

**BALTIMORE ECOSYSTEM STUDY ANNUAL REPORT – 1999**  
**Urban LTER: Human Settlements as Ecosystems: Metropolitan Baltimore from 1797 – 2100**

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## **Partner Organizations**

Baltimore City Public Schools: Facilities; Collaborative Research; Personnel Exchanges  
Bureau of the Census: Collaborative Research  
Environmental Protection Agency: Financial Support; Collaborative Research  
Johns Hopkins University: Collaborative Research; Personnel Exchanges  
Indiana University Bloomington: Collaborative Research; Personnel Exchanges  
Ohio University: Collaborative Research  
Parks and People Foundation: Facilities; Collaborative Research  
Rognel Heights Cultural Center: Facilities  
Rose Street Community Center: Facilities; Collaborative Research; Personnel Exchanges  
Towson State University: Collaborative Research  
University of Maryland, Baltimore County: Facilities; Collaborative Research  
University of Missouri-Columbia: Collaborative Research  
University of Toronto: Collaborative Research  
USDA Forest Service – Northeastern Forest Experiment Station: Financial Support; In-Kind Support; Facilities; Collaborative Research; Personnel Exchanges  
USDA Natural Resources Conservation Service: Financial Support; Facilities; Collaborative Research

## **Other Collaborators**

Baltimore City Department of Planning  
Baltimore City Department of Public Works  
Baltimore City Department of Recreation and Parks  
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  
Canton Middle School  
Center for Livable Cities, Baltimore, Maryland  
Center for Poverty Solutions, Baltimore, Maryland  
Central Arizona-Phoenix LTER Program  
Chesapeake Bay Program  
Citizen Planning and Housing Association, Baltimore  
Community Planning and Housing Association, Baltimore City  
Cooperative Research Centre for Freshwater Ecology, Canberra, Australia (Dr. Peter Cullen, Director)  
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Council for the Advancement of Science Writing  
Coweeta LTER Program  
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Global Learning and Observations to Benefit the Environment  
Glyndon Elementary School  
Gwynns Falls Watershed Association  
Herring Run Watershed Association

**Other Collaborators** *(Continued)*

Historic East Baltimore Community Action Coalition  
H. J. Andrews Forest LTER Program  
Institute for Ecological Research – Chiloe, Chile (Dr. Juan Armesto)  
Irvine Natural Science Center  
Jones Falls Watershed Association  
Junior Tree Troops  
Kids Grow  
Landcare Research, New Zealand  
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Maryland Department of Natural Resources and Forest Service  
Maryland Institute College of Art  
McDonogh School, Inc.  
Mergenthaler High School  
Ministry for Environment, New Zealand  
Morgan State University, Department of Landscape Architecture  
NASA Office of Earth Science  
National Center for Ecological Analysis and Synthesis  
National Public Radio  
Northern High School  
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Project RAISE  
Revitalizing Baltimore  
Rognel Heights Cultural Center  
Roland Park Country School  
Rose Street Community Center  
Safe and Sound  
Save Our Streams  
Seaton-Keough School  
Southeast Middle School  
Stack, Mr. William, Baltimore City Department of Public Works  
Super Kids Camp  
University of Maryland, Baltimore County – Women’s Center  
Washington Council of Governments  
World Resources Institute  
Yale University School of Forestry and Environmental Sciences

**Activities and Findings*****Research 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 program's second year.

Using patch dynamics theory, we test the hypothesis that the spatial structure of the social, ecological, physical, and infrastructural processes influence each other reciprocally. Therefore we are developing tools to represent and model the spatial complexity of the urban environment and establishing a protocol for patch assessment.

Social structure and processes are crucial components of the working model of metropolitan Baltimore as a human-dominated ecosystem. In addition to demography and summaries of population characteristics, the institutional structure and processes are hypothesized to be major controls on the structure and function of the inclusive urban ecosystem. To test this hypothesis, we are quantifying marketing reference group behavior, assessing social stratification, and documenting organizational behaviors and relationships. These social processes are being put in spatial context by discovering their patch dynamics.

Ecosystem processes, including nitrogen and litter dynamics, vegetation dynamics, soil characteristics, and the role of exotic species are a core focus. New permanent plots have been established in grass-covered areas to complement existing forested plots. The vegetation within the metropolis is being examined using the Forest Inventory Analysis plots and a rigorous analysis of tree-covered patches. Intensive studies of riparian zones, including vegetation, soils, and heavy metals were initiated this year. The riparian studies complement our ongoing measurement of stream flow and water chemistry. Paleoecological studies focus on the riparian zones and sediments in Baltimore Harbor, where cores have been extracted to measure pollen, seeds, and heavy metals.

The diverse components of the metropolitan system are being integrated not only empirically, as described above, but also through simulation modeling. We have employed different watershed-based models, including the EPA urban standard 'lumped' model, and spatially distributed models derived from natural resources management. Our efforts this year have examined the complementarities and contrasts between these models, have employed the EPA standard in a spatially distributed fashion, and have added human and urban dimensions to the natural resource based models. We are thus making progress toward an integrated model of the ecological function of watersheds suitable for the range of environments found in cities, suburbs, exurbs, and the hinterland.

Employing ecological, hydrological, and physical research methods in an urban area has required us to adopt and refine a Participant Action Research (PAR) strategy derived from social science. We have discovered that aspects of this approach are needed to engage communities and gain their formal and informal permission to work in their 'back yards,' to establish communication channels for our educational efforts, to discover compelling research questions in the metropolis, and to operate safely in a new environment. We have developed a protocol for PAR and have conducted the first annual workshop for BES participants on Community Sensitivity, Health, and Safety.

Our education program has been extremely active. Drawing on the input of a Steering Committee of 41 local and regional leaders in education, we have strengthened linkages with the Baltimore City Public Schools, the Baltimore County Public Schools, and a number of private primary and secondary schools and community centers. Our School-Community Partnership has established teams of teachers and BES researchers, and conducted a two-week long Urban Education Summer Institute during which educational activities based on BES research were designed and tested. We have held workshops on soils processes as teaching tools and have provided support for project development by teachers. Our educational activities have operated through the BES Urban Ecology Field Station, which was established in cooperation with the Rose Street Community Center, as well as through other community groups and with colleges and universities in the area. The extracurricular educational activities have been summarized as our strategy document on Neighborhood Science.

To determine how to integrate civil infrastructure empirically and conceptually into BES and to pose important long-term research questions about its role in metropolitan dynamics, we conducted a multidisciplinary workshop. Held in Baltimore in June 1999, the workshop updated BES researchers on studies and data available on civil infrastructure in the metropolitan area and identified crucial research future needs of interest to both researchers, managers, and decision makers. In addition, working partnerships were established or reinforced in the workshop.

Data management has focused on acquisition and dissemination of data required by the BES as a whole, support of GIS and GPS for specific research tasks within BES, ongoing revision of the BES web page, and training researchers in effective use of metadata.

### ***Research Findings***

The relative youth of the Baltimore Ecosystem Study LTER limits the number of findings to report to date. However, initial results are available in several key areas.

Stream flow and chemistry have been measured for approximately one year, with the chemistry of a forested reference watershed differing markedly from all stations along the Gwynns Falls, the main stem of the focal watershed. High levels of nitrate exist downstream as expected, but also on certain dates at catchments draining recently developed land.

Riparian vegetation is typical, but resides on floodplains that have been stranded as a result of the urban streams being highly incised. Urban and rural riparian stands do not differ in nitrification rate, although the urban rates are more variable.

Soil nitrogen processes differ between the exotic *Ailanthus altissima* dominated stands and those dominated by the exotic *Acer platanoides* or native trees. We will sample additional stands in the future. Exotic vines are more prevalent in gaps in urban forests than in rural forests. In addition, urban stands currently experiencing extensive canopy opening have higher plant diversity but a larger proportion of woody exotics than more closed canopy stands of mature trees.

Relationships of socioeconomic and ecological processes have been discovered. Social variables relate to vegetation variables with decadal lags. The 1970's social data are better predictors of vegetation status in the 1980's and 1990's than of contemporaneous vegetation. The relationships between social processes and ecological structure are also scale-dependent. Home ownership, expected to be a good predictor of vegetation status, fails to correlate at the census block level, but correlates well at the city block level. Such relationships suggest questions for future research and neighborhood engagement.

### **Publications**

#### ***Journal Articles***

Brun, S.E. and L.E. Band. (Accepted, pending revisions). Simulating runoff behavior in an urbanizing watershed. *Computers, Environment and Urban Systems*.

Flores, A., S.T.A. Pickett, W.C. Zipperer, R.V. Pouyat, and R. Pirani. 1998. Adopting a modern ecological view of the metropolitan landscape: The case of a green space system for the New York City region. *Landscape and Urban Planning* 39(4):295-308.

Foresman, T.W., S.T.A. Pickett, and K. Kuhlman. 1999. Link globally, act locally: Baltimore ecosystem study. *GeoInfoSystems*, 9 (February): 24-29.

Foresman, T.W. 1999. Local, state, and regional government and planning applications for remote sensing. *Earth Observing Magazine (EOM)*, 8 (April): 30-33.

Foresman, T.W., D. Adams, S. Walker, C. Daniel, V. Defries, and L. Hennessee. (In Press). Entrenchment of GIS technology for enterprise solutions in Maryland's state and local government. *Photogrammetry Engineering & Remote Sensing (Special Edition)*.

- Grimm, N.B., J.M. Grove, S.T.A. Pickett, and C.L. Redman. (In Press). Integrated approaches to long-term studies of urban ecological systems. *BioScience*.
- Pasternack, G.B. and G.S. Brush. 1998. Sedimentation cycles in a river-mouth tidal freshwater marsh. *Estuaries* 21 (3): 407-415.
- Pickett, S.T.A. (In Press). The culture of synthesis: Habits of mind in novel ecological integration. *Oikos*. 87.
- Pickett, S.T.A., W.R. Burch, Jr., and J.M. Grove. 1999. Interdisciplinary research: Maintaining the constructive impulse in a culture of criticism. *Ecosystems* 2: 302-307.
- Tague, C.E. and L.E. Band. 1999. Modeling the combined effects of forest roads and harvest on seasonal high and low flows in mountainous catchments. *EOS* 79 (45): 285.
- Thompson, H.C. (In Press). Exotic plant species in urban and suburban forest gaps as a management criterion. *Ecological Restoration*.
- Villa F., R.M.J. Boumans, R. Costanza. (Submitted). Design and use of a Model Performance Index (MPI) for the calibration of ecological simulation models. *Journal of Environmental Modelling and Software*.
- Voinov A., R. Costanza, L. Wainger, R. Boumans, F. Villa, T. Maxwell and H. Voinov. 1999. Patuxent landscape model: integrated ecological economic modelling of a watershed. *Journal of Environmental Modelling and Software* 14 (5): 473-491.
- Wainger, L., R. Voinov, R. Costanza, R.M.J. Boumans, F. Villa, T. Maxwell, H. Voinov, N. Bockstael. (Submitted). Integrated ecological economic modeling of the Patuxent River, Maryland. *Ecosystems*.
- Zipperer, W.C., S.T.A. Pickett, and R.V. Pouyat. (Submitted). Rehabilitating urban woodlands: A problem for managers and researchers. *Restoration Ecology*.

### ***Books***

- Aley, J., W.R. Burch, Jr., E. Conover, D. Field. 1999. *Ecosystem Management--Adaptive Strategies for Natural Resource Organizations in 21st Century*. Taylor and Francis, Washington, DC.
- Burch, W.R. Jr. *Daydreams and Nightmares--A Sociological Essay on the American Environment*. Madison, WI.: Social Ecology Press, Classics in Rural Sociology Reprint of 1971 book with a new introduction.
- Curtin, P.D., G.W. Fisher and G.S. Brush (eds.). (In Press). *The Chesapeake Region Ecosystem*. Johns Hopkins University Press, Baltimore, MD.

### ***Book Chapters***

- Brush, G.S. (In Press). Forests before and after the colonial encounter. In: P.D. Curtin, G.W.-Fisher and G.S. Brush (eds.). *The Chesapeake Region Ecosystem*. Johns Hopkins University Press, Baltimore, MD.
- Burch, W.R. Jr., and J.M. Grove. (1999). Ecosystem Management--some social, conceptual, scientific, and operational guidelines for practitioners. In: R.C. Szaro, N.C. Johnson, W.T. Sexton, and A.J. Malk (eds.). *Ecological Stewardship: A Common Reference for Ecosystem Management*. Vol III. World Resources Institute and Elsevier Press, Washington, D.C.

Foresman, T.W. (1998). The Baltimore Washington regional collaborative land-use history research program. In: T.D Sisk (ed.). USGS-Biological Resources Division USGS Biological Science Report, 33-41.

Grove, J.M. (In Press). New tools for exploring theory and methods in human ecosystem and landscape research: Computer modeling, remote sensing and geographic information systems. In: K. Cordell (ed.). Integrating Social Science and Ecosystem Management. Sagamore Press. Champlain, Illinois.

Grove, J.M and K. Hinson. (In Review). Education, social ecology, and urban ecosystems, with examples from Baltimore, Maryland. In: A.R. Berkowitz, C.H. Nilon and K.S. Hollweg (eds.). Understanding urban ecosystems: a new frontier for science and education. Springer-Verlag, NY.

Kinzig, A., and J.M. Grove. (In Review). The urban environment. In: Levin, S. (ed.). Encyclopedia of Biodiversity. Academic Press. London.

Parker, J.K., V. Sturtevant, M. Shannon, J.M. Grove, and W.R. Burch, Jr. (1999). Partnerships for adaptive management, communication and adoption of innovation, property regimes, and community deliberation: The contributions of mid-range social science theory to forest ecosystem management. In: R.C. Szaro, N.C. Johnson, W.T. Sexton, and A.J. Malk (eds.). Ecological Stewardship: A Common Reference for Ecosystem Management. Vol III. World Resources Institute and Elsevier Press, Washington, D.C.

Pickett, S.T.A. (In Review). Why is public understanding of urban ecosystems important to science and scientists? In: A.R. Berkowitz, C.H. Nilon and K.S. Hollweg (eds.). Understanding urban ecosystems: a new frontier for science and education. Springer-Verlag, NY.

## **Other Publications**

### ***Abstracts***

Band, L.E. 1999. Integrating hydroecological and socioeconomic processes in urbanizing watersheds. Spring Meetings of the American Geophysical Union.

Band, L.E. 1999. Urban flowpath alteration: Feedback to biogeochemical cycles. Annual Meetings of the Ecological Society of America.

Belt, K.T. 1998. The Baltimore Ecosystem Study: an urban long term ecological research study. Annual Meeting of the Maryland Water and Monitoring Council Program and Abstracts, III. Monitoring and Assessment in Streams and Rivers.

Belt, K.T., S.E. Gresens, D.C. Gwinn, P. Banks, and J.A. Tang. 1999. The effects of urban impervious watershed cover on benthic macroinvertebrate populations in streams with particular reference to disturbance from storm event frequency and magnitude. Bulletin of the North American Benthological Society 16(1):208.

Burch, W.R., Jr., and J.M. Carrera. 1999. out the door and down the street: Enhancing children's play and work environments as if adulthood mattered. The Eight Cary Conference: Understanding Urban Ecosystems: A New Frontier for Science and Education. Institute of Ecosystem Studies, Millbrook, New York.

Crawford, K. and P.M. Groffman. 1999. Comparing denitrification in urban and rural riparian wetlands in Baltimore, MD. Annual Meeting of the Ecological Society of America.

Gresens, S.E., K.T. Belt, D.C. Gwinn, P. Banks, and J.A. Tang. 1999. Level of taxonomic resolution and the response of lotic invertebrate communities to increased watershed imperviousness. *Bulletin of the North American Benthological Society* 16(1):215.

Gresens, S.E., K.T. Belt, D.C. Gwinn, and J.A. Tang. 1998. Stream invertebrate community response to increased watershed imperviousness. *Bulletin of the Ecological Society of America* 79:63.

Groffman, P.M., K. Crawford and L.E. Band. 1998. Riparian ecosystem function in urban watersheds. Fall Meeting of the American Geophysical Union.

Groffman, P.M., K. Crawford and L.E. Band. 1999. Riparian ecosystem function in urban watersheds. Spring Meeting of the American Geophysical Union.

Grove, J.M. 1998. Finding the road to integration on the human ecosystem highway: Some suggested road signs. Vice President for Science Symposium: Ecology as a Comprehensive Science. Annual Meeting of the Ecological Society of America.

Grove, J.M. (In Press). Cause and consequence: The social dimensions of ecological restoration. In *Proceedings, Conservation of Biological Diversity: A Key to the Restoration of the Chesapeake Bay Ecosystem and Beyond*. May 10-13, 1998. Annapolis, Maryland.

Grove, J.M., J. Hom, Y. Pan, H. Holt, J. Aber. 1998. Assessing the impacts of atmospheric nitrogen deposition, land use change, and climate change on forests and surface waters of the Chesapeake bay basin: an application of the PNET-CN regional ecosystem model. Annual Meeting of the Ecological Society of America.

Law, N.L. and L.E. Band. 1999. Spatial interactions of societal and biophysical attributes of urbanizing watersheds. Spring Meetings of the American Geophysical Union.

Pickett, S.T.A. 1999. Keynote Address: The benefits of long-term ecological research and its recent application to urban environments. Manaaki Whenua (Cherishing the Land) Conference, organized by Landcare Research New Zealand Limited, Page 39-40. Wellington, NZ.

### *Miscellaneous*

Parks and People Foundation, Revitalizing Baltimore. 1999. Guidance and Protocols for Community Interaction.

Parks and People Foundation, Revitalizing Baltimore. 1999. Gwynns Falls Watershed Ecological Resource Atlas.

Pouyat, R.V. (In review). Earthworm Research Protocol for Teachers.

### **Presentations Not Represented by Abstract**

Belt, K.T. The Baltimore ecosystem study: An urban long term ecological research study integrating socioeconomic and biophysical characters in the study of ecosystem structure and function. Poster presented at the Federally Supported Science and the Chesapeake Bay Program. Patuxent research refuge, Laurel, Maryland. December 9-10, 1998.

Bowes-Lyon, D. and Hinson, K. Social ecology and education in middle and high schools: Concepts, methods, and data for integrating the social and biological sciences. Making Connections, a National Conference on Science, Mathematics and Technology Education at The Park School, Baltimore, Maryland. November 6, 1998.

- Burch, W.R. Jr. Lessons for the future from our older cities--the first global change experiment. Geography and Environmental Science Department - Johns Hopkins University. January 26, 1999.
- Burch, W.R. Jr. Ecosystem Management Course (Burch, instructor). School of Forestry & Environmental Studies, Yale University. Spring, 1999.
- Burch, W.R. Jr. Participant in President's Council on Sustainable Development, Northwest Regional Council--Inventory and Monitoring in Pacific Northwest Workshop, Skamania, WA. March 10 -12, 1999.
- Burch, W.R., J.M. Grove, D. Bowes-Lyon, and C. Steele. Ecosystem Management Field trip, School of Forestry & Environmental Studies, Yale University. March 25th - 29th, 1999.
- Burch, W.R. Jr. Green Thumb, NYC Parks Department. Field meetings with Green Thumb, NYC Botanical Garden professionals and four local groups on Bronx community garden/forestry activities in restoring vacant lots and neighborhoods. April 23, 1999.
- Burch, W.R. Jr. The LTER as a strategy for education and sustainable development in Nepal and Bhutan. World Wildlife Foundation, Washington, D.C. May 13 -14, 1999.
- Cadenasso, M.L. Baltimore long-term ecological research program: Ecology of the city. Bard College, Annandale-on-the-Hudson, New York. July 21, 1999.
- Grove, J.M. Incorporating Human Ecological Analyses in Natural Resource Planning and Management. School of Forestry & Environmental Studies, Yale University. February 17, 1998
- Grove, J.M. Social Dimensions of Biodiversity. Department of Geography, University of Maryland, Baltimore County. April 30, 1998.
- Grove, J.M. Baltimore Ecosystem Study: Integration of Physical, Biological, and Social Drivers of Watershed Dynamics. Social Science in the Augmented and Urban Sites. Semi-Annual Meeting of the LTER Network. Madison, Wisconsin. October 16-19, 1998.
- Grove, J.M. Greening and Community Development. Green Spaces in Urban Places, Regional Urban Greening Forum. Philadelphia, Pennsylvania. November 6, 1998.
- Grove, J.M.. The Baltimore Ecosystem Study. Sustainability in Action Seminar Series of the Sustainable Development and Community-Based Environmental Protection Program, Region III, EPA. Philadelphia, Pennsylvania. January 20, 1999.
- Grove, J.M. A Commuting-Based, County-Level Approach: Potential Problems of the Approach. Seminar and Open Forum on Metropolitan and Non-metropolitan Areas for a New Decade. Council of Professional Associations on Federal Statistics. Alexandria, Virginia. January 21 & 22, 1999.
- Grove, J.M. Social Dimensions of Urban Forestry. Urban Forestry Class (D. Nowak and G. Heisler). College of Environmental Sciences and Forestry (ESF). March 9, 1999.
- Grove, J.M. The Social Dimensions of Human Ecosystem Analysis. University of Maryland, College Park. Seminar Series for the Maryland Department of Natural Resources. March 17, 1999.
- Grove, J.M. A Patch Dynamics Approach to the Study of Anthropogenic Ecosystems. Spring Ecosystems Seminar Series, Woods Hole Marine Biological Laboratory. April 13, 1999.

Grove, J.M.. Keynote Address to the Ohio Academy of Sciences Annual Meeting. April 23 & 24, 1999.

Grove, J.M. Integrated Science and Long Term, Urban Ecological Research. Department of Geography, Ohio University. May 7, 1999.

Grove, J.M. Panel Member. Effects of Urbanization and Land Use on Human and Ecological Health. EPA STAR (Science to Achieve Results) Graduate Fellowship Conference. July 19, 1999.

Grove, J.M. and S.T.A. Pickett. Hydrological, Ecological and Social Systems in Urban-Rural Watersheds: Integration for Restoration. Thirteenth Annual Conference: Applications of Landscape Ecology in Natural Resource Management. Michigan State University, East Lansing, Michigan. March 17-21, 1998.

Grove, J.M., C. Redman, S.T.A. Pickett, and N. Grinun. An Hierarchical Patch Dynamics Approach to the Long Term Study of Urban Ecological Systems. Seventh International-Symposium on Society and Resource Management. University of Missouri-Columbia, Columbia, Missouri. May 27-31, 1998.

Helly J., T. Fountain, S. Gage and R. Waide. Workshop on Modeling of Ecosystem Processes at Regional Scales. Presentations on the differences and merging efforts between RHESsys and the GEM/SME approach. Biological Scale Process Modeling. Proceedings from a workshop jointly sponsored by NPACI Earth System Science and NSF Long-Term Ecological Research Network Office. December, 1998.

Pickett, S.T.A. The Eco of the City. Talk given to the Council for the Advancement of Science writing, Boston, 1999.

Pickett, S.T.A. The Study and Science of Ecosystems. University of Maryland College of Agriculture and Natural Resources. September 9, 1998.

Pickett, S.T.A. Cornell Urban Ecology Working Group, Ithaca, New York, November 12, 1998.

Pickett, S.T.A. Auckland (NZ) Regional Council, Seminar to invited participants; Open Meeting, April 12, 1999.

Pickett, S.T.A. Hamilton (NZ), Presentation to Landcare Research, Hamilton office, April 13, 1999.

Pickett, S.T.A. Palmerston North (NZ), Presentation to Landcare Research, Palmerston North, April 14, 1999.

Pickett, S.T.A. Christchurch (NZ), Presentation to Landcare Research, Lincoln, April 15, 1999.

Pickett, S.T.A. Christchurch (NZ), Public Seminar at Millenium Hotel April 19, 1999.

Pickett, S.T.A. Wellington (NZ), Public Seminar sponsored by the Ministry for the Environment, April 20, 1999.

Pickett, S.T.A. University of Maryland Baltimore County, BES/Geography and Environmental Systems Department Seminar, May 1999.

Pickett. S.T.A. and J.M Grove. Integrated Science and Long Term, Urban Ecological Research. A Presentation and Field Tour for Scientists from the Austrian Academy of Sciences. May 11, 1999.

### **Internet Dissemination**

Baltimore Ecosystem Study web site  
<http://baltimore.umbc.edu/lter>

Baltimore Washington Collaboratory  
<http://research.umbc.edu/bwrdc/clickable/quad3.html>

MD National Spatial Data Infrastructure (NSDI) Node  
<http://baltimore.umbc.edu/mdnsdi>

Web site on our spatial modeling approach and our Modeling Calibration Software:  
<http://kabir.cbl.umces.edu/PLM/Welcome.html>

Web site on the GUMBO model  
<http://kabir.cbl.umces.edu/-villa/GUMBO/>

NED-1 software program:  
<http://www.fs.fed.us/ne/burlington/ned/nedwork.htm>

NED Social Ecology Web page  
<http://www.fs.fed.us/ne/burlington/ned/social-ecology/index.htm>

### **Research Training**

Participants within the BES have gained research and teaching skills through several mechanisms. In addition to the PI's and research staff, the project has closely involved eight graduate students, four postdoctoral associates, four undergraduates, and 16 secondary school students, including one independent study student in a middle school.

Various of these individuals have learned 1) Geographic Information Systems and Global Positioning System applications, 2) stream and water sampling methods, 3) soil biogeochemical methods, and 4) metadata protocols.

The project has required investigators to become conversant in disciplines outside their own, including bridge building between social and natural scientists, between modelers and empiricists, and between academic and agency cultures. The natural scientists in particular have benefited from learning the strategy of participant action research, which facilitates research and safety in a diverse, human system. BES staff at the Parks and People Foundation have prepared "Guidance and Protocols for Community Interaction" for field researchers in the program.

The establishment of an urban ecology field station in association with the Rose Street Community Center is a bold experiment that is exposing natural scientists and community youth and residents to new cultures and perspectives. The interaction is reciprocal.

Participants at all levels of the BES have learned to present results and implications to the public through field trips, classroom lectures (secondary, college, and postgraduate levels), and to agency personnel in conversation and formal settings. A graduate course has been designed to be taught by BES scientists at the University of Maryland, Baltimore County.

### **Education and Outreach**

Outreach to the public has been through our Annual Meeting, presentations, workshops, the media, advisory committees, and technology transfer.

The first BES Annual Meeting, held in October 1998, provided an overview of the research and educational activities to academics, citizens, and decision leaders in the metropolitan Baltimore region. Discussion sessions at the annual meeting also sought input from the audience concerning research, application, and education.

BES members have made presentations to the Washington Council of Governments, the Revitalizing Baltimore Technical Advisory Committee, the Making Connections educational conference in Brooklandville, Maryland, the Maryland Society of Natural History, the Maryland Association of Environmental and Outdoor Education, and the eighth biennial Cary Conference on "Understanding Urban Ecosystems: A New Frontier for Science and Education." BES scientists delivered a plenary address to the Council for the Advancement of Science Writing, and keynote addresses to the Ohio Academy of Sciences, and to 'Cherishing the Land' conference of Landcare Research and the Ministry for the Environment, New Zealand. BES has hosted delegations of decision makers and scientists from Austria and China.

Media contacts have included a number for freelance writers and reporters from such publications as The Baltimore Sun, Newsweek, Science, and Audubon. Material has been provided to National Public Radio and television production companies. A BES workshop on 'Research Frontiers and their Applications for Water Resources Infrastructure in Urban Watersheds: Making the Connections between Human and Hydro-Ecological Interactions,' which included planners, watershed association leaders, agency engineers, consultants, and decision makers. In addition, we have hosted workshops with stakeholders concerned with the inputs to and use of our integrated models.

We have shared technological expertise on GIS and Global Positioning Systems with schools and classes. A web-based spatial simulation for watershed modeling has been made available for classroom use. We have participated on technical committees for the Maryland Department of Natural Resources, and for the National State Foresters Urban Forestry Sub-committee. Members of BES have lectured in a course for personnel practicing natural resource and conservation management in Maryland, and to the World Wildlife Foundation.

## **Contributions**

### ***Contributions within Discipline***

This project, even in its initial phases, is helping to extend the scope of ecology to a major kind of ecosystem that has been conspicuously neglected by ecology. Urban systems are increasing in spatial extent and human population in the United States and world-wide. An example of a benefit to ecology of studying metropolitan areas is the application and test of patch theory in a novel ecosystem type. The BES will develop methods to calibrate complex, site-specific models to evaluate their performance and compare the output with spatially lumped models. There is also a disciplinary benefit of integrating geographic technologies to regional and long-term research. In addition, the program can stimulate the individual disciplines by integration with closely complimentary as well as contrasting disciplines. Such integration requires improved articulation of 'middle level theories' in each discipline, which should benefit the individual fields of study. For example, spurred by the existence of the five focal areas in ecosystem ecology that motivate the LTER projects, members of BES and CAP have contributed to the efforts within the LTER Network to identify and articulate a set of socioeconomic principles to motivate the application of social sciences in LTER programs.

### ***Contributions to Other Disciplines***

The program can support advances in different disciplines by linking process variables relevant and important to those contrasting disciplines. Spatially explicit watershed simulations are relevant and stimulatory to many natural and social science disciplines. The increasing application of simulation models to social science is a potential benefit. Similarly, physical sciences can benefit from the metadata practices developed for geographic and ecological sciences.

### ***Contributions to Education and Human Resources***

The project has involved students from K-12 through postdoctoral levels. Teacher training and curriculum development is being pursued in urban as well as suburban schools, and in public and private institutions. We are interacting with underrepresented populations to present science and technology as compelling career options and to increase the appreciation of scientific knowledge as a tool for enhancing local quality of life. Web-based, personal, and institutional exchanges of information are being employed to exploit a range of communication styles.

### ***Contributions to Resources for Science and Technology***

BES is developing digital data bases for computer models, Internet Map Serving applications, and integration of multiscale remote sensing imagery for urban analysis. We are integrating the usually disparate elements of landscapes into unified models that can support decision making.

### ***Contributions Beyond Science and Engineering***

We have encountered a keen desire and interest by the public and agencies for the kinds of integrated, spatial models we are developing. These can address non-point sources of pollution, community and neighborhood restoration, and watershed protection. The linkages with stakeholders will improve the utility of our models and help guide the scientific community in the inclusion of policy relevant factors in model design. The spatially explicit, multiscaled, and integrated approach that characterizes BES has the potential to make scientific information more relevant to the complex and dynamic environments that characterize urban and suburban environments, which are among the most rapidly changing on Earth.

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