Annual Report for 2000
Baltimore Ecosystem Study
Urban LTER: Human Settlements as Ecosystems: Metropolitan Baltimore from 1797 - 2001

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Baltimore City Department of Public Works: Collaborative Research
Baltimore City Public Schools: Facilities; Collaborative Research; Personnel Exchanges
Bureau of the Census: Collaborative Research
Environmental Protection Agency: Financial Support, Collaborative Research
University of Toronto: Collaborative Research
University of Maryland, Baltimore County: Facilities; Collaborative Research
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University of North Carolina at Chapel Hill: Facilities; Collaborative Research; Personnel Exchanges
University of Maryland: Facilities; Collaborative Research; Personnel Exchanges
William and Mary College: Collaborative Research
Maryland Geological Survey: Personnel Exchanges
Purdue University: Collaborative Research; Personnel Exchanges
Indiana University: Collaborative Research; Personnel Exchanges
Western School of Environmental Science: Collaborative Research

Other collaborators:
Army Corps of Engineers
Baltimore Alliance for Great Urban Parks
Baltimore Area Master Gardeners
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Baltimore City Department of Public Works.
Baltimore City Department of Recreation and Parks.
Baltimore City Development Corporation.
Baltimore City Police Department.
Baltimore City Schools.
Baltimore County Department of Environmental Protection and Resource Management.
Baltimore County Department of Recreation and Parks.
Baltimore County, Maryland Demographic Information Systems Office.
Baltimore County Schools.
Baltimore Environmentors, Baltimore City.
Baltimore Metropolitan Council of Governments.
Baltimore Neighborhood Indicators Alliance
Canton Middle School.
Center for Poverty Solutions, Baltimore, Maryland.
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Chesapeake Bay Program.
Center for Liveable Cities, Baltimore, Maryland.
Citizen Planning and Housing Association, Baltimore.
Coalition for Science in the Baltimore City Schools.
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Herring Run Watershed Association.
Historic East Baltimore Community Action Coalition.
H. J. Andrews Forest LTER Program.
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Irvine Natural Science Center.
Jones Falls Watershed Association.
Junior Tree Troops.
Kids Grow.
Landcare Research, New Zealand.
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Save Our Streams.
Seaton-Keough School.
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United States Geological Survey, National Research Program.
University of Maryland, Baltimore County - Women's Center.
Washington Council of Governments.
Western High School of Science and Technology and Environmental Science.
World Resources Institute.

Yale University School of Forestry and Environmental Sciences.

Activities and findings:
Research and Education Activities:

The Baltimore Ecosystem Study LTER seeks to integrate research on ecological, physical, social, and infrastructural components to understand the metropolitan area as a comprehensive system. By examining the past states of the system, and establishing studies for the long term, we also seek to understand the temporal dynamics of the system. In addition, formal and non-formal educational activities are a key component of the BES. This report summarizes the accomplishments of the third year of the program. Abstracts of the presentations at our third annual BES meeting, as well as detailed workplans of each participant or working group, are found on our web page at http://www.ecostudies.org/bes

The program has attracted additional collaborators who have expanded the scope of research in key areas. In addition, we continue to build on the foundation of the core LTER research areas and strengthen our capacity to integrate diverse areas of research. We have put in place an new Information management system, which has established a new web page and online data management process.

Although our research is ultimately aimed at an integrated understanding of the metropolitan ecosystem, for simplicity we present the research activities and results in the following categories: 1) Social processes and environmetal hazards, 2) Stream and riparian processes, 3) Micrometerology and climate, 4) Soil structure, function and organisms, 4) Vegetation dynamics and structure, and 5) Integrated watershed modeling. Educational and outreach activities are crucial to the success of BES, and we detail these activities below as well. We conduct quarterly science meetings to strengthen specific research areas, develop new research initiatives, and to link research efforts and results from throughout the BES.

The project continues to focus on sites concentrated along the Gwynns Falls watershed, which encompasses land now undergoing the transition from agriculture to suburban development, through old suburbs and urban residential areas, to dense, old residential and industrial areas. A reference forested watershed is located at Oregon Ridge County Park and permanent point samples have been established throughout Baltimore City. The research is integrated by the patch dynamic approach, the human ecosystem model, and the small watershed approach, all applied in a spatially explicit manner in the 17,000 ha Gwynns Falls watershed.

We are conducting research to discover the social processes that drive and are affected by biogeophysical processes in the urban ecosystem. Research has focused on the development of a framework for the analysis of land use models, and development of field data collection methods that can be linked to market and US Census surveys, to administrative records, and to remotely-sensed data. Social capital has been assessed through organizational analysis and assessment of regulations and programs that affect environmental management regimes and water quality. Measurements of boundaries, pattern and process in social patches have been compared with biophysical approaches. Patterns and processes of environmental equity are being addressed through Census data and EPA Toxics Release Inventory data, and various local historical records. Various data sources are being evaluated for their utility in explaining demographic and land use dynamics over time.

Our research on stream processes is based on USGS guaging stations in the Gwynns Falls watershed and elsewhere in the Baltimore region. These stations provide a continuous data record. USGS is investigating new approaches for high-flow storm sewer outfalls, as well as ground water hydrology. Geologic remapping is being conducted to improve hydrological data. Flow and stream chemistry are being measured at the guaging stations. Water samples are archived.

Riparian areas are key locations in which to assess the function of urban ecosystems and to link human history with ecological processes. Integrated studies of soils, vegetation, and biogeochemical processes are being conducted in riparian zones along the Gwynns Falls watershed. These studies also include paleoecological core sampling resolved into 1 cm depth increments. Cores also are collected from the Inner Harbor.

Meteorology links important processes in the ecosystem. The BES now has an LTER Network class 4 meterological station installed at the McDonogh School. Additional stations are being planned and intensification of the type of data collected at existing stations is being evaluated. Data from the Global Historical Climate Network have been used to assess the status and change of Baltimore heat island, and to compare this with Phoenix. Existing meterological stations were examined for usefulness in climate change study. A flux tower installation is being scoped.

Soils and ecosystem processes are a core part of our LTER effort. Long term biogeochemical monitoring encompasses 2 yr of monthly data on soil nitrogen cycling (mineralization, nitrification, denitrification, nitrate leaching and N_2O flux in eight forested permanent plots. One year of data exists on two permanent grass plots. Extensive surveys for biogeochemical processes include 12 forest, 12 grass, and 12 cropland plots where soil N and microbial processes were measured. The role of exotic species on nutrient dynamics continues to be investigated.

Ecosystem process studies described above require detailed knowledge of the urban soils. Soil survey at a fine scale has been conducted on130 plots throughout Baltimore City. Riparian soils have been examined in 70 undisturbed cores. Heavy metals content has been assessed in soils.

Soil organisms are being investigated using two approaches. Monthly pitfall sampling and has been conducted in forested plots in Oregon Ridge, Hillsdale Park, and Leakin Park. These plots have also been sampled for earthworms. Qualitative sampling of Isopoda and Diplopoda is conducted in unmanaged grass plots, managed lawns, city parks, roadsides and abandoned fields. Arthropod sampling is conducted at sites with data on soils, biogeochemical processes, and vegetation. Soil organism data are being compared with climatic models.

Interaction of exotic arthropods and vegetation can have major impacts on urban vegetation. Data from permanent point-based plots throughout Baltimore City was analyzed and integrated with data from other metropolitan areas to assess 1) the potential impact of Asian longhorned beetle on US urban forests, 2) the total compensatory value of carbon in US urban forests, and 3) national carbon storage and sequestration rates by US forests.

Vegetation processes in and around the urban center are a fundamental structural and dynamic component of the metropolitan ecosystem. Maryland forest history is being analyzed using historical maps, State Forestry Board archives, and other archival data. The status of Maryland forest and parkland conservation and management is being compared with other states. High resolution, digital imagery was obtained for the Gwynns Falls watershed and Oregon Ridge in October 1999, extending our long-term record of growing season coverages. Forest patches are being quantified, and the vegetation structure and composition of forested permanent plots, extensive permanent point samples, forest gaps, and riparian zones assessed. Ecological delimitation of patches types in and around the small gauged catchments along Gwynns Falls is being conducted, and the patterns of heterogeneity in those areas assessed via transects.

Integrated watershed modeling has focused on construction, linking, and accessing data to support the models. Acquisition of new data bases for modeling has been accomplished. Spatial data frameworks and simulation models are being developed for water, energy, carbon, and nutrient balance in catchments of the Baltimore region. The BASINS simulator is being employed over the period 1973-1990 for land use change. The models include social survey data on managment decisions at the household level. Large scale unit models of landscape processes have been modularized for Gwynns Falls. The General Human Ecosystem model is being run using demographics from Batimore. Social capital is being translated into a simulation module. The carbon dynamics of built capital is being incorporated. The Human Ecosystem Model is being linked to the Global Unified Metamodel of the Biosphere in order to integrate social and natural processes. Valuation will be possible using this model.

Findings:

The report of findings is organized around the five major categories used to outline research activities: 1) Social processes and environmental hazards, 2) Stream and riparian processes, 3) Micrometerology and climate, 4) Soil structure, function and organisms, 4) Vegetation dynamics and structure, and 5) Integrated watershed modeling. The outcomes of education and outreach activities are described later.

Our survey of land use change models has demonstrated that they rarely include human decision making. A modular approach to land use change models is advanced, which exploits the comparability of social, ecological, and physical assessments of patch types we have documented. Social patches have a high degree of local scale homogeneity and contribute to high diversity at larger landscape scales. Comparison of social process models focusing on Baltimore with those used in the international development arena confirms that accounting for property institutions is a key process in the role of humans as ecological agents.

The kind and location of environmental hazards is a key component of urban structure and linked social-ecological dynamics. Distribution of toxic releases in Baltimore is uneven and concentrated primarily in working class, white neighborhoods. A history of residential segregation and varying perceptions emerge as potential explanations for this pattern.

The stream flow record is published annually with some data available in near real time (http://md.water.usgs.gov/BES/). The stream data represent the four subwatersheds, and four additional sites along the Gwynns Falls that represent different degrees of urban land use and demographic characteristics. Variation in stream chemistry shows improvements downstream. Initial analysis of trends reflects road density and housing age, among other features. Questions of the role of agricultural legacies in upstream and rural stations have emerged.

Urban riparian zones tend to be relics that are now separated from stream influence by stream downcutting. Many riparian soils have buried surface or organic horizons and lowered water tables. Species distributions differ along the length of the watershed, with an increase in some fast growing exotic riparian species in lower reaches. Exotics are more prevalent among the herbaceous than the arboreal flora. Distributions of groups of plants correspond to rural, urban residential and dense urban residential-industrial zones, and relate to history of disturbance, mode of invasion and life cycles of individual species.

The heat island is better developed in Baltimore compared to Phoenix due to the cooling effect of watering of urban plantings in the arid Southwest. Urban maximum is cooler than rural sites in Phoenix, but higher in Baltimore, as expected for urban heat islands. Urban heat island development has followed expected patterns with population change. Movement of meteorological stations has compromised their utility for climate change studies. Poor local location of rain gauges is a limit to their utility.

Soils with recognizable profiles behave differently in urban sites than rural sites. Most urban soils in Baltimore have high base saturation, often approaching 100%. Nitrogen transformation processes are highest in agricultural plots, followed in order by lawns and forest soils. Lawn areas near roads have the highest heavy metal contents.

All 10 species of isopods found are exotic. One is new to the fauna of North America. The highest numbers of individuals are found in the urban forest sites, and decrease in the rural reference forest stand. Eight species of earthworms include 2 natives, and 6 exotics. The rural reference forest contains all 8 species, but natives are rare. The two remaining urban sites have only exotics, with biomass declining from urban to rural forest soils.

The Asian longhorned beetle, recently found in New York and Chicago has prompted removal of trees in an attempt to control the invader. Data from nine cities including Baltimore, based on tree species preference by the beetle, show from 12-61 % of trees to be at risk, with potential damage ranging from $72 million to $2.3 billion per city. The maximum potential national urban impact of the beetle is associated with a value loss of $669 billion.

Data on forest vegetation exposes important features of the urban ecosystem and its dynamics. Maryland forests were in relatively poor condition for the 1906-1916 survey, and the state established the 3rd state forester position in the nation. Multiple forest uses were promoted. Urban forested plots are more structurally and compositionally heterogeneous than rural reference stands, and urban and suburban forest gaps support more exotic vines than rural.

Integrated watershed models have yielded promising results. The BASINS software adequately simulates land use change and runoff production. This model uses the lumped hydrological approach to watershed covers. This approach is not as useful for changing nutrient regimes, since integration of distributed hydrological modeling regime with a plot based ecosystem modeling approach improves the simulation of terrestrial delivery of nitrate to stream channels in the BES forest reference watershed. Growing season nitrate export in the reference watershed does not

indicate nitrogen saturation, but results from seasonal dynamics of the distribution of nitrate sinks and sources along the hydrological flowpaths.

Training and Development:

The BES education program is organized around two activities: School/Community Partnership Program, and the Neighborhood Science Program. The program builds partnerships between BES scientists, teachers, students and community groups to engage students in on-going studies of the local environment. Teachers who participated in a two week, Urban Ecosystem Education Summer Institute developed action plans for the 2000 school year. Teachers at six partnership schools received financial assistance for equipment, materials and supplies, and software to support student researcher in their schoolyards. During 2000, we offered three professional development workshops for current and new partnership schools: 1) Investigating Earthworms, 2) Modeling the local ecosystem, and 3) Animal life in urban ecosystems. As a complement to the partnership program, we offered a High School Internship Program for 5 students from the Western High School of Technology and Environmental Science.

The Neighborhood Science Program worked with two community centers. At the Rose Street Community Center, BES educators, staff and scientists expanded an existing tutoring program, and brought ecological expertise to field and local activities at the center. Through the Rognel Heights Cultural Center, BES members helped students understand sustainable agriculture in an urban setting. Field activities, cross-generational exchanges, and writing are a part of that program.

College and university based education involved two Research Experiences for Undergraduates students, and six students who were part of the Baltimore Collaborative for Environmental Biology, a UMEB program based at Towson University. Student interns with the Revitalizing Baltimore program worked on technology transfer projects, and therefore developed both science and policy experience.

Training and information exchange were important activities. Two sessions were offered for educators and volunteers from the Baltimore City Department of Recreation and Parks, and from the Irvine Science Center was conducted on the topic of urban soils and earthworms. BES has been integrated into the Revitalizing Baltimore Steering Committee, and Technical Advisory Committee. The Parks and People Foundation has played a crucial role in the development of PARKSTAT: Baltimore City Department of Recreation and Parks' geographical information system inventory, as well as a supervisory role in the assessment of Baltimore's 'Friends of the Park' groups.

Education of BES staff and scientists about the nature of the complex and diverse communities they work in, is also necessary for success of the project. In addition to educating participants in safety procedures, the training was designed to enhance the interaction of BES members with the public and organizations in the various neighborhoods where they work. This Staff Safety and Community Awareness training occurs annually near the beginning of the field season, and is required of all BES participants.

Results of educational and outreach activities are diverse. Advanced placement students in American History who participated in the social ecology (Human Ecosystem Model) based activities had higher scores on the advanced placement test than other students. The AP students produced a book on the environmental history of Baltimore. Students at other schools participated in wetland planning; conducted research on streams, woods, soils and earthworms; or designed, installed and tested a stream gauge. In other schools students researched water quality in Herring Run and collected data on stream invertebrates. Northern High School students conducted a symposium and field trips for students throughout the city.

Outreach Activities:

Education and outreach are fundamental to the mission and success of the Baltimore Ecosystem Study. As a research question, we are concerned to know how people develop and use knowledge of the metropolitan area as an ecological system. In addition, we have learned from the literature and from a 10 yr social science and community restoration research program in Baltimore predating the LTER effort, that informing and working with communities and constituencies is required to site ecological research in the city and suburbs. Hence we conduct a wide variety of community and educational activities.

Public outreach was accomplished through the BES Annual Meeting, attended by scientists, educators, community members, and decision leaders from the Baltimore region as well as by BES researchers and educators. A quarterly newsletter, entitled Baltimore Ecosystem News, and written in plain language, was initiated and widely distributed to the public. The distribution of the Gwynns Falls Ecological Resource Atlas to public libraries was accompanied by an educational seminar series at each library.

Following is a list of presentations and meetings to be considered outreach activities:

Agarwal, C., Green, G., Grove, J.M., Evans, T., Schweik, C. 2000. A Review and Assessment of Land Use Change Models: dynamics of space, time, and human choice. Proceedings of 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4): Problems, Prospects and Research Needs. Banff, Alberta, Canada, September 2 -8.

Band, L. E. 1999. Hydrologic interactions and adjustments of soil-plant systems in catchments. Paper given at Fall Meetings of the American Geophysical Union, San Francisco, December 1999.

Band, L. E., C. Tague and P. Groffman 2000. Integrated modeling and monitoring of urbanizing watersheds. Paper given at the Annual Meeting of the American Association of Geographers, Pittsburgh, March 2000.

Band, L. E., C. Tague 2000. Ecosystem processes at the watershed scale: Hydrologic and ecological controls on nitrogen export. Paper given at the 2nd USA-Japan Hydrology Seminar, Honolulu, Hawaii, January 2000.

Band, L. E., C.L. Tague, S.E. Brun, D.E. Tenenbaum, R.A. Fernandes, 2000. Modeling watersheds as spatial object hierarchies: Structure and dynamics. Plenary talk given at the 4th Intl. Conf. On GIS and Environmental Modeling. Banff, Alberta, September 2000.

Belt, K.T., P.M. Groffman, G. Fisher and L.E. Band. 2000. Stream chemistry patterns along an urban-rural gradient: Preliminary results from the Baltimore Ecosystem Study, an Urban LTER (Long-Term Ecological Research) site. American Geophysical Union Spring Meeting Abstracts.

Berkowitz, A. R. and Fabiyi, V. BES Education Display. Jones Falls Watershed Association, Annual Celebration, Baltimore, MD. October 1999.

Berkowitz, A. R. and Fabiyi, V. School/Community Research Partnership Program. BES Annual Meeting, Baltimore, MD. October 1999.

Berkowitz, A. R. and Wolfson, J. Orientation Workshop, Baltimore Collaborative for Environmental Biology. Towson, MD. April 8, 2000

Boone, C. 'Census Data as a Core Demographic, Social, and Economic Dataset for Long Term Ecological and Social and M. Ratcliffe]. All Scientists Meeting of the Long Term Ecological Research Network, Snowbird, Utah (August 2000).

Boone, C. 'Utility of Historical Census Data for Long Term Ecological Studies: A Case Study of the Baltimore Metropolitan Region through the Baltimore Ecosystem Study.' [with G.L. Buckley and J. Dyer]. Invited Seminar, United States Census Bureau, Suitland, Maryland (July 2000).

Boone, C. 'Environmental Equity Research: Historical and GIS Methodologies.' Presentation at Association of American Geographers 96th Annual Meeting, Pittsburgh, Pennsylvania (April 2000).

Boumans, R.M., A.Voinov, H.Voinov, T.Maxwell, F.Villa, R.Costanza, SPATIAL INTEGRATED ECOLOGICAL ECONOMIC MODELING OF THE PATUXENT WATERSHED, MARYLAND Invited talk. Estuarine Research Federation,15th Biennial International Conference, New Orleans, Louisiana, September 25-30, 1999

Boumans, R, M. Grove, S. Dalton, and R. Costanza, Spatial Models On The Human System Of An Urbanized Watershed. Baltimore Ecosystem Study (BES) ANNUAL MEETING Baltimore, 27 September 1999

Buckley, G. L., April 5, 2000, 'Historical Analysis of Forest Cover in the Baltimore Ecosystem Study Area, 1906-1916.' Annual Meeting of the Association of American Geographers, Pittsburgh, Pennsylvania. (An abstract was published on CD and distributed to meeting attendees)

Burch, Jr. W. and Clark, T. Developing the means for integrating social and biophysical ecological approaches. 'Society and Natural Resources. 746a. 23 students.

Burch, Jr., W. Seminar in Ecosystem Management. 15 students at 6 credits or 30 FTE's. The students did a follow up on use of web sites for data collection and developed a critical analysis of these sites for reproduction on the BES web site. Field trip to Baltimore Ecosystem Study.

Burch, Jr., W. 18-22 January...meeting organized by NSF-CAP\BES LTERs on integrating the social and biophysical sciences. Presentation on The unifying influence of social ecology in ecosystem studies'

Burch, Jr., W. The Restoration Agenda: Blueprint 2,000, Yale University. 29 March–'Vine of life, Ax of Hope–Lessons of Restoration from Country and City.'

Burch, Jr., W. 1-2 February...Fairmont Park Commission\William Penn Foundation, Philadelphia. 'The importance of trails and volunteer coordinator systems in ensuring sustainable ecosystem restoration'

Burch, Jr., W. 14-15 April–Cuyahoga Valley National Recreation Area, Ecosystem Research Consortium. 'People as an ecosystem component–lessons from Baltimore, New Haven and Philadelphia.'

Burch, Jr., W. 17 Earthday Keynote sponsored by Environmental Science program, Cleveland State University

Burch, Jr., W. 18 May–Glasgow, Scotland: Central Scotland Conservation Trust–'Putting the social into ecosystem restoration–an agenda for community and conservation.'

Burch, Jr., W. 19-22 June–Society and Natural Resources meetings, Bellingham, Washington, present paper on 'Travelers in the forest–the co-evolution of social ecology and silviculture'; panelist on two discussion sessions revolving around ecosystem management research.

Burch, Jr., W. 1-10 August–NSF-LTER All scientists meeting participation. Snowbird, Utah. Ecological Society of America, paper, 'Perspectives on the methods and applications of biosocial patch analysis in three different anthropogenic ecosystems–Gansu Province, PRC, Western Nepal, and Baltimore, MD.'

Costanza, R. International Congress on Ecosystem Health: Managing for Ecosystem Health. Invited symposium speaker: 'Whole watershed health and restoration: Applying the Patuxent and Gwynns Falls landscape models to designing a sustainable balance between humans and the rest of nature'. Sacramento CA, August 15-20, 1999.

Cosatnza, R. Town Hall Meeting on 'Environmental Health on the Ag/Urban Frontier.' Invited plenary speaker: 'Ecological economics and sustainable agriculture' and panelist (with K. Olden, Director, NIEHS and R. Rominger, Deputy Director, USDA). Sacramento, CA August 17, 1999.

Costanza, R. UIC Great Cities/Illinois-Indiana Sea Grant Urban Water Resources Conference: Improved Decision-Making for Water Resources: the Key to Sustainable Development for Metropolitan Regions. Invited plenary speaker: 'Integrated Ecological Economic Modeling of Water Resources'

Cosatnza, R. University of Illinois at Chicago, Chicago, IL, September 16-17, 1999. (talk given from Maryland via Interactive Video) Association of Ecosystem Research Centers (AERC) Symposium: Biocomplexity and Ecosystem Research: Necessities for the 21st Century. Invited Plenary Speaker: 'Human systems, Ecosystems, and Biocomplexity. Washington, DC, Nov. 4, 1999.

Costanza, R. First Lancaster Environmental Symposium: 'Human Impact on Natural Resources: a Regional Perspective'. Invited keynote speaker:'Dynamics and Economic Value of Ecosystem Services.'

Costanza, R. Millersville University, Millersville, PA, Feb. 12, 2000. 15th Annual Symposium of the US Regional Association of the International Association for Landscape Ecology: Integration of Societal and Landscape Heterogeneity: Problems and Solutions.

Costanza, R. Invited plenary speaker: 'Landscape models as tools in integrated, adaptive management of regional ecological economic systems.' Ft. Lauderdale, FL, April 15-19, 2000.

Costanza, R. University of Vermont Aiken Lectures 2000: Vermont watersheds: sustaining ecological and economic vitality. Invited plenary speaker: 'Integrated ecological and economic modeling of watersheds' Burlington, VT, May 1, 2000.

Costanza, R. US Forest Service and Wilderness Society National Wilderness Values Workshop. Invited opening speaker: 'The role and value of ecosystems and natural capital.' Washington, DC, July 11-12, 2000

Costanza, R. 4th International Conference on Integrating Geographic Information Systems (GIS) and Environmental Modeling. Invited Opening Plenary speaker: 'Humans as subjects and participants in landscape modeling'. Banff, Alberta, Canada, Sept. 2-8, 2000

Dalton, Shawn E. (2000). The Changing Roles of Organizations in Natural Resource Management Regimes. LTER All Scientists Meeting, Snowbird, Utah, August, 2000. Abstracts were published.

Fabiyi, V. and Parfitt E. School/Community Research Partnership Program Workshop. Maryland Association of Science Teachers (MAST) Annual conference, Ocean City, MD. 2000.

Fabiyi, V. and Staff from Mcdonogh School. BES Education Programs. Maryland Association of Biology Teachers (MABT), [location]. April 8, 2000.

Fabiyi, V. BES exhibit. Herring Run Watershed Association's Annual Spring Migration. Baltimore, MD. April, 2000.

Fabiyi, V. and other BES Education Team Members. BES exhibit and field studies. Gun Powder Falls Watershed Association, Earth Day Celebration, Oregon Ridge Nature Center, Baltimore County, MD. May 2000.

Fabiyi, V. Promotional presentations about the 2000 School/Community Research Partnership Program workshops. Baltimore City Public Schools' science teachers department heads, Baltimore, MD. March, April and May 2000.

Groffman, P. M. Presentation to Chesapeake Bay Program Scientific and Technical Advisory Committee on Baltimore Ecosystem Study. March 2000.

Groffman, P. M. Invited seminar, Seminar Series of Earth Systems and Environment, University of Maryland, Baltimore County. April 2000.

Grove, J.M. 1999. The Relationship between Patterns and Processes of Social Stratification and Vegetation Structure of an Urban-Rural Watershed. Baltimore Ecosystem Study Annual Meeting. Baltimore, Maryland. October.

Grove, J.M. 1999. Initiating the Baltimore Ecosystem Study. A National Conference: Building on Leopold's Legacy: Conservation for a New Century. Madison, Wisconsin. October 4 – 7.

Grove, J.M. 1999. I have Stood on the Shoulders of Giants (or the feet of dwarfs) so that I Might See so Far: some thoughts on the lessons learned from Dr. William R. Burch, Jr. Festschrift for William R. Burch, Jr.

Grove, J.M. 1999. The Baltimore Experience: Bottom-up Approaches to Policy and Organizational Change of a Natural Resource Agency. Policy Analysis in Natural Resource Management (Burch. W.R., Jr., and Clark, T.). School of Forestry & Environmental Studies. Yale University (Fall).

Grove, J.M. 2000. Data in the 21st Century: The Internet, WWW, and GIS. Ecosystem Management (William R. Burch, Jr.). School of Forestry & Environmental Studies. Yale University (Spring).

Grove, J.M. 2000. Durkheim, Marx, and, Weber: the Pep Boys of interdisciplinary research for urban field stations. NSF Workshop on Urban Field Stations for Long Term Ecological Research (Mike Walton). Cleveland State University, Cleveland, Ohio. April.

Grove, J.M. 2000. Interdisciplinary Approaches to Ecosystem Management. Ecosystem Management (Bob Kratchovil). Natural Resources Department. University of Maryland, College Park, Maryland. March.

Grove, J.M. 2000. Interdisciplinary Approaches to Urban Watershed Research. Urban Geography (Beverley Wemple). Geography Department, University of Vermont, Burlington, Vermont. April.

Grove, J.M. 2000. Interdisciplinary Approaches to Watershed Research. Watershed Management (Mike Rechlin). Paul Smith's College, Paul Smiths, New York. April.

Grove, J.M. 2000. O'Malley Rocks—Ecosystems Flux: ecological studies where people are a part of the story. Environmental Science and Studies Seminar Series. Towson University, Towson, Maryland. April.

Grove, J.M. 2000. GIS and Human Dimensions of Environmental Systems. Proceedings of 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4): Problems, Prospects and Research Needs. Banff, Alberta, Canada, September 2 - 8.

Heisler, Gordon M., Anthony Brazel, Nancy Selover, and Russell Vose. 1999. Urban influences on temperatures of Baltimore and Phoenix urban LTER sites. Presented at 1999 Annual Meeting of the Baltimore Ecosystem Study. October 14-15, 1999, Baltimore, MD.

Heisler, G. M. Urban climate. Lecture to University of Maryland Baltimore County Urban Ecology class. October 1999.

Law, N., Grove, J.M. 2000. Households as Ecological Agents: Integrating household survey information in a spatially-explicit, dynamic urban watershed model. All Scientsts' Meeting of the Long Term Ecological (LTER) Network, Snowbird, Utah, August 2-5.

Parks and People Foundation. Hosted Yale University's School of Forestry and Environmental Studies, Ecosystem Management class (March 2000). This field exercise examined the fluxes and flows of information through the metropolitan area, and considered the consequences for natural resource management at various scales.

Patterson, T., Boumans, R. and Grove, J. M. Modeling Human Ecological Systems: a review of social capital approaches for dynamic modeling. 4th International Conference on Integrating Geographic Information Systems (GIS) and Environmental Modeling. Invited Opening Plenary speaker: 'Humans as subjects and participants in landscape modeling'. Banff, Alberta, Canada, Sept. 2-8, 2000.

Pouyat, R.V. and S.T.A. Pickett. 2000. A multidisciplinary approach to the study of urban ecosystems: The Baltimore Ecosystem Study. American Geophysical Union 2000 Spring Meeting, Washington, DC, May 30-June 3, 2000. EOS supplement May 9 issue: S-11.

Pouyat, R.V. 1999. Long-term research in urban settings: The Baltimore Ecosystem Study. Society for Conservation Biology's 13th Annual Meeting. University of Maryland, College Park, 17-21 June, 1999.

Pouyat, R.V., I.D. Yesilonis, and W.R. Effland. 1999. The characterization of human modified soils in the Baltimore Ecosystem Study. Conference on Soil Resources: Their Inventory, Analysis, and Interpretation for use in the 21st Century, Minneapolis, MN, June 10-12. p. 58.

Pouyat, R. V. 1998. The Baltimore Ecosystem Study: A Long-Term Ecological Study of a Metropolitan Area. MAIA Working Conference, Environmental Protection Agency, 30 November-2 December, 1998, Baltimore, Maryland.

Pouyat, R.V. 1998. The Baltimore Ecosystem Study. LTER Workshop: The New Urban Focus. National Science Foundation LTER Network Office. Ecological Society of America Annual Meetings, August 2-8, Baltimore, Maryland.

Ratcliffe, M., Boone, C., Grove, J.M. 2000. Census Data As A Core Demographic, Social, And Economic Dataset For Long Term Ecological and Social Research. All Scientsts' Meeting of the Long Term Ecological (LTER) Network, Snowbird, Utah, August 2-5.

Schweik, C.M., Grove, J.M. 2000. 'Fostering Open-Source Research Via a Web System.' Paper Presented at the Association for Computers and the Social Sciences Annual Online Conference, April 15-May 15.

Schweik, C.M., Grove, J.M., 2000. 'Fostering Open Source Research and Modeling Collaboration Over the Web.' Proceedings of 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4): Problems, Prospects and Research Needs. Banff, Alberta, Canada, September 2 - 8.

Schweik, C.M. 2000. 'Global Monitoring and the Human Dimensions of Global Change (HDGC),' Invited presentation at the Workshop on human dimensions of global change, Castle Wendgräben, Germany, July 13-15. Workshop to advise the German national committee for Global Change research on HDGC research directions.

Smith, J., S.T.A. Pickett and P.M. Groffman. 2000. Urban carbon: Sources, sinks and people in Baltimore. Ecological Society of America Annual Meeting Abstracts.

Sprott, P., Shears, B. and Fabiyi, V. Urban LTER and Science Education. Poster at the American Association for the Advancement of Science. Washington, DC. February 21, 2000.

Szlavecz, K., R.V. Pouyat, P.M. Groffman, and A. Lorefice. 2000. The effects of urbanization on forest soil dynamics. American Institute of Biological Sciences Annual Meeting, Washington, DC, 22-24 March, 2000. Final Program: 30-31.

Szlavecz, K. and Nilon, C. - 2000: Workshop host and leader 'Animal Life in Urban Landscapes'.

Szlavecz, K. - 2000: Visited to Roland Park Country School, for student presentation of results of earthworm sampling.

Tague, C. and L.E. Band 2000. Spatially Distributed Modeling of the Hydro-geologic and Ecologic Controls on Nitrogen Cycling and Nitrate Export for a Small Forested Watershed, Paper given at Spring Meetings of the American Geophysical Union, Washington, June 2000.

Tenenbaum, D. and L.E. Band 2000. Developing the RHESSys/Arc-View Integrated Modeling Environment for use in Urban Watersheds. Paper given at the Annual Meeting of the American Association of Geographers, Pittsburgh, March 2000.

Villa, F., Costanza, R. Calibration techniques for complex simulation models. IALE (International Association for Landscape Ecology) 15th Conference. Fort Lauderdale, FL, March 2000.

Villa, F., Costanza, R. Integrating Modeling Architecture: a declarative framework for multi-scale, multi-paradigm ecological modeling. Modeling Complex Systems 2nd Conference, Montreal, Quebec, August 2000.

Voinov*, Alexey A., Robert Costanza, Roelof Boumans and Helena Voinov: Modular Ecosystem Modeling: Application to the Patuxent Watershed IALE (International Association for Landscape Ecology) 15th Conference. Fort Lauderdale, FL, March 2000.

Voinov A. Modular Ecosystem Modeling: Application to the Patuxent Watershed. IEEE Geosciences and Remote Sensing Society, Washington-North Virginia Chapter seminar. Feb. 22, 2000

Voinov A. Modular modeling of watersheds. Invited panel presentation. 2000 AAAS annual meeting. Washington, DC. Feb. 21, 2000.

Journal Publications:

Band, L. E., C. L. Tague, S. E. Brun, D. E. Tenenbaum, R. A. Fernendes, "Modeling watersheds as spatial object hierarchies: structure and dynamics", *Transactions in Geographic Information Systems*, vol. 4, (2000), p. 181. Published

Band, L. E., C. L. Tague, P. Groffman, K. Belt, "Forest ecosystem processes at the watershed scale", *Hydrological Processes*, vol. , (), p. . Accepted

Brazel, A., Nancy Selover, Rissell Voce, Gordon Heisler, "The Tale of Two Climates – Baltimore and Phoenix LTER Sites", Climate Research, vol. 15(2), (2000) p. 123 Published.

Brun, S. E. and L. E. Band, "Simulating runoff behavior in an urbanizing watershed.", *Computers, Environment and Urban Systems*, vol. 24, (2000), p. 5. Published

Dalton, S., "USDA Forest Service General Technical Report", *Social Capital Literature Review*, vol. , (2000), p. 1. Published

Grimm, N., JM Grove, STA Pickett, C. Redman, "Integrated Approaches to Long-Term Studies of Urban Ecological Systems", *Bioscience*, vol. 50(7), (2000), p. 571. Published

Machlis, Gary E., Jo Ellen Forec, William R. Burch, Jr., "The Human Ecosystem as an Organizing Concept in Ecosystem Management", *Elsevier Science, Ltd.*, vol. , (1999), p. 21. Published

McDonough, Maureen, Don, Callaway, L. Marie Magleby, William R. Burch, Jr., "Social Classification in Ecosystem Management", *Elsevier Science, Ltd.*, vol. , (1999), p. 227. Published

Schweik, CM, Grove, JM, "Fostering Open-Source Research Collaboration Via a Web System", *Public Administration and Management: An Interactive Journal HTTP://WWW.PAMIJ.COM*, vol. , (2000), p. . Published

Book(s) of other one-time publications(s):

Berkowitz, A.R., K.S. Hollweg and C.H. Nilon., "A New Frontier for Science and Education." , bibl. Springer - Verlag, Inc., NY. *Book* Submitted, Berkowitz, A.R., K.S. Hollweg and C.H. Nilon., "Understanding Urban Ecosystems: Springer-Verlag, Inc., New York."

Berkowitz, A.R., K.S. Hollweg and C.H. Nilon., "New directions for research and education in and about urban ecosystems." , bibl. Springer-Verlag, Inc., New York., (). *Chapter 30* Submitted Berkowitz, A.R., K.S. Hollweg and C.H. Nilon., "Understanding Urban Ecosystems: A New Frontier for Science and Education."

Boumans Roelof, Robert Costanza and Josh Farley, "A model on the Human System, calibrated and tested for the Baltimore MD urban area for urban ecology." , bibl.. *paper* Published

Burch, Jr., W.R. and Jacqueline M. Carrera,, "Out the door and down the street–enhancing play, community and work environments as if adulthood mattered.' " , bibl. , (). *chapter* forthcoming Alan R. Berkowitz, et. al, "Understanding Urban Ecosystems: A New Frontier for Science and Education."

Costanza Robert, Alexey Voinov , Roelof Boumans, Thomas Maxwell, Ferdinando Villa, Lisa Wainger, and Helena Voinov, "Integrated ecological modeling of the Patuxent watershed, Maryland." , bibl. , (). *article* in revision , "Ecological Monographs "

Costanza Robert, Roelof Boumans, Joshua Farley, Monica Grasso, Bruce Hannon, Richard Howarth, John Hobbie, Jan Rotmans, Mattias Ruth, Ferdinando Villa, and James Wilson, "Modeling the Dynamics and Value of Global Ecosystem Services." , bibl. , (). *paper* in preparation "Ecological Economics"

Costanza, R. and A. Voinov., "Integrated ecological economic regional modeling: linking consensus building and analysis for synthesis and adaptive management" , bibl. Island Press. 539 pp. , (2000). *chapter* Published J. Hobbie (ed.), "Pp. 461-506 in: Estuarine science: a synthetic approach to research and practice. "

Diamond, M. and R. V. Pouyat., "The movement and fate of toxics in urban ecosystems." *article* "Urban Ecosystems"

Doheny, E., "Index of hydrologic characteristics and data resources for the Gwynns Falls watershed, Baltimore County abd Baltimore City, Maryland". p. 17 (1999) *data*. Published. "US Geological Survey Open File Report, 99 – 213

Effland, W.R. and R.V. Pouyat., "The genesis, classification, and mapping of soils in urban areas." , bibl. 1:217-228. , (1997). *article* Published "Urban Ecosystems"

Grove, J.M. and K. Hinson, Northrop, R., "Education, Social Ecology, and Urban Ecosystems, with Examples from Baltimore, Maryland." , bibl. Springer-Verlag, N.Y., (2001). *chapter* Submitted
of Collection: A.R. Berkowitz, D.H. Nilon and K.S. Hollweg,, "Understanding Urban Ecosystems: a new frontier for science and education."

Grove, J.M, Hinson, K., Northrop, R., "Education, Social Ecology, and Urban Ecosystems, with examples from Baltimore, Maryland.'" , bibl. Springer-Verlag, NY. , (2001). *Book* in press A.R. Berkowitz, C.H. Nilon and K.S. Hollweg, "Understanding urban ecosystems: a new frontier for science and education."

Grove, J.M., C. Schweik, T. Evans, and G. Green., "'Modeling Human-Environmental Systems." , bibl. Upper Saddle River, NJ: Prentice-Hall. , (2001). *article* in press Clarke, K. C., B.E. Parks, and M.P. Crane, "Geographic Information Systems and Environmental Modeling."

Hollweg, K.S., C. Pea and A.R. Berkowitz., "Why is understanding urban ecosystems an important frontier for education and educators?" , bibl. Springer-Verlag, Inc., New York. Chapter 2, (). *Chapter 2* Submitted
of Collection: Hollweg, K.S., C. Pea and A.R. Berkowitz., "Understanding Urban Ecosystems: A New Frontier for Science and Education."

Hornung, E., K. Szlavecz, Cs. Csuzdi, Z. Korsos:, "Stowaways on ships -Introduced invertebrates in the soil fauna of North America." , bibl. Debrecen, Hungary, (2000). *Printed Abstract* Published "Fifth Congress of the Hungarian Ecological Society"

Hornung, E., K. Szlavecz, Cs. Csuzdi, Z. Korsos:, "Stowaways on ships -Introduced invertebrates in the soil fauna of North America." , bibl. Debrecen, Hungary, (2000). *Printed Abstract* Published "Fifth Congress of the Hungarian Ecological Society"

James, R.W., Jr., Saffer, R.W., and Tallman, A.J., "Water resources data, Maryland and Delaware, water year 1999: Volume 1, Surface-water data" , bibl. 99-1, 408 p. , (2000). *report* Published "U.S. Geological Survey Water-Resources Data Report MD-DE"

Kinzig, A., and Grove, J.M., "'The Urban Environment.", bibl. Academic Press., (2000). *article* In press Levin, S., "Encyclopedia of Biodiversity."

Low, B., R. Costanza, E. Ostrom, and J. Wilson., "Human-ecosystem interactions: a dynamic integrated model." , bibl. 31:227-242, (2000). *Book* Published "Ecological Economics"

Low, B., R. Costanza, E. Ostrom, and J. Wilson., "Human-ecosystem interactions: a dynamic integrated model." , bibl. 31:227-242, (2000). *article* Published "Ecological Economics"

Machlis, Gary E., Jo Ellen Force and William R. Burch, Jr., "The human ecosystem as an organizing concept in ecosystem management." , bibl. Oxford: Elsevier Science, Ltd. Pp 21-36. , (1999). *article* Published Johnson, N.C., A.J. Malk, W.T.Sexon and R. Szary, "Ecological Stewardship: A Common Reference for Ecosystem Management."

McDonough, Maureen H., Don Callaway, L. Marie Magleby and William R. Burch, Jr.,, "Social Classification in Ecosystem Management." , bibl. Pp 227-244. Oxford, Elsvier Science, Ltd. , (1999). *article* Published , "Ecological Stewardship: A Common Reference for Ecosystem Management"

Patterson, Trista, Roelof Boumans, and Morgan Grove,, "Modeling Human Ecological Systems: a review of social capital approaches for dynamic modeling." , bibl. , (2000). *paper* Published "International Conference of Geographic Information Systems and Environmental Modeling (GIS/EM4)"

Pouyat, R.V. and W.R. Effland., "The investigation and classification of humanly modified soils in the Baltimore Ecosystem Study." , bibl. Pages 141-154., (1999). *article* Published In Kimble, J.M., R.J. Ahrens, and R.B. Bryant (eds.)., "Classification, Correlation, and Management of Anthropogenic Soils, Proceedings--Nevada and California, September 21-October 2, 1998. USDA Natural Resource Conservation Service, National Survey Center, Lincoln, Nebraska. "

Pouyat, R.V. and W.C. Zipperer., "Protecting forests in urbanizing landscapes: Is it possible?" , bibl. , (1999). Published "Proceedings of the Ninth National Urban Forestry Conference, August 30 to September 2, 1999, Seattle, Washington. Washington, DC: American Forests. "

Pouyat, R., K. Szlavecz, P. Groffman, and A. Lorefice, "The effects of urbanization on forest soil dynamics" , bibl. , (2000). *printed abstract* Published "AIBS Annual Meeting, Washington DC, March 2000"

Redman, C., Grove, J.M, and Kuby, L., "Toward a Unified Understanding of Human Ecosystems: Integrating Social Sciences into Long-Term Ecological Research." , bibl. http://www.lternet.edu/research/pubs/informal/socsciwhtppr.htm, (2000). *paper* Published "White Paper of the Social Science Committee of the LTER Network."

Szlavecz, K, "Arthropod studies in BES." , bibl. , (2000). *Workshop Study* presented "Arthropod Workshop on ESA LTER All Scientist Meeting, Snowbird, Utah,"

Villa, F., and Costanza, R.,, "Design of multi-paradigm integrating modelling tools for ecological research." , bibl. 15: 169-177. , (2000). *chapter* Submitted "Environmental Modelling and Software"

Villa, F., McLeod, H., "Frameworks for the calculation of synthetic environmental vulnerability indicators for environmental planning and decision-making." , bibl. , (2000). *paper* Submitted "Environmental Management"

Villa, F., Boumans, R.M.J., Costanza, R., "Design and use of a Model Performance Index (MPI) for the calibration of ecological simulation models." (2000). *paper* Submitted "Environmental Modelling and Software"

Vogt KA., Grove J.M., Asbjornsen H., Maxwell K., Vogt D.J., Sigurdardottir R., Dove M., "'Linking ecological and social scales for natural resource management." , bibl. Cambridge University Press: New York. , (2000). *article* In press J. Liu and WW Taylor, "Integrating Landscape Ecology into Natural Resource Management"

Voinov. A, R. Costanza, L. Wainger, R. Boumans, F. Villa, T. Maxwell and H. Voinov., "The Patuxent landscape model: Integrated ecological economic modeling of a watershed." , bibl. 14:473-491 , (1999). *article* Published "Environmental Modelling and Software"

Voinov. A, H. Voinov and R. Costanza., "Surface water flow in landscape models: 2. Patuxent watershed case." , bibl. 119:211-221 , (1999). *chapter* Published "Ecological Modeling"

Voinov, A. and R. Costanza., "Watershed management and the web." , bibl. . 56:21-245. , (1999). *paper* Published "Journal of Environmental Management"

Wilson, J. B. Low, R. Costanza, and E. Ostrom., "Scale misperceptions and the spatial dynamics of a social-ecological system" , bibl. 31:243-258 , (1999). *paper* Published, "Ecological Economics"

Zipperer, W.C., J. Wu, R.V. Pouyat, and S.T.A. Pickett., "The application of ecological principles to urban and urbanizing landscapes." , bibl. vol. 10 pp. 685-688, *article* in press "Ecological Applications."

Other Specific Products:

Software (or netware)
Arcview and GRASS software for processing terrain, land cover, soils information for use in catchment modeling, hydroecological modeling tools. All are available for use within the scientific community. Information will be shared through the internet

Teaching aids
Baltimore Urban Ecosystem Teaching Modules for we-based support of BES Educators, via Internet

Data or databases
Inventory of 121 ground-water wells within the Gwynns Falls watershed and a search or current literature in urban groundwater hydrology, via Microsoft Access database

Working Paper Series
Parks & People Foundation. 2000. Neighborhood Open Space Management: A Report on Greening Strategies in Baltimore and Six Other Cities. Baltimore: Urban Resources Initiative Working Paper Series.

Levendosky, Katherine. 2000. A Reference Guide and Bibliography to the Ecology and Natural Resources of the Baltimore Metropolitan Area. Baltimore: A Joint Publication of the Urban Resources Initiative and Institute of Ecosystem Studies. (in press)

Brewer, Andrea. 2000. Preliminary Master Planning Recommendations to the Cylburn Arboretum Board of Directors. Baltimore: Urban Resources Initiative Working Paper Series. (draft)

Sekine, Marina. 2000. An Assessment of Baltimore's 'Friends of the Park' Groups. Baltimore: Urban Resources Initiative Working Paper Series. (draft) Internet

Internet Dissemination:

www.unc.edu/dept/geog/them
www.ecostudies.org/bes
http://md.water.usgs.gov/BES/
http://md.water/usgs.gov/BES/architecture/
www.parksandpeople.org/gfatlas
www.parksandpeople.org/news/openspace.pdf
www.parksandpeople.org
http://128.119.99.210/

Contributions:
Contributions within Discipline:

This third year of the Baltimore Ecosystem Study has continued to extend the scope of ecology to the ecologically neglected urban realm. The world-wide increase in urbanization makes ecological attention to urban systems both practically and intellectually appropriate. The testing of patch theory in a novel ecosystem type is one example of an intellectual benefit to ecology. An additional benefit is the comparison spatially explicit watershed models with spatially lumped models. We have obtained initial results that confirm the applicability of patch theory to integrated social and ecological systems, and the improved capacity of spatially explicit watershed models in urban systems. We continue to explore research and modeling approaches in disciplines outside ecology as potential tools for integration with ecology and within ecology per se. We, in association with colleagues from the CAP LTER and other scientists in the LTER Network, have furthered the articulation of socioeconomic principles for research in LTER programs.

Contributions to Other Disciplines:
The main contribution to different disciplines continues to be the exploration of variables and approaches that are useful for integration. Patch dynamics, spatially explicit catchment models, social capital models, and now different

scales of environmental valuation are issues that we have begun to investigate. We continue to be a source for importing spatially explicit simulations to additional natural and social science specialties. Our work also continues to illustrate the utility of metadata in physical sciences.

Contributions to Education and Human Resources:

BES continues its manifest commitment to involve students from K-12, through postdoctoral levels. Teacher training and curriculum development reaches urban and suburban, and public and private schools. We work substantially with underrepresented populations in all our educational and outreach activities.

Contributions to Resources for Science and Technology:

BES continues to develop digital data bases, and integration of multiscale remote sensing imagery for urban analysis. We are integrating the diverse elements of landscapes into unified models that can support decision making. We are exploring the strategies for urban field stations, and web based linkage of communities and environmental organizations with scientists and decision makers.

Contributions Beyond Science and Engineering:

Both the general public and governmental agencies desire the integrated, spatial models we are developing. The public is concerned with processes of non-point sources of pollution, community and neighborhood restoration, and watershed protection our models are designed to evaluate. We are exploring new ways to link with stakeholders in our region and neighborhoods. The public concern with smart growth, the new urbanism, and with metropolitanism as policy alternatives all intersect tightly with our scientific and educational mandate.