium's use and these data will allow testing of different water quality indices for later use in distinguishing site quality within our range of conditions or through comparison with other data sets.

Landscape Measures

The Consortium's interest in landscape-scale indicators can be tested using a wide range of GIS data layers collected and created for the Biocomplexity Project. We have already assessed the land cover composition of all our study site watersheds. The land classification and summary statistics are at the project web site (http://Ontario.cfe.Cornell.edu/) under Study Sites. All the Consortium's landscape indicators can be computed now, or easily with some minor additions like navigation channels (few and prominent) or air photo and field based channel inspections. These data and spatial images of indicator distributions will be contributed from our current work.

Project-Wide Tasks

All data collections will be made with precise UTM coordinates using global positioning system (GPS) readings. Spatial displays of all data collections will be made using our study areas GIS. Field protocols will be accurately described with data on the actual effort expended in people, equipment (costs for acquisition and operation), and analysis. Data and all research findings are being posted on the Lake Ontario Biocomplexity web server at: http://Ontario.cfe.Cornell.edu/. We are aware of the large number of Great Lakes coastal ecology studies that can provide a context for interpreting our results. We will consolidate relevant data from original study reports for our sites (numerous reports and theses by New York universities and organizations) and others, reviews and syntheses in SOLEC Conference publications, agency sources (e.g., www.epa.gov/glnpo/ecopage), and current investigations in New York. Finally, we have developed integrated (biophysical/multi-taxa levels) environmental indicator sets for lakes (Harig and Bain 1999) that were very effective at detecting stress. We want to do this again for Consortium needs and it requires broad based systems data and results from a range of stressed and unstressed sites. We will have broad based data on the biocomplexity sites, and the results from a range of stressed systems will come from collaborations with other project teams.

Project Team

Lake Ontario Biocomplexity Project Team

The Lake Ontario Biocomplexity Project is based at Cornell University in the Center for the Environment with Mark Bain serving as the research team leader. Short resumes for all team members are below. Dr. D. Peter Loucks (Cornell Civil & Environmental Engineering) is developing watershed hydrologic simulation capability. Dr. Rolf J. Pendall (Cornell City & Regional Planning) is modeling land use and land cover. Ms. Andrea Parmenter (Cornell Center for the Environment) is the project's computing specialist focused on executing in these tasks. Dr. Edwin A. Cowen (Cornell Civil & Environmental Engineering) is modeling waterbody hydrodynamics, especially water exchange between the lake and bay systems. Dr. Nelson Hairston (Cornell Ecology and Evolutionary Biology) and Dr. Mark Bain (Cornell Natural Resources) are covering biological limnology and fish. Dr. Charles Driscoll (Syracuse University Civil and Environmental Engineering) is analyzing chemical budgets and nutrients. Dr. Donald Leopold (SUNY College of Environmental Science and Forestry) and Mr. Robert Johnson (Cornell Ecology and Evolutionary Biology) are characterizing wetland and aquatic plant communities. Ms. Gail Steinhart (Cornell Center for the Environment) is leading all field activities and serving as the operational coordinator for the Biocomplexity project. Dr. Stephen Ellner (Cornell Ecology and Evolutionary Biology) provides our integrative analytic capability to synthesize group efforts. A new project leader will be hired to serve as a point of contact for coordinating activities with the Consortium and other investigators identified below. This specialist will be charged with conducting the new activities funded by this proposed project and assembling data from the ongoing efforts of the Biocomplexity Study Team.

Collaborations with Related Investigations

We have discussed how we can maximize the opportunity to compare and contrast our results with similar investigations by other scientists. Without the perspective of having completed parallel studies, it appears the most productive approach for coordinating the analysis and interpretation among related Consortium teams would be to hold a meeting for this purpose after fieldwork is completed. Therefore we plan to work with other Consortium sponsored projects and interested scientists to hold a coordination meeting in September 2002. At this time we can exchange data and compare our efforts and study sites to make the most of our joint efforts. From our collaboration discussions to date, Joel Ingram of Environment Canada (Downsview, ON) is proposing to evaluate plant community indicators with data from 10 sites on lakes Ontario and Huron. Donald Uzarski of Grand Valley State University (Muskegon, MI) is proposing invertebrate indicator evaluations in a large set of sites on lakes Michigan and Huron. His proposed work includes sites with known stresses, and the protocol follows that used by Burton et al. (1999) in proposing an invertebrate biotic index for Lake Huron wetlands. Doug Wilcox of the US Geological Survey (Great Lakes Science Center, Ann Arbor, MI) will be conducting detailed wetland plant analyses on 16 Lake Ontario sites with 2 sites in common with the Biocomplexity study waters. William Coon (USGS Water Division NY) will not be requesting consortium funding but he wants to join this proposed coordination effort to extend the value of his extensive physical and biological data on the wetland south of Irondequoit Bay. Steve Timmermans (Bird Studies Canada, Ontario) seeks coordination involvement as part of his proposed work on marsh bird and amphibian indicators and standardized sampling approaches (http://www.bsc-eoc.org/mmpreport.html). We expect further collaboration opportunities to emerge as the Consortium's program is defined and we will seek to include these efforts in our coordination meeting.

Project Schedule

Begin Project	3 December 2001
Quality Assurance Project Plan	3 December 2001
Assembly and analysis of 2000 data	December - January
Relate 2000 data with other studies	February
Quarterly update report	28 February 2002
Prepare for 2002 fieldwork	March - April
Start 2002 field activities	May
Semi-annual progress report	31 May 2002
2002 fieldwork	June-August
Quarterly update report	30 August 2002
Summarize 2002 data	September
Coordination meeting with matched studies	Early September
Final analysis and report preparation	October - November
Final report completed	29 November 2002

References

Burton, T. M., D. G. Uzarski, J. P. Gathman, J. A. Genet, B. E. Keas. 1999. Development of a preliminary invertebrate index of biotic integrity for Lake Huron coastal wetlands. Wetlands 19: 869-882.

Harig, A. L., and M. B. Bain. 1998. Defining and restoring biological integrity to wilderness lakes. Ecological Applications 8:71-87

Sanders, R. E., R. J. Miltner, C. O. Yoder, and E. T. Rankin. 1999. The use of external deformities, erosion, lesions, and tumors (DELT anomalies) in fish assemblages for characterizing aquatic resources: a case study of seven Ohio streams. Pages 225-246 in T. P. Simon (editor). Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press, New York, NY.

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Education

B. S. Wildlife Resources, West Virginia University, Morgantown, WV. 1977.
M. S. Fisheries Science, Virginia Polytechnic Institute & State Univ., Blacksburg, VA. 1980.
Ph. D. Fisheries Biology, University of Massachusetts, Amherst, MA. 1984.

Professional Employment

1991 - Present New York Cooperative Fish & Wildlife Research Unit, Cornell Univ., Ithaca, NY
Assistant Leader and Associate Professor, Department of Natural Resources, Cornell U.

1998 Massacusetts Cooperative Fish & Wildlife Research Unit, U. Massachusetts, Amherst, MA
Unit Leader

1986 to 1991 Alabama Cooperative Fish & Wildlife Research Unit, Auburn Univ., Auburn, AL
Assistant Leader, Assistant and Associate Professor, Department of Fisheries and Allied Aquacultures, Department of Zoology and Wildlife Sciences, Auburn University

1985 to 1986 Energy & Environmental Systems Div., Argonne National Laboratory
(US DOE/Univ. Chicago), Argonne, Illinois - - Ecologist/Statistician

Select & Recent Publications

N. L. Poff, J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47:769-784.

Harig, A. L., and M. B. Bain. 1998. Defining and restoring biological integrity to wilderness lakes. Ecological Applications 8:71-87

Bain, M. B., T. C. Hughes, and K. K. Arend. 1999. Trends in methods for assessing freshwater habitats. Fisheries 24(4):16-21.

Bain, M. B., and D. P. Loucks. 1999. Linking hydrology and ecology in simulations for impact assessment. Proceedings of the 26th Water Resource Planning and Management Conference, American Society of Civil Engineers, Phoenix, AZ.

Bain, M. B., and N. Stevenson. 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society, Bethesda, Maryland. ISBN 1-888569-18-2

Bain, M. B., A. L. Harig, D. P. Loucks, R. R. Goforth, and K. E. Mills. 1999. Criteria for aquatic ecosystem protection and restoration: approaches using biological and physicochemical structure. Journal of Environmental Science and Policy 3:S89-98.

Bain, M., N. Haley, D. Peterson, J. Waldman, and K. Arend. 2000. Harvest and habitats of Atlantic sturgeon *Acipenser oxyrinchus* Mitchill, 1815 in the Hudson River estuary: lessons for sturgeon conservation. Boletín Instituto Español de Oceanografía 16(1 y 2):65-75.

Walsh, M., M. Bain, T. Squiers, Jr., J. R. Waldman and I. Wirgin. 2001. Morphological and genetic variation among shortnose sturgeon Acipenser brevirostrum from adjacent and distant rivers. Estuaries 24:41-48.

Bain, M. B., and S. Zhang. 2001. Threatened fishes of the world: Aspiorhynchus laticeps Day 1877 (Cyprinidae). *Environmental Biology of Fishes*, In press

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Education:
Stanford University, Environmental Fluid Mechanics, 9/96 - 10/97
Stanford University, Civil Engineering, Ph.D., 1997
Stanford University, Civil Engineering, M.S., 1990
Brown University, Civil Engineering, B.S., 1987

Present Position:
11/97 - Assistant Professor & Director, DeFrees Hydraulics Laboratory
School of Civil & Environmental Engineering, Cornell University

Selected Publications:
Wu, C.H.; Cowen E.A.; Nepf, H.M. (1999). Surface drift and vorticity induced by three-dimensional wave breaking. Submitted to *J. Fluid Mech*.

Stacey, M.T., Cowen, E.A., Powell, T.M., Monismith, S.G., Koseff, J.R., Dobbins, E. (1999) Plume dispersion in a stratified near-coastal flow: Measurements and modeling. In press *Continental Shelf Research.*

Denny, M.W.; Gaylord, B.P.; E.A. Cowen (1997). Flow and flexibility II: The roles of size and shape in determining wave forces on the bull kelp, Nereocystis luetkeana. *Journal of Experimental Biology* 200, 3165-3183.

Nepf, H.M.; Cowen, E.A.; Kimmel, S.J.; Monismith, S.G. (1995). Longitudinal vortices beneath breaking waves. *J. of Geophysical Research (Oceans)* 100, 16,211- 16,221.

Cowen, E.A.; Chang, K.-A. (1999). A Single Camera Coupled PTV-LIF Technique. Submitted to *Experiments in Fluids*.

Cowen, E.A.; Monismith, S.G. (1997). A hybrid digital particle tracking velocimetry technique," *Experiments in Fluids* 22, 199 - 211.

Monismith, S.G.; Cowen, E.A.; Nepf, H.M.; Magnaudet, J.; Thais, L. (1998). Mean flows under surface gravity waves. Submitted to *Journal of Fluid Mechanics*.

Synergistic Activities:
- Chairman, Task Committee on New Developments in Velocity and Discharge Measurements in Hydraulic Engineering, American Society of Civil Engineers
- Vice-Chairman, Technical Committee on Hydraulic Measurements and Experimentation, American Society of Civil Engineers, http://www.usbr.gov/wrrl/asce/tchme/index.html
- Convener: Symposium on Modern Velocity and Discharge Measurement Techniques and Applications
- Developer of experimental technologies in fluid mechanics. Examples include Particle Tracing Velocimetry (PTV) algorithm and coupled Laser Induced Fluorescence (LIF) - PTV algorithm.
- Developed a new course in experimental methods in fluid mechanics. For details see http://www.cee.cornell.edu/cee637/

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Education:

- Pennsylvania State University, BS (Forestry), 1954
- Yale University, MF, (Forestry), 1955
- Cornell University, Ph.D., (Environmental Systems Engrg.), 1965

Professional Employment:

- Cornell University 1965- Present (Dept. Chair, 74-80; College Assoc. Dean, 80-81)
- Visiting Prof: University of Texas, Austin, 2000; Int. Inst. Hydraulic and Env. Engrg, Delft, NL, 1976-present; Tech. Univ. Delft, NL, 1995; Aachen Univ. Tech., Germany, 1993, 1995; Univ. Colo., Boulder, 1992; Univ. Adelaide, Australia, 1992.
- Research Scholar, Int. Inst. for Applied Systems Anal., Austria, 1981-82.
- Visiting Professor, Massachusetts Inst. Tech., 1976-77;
- Economist, World Bank, 1972-73;
- Research Fellow, Harvard University, 1968;

Selected Publications:

- Loucks, D.P., 1995, Developing and Implementing Decision Support Systems, Water Resources Bulletin, Vol. 31, No. 4, August, pp 571-582.
- Loucks, D.P., et al., 1996, Development and Use of Simulation Shells for Creating Shared Vision Models, in Applications of Geographic Information Systems in Hydrology and Water Resources Management, Kovar and Nachtnebel (eds.), IAHS Pub. 235, Wallingford, UK
- Jokiel, C. and Loucks, D.P., 1997, Water Quality Prediction and Management, Handbook of Water Resources Development, McGraw Hill Pub., NY. A.K. Biswas, editor, pp 249-296.
- Loucks, D.P., (ed.), 1998, Restoration of Degraded Rivers: Challenges, Issues and Experiences, NATO ASI Series, Environment, Vol. 39. Kluwer Academic Press, Dordrecht, The Netherlands, 484 pp.
- Loucks, D.P., 1998, "Watershed Planning: Changing Issues, Processes and Expectations," Update Water Resources, Issue No. 111, Spring, pp. 38-45.
- Loucks, D.P. et al., 1991, "Interactive River Simulation Program," Environmental Software, Vol. 6, No. 1, March
- Loucks, D.P. and de Costa, J.R., 1991, Decision Support Systems: Water Resources Planning, Springer-Verlag, Berlin, 576 pp.

Professional Activities:

Principal author of widely used textbook in past two decades in water resource systems engineering, and development of interactive river-basin simulation and optimization models used for teaching in North America, Australia and Europe. Consultant for numerous private, government and international agencies involved with regional development and environmental resources management in North America, Europe, Asia, Africa, Australia, South America, 1969-present. Chair of technical committees in various professional societies. Editorial Boards of several professional journals and advisory boards of several institutes and universities. Chair of Environmental Advisory Board, US Army Corps of Engineers, 1996-98. Current NRC committees: Flood Risk Based Analyses, '98-'00, and Everglades Restoration, '99-present.

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PROFESSIONAL PREPARATION

University of Michigan, Ann Arbor, Zoology - B.S. with Honors, 1971
University of Washington, Seattle, Zoology - Ph.D., 1977

APPOINTMENTS

1996- Frank H. T. Rhodes Professor of Environmental Science, College of Arts and Science, Cornell University
1988- Professor, Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, New York
1985-1987 Associate Professor, Section of Ecology and Systematics, Cornell University
1981-1985 Associate Professor, Department of Zoology, University of Rhode Island, Kingston, Rhode Island
1977-1981 Assistant Professor, Department of Zoology, University of Rhode Island

SELECTED PUBLICATIONS

1999 Hairston, N. G., Jr., L. J. Perry, A. J. Bohonak, M. Q. Fellows, C. M. Kearns, and D. R. Enstgrom. Population biology of a failed invasion: Paleolimnology of *Daphnia exilis* in upstate New York. *Limnology and Oceanography.* 44:477-486

1999 Hairston, N. G., Jr., W. Lampert, C. E. Cáceres, L. J. Weider, J. M. Fischer, J. A. Fox, C. L. Holtmeier and D. M. Post. Evolution of grazer resistance to toxic cyamobacteria demonstrated using long-dormant eggs. *Nature.* 401: 446

1998 Johnson, R. L., E. M. Gross, and N. G. Hairston, Jr. Eurasian watermilfoil decline in Cayuga Lake associated with herbivory by the aquatic moth larva *Acentria ephemerella*. *Aquatic Ecology* 31:283-289.

1997 Hairston, N. G., Jr., and N. G. Hairston, Sr. Does food web complexity eliminate trophic-level dynamics? *American Naturalist* 149:1001-1007.

1996 Hairston, N. G., Jr. Zooplankton egg banks as biotic reservoirs in changing environments. *Limnology and Oceanography* 41:1087-1092.

1996 Hairston, N. G., Jr., S. Ellner, and C. M. Kearns. Overlapping generations: The storage effect and the maintenance of biotic diversity. *In* Rhodes, O. E. Jr., R. K. Chesser, and M. H. Smith (eds). Population dynamics in ecological space and time. University of Chicago Press, Chicago, IL. pp. 109-145.

1995 Hairston, N. G., Jr., R. A. Van Brunt, C. M. Kearns, and D. R. Engstrom. Age and survivorship of diapausing eggs in a sediment egg bank. *Ecology* 76:1706-1711.

1993 Hairston, N. G., Jr., and N. G. Hairston, Sr. Cause-effect relationships in energy flow, trophic structure, and interspecific interactions. *American Naturalist* 142:379-411.

PROFESSIONAL ACTIVITIES

Public outreach and education concerning the limnology of Cayuga Lake and the ecological implications of the $55-million Lake Source Cooling project of Cornell University, 1994-2000.

Member, College Board Committee to develop SAT II Biology Subject Test, 1995-1997

Cornell University Faculty-Fellows-in-Service program, 1993. Development of a grade-school (K-4) photographic guide and simple key to plants and animals of the Trumansburg School .

Panel Member, Population Biology & Physiological Ecology Prog, National Science Foundation, 1985-87

Co-organizer, University of Rhode Island Honors Colloquium, 1982-83 -Preservation of Biological and Cultural diversity.

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a. Professional Preparation

1984: B.A., summa cum laude, Kenyon College, Ohio, anthropology and sociology.
1989: M.S., Community and Regional Planning; M.A., Latin American Studies, The University of Texas at Austin.
1995: Ph.D., City and Regional Planning, University of California at Berkeley.

b. Appointments

1998–present: Assistant Professor, City and Regional Planning, Cornell University
1995–1997: Assistant Professor, Graduate Curriculum in Community Planning and Area Development, University of Rhode Island
1989-92: Director of Housing, Bay Area Council, San Francisco.

c. Publications

Pendall, Rolf. 2000. “Local Land-Use Regulation and the Chain of Exclusion.” *Journal of the American Planning Association,* forthcoming, Spring.

Pendall, Rolf. 2000. “Municipal Plans, State Mandates, and Property Rights: Lessons from Maine.” Resubmitted to *Journal of Planning Education and Research.*

Pendall, Rolf. 1999. “Opposition to Housing: NIMBY and Beyond.” *Urban Affairs Review* 35(1): 112-136.

Pendall, Rolf. 1999. “Do Land-Use Controls Cause Sprawl?” *Environment and Planning B: Planning and Design* 26(4): 555-57.

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Education

December 1984, Ph.D., Purdue University, Dept. Forestry and Natural Resources (Forest Ecology).
December 1981, M.S.F., University of Kentucky, Department of Forestry (Forest Ecology).
May 1978, B.S., University of Kentucky, Department of Horticulture and Landscape Architecture.

Appointments

June 1998 to present, Distinguished Teaching Professor, Faculty of Environmental and Forest Biology, State University of New York, College of Environmental Science and Forestry (SUNY-CESF), Syracuse, New York.
August 1995 to June 1998, Professor, Faculty of EFB, SUNY-CESF.
August 1989 to July 1995, Associate, EFB, SUNY-CESF.
August 1985 to August 1989, Assistant Professor, EFB, SUNY-CESF.
March to August 1985, Research Associate, Institute of Ecology, University of Georgia, Athens, Georgia.

Selected Publications

Bedford, B.L., D.J. Leopold, and J.P. Gibbs. 2000. Wetland biodiversity, pp. xxx-xxx, In: Encyclopedia of Biodiversity, Academic Press, San Diego, CA. (in press)
Fisher, A.S., G.S. Podniesinski, and D.J. Leopold. 1996. Effects of drainage ditches on vegetation patterns in abandoned agricultural peatlands in central New York, USA. Wetlands 16:397-409.
Podniesinski, G.S. and D.J. Leopold. 1998. Plant community development and peat stratigraphy in forested fens in response to groundwater flow systems. Wetlands 18:409-430.
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McGee, G.G., D.J. Leopold, and R.D. Nyland. 1999. Structural characteristics of old-growth, maturing, and managed northern hardwood stands: implications for forest ecosystem management. Ecological Applications 9:1316-1329.

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Professional Preparation: University of Maine, Civil Engineering, B.S., 1974; Cornell University, Environmental Engineering, M.S., 1976; Cornell University, Environmental Engineering, Ph.D., 1980

Appointments: Distinguished Professor of Civil and Environmental Engineering, Syracuse University, 1993-present; Director, Hydrogeology Program, Syracuse University, 1986-1996; Professor, Department of Civil and Environmental Engineering, 1985-1993; Visiting Scientist, Institute of Ecosystem Studies, 1987-1988; Associate Professor, Department of Civil and Environmental Engineering, 1983-1985; Visiting Scholar, Wageningen Agricultural University, the Netherlands, 1983; Assistant Professor, Department of Civil and Environmental Engineering, Syracuse University, 1979-1983.

Selected Publications:

Driscoll, C.T., S.W. Effler, M.T. Auer, S.M. Doerr and M.R. Penn. 1993. Supply of phosphorus to the water column of a productive hardwater lake: controlling mechanisms and management considerations. Hydrobiologia 253:61-72.

Driscoll, C.T. S.W. Effler, S.M. Doerr, J. Addess and C.M. Brooks. 1996. Anoxic organic carbon decomposition and the distribution of related chemical species. In: S.W. Effler (ed.) Limnological and Engineering Analysis of a Polluted Urban Lake: Prelude to Environmental Management of Onondaga Lake, New York. Springer-Verlag, New York, pp. 324-352.

Aber, J.D. and C.T. Driscoll. 1997. Effects of land use, climate variation and N deposition on N cycling and C storage in northern hardwood forests. Global Biogeochem. Cycles 11:639-648.

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Professional Preparation

Undergraduate: University of California, Berkeley (Mathematics) B.A.1975
Graduate: Cornell University (Applied Mathematics), Ph.D. 1982
Postdoctoral: Weizmann Institute of Science (Applied Mathematics) 1984-1985

Professional Appointments

2000-present: **Professor**, Department of Ecology and Evolutionary Biology, Cornell University.
1986-2000: Biomathematics Graduate Program, Department of Statistics, North Carolina State University, Raleigh NC. **Professor** 1994-present, **Associate Professor** 1989-1994, **Assistant Professor** 1986-1989. **Director of Graduate Studies** for the Biomathematics Program, 1991-1995 and 1997.
1982-1986: Department of Mathematics and Program in Ecology, University of Tennessee, Knoxville. Assistant Professor.

Selected Publications:

Pascual, M. and S.P. Ellner. Linking ecological patterns to environmental forcing via nonlinear time series modeling. Ecology (in press, to be published in 2000).

P. Turchin and S.P. Ellner. Living on the edge of chaos: population dynamics of Fennoscandian voles. Ecology (in press, to be published in 2000).

B.E. Kendall, C.J. Briggs, W. W. Murdoch, P. Turchin, S.P. Ellner, E. McCauley, R. Nisbet, and S.N.

Wood. 1999. Why do populations cycle? a synthesis of statistical and mechanistic modeling approaches. Ecology 80: 1789-1805.

S. P. Ellner, B. A. Bailey, G. V. Bobashev, A. R. Gallant, B. T. Grenfell, and D.W. Nychka. 1998. Noise

and nonlinearity in measles epidemics: combining mechanistic and statistical approaches to population modeling. American Naturalist 151: 425-440.

S. Ellner and P. Turchin, 1995. Chaos in a noisy world: new methods and evidence from time series analysis. American Naturalist 145: 343-375.

A. Shmida and S. Ellner, 1984. Coexistence of plant species with similar niches. Vegetatio 58: 29-55.

M.E. Cochran and S. Ellner, 1992. Simple methods for calculating age-specific life history parameters from stage-structured models. Ecological Monographs 62: 345-364.

S. P. Ellner, N.G. Hairston, Jr., C.M. Kearns, and D. Babaï. 1999. The roles of fluctuating selection and long-term diapause in microevolution of diapause timing in a freshwater copepod.Evolution 53:111-122.

Professional activities

Co-development of the public-domain statistical software package FUNFITS, providing a simple graphical interface (in the S-plus environment) for advanced statistical methods of function estimation including nonlinear dynamic modeling and spatial modeling.

Member of the Working Group on Complex Population Dynamics at the National Center for Ecological Analysis and Synthesis, Santa Barbara (1996-1999).

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Education

College of Agriculture and Life Sciences at Cornell University BS June 1965
Completed 31 additional credits at Cornell University since 1965

Professional Experience:

Manager of the Cornell Research Ponds' Facilities at Warren Drive and Neimi Road since 1966. These field sites support research, teaching and Cornell Cooperative Extension activities of Cornell faculty, graduate and undergraduate students, staff and many non-Cornell users. I facilitate the use of these research areas by the Cornell community and visiting researchers from other states and countries. I have conducted and helped conduct numerous experiments at the Experimental Ponds and throughout New York State on many different aspects of freshwater ecology since 1966. In addition, at the Ponds and from many lakes throughout New York State I collect aquatic plant and aquatic insect herbivore data as part of a larger Eurasian watermilfoil project.

Recent Publications:

Gross, E. M., R. L. Johnson, and N. G. Hairston, Jr. (2001) Experimental evidence for changes in submersed macrophyte species composition caused by the herbivore *Acentria ephemerella* (Lepidoptera). Oecologia. 127: 105-114.

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Education

M.S. 1996. Ecology and Evolutionary Biology, Cornell University; Ithaca, NY. Thesis: Nutrient Limitation of Primary Production and Nutrient Deficiency in Phytoplankton in Southern Chilean Lakes.
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Professional Employment

May 2001 – Present. Research Coordinator, Lake Ontario Biocomplexity Project. Center for the Environment, Cornell University, Ithaca, NY.

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August 1992 - May 1994. Teaching Assistant, Cornell University, Ithaca, NY.

February 1990 - August 1992. Research Assistant, Institute of Ecosystem Studies, Millbrook, NY.

May 1989 - November 1989. Field Technician, North Temperate Lakes Long Term Ecological Research Site, University of Wisconsin Trout lake Station, WI.

Publications

Steinhart, G.S., G.E. Likens, and D. Soto. Physiological Indicators of Nutrient Deficiency in Phytoplankton in Southern Chilean Lakes. Submitted.
Steinhart, G.S., G.E. Likens, and P.M. Groffman. 2000. Denitrification in stream sediments in five northeastern (USA) streams. Internationale Vereinigung fur Theoretische und Angewandte Limnologie, Verhandlungen. In Press.
Steinhart, G.S., G.E. Likens, and D. Soto. 1999. Nutrient limitation in Lago Chaiquenes (Parque Nacional Alerce Andino, Chile): Evidence from nutrient enrichment experiments and physiological assays. Revista Chilena de Historia Natural 72(4): 559-568.
Cole, J.J., M.L. Pace, N.F. Caraco, and G.S. Steinhart. 1993. Bacterial biomass and cell size distributions in lakes: More and larger cells in anoxic waters. Limnology and Oceanography 38(8): 1627-1632.
Lippelt, I.D. and G.S. Steinhart. 1989. Groundwater investigation of Clark County, Wisconsin. Wisconsin Geological and Natural History Survey miscellaneous map series 89-4 (7 plates).

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Education

M.S. Earth Science, Montana State University, Bozeman, MT, 1997.
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Professional Employment

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8/98-8/00 Faculty Research Associate (GIS specialist and remote sensing project leader)
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5/98-8/98 Research Associate (GIS system analyst)
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5/97-8/94 Research Assistant (GIS specialist)
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Geographic Information and Analysis Center, Montana State University

5/93-5/98 Teaching Assistant; Department of Earth Science, Montana State University;
Department of Geology, Indiana University

Recent Publications

Wright, A., Marcus, W.A., and Aspinall, R.A., 2000, Evaluation of multispectral, fine sale digital imagery as a tool for mapping stream morphology, Geomorphology, 33:107-120.

Lawrence, R.L. and Parmenter, A., October 2001, Development of rule-based classification systems using classification and regression tree (CART) analysis, Photogrammetric Engineering and Remote Sensing.

Hansen, A.J., Cohen, W., Johnson, J., Maxwell, B., Rotella, J., and Parmenter, A., *in review*, Assessing the risk to biodiversity in the Greater Yellowstone Ecosystem, Bioscience.

Parmenter, A.W., Hansen, A.J., Kennedy, R.K., Cohen, W.B., Langner, U.L, *in review*, Vectors of change in the American West: The Greater Yellowstone Ecosystem 1975-95, Ecological Applications.

Hansen, A.J., Parmenter, A,Cohen, W..B., Maxwell, B., Rasker, R., and Rotella, J.,*in review*, Ecology and socioeconomics in the New West: A case study from Greater Yellowstone, Landscape Ecology.

Parmenter, A., DeGloria, S.D., and Sydenstricker, J. *in prep*, The Use of Landsat 7 ETM Panchromatic Band for Rectification of Vector Data, Rhondonia, Brazil