Baltimore Ecosystem Study

Annual Report

August 2004—August 2005

To National Science Foundation

Urban LTER: Human Settlements as Ecosystems: Metropolitan Baltimore from 1797 – 2100

Revised: August 2005

www.beslter.org

Preface to the Annual Report

On the following pages is the Annual Report of the Baltimore Ecosystem Study (BES) for the period 2004-2005. The Baltimore Ecosystem Study, a Long-Term Ecological Research (LTER) project, was initiated in 1997. The BES is one of 26 LTER projects, representing diverse ecosystems and research emphases. It is funded by the National Science Foundation to learn how an urban area works as an ecological system. Over the last eight years we have learned new, and sometimes surprising, things about Baltimore's urban ecosystem. This report summarizes the most recent scientific and educational contributions BES has made.

As one of only two Long-Term Ecological Research sites located in an urban environment, we want to know the ecological interactions in the whole range of habitats—from the center city of Baltimore, out into the surrounding rural areas. We are conducting research on the soil, the plants and animals on land and in the streams, the water quality, and condition of the air in and around Baltimore. For that information to make sense, we are also studying how families, associations, organizations and political bodies make decisions that affect ecological processes. In other words, we are treating the whole collection of urban, suburban and rural areas as an ecological system that includes people and their activities.

This is a really unusual approach to ecology because it combines with social sciences, physical sciences, and education to understand a big metropolitan area as an ecological system. Saying that an urban area is a system just means that we are concerned with the interactions between wild and domestic organisms, people and their organizations, the natural and built environment, and how they all affect one another. It is these relationships that determine the quality of the environment we experience.

The program brings together researchers from many disciplines and organizations to collect new data and synthesize existing information on both the ecological and engineered systems of Baltimore. Our interest is not only with the present environment, but with the historical changes that have led to the conditions we experience today, and with the environmental trends into the future. The ecological knowledge BES creates helps support educational and community-based activities. Indeed, the interactions between our researchers and the Baltimore community are important components of our project. We hope that the information produced by our work, which integrates many disciplines and the efforts of many research and educational institutions in Baltimore and beyond, is of interest and use to you.

You may contact the researchers, educators, and professional members of the Baltimore Ecosystem Study through the Project Facilitator, Holly Beyar (BeyarH@ecostudies.org), and locate updated information and additional information on the project through its website (http://www.beslter.org).

Steward T.A. Pickett, BES Project Director and Principal Investigator
Institute of Ecosystem Studies
Box AB
Millbrook NY 12545

Table of Contents

Acknowledgement of Support

The Baltimore Ecosystem Study project is supported by the National Science Foundation Long-Term Ecological Research program, grant number DEB 0423476. The USDA Forest Service Northeastern Research Station contributes research staff time, equipment, funds and in kind services to BES. In addition we thank the University of Maryland, Baltimore County for their contribution to office, laboratory and field space at the Center for Urban Environmental Research and Education. The US Geological Survey, the City of Baltimore Department of Recreation and Parks, the Baltimore City Department of Public Works, the Baltimore County Department of Parks, the Baltimore County Department of Environmental Protection and Management, the Maryland Department of Natural Resources, and the McDonogh School all kindly provide access or management of land and equipment used by the Baltimore Ecosystem Study for ecological, hydrological, and meteorological field studies. The USDA ARS Environmental Microbial Safety Lab contributes resources for water pathogen analysis. Additional support and assistance has been provided by many agencies, communities and individuals who are listed in the report.

Participants

Project Director: Dr. Steward T.A. Pickett, Institute of Ecosystem Studies

Co-Principal Investigators

Dr. Daniel Bain, US Geological Survey
Dr. Lawrence E. Band, University of North Carolina, Chapel Hill
Mr. Kenneth Belt, USDA Forest Service
Dr. Alan R. Berkowitz, Institute of Ecosystem Studies
Dr. Christopher G. Boone, Ohio University
Dr. Grace S. Brush, The Johns Hopkins University
Dr. Geoffrey Buckley, Ohio University
Dr. William R. Burch, Jr., Yale University
Dr. Mary L. Cadenasso, Institute of Ecosystem Studies
Ms. Jacqueline M. Carrera, Parks and People Foundation
Dr. Janet E. Coffey, University of Maryland, College Park
Dr. Robert Costanza, University of Vermont, Gund Institute for Ecological Economics
Dr. Shawn E. Dalton, University of New Brunswick
Dr. Erle Ellis, University of Maryland, Baltimore County
Mr. Gary T. Fisher, US Geological Survey
Dr. Susan B. Grimmond, Indiana University, Bloomington
Dr. Peter M. Groffman, Institute of Ecosystem Studies
Dr. J. Morgan Grove, USDA Forest Service
Dr. Gordon M. Heisler, USDA Forest Service
Dr. John Hom, USDA Forest Service
Dr. Jennifer Jenkins, University of Vermont, Gund Institute for Ecological Economics
Dr. Quintaniay Holifield, USDA Forest Service
Dr. Sujay Kaushal, University of Maryland, Center for Environmental Science
Dr. Gail Langellotto, Fordham University, Louis Calder Center-Biological Station
Dr. Neely Law, Center for Watershed Protection
Mr. Brian McGrath, Columbia University
Dr. Andrew J. Miller, University of Maryland, Baltimore County
Dr. Charles H. Nilon, University of Missouri, Columbia
Dr. David J. Nowak, USDA Forest Service
Dr. Richard V. Pouyat, USDA Forest Service
Dr. Charles Schweik, University of Massachusetts, Amherst
Dr. Katalin Szlavecz, The Johns Hopkins University
Dr. Christina L. Tague, San Diego State University
Dr. Austin Troy, University of Vermont
Dr. Mark Twery, USDA Forest Service
Dr. Paige Warren, University of Massachusetts, Amherst
Dr. Claire Welty, University of Maryland, Baltimore County, Center of Urban Environmental Research and Education
Dr. Matthew A. Wilson, University of Vermont, Gund Institute for Ecological Economics
Dr. Jane Wolfson, Towson University
Dr. M. Gordon Wolman, The Johns Hopkins University

Staff

Ms. Holly J. Beyar, BES Project Facilitator, Institute of Ecosystem Studies
Ms. Mary Cox, Urban Resources Initiative Coordinator, Parks and People Foundation
Ms. Janie Gordon, BES Education Coordinator, Institute of Ecosystem Studies
Ms. Amy Rynes, University of Maryland, Baltimore County, Center of Urban Environmental Research and Education
Mr. Jonathan Walsh, Information Manager, Institute of Ecosystem Studies

Collaborators

Dr. Juan Armesto, Institute for Ecological Research - Chile
Mr. Ronald Barns, Baltimore County Public Schools
Ms. Rebecca Bell, Maryland State Department of Education
Dr. Susan M. Blunck, University of Maryland, Baltimore County
Dr. Roelof Boumans, University of Vermont, Gund Institute for Ecological Economics
Dr. Andrea Bowden, Baltimore City Public Schools
Ms. Patricia Bradley, US Environmental Protection Agency
Dr. Anthony J. Brazel, Arizona State University
Ms. Valerie Brennan, Baltimore County Public Schools
Dr. Robert Bridges, USDA Forest Service
Dr. David R. Brooks, Drexel University, Globe Program
Dr. Michel Cavigelli, USDA Agricultural Research Service (ARS)
Dr. Marta Cironi, University of Vermont, Gund Institute for Ecological Economics
Ms. Andrea Claypoole, Parks and People Foundation
Ms. Anne Conklin, USDA Forest Service
Mr. Peter Conrad, Baltimore City Planning
Ms. Amanda Cunningham, Parks and People Foundation
Dr. Csaba Csuzdi, Hungarian Museum of Natural History, Budapest, Hungary
Dr. Kate Denniston, Towson University
Ms. Rachel Doebber, Parks and People Foundation
Mr. Edward J. Doheny, US Geological Survey
Ms. Anne Draddy, Baltimore City Department of Recreation and Parks
Mr. Kirk Dreier, Baltimore County, Oregon Ridge Nature Center
Mr. William F. Eberhart, Jr., Gwynns Falls Trail Council
Dr. William Effland, US Environmental Protection Agency
Dr. Joshua Farley, University of Vermont, Gund Institute for Ecological Economics
Ms. C. Erin Feehley, US Geological Survey
Dr. Beverly Feig, Baltimore City Public Schools
Mr. Emil Feldsher, Baltimore City Department of Public Works
Dr. Donald Field, University of Wisconsin, Madison
Ms. Kidada Fields, Parks and People Foundation
Ms. George Friday, Parks and People Foundation
Mr. Mike Galvin, Maryland Department of Natural Resources
Mr. Daniel Golub, USDA Forest Service
Dr. Richard H. Grant, Purdue University
Mr. Earl A. Greene, US Geological Survey
Ms. Cindy Grove, Maryland Department of Natural Resources
Mr. Guy Hager, Parks and People Foundation

Mr. Joe Harber, Irvine Natural Science Center
Mr. Gary Heath, National Aquarium in Baltimore
Dr. James Higgins, USDA ARS Environmental Microbial Safety Lab, Beltsville
Dr. Elizabeth Hornung, St. Stephen University, Hungary
Mr. Edward Huff, Baltimore City Department of Public Works
Mr. Bruce James, University of Maryland
Dr. Ann P. Kinzig, Arizona State University
Dr. Zoltan Korsos, Hungarian Museum of Natural History, Budapest, Hungary
Dr. Marianne Krasny, Cornell University
Mr. Peter Krawczel, USDA Forest Service
Dr. Serguei Krivov, University of Vermont, Gund Institute for Ecological Economics
Mr. Richard Kruzansky, Natural Resources Conservation Service
Dr. Li, Lanzhou University, PRC
Ms. Ethel Locks, US Department of Housing and Urban Development
Ms. Monica Logan, Parks and People Foundation
Dr. Gary Machlis, University of Idaho, Department of Forest Resources
Dr. Chris Martin, Arizona State University
Mr. Thomas Maxwell, University of Vermont, Gund Institute for Ecological Economics
Mr. Paul Mayer, US Environmental Protection Agency
Mr. Michael P. McGuire, University of Maryland, Baltimore County, Center of Urban Environmental Research and Education
Dr. Elinor Ostrom, Indiana University, Bloomington, Center for the Study of Institutions, Population and Environmental Change
Mr. Donald Outen, Baltimore County Department of Environmental Protection and Management
Mr. Glenn Page, National Aquarium in Baltimore
Ms. Corrine Parks, Carrie Murray Nature Center
Mr. Matt Patterson, USDA Forest Service
Ms. Susan Patz, Baltimore City Department of Recreation and Parks
Dr. Mary Rivkin, University of Maryland, Baltimore County
Mr. Carl Robinette, USDA Natural Resources Conservation Service
Mr. Frank Rodgers, Parks and People Foundation
Ms. Lissa Rotundo, Baltimore Polytechnic Institute
Dr. Jonathan Russell-Anelli, Cornell University
Ms. Chris Schumacker, Baltimore County Public Schools
Mr. Rex Shepherd, Baltimore County Public Schools
Mr. David Smith, US Geological Survey
Dr. James Smith, Princeton University
Ms. Beth Snyder-Jones, University of Maryland, Baltimore County
Dr. Phillip G. Sokolove, University of Maryland, Baltimore County
Ms. Fran Spero, Baltimore City Department of Recreation and Parks
Mr. William Stack, Baltimore City Department of Public Works
Mr. Roger J. Starsoneck, US Geological Survey
Dr. Chris Swan, University of Maryland, Baltimore County
Dr. Ferdinando Villa, University of Vermont, Gund Institute for Ecological Economics
Dr. Alexey Voinov, University of Vermont, Gund Institute for Ecological Economics
Ms. Helena Voinov, University of Vermont, Gund Institute for Ecological Economics

Mr. Thomas Whitlow, Cornell University
Ms. Lois Williams, Baltimore City Public Schools
Mr. Ian Yesilonis, Institute of Ecosystem Studies, University of Maryland
Dr. Wayne Zipperer, USDA Forest Service

Pre-College Teachers

Ms. Myrtha Allen, Patterson High School
Ms. Beatrice Christian, middle school, Baltimore City Schools
Mr. Jehu Dongmo, junior high school, Baltimore City Schools
Ms. Amanda Ellison, high school, Baltimore City Schools
Mr. Don Finkelstein, middle school, Baltimore County Schools
Mr. Brad Harrison, Fellow, high school, Baltimore County Schools
Ms. Jenny Harvey, Fellow, high school, Baltimore County Schools
Ms. Karen Hinson-Steele, Western High School of Environmental Technology and Science
Mr. David Hong, middle school, Baltimore County Schools
Ms. Kenneth Itefia, middle school, Baltimore County Schools
Mr. Michael Jarman, high school, Baltimore City Schools
Ms. Lisa Jones, middle school, Baltimore City Schools
Mr. Kyle Kerner, middle school, Baltimore City Schools
Mr. Marvin Martin, high school, Baltimore City Schools
Ms. Betsy Masson, Fellow, middle school, The Park School
Ms. Elaine McCauley, junior high school, Baltimore City Schools
Ms. Sue McQuiston, high school, Baltimore County Private School
Ms. Nancy Miller, middle school, Baltimore County Schools
Ms. Heather Pankey, middle school, Baltimore County Schools
Ms. Marguerite Parker, middle school, Baltimore City Schools
Ms. Lisa Perkins, middle school, Baltimore City Schools
Ms. Nadine Redditt, middle school, Baltimore City Schools
Mr. Michael Rest, elementary school, Baltimore City Schools
Mr. Bill Reusing, middle school, Baltimore County Schools
Ms. Ellen Reynolds, Fellow, private high school
Ms. Damita Saunders, high school, Baltimore City Schools
Ms. Jessica Saven, Fellow, middle school, Baltimore City Schools
Mr. Martin Schmidt, Fellow, high school, The McDonogh School
Ms. Veronica Shannon, high school, Baltimore City Schools
Ms. Darlene Shoats, middle school, Baltimore City Schools
Mr. Ben Wallace, high school, Baltimore City Schools
Ms. Georgina Whalen, middle school, Baltimore City Schools
Ms. Ellen Wright, Fellow, high school, Baltimore City Schools

Research Assistants

Ms. Janelle Burke, The Johns Hopkins University
Ms. Marianne Butler, Intern, Parks and People Foundation
Ms. Andrea Taylorson-Collins, USDA Forest Service
Ms. Elizabeth Cook, Institute of Ecosystem Studies

Mr. Dan Crane, USDA Forest Service
Mr. Dan Dillon, Institute of Ecosystem Studies
Mr. Joseph M. Fisher, US Geological Survey
Ms. Mary Ford, Institute of Ecosystem Studies
Mr. Adam Grossman, Institute of Ecosystem Studies
Ms. Ellen Henrikson, Institute of Ecosystem Studies
Ms. Caitlin Hicks, Institute of Ecosystem Studies
Ms. Amanda Holland, Institute of Ecosystem Studies
Ms. Sabrina Hudson, Parks and People Foundation
Mr. Robert W. James, Jr., US Geological Survey
Ms. Tara Krebs, Institute of Ecosystem Studies
Ms. Cheryl Laskowski, Institute of Ecosystem Studies
Mr. David Lewis, Institute of Ecosystem Studies
Mr. William C. Lewis, U.S. Geological Survey
Ms. Kelly McManus, University of Maryland, Baltimore County
Ms. Stephanie Marudas, Intern, Parks and People Foundation
Mr. Jarlath O'Neil-Dunne, University of Vermont
Mr. Robert H. Pentz, US Geological Survey
Ms. Emily Rogevich, The Johns Hopkins University
Mr. Richard W. Saffer, US Geological Survey
Mr. David Schindler, University of Maryland, Baltimore County
Mr. Steve Scott, Indiana University, Bloomington
Mr. Ben Smith, USDA Forest Service
Mr. Bryant E. Smith, USDA Forest Service
Mr. Jack Stevens, USDA Forest Service
Ms. Sabrina Strohmier, University of Maryland, Baltimore County, Center of Urban Environmental Research and Education
Mr. Ashley Traut, Intern, Parks and People Foundation
Mr. Jeff Walton, USDA Forest Service
Ms. Lauren Wanzer, University of Maryland, Baltimore County, Center of Urban Environmental Research and Education
Ms. Una Wiegand, USDA Forest Service
Ms. Rosemarie Williams, USDA Forest Service

Postdoctoral Associates

Dr. David Tenenbaum, University of North Carolina, Chapel Hill

Graduate Students

Mr. Wayne Beyers, Ohio University
Ms. Chrissa Carlson, University of Georgia
Mr. Kevin Cox, Fordham University
Ms. Emily Elliot, University of Vermont, Gund Institute for Ecological Economics
Ms. Evelyn Fetridge, Fordham University
Mr. Jonathan P. Fisher, University of Maryland, College Park
Ms. Mary Hegarty, SUNY Environmental Science and Forestry
Ms. Sarah Hinman, Ohio University

Mr. Jeno Kontschan, M C Eotvos University, Budapest, Hungary
Ms. Cassandra Korth, Ohio University
Ms. Yan Li, Ohio University
Ms. Shuang Liu, University of Vermont, Gund Institute for Ecological Economics
Ms. Sandy Maunz, University of North Carolina, Chapel Hill
Ms. Kimberly Mead, University of Maryland, College Park
Ms. Molly Michaud, University of Vermont
Ms. Cyndy Merse, Ohio University
Mr. Brian Offerle, Indiana University, Bloomington
Ms. Sunjeong Park, The Johns Hopkins University
Ms. Rosimery Portela, University of Maryland
Ms. Carol Rinke, University of Maryland, College Park
Ms. Caroline Runser-Turner, Ohio University
Mr. Andrei Semenov, University of Massachusetts
Ms. Kirsten Schwarz, Rutgers University
Ms. Catherine Shields, Ohio University
Mr. Daehyok Shin, University of North Carolina, Chapel Hill
Mr. Joseph M. Smith, The Johns Hopkins University
Mr. Alexander Stepanov, University of Massachusetts
Mr. Baohua Tao, SUNY College of Environmental Science and Forestry, Syracuse
Mr. Mason Throneburg, The Johns Hopkins University
Ms. Amanda Walker, University of Maryland
Mr. James Wells, Ohio University
Mr. Jordan Wolf, SUNY School of Forestry
Mr. Jason Zhou, University of Maryland, Baltimore County
Mr. Weiqi Zhou, University of Vermont

Undergraduate Students

Ms. Kyra Appleby, The Johns Hopkins University
Ms. Caitlin Marie Bell, Cornell University
Ms. Kinya Boyd, Morgan State University
Mr. Ryan Boylan, University of Vermont
Mr. Joshua Cogan, The Johns Hopkins University
Mr. Ben Crawford, Indiana University
Mr. Christian Escobar, Fordham University
Mr. Jeffrey Fields, Drexel University
Mr. Justin Freedman, Towson University
Ms. Krystal Freeman, Towson University
Mr. Joshua Grinath, Cornell University
Mr. Michael A. Hansen, Towson University
Ms. Margaret Hurwitz, The Johns Hopkins University
Mr. Brett A. Kelly, SUNY Environmental Science and Forestry
Ms. Ashley King, The Johns Hopkins University
Ms. Elizabeth Klein, Morgan State University
Ms. Miki Kuroda, SUNY Environmental Science and Forestry
Mr. Lawrence McCoy, Morgan State University
Mr. Collin Miller, SUNY Environmental Science and Forestry

Mr. Ronald Nanni, SUNY Environmental Science and Forestry
Ms. Sarah Placella, The Johns Hopkins University
Ms. Megan Roop, University of Maryland at College Park
Ms. Kriti Sharma, University of North Carolina
Ms. Michelle Shively, Ohio University
Mr. Anthony Spano, The Johns Hopkins University
Ms. Rachel Smith, Indiana University
Ms. Summer Smith, The Johns Hopkins University
Ms. Cristina Suarez, Virginia Tech University
Ms. Kimberly Townsend, The Johns Hopkins University
Mr. Tracy Williams, University of Maryland-Baltimore County
Mr. Andrew Yang, The Johns Hopkins University

Baltimore Collaborative For Environmental Biology Students

Ms. Stephanie Atueyi, Towson University
Ms. Katey Kritcher, Towson University
Mr. Samuel Locoh-Donou, Towson University
Mr. Mark Nejako, Towson University
Ms. Mojirayo Sarumi, Towson University
Ms. Jahmilla Wilson, Towson University

Research Experience for Undergraduates

Ms. Annie Christian, Bard College
Ms. Katarina Juhaszova, The Johns Hopkins University
Ms. Alethea Kimmel-Guy, Ohio University
Ms. Laura Murawski, State University of New York, New Paltz
Ms. Christina Wong, Occidental College

Partner Organizations

Baltimore City Department of Public Works, Water Quality Management
Baltimore City Department of Recreation and Parks
Baltimore City Public Schools
Baltimore City Public Schools, Teaching Institute of Essential Science (TIES)
Baltimore County Department of Environmental Protection and Resources Management
Baltimore County Department of Recreation and Parks
Carrie Murray Nature Center
Center for Urban Environmental Research and Education (CUERE) (UMBC)
Center for Watershed Protection
Central Arizona-Phoenix LTER Program
Columbia University
Cornell University
Eotvos University, Budapest, Hungary
Fordham University, Louis Calder Center

GLOBE Program
Glyndon Elementary School
Indiana University, Bloomington
Institute of Ecosystem Studies
The Johns Hopkins University
Maryland Department of Natural Resources and Forest Service
McDonogh School, Inc.
Mid-Atlantic Federal Partnership for the Environment
National Science Foundation
Ohio University
Oregon Ridge Nature Center
Parks and People Foundation
Purdue University
San Diego State University
St. Stephen University, Budapest, Hungary
SUNY School of Environmental Science and Forestry
Towson University
University of Maryland, Baltimore County
University of Maryland, College Park
University of Massachusetts, Amherst
University of Missouri, Columbia
University of New Brunswick
University of North Carolina at Chapel Hill
University of Vermont, Gund Institute for Ecological Economics
USDA Forest Service-Northeastern Research Station
USDA ARS Environmental Microbial Safety Lab, Beltsville
USDA Natural Resources Conservation Service
US Environmental Protection Agency - Mid-Atlantic Integrated Assessment (MAIA)
US Geological Survey
Yale University, Hixon Center for Urban Ecology, School of Forestry and Environmental Studies

Other Collaborators

Arizona State University
Baltimore Alliance for Great Urban Parks
Baltimore Area Master Gardeners
Baltimore-Chesapeake Bay Outward Bound Program
Baltimore City Department of Planning
Baltimore City Forest Conservancy District Board
Baltimore County Forest Conservation District Board
Baltimore County, Maryland Demographic Information Systems Office
Baltimore County Schools
Baltimore Harbor Watershed Association
Baltimore Neighborhood Indicators Alliance
Central Arizona-Phoenix (CAP) LTER
Chesapeake Bay Program
Civic Works

College of Notre Dame of Maryland
Franklin Square Elementary School
Friends of Gwynns Falls/Leakin Park
Greenmount Community Planning Council
Gwynns Falls Trail Council
Gwynns Falls Watershed Association
Harlem Park Middle School
Herring Run Watershed Association
Hungarian Museum of Natural History, Budapest
Institute for Ecological Research, Chiloe, Chile
Irvine Natural Science Center
Jones Falls Watershed Association
Living Classrooms Foundation
Maryland Department of the Environment
Maryland Geological Survey
Maryland Institute College of Art
Maryland State Department of Education
Morgan State University
National Aquarium in Baltimore
National Weather Service, Washington-Baltimore Office
Neighborhood Design Center
Operation Reach Out Southwest
Reveal Baltimore
Revitalizing Baltimore
Sandtown-Winchester Community Building in Partnership – Urban Youth Corps
University of Idaho, Department of Forest Resources
University of Maryland, Department of Natural Resource Sciences
University of Missouri, Columbia
US Army Corps of Engineers
USDA Natural Resources Conservation Service
Urban Ecology Collaborative
Washington Village / Pigtown Neighborhood Planning Council
Western High School of Technology and Environmental Science
Woodberry Urban Forest Initiative

Activities

How urban and suburban areas function as integrated, ecological systems is poorly known. This gap in knowledge means that our basic understanding of ecology does not yet include one of the most widespread and extreme human interventions in the biosphere. It also means that people's ability to assess options for ecological management and restoration in and around cities is limited. The ecological knowledge gap in urban areas is a crucial lapse because urbanization in all its forms is one of the main components of global change.

The Baltimore Ecosystem Study LTER (BES) has three components. The first two are the complementary research approaches needed to build ecological knowledge of urban systems. First, social and economic processes are combined with physical dynamics and ecological processes. Second, because cities and suburbs are characterized by rapid change, both retrospective and long-term perspectives are critical. The third component of BES recognizes the responsibilities and opportunities of conducting research in an inhabited system. Developing and making the most of a broad range of educational opportunities satisfies the responsibility to share ecological knowledge with the widest audience. Applying ecological knowledge to management, environmental quality, and social justice acknowledges society's needs. Finally, the use of new ecological knowledge of urban systems in planning and restoration provides an important opportunity to test ecological theory and to improve urban quality of life.

The scientific knowledge gap, new scientific opportunities, and responsibility to the public have prompted us to pose three questions to guide our scientific research and our interactions with citizens in metropolitan Baltimore:

1. How do the spatial structure of socio-economic, ecological, and physical factors in an urban area relate to one another, and how do they change through time?

2. What are the fluxes of energy, matter, capital, and population in urban systems, and how do they change over the long term?

3. How can people develop and use an understanding of the metropolis as an ecological system to improve the quality of their environment, and to reduce pollution loadings to downstream air- and watersheds?

In our seventh year we have continued and enhanced core long-term activities, and initiated new work that promotes the goals of the Long-Term Ecological Research program. Field studies continue to emphasize the 17,150 ha Gwynns Falls Watershed, with a forested reference watershed at Oregon Ridge County Park, an urban atmospheric flux tower at Cub Hill, and a new initiative focusing on a highly urbanized storm drainage—Watershed 263—in West Baltimore. Gwynns Falls includes land that is currently being converted from agricultural to suburban uses, as well as areas that have been intensively urbanized for a long time. The Cub Hill site is on the edge of the city and represents extensive suburban landscapes. In addition to these intensively studied sites, our research also includes 200 sample

points spread throughout the city. We list key activities under each of our three guiding questions.

Ongoing Major Activities Addressing Question 1: *How do the spatial structure of socio-economic, ecological, and physical factors in an urban area relate to one another, and how do they change through time?*

To answer question one, we are conducting the following major research activities:

- Quantify the patch structure of Baltimore.
- Document patch change.
- Discover biotic changes.
- Survey soil heterogeneity.
- Operate a meteorological network.
- Conduct modeling at various scales.
- Compare gradients within metropolitan Baltimore, and with other cities.

The activities answering question one address the spatial structure, the temporal dynamics, and the integration of the social, ecological, and physical components of the Baltimore ecosystem. The specific research projects are listed below, and are described in greater detail in the research section of the BES web page at http://beslter.org

New Activities Addressing Question 1:

Patch delimitation

Social patches. An important advance in BES is to articulate and test new theories of social organization. Because the American city has changed dramatically in terms of the social and economic drivers in play, it is important to examine factors in addition to the usual roster focusing on social status – income, education, and education. BES researchers have pioneered the use of marketing models to explore the role of group identity and lifestyle clusters as drivers for environmental decisions at the household level.

- Tested four theories of social drivers—population density, social stratification, lifestyle behavior, and housing age—and their relationships to potential for vegetation stewardship, realized stewardship, vegetation cover, and vegetation structure

- Development of lifestyle clusters from historic data to examine relationships between group and housing characteristics of recent past and present day land cover (assessed via HERCULES; see below).

- Conducted research focused on individual and neighborhood life satisfaction and socioeconomic status, social capital, and environmental quality.

- Conducted research projects examining the relationship between urban vegetation and socio-economic factors. Also tested the influence of urban environmental amenities and disamenities on property values. Other researchers have used object-oriented remote sensing to automate the classification of aerial imagery. For all research projects, we created GIS data layers using remote sensing classification and geoprocessing. Among these is a topologically correct layer of property parcels for Baltimore, coded with the amount of tree, grass, building and other impervious cover. This data set is a crucial one for future socio-economic research in Baltimore.

Ecological-structural patches (surfaces, built, and biogeophysical components)

- *Land cover classification system.* The existing standard land cover classifications are too coarsely resolved to represent the fine scale and complex heterogeneity of spatial structures throughout the metropolis. We have found that analyses based on such Anderson-derived classifications to be inadequate for assessing structure-function relationships in the urban ecosystem. Therefore, we have devoted considerable effort to conceptualizing land cover classification in a new way, and to operationalizing this new model in Baltimore.

    - Finalized a new land cover classification called HERCULES (High Ecological Resolution Classification of Urban Landscapes and Environmental Systems).
    - Applied HERCULES to the Gwynns Falls watershed and Baisman Run watershed.
    - Initiated work with urban designers to construct a three dimensional visualization of HERCULES to promote its use in community and expert decision making.

- *Heterogeneity among patches.* A key aspect of urban ecosystem heterogeneity is the spatial structure imposed by or related to land ownership and management on a parcel basis.

    - Digitized the parcel structure of city blocks for Baltimore (1960, 1970), and populated the blocks with housing data.

- *Park and neighborhood survey.* In addition to data available through census, marketing, and property records, important details of patch structure must be assessed in the field.

    - Field data was collected for contrasting neighborhoods and parks. We collected data and created and analyzed GIS data layers on a variety of environmental indicators, including: tree locations, size and species; location and condition of vacant lots; and location and condition of stormwater inlets. Created numerous maps for analysis of environmental and social conditions in Watershed 263.

Patch change

- *Historical US census data and GIS.* It is important to organize historical census data in the same format and spatial frame as current census data in order to permit rigorous comparisons to be made.

    - Development of historic census database in a GIS framework.
    - Sampling (10 percent) of household characteristics from the 1920 and 1930 manuscript census data to populate enumeration districts in Baltimore. City Ward level data are too coarse to be useful for analysis with ecological data.
    - Georeferenced and digitized enumeration district boundaries for Baltimore City in 1920 and 1930.

- *Development of Open and Green Space*

    - Georeferenced and digitized open space layers for 1876, 1904 and 1914 for the Gwynns Falls Watershed.
    - Collected and interpreted primary documents on street tree management of Bolton Hill.
    - History of land acquisition for development of Leakin Park.

Biotic community change

- Sampling of vegetation to permit comparison with prior BES censuses on permanent plots, and reference transects through riparian zones.

- Assess ecological value of gardens in urban environments to native pollinators, particularly bees and butterflies, and work with community gardeners to promote pollinator conservation. Although this research was conducted in New York City community gardens, the intention is to apply the same method in Baltimore.

Soil heterogeneity

We continue to pioneer work treating urban soils in a sophisticated way that parallels soil classification and quantification in non-urban landscapes. Activities this year focused on two initiatives:

- Exploration of the use of wireless sensor network monitoring of soil ecology. Sampled soils to assess heavy metal distribution.

- Urban watershed management and restoration. Currently developing management strategies to deal with contaminated soils (very fine scale contamination, unlike typical brownfields).

Ongoing Major Activities Addressing Question 2: *What are the fluxes of energy, matter, capital, and population in urban systems, and how do they change over the long term?*

To answer question two, we are conducting the following major research activities:

- Document human demographic and social processes.
- Quantify stream flow, chemistry, and key biota.
- Measure extreme storm water flows and flooding.
- Measure vegetation processes and nitrogen flux in riparian zones.
- Measure biogeochemical pools and fluxes in contrasting upland patch types.
- Quantify meteorological exchanges between surface and atmosphere using flux tower technology.
- Model atmospheric, hydrological and socio-economic fluxes in and across contrasting watersheds.

The research aimed at answering question two takes into account the spatial structure of the Baltimore ecosystem, seeks feedbacks between socio-economic and biogeophysical processes, and has established sites in which long-term status and changes in fluxes are being measured. Integrated models, which incorporate ecological, hydrological, built, human and social capital, are key tools for understanding processes of flux and projecting changes into the future. The specific research projects contributing to answering question two are outlined below and described more fully on our web site.

New Activities Addressing Question 2:

Human demographic and social processes.

BES has to date, focused on biophysical and socio-economic relationships in the metropolitan ecosystem. We are establishing new partnerships in public health to extend our models to this important urban causal factor. BES social scientists have explored research opportunities related to public health and have begun to develop a research plan focused on asthma, Type II diabetes, physical activity, and access to open spaces

Stream measurements

Water chemistry
Chloride dynamics in urban streams: One of our core activities is using the watershed approach to evaluate integrated ecosystem function. Our long-term sampling network includes four longitudinal sampling sites along the Gwynns Falls as well as four small (40 – 100 ha) watersheds located within or near to the Gwynns Falls. The longitudinal sites provide data on water and nutrient fluxes in the different land use zones of the watershed (rural/suburban, rapidly suburbanizing, old suburban, urban core) and the small watersheds provide more focused data on specific land use areas (forest, agriculture, rural/suburban, urban). Each of the

gauging sites is continuously monitored for discharge and is sampled weekly for chemistry. Additional chemical sampling is carried out in a supplemental set of sites to provide a greater range of land use. Water quality analysis includes major cations, nutrients including inorganic and organic forms, total suspended solids, temperature, dissolved oxygen. Analysis during this past year has focused on chloride.

Stream geomorphology
We are investigating the effects of geomorphic stream restoration on riparian and in-stream denitrification activity. We hypothesize that restoration will result in increased riparian water table levels and will create stream features that can support significant denitrification activity. The Baltimore County (MD) Department of Environmental Protection and Management (DEPRM) has restored two sections of Mine Bank Run, a highly incised, degraded suburban stream, one in 2000/2001 and one in 2004/2005. Restoration efforts included filling the stream channel with sediment, cobble, and boulder, reconstruction of point bars, riffles and meander features and revegetation of the riparian zone. While the stated goal of restoration at Mine Bank Run is to restore geomorphic stability of the stream, we suggest that these restoration efforts will have significant positive effects on riparian and hyporheic zone denitrification. Our specific research objectives are to 1) quantify denitrification potential in riparian soil profiles before and after restoration to assess the response of denitrification to changes in water table levels associated with restoration, 2) quantify denitrification potential in selected stream features, especially those created by the restoration (e.g., point bars, riffles, and meanders) and 3) quantify actual denitrification rate in shallow groundwater before and after restoration to assess the actual NO_3^- removal capacity of the riparian and hyporheic zones and the effects of restoration on this capacity.

To help support broader watershed research efforts and their application, the Parks and People Foundation developed a proposal and secured Congressional support for Urban Watershed Forestry Cooperative to conduct applied urban environment/ecology research and restoration.

Assessment of major storm impacts (Dead Run and Moores Run).
We have stage hydrograph records at a set of stream gages that we have been monitoring for information about summer thunderstorms. Stage-discharge relationships are still under development because we cannot make field measurements at high discharges and must use modeling to develop appropriate relationships in order to convert stage data to discharge data. Similarly we have collected field data on high-water marks for several floods in the Dead Run and Moores Run watersheds and we are presently working on hydraulic models to determine flood magnitudes and flow patterns matching the surveyed high-water marks.

Much of this research has been supported by a grant, entitled Collaborative Research on Hydrology, Hydraulics and Hydrometeorology of Flood Response in Urbanizing Drainage Basins, EAR-0208225/0208669, 8/1/02–7/31/04, $300,000, UMBC PI: A. J. Miller, Princeton PI: J. A. Smith.

We have been able to document extreme flood response in small urban watersheds in the Baltimore area which includes discharge peaks that approach the envelope curve for the mid-Atlantic and central Appalachian region. These floods are generated by short-duration high-intensity warm season thunderstorms in some of the flashiest watersheds in the continental United States. This research focuses on three key questions: (1) How does the scale-dependent flood response of urban drainage basins depend on the space-time structure of rainfall for warm season systems of thunderstorms? (2) How does flood response vary with land-surface properties including impervious cover and structure of the urban drainage network? and (3) What is the relative role of changing channel/floodplain morphology due to urbanization, as compared with geologic controls of channel floodplain morphology, in determining the transmission and attenuation of flood waves in an urbanizing drainage basin? A large number of extreme discharge events occurred in the summers of 2003 and 2004, including the floods of record in two of our study watersheds. Modeling of flood behavior reveals important controls exerted by both anthropogenic and natural features, including bridges and road embankments, valley fill, channelized reaches, and longitudinal changes in gradient and valley width controlled by bedrock geology. Storage effects and longitudinal changes in the flood hydrograph and flow fields are observed and historical information from pre-development topographic maps is being used to investigate the effect of channel and floodplain modification on flood inundation extent and flood-wave propagation. Field work is continuing through summer 2005. Additional funding was received through an agreement with the Maryland Department of the Environment entitled Assessment of LiDAR for Hydraulic Modeling of Flood Hazards.

Biogeochemical fluxes

In order to explore the undocumented and potentially important role of urban (including suburban) residential lawns and landscapes in regional and global carbon dynamics, we have initiated new studies. We have assessed carbon stocks and fluxes in urban and suburban residential landscapes using a pilot study of field plots on landowners lawns in South Burlington, VT to field-test methods prior to Baltimore implementation. Methods involve quantification of grass clippings, thatch and stubble production, biomass turnover, soil C and N, soil CO_2 flux. BES partners participated in the development of this research proposal to assess carbon stocks and fluxes in Baltimore's residential forest, in order to assure community buy in and integration with stakeholders.

Ongoing Major Activities Addressing Question 3: *How can people develop and use an understanding of the metropolis as an ecological system to improve the quality of their environment, and to reduce pollution loadings to downstream air- and watersheds?*

To answer question 3, we are conducting the following major education, interaction, and research activities:

- Develop or participate in educational partnerships.
- Analyze the ecological knowledge base and its use in different social contexts.
- Interact with governmental agencies at various levels to exchange ecological knowledge and information.
- Interact with communities, community groups, and non-governmental organizations to enhance ecological understanding.
- Design social and educational assessments to determine the changing role of ecological knowledge in Baltimore.
- Conduct mediated modeling that incorporates the concerns of stakeholders.
- Manage information to enhance flow of data and knowledge within BES, and between BES and agencies, communities, and individuals.
- Participate in assessment of storm drain watershed (263) restoration activities and evaluation.
- Provide internships for secondary, college, and graduate students, and fellowships for teacher involvement in ecological research.
- Focus studies in Mine Bank Run stream restoration project.

In addressing question three, the partnerships are crucial. Because this question deals with the flow of information and its use, our activities recognize the diversity of sources and users of ecological and other relevant information, and the need to maintain two way flows of information and understanding of ecological issues. Of the three areas of activity in BES, this one is the most fluid and developmental, since it depends on evolving and expanding relationships in the Baltimore region as well as evolving and expanding ecological understanding. Specific activities we are currently undertaking in pursuit of question three are listed below and detailed on our web page:

New Activities Addressing Question 3:

<u>Education partnerships.</u>

We have realized that the most effective use of our education resources is in bringing ecological rigor to existing efforts, in focusing on exemplary programs targeting under represented populations, and in the multiplier effect of training educators. Therefore, partnerships are a crucial component of our efforts.

- Developed program with Living Classrooms Foundation for schoolyard greening and curriculum development at targeted elementary schools. Supported

Baltimore City effort to remove nine acres of asphalt and re-green schoolyards in Watershed 263 neighborhoods.

- Neighborhood Science Program. Washington Village/Pigtown – Garden Mosaics participatory youth science research and educational project: Leadership, development and revision of youth research activities in community gardens; implemented youth research activities with youth group; trained 20 educators in use of Garden Mosaics education program.

- Curriculum development

  - SuperKidsGrow Program – We had a productive year with curriculum development for two sites (Franklin Square Elementary and Harlem Park Middle School). In collaboration with BES scientists and a BES/URI intern, we developed a comprehensive decomposition unit which included deploying leaf bags in streams and a visit to Dr. Swan's lab for analysis. We have also developed Micro-climate and Phenology units which will be piloted in the Fall 2005.
  - Three Investigating Urban Ecosystems units, developed by BES Ecology Education Fellows, have been written, piloted and presented through teacher workshops. Three Units are now being finalized for distribution: Investigations in Urban Soils – Earthworm Populations (middle school), Exploring Watersheds in Baltimore (high school) and Urban Hydro-Ecology Handbook (middle school). During this period, three additional fellows piloted units on Land-Use Transition in Baltimore County, CO_2 in the City's Air and Animals in the City – Squirrel Ecology. A fourth fellow has piloted parts of a Social Studies unit on Neighborhood Environmental History.

- Resources for educators

  - During this period we have continued to work, through the BES Ecology Education Fellowship program, with eight educators who are learning about the local environment and about BES research, developing lesson plans for their own use and then crafting these into instructional support materials for others. Three of these Fellows helped run workshops for other educators during the reporting period. The Ecology Education Internship Program engaged three young educators/ecologists in projects through the Urban Resources Initiative program at Parks and People.
  - Trained educators in use of "Tree Treasures" educational activities for use in formal and informal educational environments.

- Educational Research. In response to interactions with educators at the national level, and in recognition of the need to better understand the nature and constraints on ecological education, we have increased our commitment to education research.

  - Ecology Teaching Study - We conducted a study of how ecology is being taught in Baltimore City and County schools, focusing on the use of

fieldwork, genuine data (from students or on-line sources), community resources and action projects, and the extent of teaching about the urban ecosystem. With a BES intern we were able to reach teachers in Baltimore County High Schools and most notably, Baltimore City High Schools. We received completed surveys from at least one teacher from 93% of the Baltimore County public school pool (105 surveys), 22% of the Baltimore City public school pool (20 surveys), 25% of the Baltimore City private school pool (5 surveys); 1% of the Baltimore County private school pool (2 surveys). Total Surveys returned – 132. With an intern, we also carried out a more intensive study of ecology teaching by interviewing teachers and administrators in all of the public schools in Watershed 263.

- In collaboration with the six-city Urban Ecology Collaborative, we conducted an Environmental Education Provider Inventory. With a BES/URI intern, we implemented the Baltimore portion of this multi-city inventory of environmental education providers. Baltimore had one of the highest response rates in the Urban Ecology Collaborative (70%)! Multi-city and Baltimore-only reports will be prepared and disseminated in the next reporting period.
- What Influences Teachers' Modifications of Curriculum project – Two BES co-principal investigators are collaborating on a newly funded (NSF) project to study responsive teaching in Maryland high school classrooms. BES will work closely with ten Baltimore environmental science teachers over the next three years to explore with them and the project team how they use and modify BES Investigating Urban Ecosystem units in their regular course of instruction.

Interactions with agencies

- Infusing BES Science into Partners' Ecology Education Programs
  - SuperKidsGrow (Parks and People Foundation) - BES assisted with the school year program serving approximately 60 inner city (predominantly African American) 3rd, 4th and 5th graders at Franklin Square Elementary School and 20 inner city (predominantly African American) 6th and 7th graders at Harlem Park Middle School.
  - WS263 - BES continues to be part of the Parks and People Foundation team collaborating on educational outreach to youth and adults in Watershed 263.
  - Baltimore City Public School System - BES has worked closely with the Teaching Institute of Essential Science (TIES) on science curriculum for high schools. The Investigating Urban Ecosystems Program (IUE) Exploring Watersheds in Baltimore unit will be a part of a new 9th grade science course to be piloted at approximately 16 of Baltimore City's 39 High Schools.

- Implemented training and education in urban forestry through summer work program with high school work teams in three city parks.

- Baltimore has been selected to be a site involved in the USGS Cooperative Urban Ecosystem Studies (CUES) program. The CUES program is in search of

ways to focus resources on the integrated assessment and monitoring of critical urban ecosystems to support the development of digital map products. An ongoing effort has begun to develop collaborations between BES and the CUES program.

Interactions with communities

- Facilitated by Parks and People Foundation

  - Pilot neighborhood street tree inventory project to identify and solve issues related to conducting citywide street three inventory project in 2006.
  - Conducted MERGE (Methods for Engaging Residents and Grassroots in the Environment) informal neighborhood surveys to identify opportunities and barriers to increased citizen involvement in urban forestry; held grassroots forum to disseminate survey results and identify effective outreach strategies to increase participation in urban forestry activities.
  - Developed case studies of successful neighborhood greening projects.
  - Worked with City agencies to advise CityStat and Baltimore Neighborhood Indicators Alliance (BNIA) on environmental data and indicators; contributed data on environment/ecology indicators for citywide assessment in BNIA Vital Signs Report.
  - Worked with federal, state, and local government and community-based organizations to develop and implement restoration plan for 900-acre storm drain watershed (Watershed 263) incorporating 11 neighborhoods in Southwest Baltimore to demonstrate impact of greening strategies on quality and quantity of storm water runoff and quality of life; collaborated with the US Forest Service and Baltimore City Department of Public Works to collect baseline data for assessing impact of restoration activities.
  - Implemented BRANCHES youth forestry training and summer employment program with Department of Recreation and Parks in three public parks in Baltimore; provided economically disadvantaged youth with training and employment experience to develop useful job skills that lead to long-term opportunities in tree care related professions; coordinated consultation between BES scientists and Department of Recreation and Parks staff to develop restoration work plans and training for youth team supervisors.
  - Participated in Baltimore Sanitary Sewer Oversight coalition to address polluted urban streams.

- Urban design

  With the June 2005 Science Meeting, BES inaugurated an Urban Design Working Group. Including urban design in BES recognizes that the professions of architecture, planning, design, and landscape architecture can contribute to the improved understanding of the ecology of the urban ecosystem, and can facilitate the transfer of ecological knowledge to design, planning, and management decisions. Formalizing the place of urban design in BES follows on three years of close interaction between BES researchers and the urban design studios at Columbia University. The June Quarterly Science Meeting brought

together members of the Baltimore urban design community, the already active members of the Urban Design Working Group, and BES researchers, in order to explore the further integration of urban design into BES, and to increase the participation of new members of the design and planning community in Baltimore. In particular, links with additional research projects were explored, and opportunities for providing input into designs for specific projects in Baltimore were highlighted. Enhancing the involvement of BES in urban design positions us to both understand and bring greater ecological knowledge to bear in the feedbacks addressed by Question 3.

- Information management

  - Web page development and management (www.beslter.org)

  - Open Research System (ORS) (www.open-research.org). Data layers from the BES spatial database were developed and were put on the web at ORS Private, including extensive documentation of the data. We maintained and supported the Open Research System, including developing a system to export metadata records and automatically format a static webpage off the BES website. Since the ORS is a “deep web” application, not searched by Google, for example, having a mirror of the data in a static website allows those surfing the web to discover BES data using web searchers such as Google.
  - Creation of BES ArcGIS geodatabase at the University of Vermont Spatial Analysis Lab. This is a collection of spatial data for BES stored in a standardized GIS-enabled database framework. All data are standardized for spatial reference and naming and is extensively and consistently documented. Many new layers have been created through primary analysis. Currently, all individual layers of the database that do not have access constraints are accessible to all BES participants via the ORS private website. Upcoming migration to an ArcSDE server will allow outside participants to connect from their PC directly to the database.
  - Flood Response: Much of our work is based either at our network of field data collection sites (principally in Dead Run, with activities in other watersheds as floods occur) or in the Center for Urban Environmental Research and Education at UMBC (CUERE) GIS lab, which supports our work by making computer workstations and servers available to host our data and modeling work. LiDAR data housed at UMBC are of key importance; streamflow data from USGS and additional data collected by our research assistants are also critical to the project; rainfall data are collected by field assistants after summer precipitation events at a network of non-recording rain gages and are used to calculate bias corrections to precipitation fields derived from NEXRAD weather radar at Sterling, VA and processed at Princeton.
  - Compilation of BES Monitoring Site Locations. Efforts were taken to compile recorded monitoring site locations for BES projects. Further steps are being taken to collect and post-process GPS positions for unrecorded and new site locations.

  - Bird database. We continue to maintain an online database of bird monitoring activity, which is undergoing some system improvement.

- Watershed 263 storm water management research and restoration in Baltimore City. Coordination through Parks and People Foundation:

  - Developed and delivered storm drain/water quality education program curriculum at three after-school programs in Watershed 263; stenciled and cleaned up storm drains near program sites; educated youth about the impact of littering and pollution on water quality and habitat in Chesapeake Bay.
  - Worked with Watershed 263 Stakeholder Council to develop indicators to monitor and evaluate outcomes of large-scale watershed restoration project.

Outreach

Outreach is 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 year 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.

Formal 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. The Annual Meeting was attended by approximately 85 people in 2004 and approximately 125 people attended the Open House. The Open House is held annually, during the evening of the Annual Meeting, in conjunction with the Parks and People's Annual Greening Celebration. Over time, the number of attendees at these functions has grown. At the 2004 Open House, it was announced that Mayor Martin O'Mally had declared the day "Baltimore Ecosystem Day" in recognition of the scientific work and community improvements facilitated by BES. We held three additional Science Meetings at roughly three month intervals focused on research planning and results but open to potential collaborators and clients for the information. The interaction with the Baltimore urban design and planning community and agencies in the June Science Meeting broke new ground in BES outreach.

Presentations, Displays, Posters and Websites Considered Outreach Activities

Presentations

Belt, K.T. 2004. Ecological research: A comprehensive urban catchment restoration (Watershed 263). Presentation. Panel discussion with J.M. Grove, G. Hager, W. Stack. 8th Annual Tributary Team Meeting, Maryland Department of the Environment, Montgomery Park, Baltimore, MD. March 13.

Belt, K.T. 2004. Aquatic terrestrial linkages in urban ecosystems: Role of vegetation and land use in determining urban stream ecosystem structure and function. Northeastern Research Station TAV Unit Review, Syracuse, NY. November 8-9.

Belt, K.T. 2004. E. Coli in urban streams: Season, land use, and hydrologic drivers. Seminar at University of Maryland-Baltimore County, Department of Geography and Environmental Systems. December 2.

Belt, K.T. 2005. Alteration of urban hydrologic flow paths: Thermal consequences for E. Coli and organic matter decomposition. Revitalizing Baltimore Technical Committee, Baltimore, MD. April 12.

Belt, K.T., R.V. Pouyat, W.P. Stack, G. Heisler, P.M. Groffman, U. Ghosh, A. Taylorson, and J. Zhou. 2005. Watershed 263 small headwater storm drain catchment hydrology: Preliminary water quality results. University of Maryland-Baltimore County-SERC Workshop, Smithsonian Environmental Research Center, Edgewater, MD. January 18.

Belt, K.T., C. Swan, R.V. Pouyat, and A. Miller. 2005. Leaf litter sources, composition, transport and breakdown in small urban streams: The effects of altered hydrology and upland riparian zones. University of Maryland-Baltimore County-SERC Workshop, Smithsonian Environmental Research Center, Edgewater, MD. January 18.

Belt, K.T., R.V. Pouyat, G. Heisler, A. Taylorson, J. Stubbs, and B. Smith. 2005. Thermal fluxes and impacts in small urban headwater catchments: A question of spatial and temporal scale. University of Maryland-Baltimore County-SERC Workshop, Smithsonian Environmental Research Center, Edgewater, MD. January 18.

Belt, K.T., K. Readel, J. Higgins, and P.M. Groffman. 2005. E. Coli in urban streams: Season, land use, and hydrologic drivers. University of Maryland-Baltimore County-SERC Workshop, Smithsonian Environmental Research Center, Edgewater, MD. January 18.

Belt, K.T., R.V. Pouyat, W.P. Stack, G. Heisler, P.M. Groffman, U. Ghosh, A. Taylorson, and J. Zhou. 2005. Watershed 263 small headwater storm drain catchment hydrology: Preliminary water quality results. Annual Ecological Society of America Mid-Atlantic Chapter, University of Maryland-Baltimore County, Baltimore, MD. March 12.

Berkowitz, A. 2004. Baltimore is an ecosystem! New York ReLEAF Conference. Marist College, Poughkeepsie, NY. July 9.

Berkowitz, A. 2005. Field- and inquiry-based ecology teaching: Challenges and opportunities for teacher professional development. Michigan State University, East Lansing, MI. April 27.

Buckley, G.L. 2005. Cradle of conservation: Professional forestry comes to the South. Annual Meeting of the Association of American Geographers, Denver, CO. April 5-9.

Cadenasso, M. 2004. Spatial heterogeneity in urban ecosystems: Land cover as an integrator of complex system dynamics. University of Vermont, Burlington, VT. February 12.

Cadenasso, M. 2004. Ecological flows in heterogeneous landscapes: A framework and application to forest, savanna, and urban systems. Columbia University, New York, NY. March 9.

Cadenasso, M. 2004. Landscape heterogeneity and ecological flows: Building understanding across forest, savanna, and urban systems. Yale University, New Haven, CT. October 25.

Cadenasso, M. 2005. Human alterations to landscape structure and function: Heterogeneity and ecological flows. University of Colorado, Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, CO. February 4.

Cadenasso, M. 2005. Landscape heterogeneity and ecological flows: Building understanding across forest, savanna, and urban systems. University of Toronto, Mississauga, Ontario, Canada. February 10.

Cadenasso, M. 2005. Landscape heterogeneity and ecological flows: Building understanding across forest, savanna, and urban systems. California State University, Chico, CA. March 7.

Cadenasso, M. 2005. Ecological flows and heterogeneous landscapes: Building understanding across forest, savanna, and urban systems. University of California, Davis, CA. June 22.

Cox, K. 2005. Insects of New York City Community Gardens. New York Restoration Project. New York, NY. May 20.

Dalton, S.E. 2004. Social assessment in action: The art of science in human-dominated ecosystems. National Oceanic and Atmospheric Administration, Wells, ME. October 19.

Grimmond, C.S.B. 2005. Urban meteorology field experiments: Approaches and results from field campaigns. Urban climatology and its applications, UK UWERN (Universities Weather Research Network), Pembroke College, Cambridge, England (Keynote). July 7-8.

Grimmond, C.S.B. 2005. Measuring and modeling urban climates. King's College, London, March 9.

Grimmond, C.S.B. 2005. Understanding urban climates: Measuring and modeling surface-atmosphere exchanges, University of California, Los Angeles, CA. February 18.

Grimmond, C.S.B. 2005. Urban surface-atmosphere exchanges: Focus on water, Ecoclimatology, Geography and Ecology. Arizona State University, Phoenix, AZ. February 17.

Grimmond, C.S.B. 2005. Understanding urban climates: Measuring and modeling surface-atmosphere exchanges. Institute for International Sustainability, Arizona State University, Phoenix, AZ. February 16.

Grimmond, C.S.B. 2004. Surface-atmosphere exchanges in urban areas: Observations and models. Numerical Prediction Research Division, Meteorological Research Branch, Environment Canada, Dorval, Canada. October 18.

Heisler, G.M., J. Walsh, and G. Fisher. 2005. Accessing national long term ecological research program climate and hydrology data. Ecological Society of America, Mid-Atlantic Ecology Conference, University of Maryland-Baltimore County, Baltimore, MD. March 12-13.

Krasny, M. and L. Pohl-Kosbau. 2004. Exploring urban ecology through community gardens. Workshop at Annual Meeting of the Ecological Society of America, Portland, OR. August 1.

Pickett, S.T.A. 2004. Panel Discussion – Open fire: Can cities be sustainable? Cosponsored by Machael Kalil Endowment for Smart Design, Parsons School of Design. Graduate Center at City University, New York City. October 18.

Pickett, S.T.A. 2004. Plenary Keynote Speaker – Ecological Society of Australia Annual Conference, University of Adelaide. December 7-10.

Pickett, S.T.A. 2004. Keynote Symposium Speaker – Urban Ecology Symposium, Ecological Society of Australia Annual Conference, University of Adelaide. December 7-10.

Pickett, S.T.A. 2005. Keynote Speaker – Ecosystem heterogeneity and the problem of hydrological overconnectivity in urban environments. Green Infrastructures for Water in the City Symposium, Harvard University Graduate School of Design. February 19.

Pickett, S.T.A. 2005. Panel Discussion – Green infrastructures for water in the city. Symposium, Harvard University Graduate School of Design, New Haven, CT. February 19.

Pickett, S.T.A. 2005. Urban legends and ecological insights. Yale School of Forestry and Environmental Studies, Hixon Center for Urban Ecology, New Haven, CT. April 28.

Pickett, S.T.A. 2005. Science as discovery, community, and communication. Keynote Speaker – Urban Ecology Institute's Annual Student Research Conference. Boston College. May 27.

Pouyat, R.V. 2005. Entitation training (vegetation mapping). USDA Forest Service, Baltimore City Parks, Baltimore, MD. May 24-25.

Pouyat, R.V. and K.T. Belt. 2005. Provided discussions and handouts describing BES research, and a field tour of BES labs, permanent plots and hydrology field sites, as part of the annual Ecological Society of America Mid-Atlantic Chapter meeting, University of Maryland-Baltimore County, Baltimore, MD. March 12.

Rinke, C., S. Marudas and J. Gordon. 2004. The ecology teaching study: Learning about the environment in Baltimore schools. Urban Ecology Collaborative Education Strategic Planning Meeting, Washington, DC. September 23.

Szlavecz, K. and P. Groffman. 2004. Invasive earthworms and N-cycling: Do species matter? Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Taylorson, A., K.T. Belt, R.V. Pouyat, W.P. Stack, M. Cherigo, D. Schindler and J. Zhou. 2005. Monitoring the subterranean urban realm: Watershed 263 storm water sampling and flow measurement. University of Maryland-Baltimore County-SERC Workshop, Smithsonian Environmental Research Center, Edgewater, MD. January 18.

Taylorson, A., K.T. Belt, R.V. Pouyat, W.P. Stack, M. Cherigo, D. Schindler and J. Zhou. 2005. Monitoring the subterranean urban realm: Watershed 263 storm water sampling and flow measurement. Annual Ecological Society of America Mid-Atlantic Chapter, University of Maryland-Baltimore County, Baltimore, MD. March 12.

Wilson, M.A. and A. Troy. 2005. Accounting for ecosystem services in a spatially explicit format: Value transfer and geographic information systems. International Workshop on Benefits Transfer and Valuation Databases: Are We Heading in the Right Direction? U.S. Environmental Protection Agency and Environment Canada. Washington DC. March 21-22.

Displays

Hom, J. 2005. Display of working BES urban flux tower. Forest Service Centennial Congress, Washington, DC. January 3-6.

Hom, J. 2004. Display of working BES urban flux tower. Open Spaces to Crowded Places: Landscape Change along the I-95 Corridor. Forest Service Northeast Regional Centennial Forum. The Academy of Natural Sciences, Philadelphia, PA. November 14-15.

Posters

Atueyi, S., J.A. Simon, J.W. Snodgrass and R.E. Casey. 2005. Temporal trends of trace element levels in macroinvertebrates from stormwater retention ponds. Sixth Annual Student Research and Scholarship Expo, Towson University, Towson, MD. April 28.

Atueyi, S., R.E. Casey, J.A. Simon and J.W. Snodgrass. 2005. Temporal trends of trace element levels in macroinvertebrates from stormwater retention ponds. p.11. 15th Annual Honors Convocation Research Poster Session, Towson University College of Science and Mathematics, Towson, MD. April 16.

Atueyi, S., J.A. Simon, J.W. Snodgrass and R.E. Casey. 2005. Temporal trends of trace element levels in macroinvertebrates from stormwater retention ponds in the Baltimore-Washington area. Undergraduate Student Research Days Sponsored by the Council of University System Faculty and the Office of the Chancellor. March 1-3.

Atueyi, S., J.A. Simon, J.W. Snodgrass and R.E. Casey. 2004. Temporal trends of trace element levels in macroinvertebrates from stormwater retention ponds. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Atueyi, S., J.A. Simon, J.W. Snodgrass and R.E. Casey. 2004. Temporal trends of trace element levels in macroinvertebrates from stormwater retention ponds in the Baltimore-Washington area. Fourth SETAC World Congress. Portland, OR. November 14-18

Atueyi, S., J.A. Simon, J.W. Snodgrass and R.E. Casey. 2004. Temporal trends in trace element levels in macroinvertebrates from stormwater retention ponds. Seventh Annual Undergraduate Research Symposium in the Chemical and Biological Sciences, Catonsville, MD.

K. Belt, R. Pouyat, U. Ghosh, P. Groffman, L. Band, E. Ellis, K. Readel, M. McGuire, J. Higgins, D. Shelton, J. Zhou, A. Taylorson, et al. 2004. Measuring environmental improvement: Stormwater runoff volume and quality in two small urban catchments. WS263 project poster at Chesapeake Bay Trust Pioneer Grant award, media event at BRESCO (Baltimore Harbor), August 17.

Belt, K.T., R.V. Pouyat, G. Heisler, A. Taylorson, J. Stubbs and B. Smith. 2004. Thermal fluxes and impacts in small urban headwater catchments: A question of spatial and temporal scales. Baltimore Ecosystem Studies Annual Meeting, Baltimore, MD. October 21-22.

Belt, K.T., K. Readel, J. Higgins and P. Groffman. 2004. *E. Coli* in urban streams: Season, land use and hydrologic drivers. Maryland Water Monitoring Council 10th Annual Conference, at Maritime Graduate School and Institute, Linthicum, MD. November 18. Abstract published in program, in hard copy and on MWMC web.

Belt, K.T., K. Readel, J. Higgins and P. Groffman. 2004. *E. Coli* in urban streams: Season, land use, and hydrologic drivers. Baltimore Ecosystem Studies Annual Meeting, Baltimore, MD. October 21-22.

Belt, K.T., K. Readel and K. Zoller. 2004. E.coli in urban streams: Season, land-use, and hydrologic drivers. Ecological Society of America 89th Annual Meeting, Portland, OR. August 1-6.

Chumble, P., J. Zhao, R. Pouyat, K. Belt and U. Ghosh. 2004. Use of caffeine to identify and quantify wastewater contamination in urban streams. Gordon Research Conference. July 31.

Chumble, P., J. Zhao, R. Pouyat, K. Belt and U. Ghosh. 2004. Use of caffeine to identify and quantify wastewater contamination in urban streams. Maryland Water Monitoring Council 10th Annual Conference. Maritime Graduate School and Institute, Linthicum, MD. November 18. Abstract published in program, in hard copy and on MWMC website.

Crawford, B., C.S.B. Grimmond, J. Hom, B. Offerle, D. Golub. 2004. Surface characteristics and carbon dioxide fluxes in a suburban area of Baltimore, MD: A GIS based methodology. Annual Assembly of the University Consortium of Geographic Information Science (UCGIS), Washington, DC. October 20-23.

Crawford B., C.S.B. Grimmond, J. Hom, B. Offerle, D. Golub. 2004. Surface characteristics and carbon dioxide fluxes in a suburban area of Baltimore, MD: A GIS based methodology. Baltimore Ecosystem Studies Annual Meeting, Baltimore, MD. October, 21-22.

Force, J., G. Machlis and W. Burch. 2005. Human Ecosystem Model. UFRO Meeting, Australia.

Grimmond S., D. Dragoni, D.E.Anderson, J. Beringer, A. Coutts, B. Crawford, D. Fowler, F. Hu, J. Hom, M. Kanda, T.S. King, W. Kuttler, V. Masson, H. Mayer, J. McFadden, F. Miglietta, R. Moriwaki, E. Nemitz, B. Offerle, T.R. Oke, D. Scherer, H. Soegaard, N. Tapper, C.J. Walsh and R. Vogt. 2004. Urban FluxNet: CO_2 - flux measurements. FLUXNET 2004 Open Workshop, Firenze, Italy. December13-15.

Jenkins, J.C., P.M. Groffman, M.L. Cadenasso, S.T.A. Pickett, M. Cox, J.M. Grove, R.V. Pouyat. 2005. Carbon stocks and fluxes in urban and suburban residential landscapes. Third USDA Symposium on Greenhouse Gases and Carbon Sequestration in Agriculture and Forestry. Baltimore, MD. March 21-24.

Juhaszova K. and K. Szlavecz. 2004. Variation over time in population size and reproductive characteristics of two invasive isopod species. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Kritcher, K.J., R.P. Roberts and J.C. Hull. 2005. Development and characterization of a microsatellite library for Gentianopsis crinita (Froel.) Ma (fringed gentian). Sixth Annual Student Research and Scholarship Expo, Towson University, Towson, MD. April 28.

Kritcher, K.J., R.P. Roberts and J.C. Hull. 2005. Development and characterization of a microsatellite library for Gentianopsis crinita (Froel.) Ma (fringed gentian). p. 25. 15th Annual Honors Convocation Research Poster Session, Towson University College of Science and Mathematics, Towson, MD. April 16.

Kritcher, K.J., R.P. Roberts and J.C. Hull. 2004. Development and characterization of a microsatellite library for Gentianopsis crinita (Froel.) Ma (fringed gentian). Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Locoh-Donou, S. and C. Berkower. 2004. Efforts to enhance immunogenicity of a recombinant malaria vaccine: Fusion to a mouse complement protein. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Nejako, M. and W. Hilgartner. 2005. A paleoecological test of the fire hypotheses in serpentine vegetation. Sixth Annual Student Research and Scholarship Expo, Towson University, Towson, MD. April 28.

Nejako, M. and W. Hilgartner. 2005. A paleoecological test of the fire hypotheses in serpentine vegetation. p.10. 15th Annual Honors Convocation Research Poster Session, Towson University College of Science and Mathematics, Towson, MD. April 16.

Nejako, M. and W. Hilgartner. 2005. A paleoecological test of the fire hypotheses in serpentine vegetation. Colonial Academic Alliance Undergraduate Research Conference, Hofstra University, Hempstead, NY. April 8-9.

Nejako, M., W. Hilgartner and J. Wolfson. 2005. A paleoecological test of the fire hypotheses in serpentine vegetation. University System of Maryland Undergraduate Student Research Days. March 1-3.

Nejako, M. and W. Hilgartner. 2004. A paleoecological test of the fire hypotheses in serpentine vegetation. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Sarumi, M.A. and N.A. Kreiter. 2005. The influence of intraspecific density on male courtship and copulatory behavior in the fishing spider, Dolomedes triton. Sixth Annual Student Research and Scholarship Expo, Towson University, Towson, MD. April 28.

Sarumi, M.A. and N.A. Kreiter. 2005. The influence of intraspecific density on male courtship and copulatory behavior in the fishing spider, Dolomedes triton. p.8. 15th Annual Honors Convocation Research Poster Session. Towson University College of Science and Mathematics, Towson, MD. April 16.

Sarumi, M.A. and N.A. Kreiter. 2004. The influence of intraspecific density on male courtship and copulatory behavior in the fishing spider, Dolomedes triton. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Sarumi, M.A., N.A. Kreiter and A. Ehlman. 2004. Copulation and cannibalism in fishing spiders Dolomedes Triton (Aranleau: Pisauridae). Towson University Student Research and Scholarship Expo, Towson, MD. April 22.

Sarumi, M.A., N.A. Kreiter and J.L. Wolfson. 2004. The influence of intraspecific density on male courtship and copulatory behavior in the fishing spider, Dolomedes triton. 7th Annual Undergraduate Research Symposium in the Chemical and Biological Sciences, Catonsville, MD.

Juhaszova, K. and K. Szlavecz. 2004. Variation over time in population size and reproductive characteristics of two invasive isopod species. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Taylorson, A., K.T. Belt, R.V. Pouyat, W.P. Stack, M. Cherigo and J. Zhou. 2004. Monitoring the subterranean urban realm: Watershed 263 stormwater sampling and flow measurement. Baltimore Ecosystem Studies Annual Meeting, Baltimore, MD. October 21-22.

Wilson, J. and J.L. Wolfson. 2005. Periodical cicadas in the suburbs: Magicicada in Cub Hill, MD. Sixth Annual Student Research and Scholarship Expo. April 28.

Wilson, J. and J.L. Wolfson. 2005. Periodical cicadas in the suburbs: Magicicada in Cub Hill, MD. p. 7. 15th Annual Honors Convocation Research Poster Session, Towson University College of Science and Mathematics, Towson, MD. April 16.

Wilson, J. and J.L. Wolfson. 2004. Periodical cicadas in the suburbs: Magicicada in Cub Hill, MD. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Websites

www.beslter.org – Main website for the Baltimore Ecosystem Study

www.open-research.org – The ORS system provides partnering research groups and the broader environmental research community a mechanism to share research and data products on the web.

www.umbc.edu/cuere – Website for BES contributing organization—Center for Urban Environmental Research and Education.

www.lifeunderyourfeet.org **–** Website dealing with soil invertebrates investigated in BES.

http://www.as.phy.ohiou.edu/Departments/Geography/lter.html – Ohio University webpage describing faculty, students, publications and theses related to BES.

www.fsl.orst.edu/climhy/ **–** Meteorological data supplied to the ClimDB, an interest-available dataset for public access to LTER climate and hydrological data. The CLIMDB/HYDRODB, is a centralized server to provide open access to long-term meteorological and streamflow records from a collection of research sites.

http://ecovalue.uvm.edu/ **–** Based at the University of Vermont, the EcoValue project provides an interactive decision support system for assessing and reporting the economic value of ecosystem goods and services in geographic context.

http://md.water.usgs.gov/BES **–** USGS webpage describing BES and USGS related activity.

http://md.water.usgs.gov/ **–** Select Watershed Projects, then Baltimore Urban LTER for a project summary and description of stream gaging station operations.

Findings

For each of the three overarching research questions for BES, we highlight new findings below.

Findings Addressing Question 1: *Structure, Integration, and Dynamics of Ecological, Socio-economic, and Physical Factors in the Baltimore Ecosystem*

BES is founded on the hypothesis that ecosystem structure is related to ecosystem function. Therefore, findings concerning the structure of patchiness throughout the metropolitan ecosystem are crucial. We highlight new findings in the social aspects of patches, the reconceptualization and refinement of patch classification in the urban matrix, the role of gardens as hotspot patches for certain organisms, the associations of biodiversity with spatial structure.

Patch delimitation

Social patches. Our new findings emphasize the role of property regime, social identity and lifestyle clusters, and complex temporal and spatial patterns of association between amenities or disamenities and social variables.

- Measures of lifestyle behavior are better predictors of variations in realized stewardship and vegetation cover.
- Vegetation structure varies among different lifestyle groups.
- Measures of social stratification are better predictors of variations in potential stewardship.
- Remote sensing techniques are necessary but insufficient for understanding the complex relationships between social and vegetation structure. Intensive, field-based measurements are needed.
- Urban foresters and environmental planners can use marketing approaches for building constituencies for and participation in urban greening programs.
- Socioeconomic status is not a significant predictor neighborhood quality of life, but is a significant predictor of individual quality of life
- Social capital and environmental quality are significant predictors of neighborhood quality of life.
- Different factors affect individual and neighborhood quality of life, indicating differences in scale. This research suggests that it is important to be clear in discussions of quality of life to distinguish between individual and neighborhood measures.

- In our research on predicting patterns of vegetation and opportunities for greening on private urban lands, we found that among several possible variables, social stratification indicators best predict differences in the plantable area by parcel (the area not covered by buildings and hence theoretically available for planting), while lifestyle indicators best predict the percentage of plantable area that is actually "greened." We also find that housing age is a key predictor of both outcome variables.

- Crime is a critical factor in mediating whether property values rise or fall with distance to city parks and green spaces and that parks with high robbery rates are valued negatively by the housing market and vice versa.

- Tree canopy percentage by parcel has a nonlinear relationship with property value, with the effect of the first few trees being negative and then turning positive after canopy exceeds 50%.

Structural patches. Current results address the nature of patch classifications, and the stability of certain patch boundaries over long times in urban systems.

- Our efforts to evaluate existing land cover/land use classifications, and to provide a new, more refined and integrated system of land cover classification suitable to urban ecological research, have allowed us to compare the traditional systems with our new classification. HERCULES captures urban land cover heterogeneity effectively. HERCULES is an improvement over standard land use descriptors for relating residential land use and nitrate export.

- The resiliency of historical land use on the landscape including the influence of historical activities—particularly the removal of dams on the Gwynns Falls hydrology and geomorphology. Early agricultural land use has a persistent effect on Baltimore stream channel sedimentation and morphology.

Biotic community change. The biota are important components of urban patches, as well as important responders to urban patch structure.

- The hydrologic changes in riparian patches affect vegetation distributions. We have discovered that the hydrological changes associated with riparian zones are related to the increased invasion of riparian zones by upland tree species.

Breeding bird populations.

- Birds in Baltimore appear to be less sensitive to differences associated with human socioeconomic status than birds in Phoenix, AZ. We believe this is largely due to higher human densities in Baltimore, and are testing this hypothesis now.

- Birds species richness of parks in Baltimore appears to be more strongly area-dependent than those in Phoenix. We believe this is due to greater contrast between parks and neighborhoods in Baltimore.

Ecological value of urban gardens to native pollinators.

- Species richness of beneficial insects within urban gardens increases as a function of floral resources within gardens and increases as a function of landscape level greenspace surrounding individual gardens.

- The butterfly *Pieris rapae* (cabbage white) is capable of navigating through the urban matrix to utilize floral resources within gardens.

- Large urban gardens retain cabbage white butterflies longer than small urban gardens.

- Cucumbers, which have a high pollination requirement to set healthy fruit, are able to set fruit in New York City community gardens. This result suggests that the ecological service of pollination is not absent in New York City gardens.

- Fruit yield of cucumbers in New York City community gardens is negatively associated with the total number of flowers within gardens. This suggests that the ecological service of pollination, while not absent, is limited in New York City gardens.

Survey, mapping, and interpretation of urban soils.

- Heavy metal contamination in urban soils fairly ubiquitous; land use does not explain spatial patterns; age of housing and transportation corridors associated with Pb, Cu, and Zn contamination.

- Land use and cover explains those soil characteristics most affected by horticultural management. Horticultural management effects occur at relatively fine scales.

- Surface geology/parent material explain spatial distribution of trace metals and soil texture.

- Development of urban soil quality indicators

    - Urban soils tend to have adequate nutrient availability, neutral soil reaction, and are fertile in general.
    - Most soil limitations to growth related to physical characteristics.

- Urban environmental effects on woodlands

    - Urban environmental factors have a significant impact on biogeochemical cycles and plant performance. Some exotic species appear to be favored by urban environmental changes.

Findings Addressing Question 2: *Fluxes of Energy, Matter, Capital, and Population in the Baltimore Ecosystem*

This year, we have focused on new findings concerning fluxes on Chloride in streams, the ecosystem fluxes associated with stream restoration, the microbial impact of a widespread exotic species, the functional significance of exotic soil invertebrates, and the role of residential areas in carbon flux and storage.

Chloride flux. We observed chloride concentrations up to 25% of the concentration of seawater in BES streams during winters, and chloride concentrations remaining up to 100 times greater than unimpacted forest streams during summers. Mean annual chloride concentration increased as a function of impervious surface and exceeded tolerance for freshwater life in many streams (Figure 1). Our analysis shows that if salinity were to continue to increase at its present rate due to changes in impervious surface coverage and current management practices, many surface waters in the northeastern U.S. would not be potable for human consumption and would be toxic to freshwater life within the next century.

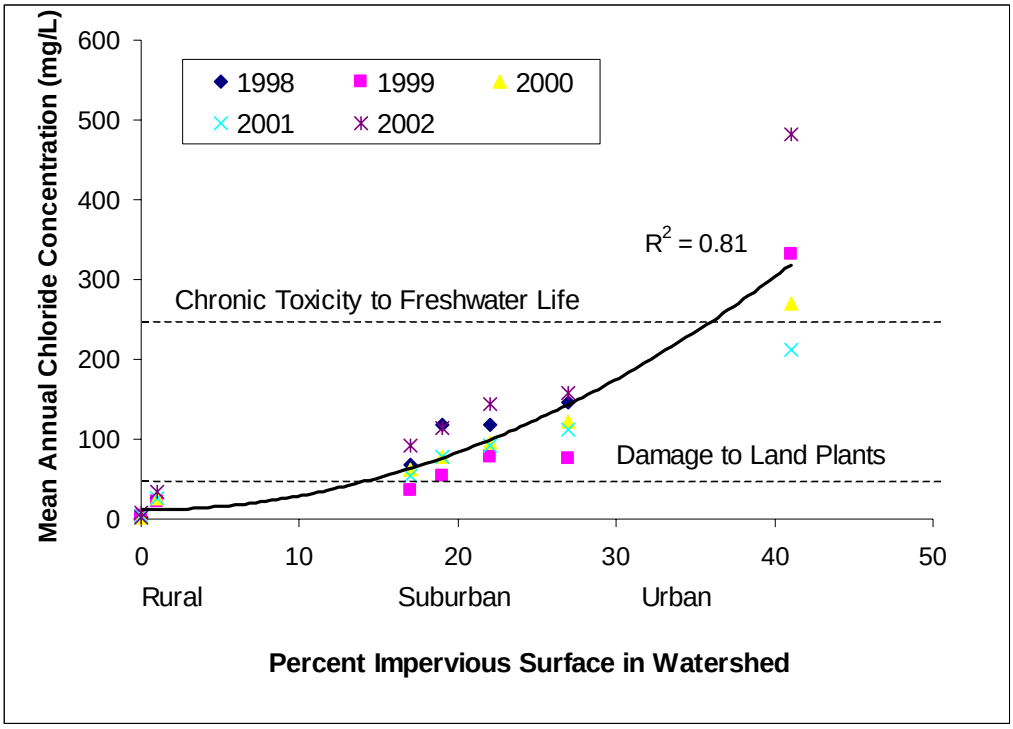

Figure 1. Relationship between impervious surface and mean annual concentration of chloride in streams of the Baltimore Long Term Ecological Research site during a five-year period (R^2 = 0.81). Kaushal, et al. (unpublished data).

Stream restoration. Measurements of *in situ* denitrification rates in unrestored and previously restored (2000/2001) reaches of Mine Bank Run suggest that restoration increases hyporheic/riparian denitrification, especially in areas where stream water is directed out of the stream, into the riparian zone, to diminish runoff velocity and erosive potential (Figure 2). These "sandy floodplain" areas may represent importance "reconnections" in the restored stream/riparian ecosystem with important biogeochemical implications.

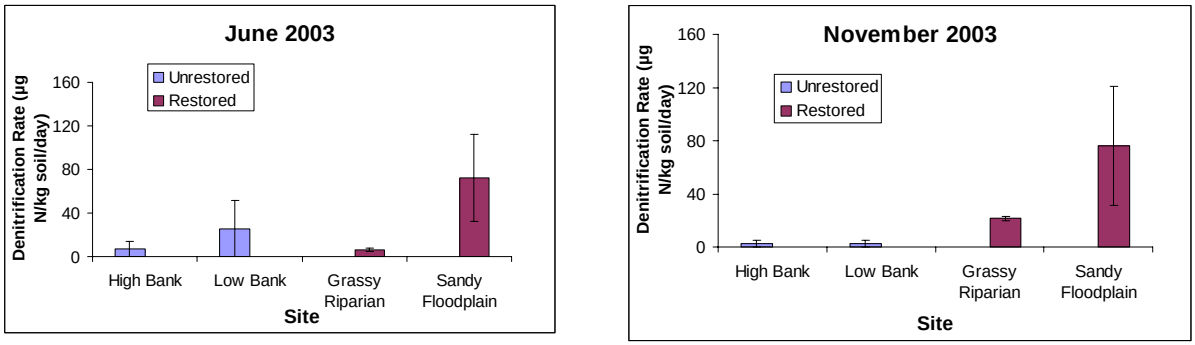

Figure 2. *In situ* denitrification rates in unrestored and restored reaches of Mine Bank Run in June and November, 2003. Kaushal, et al. (unpublished data).

Lawn C stocks and fluxes. Soil C:N declines linearly with age of lawn/ home (tested homes from 2-6 years old in Burlington, VT in pilot study), and that this trend is most pronounced in the shallow soil layer.

Comparisons of Fluxes associated with Native and Exotic Species

We measured how potential N-mineralization and nitrification rates are influenced in the presence of earthworms and terrestrial isopods. We compared the effects of three earthworm species native (*Eisenoides loennbergi*), Asian (*Amynthas hilgendorfi*) and European (*Lumbricus terrestris*)) and six non-native isopod species on leaf litter disappearance and N-cycling. The Asian Amynthas had the largest impact on N-cycling processes, while there was no difference between Eisenoides and the European Lumbricus. In contrast, incubation experiments with six terrestrial isopod species resulted in net immobilization. The overall effect was the same, but the rates were different among the species. Our results point to strong species effects, which has to be taken into account when different microhabitats are invaded by different species.

A preliminary study indicates the role of the microbial community in the spread of Japanese knotweed. This species is a serious invader of riparian zones, as well as upland sites in the northeastern megalopolis.

Findings Addressing Question 3: *Development and Use of Ecological Understanding in the Baltimore Region*

Most of the activities undertaken in response to Question 3 have performance indicators, which have been detailed in sections where the activity was presented. The education research, which is a new initiative, has not yet reached the stage when analyses and conclusions can be presented.

Contributions

Contributions within the discipline and to different disciplines

Because BES is such an integrated project involving many disciplines, we combine the discussions of contributions to individual disciplines and contributions to different disciplines. In order to show how BES contributes to scientific knowledge, we highlight contributions that have emerged or developed during the past year. Many of our contributions are ongoing, and the value of contributions reported in prior years grows with additional years of data collection.

Lifestyle behavior theory research has provided:

- An alternative approach and explanation of land management behaviors in contrast to traditional, population and class-based analyses.
- A rationale for developing intensive, field based methods and data for understanding the relationship between social and vegetation structure.

Quality of life analyses provide substantial, systematic evidence for:

- The importance of the environment to neighborhood quality of life and
- The importance of distinguishing between individual and neighborhood quality of life theories and measures.

Refinement of a novel land cover classification.

- Providing a novel approach to characterizing and quantifying land cover in urban areas that focuses on an ecological perspective.
- Creating a new tool to capture spatial heterogeneity in urban systems and a scale appropriate for the system.
- This tool integrates built and non built components of the system recognizing that urban systems are coupled human-natural systems.

- Connecting the structure of the urban landscape, as described by this new ecological view of land cover, to the functioning of the urban ecosystem. Examples include nitrate export into the Chesapeake Bay, and carbon storage and flux in residential lands.

- Spatially explicit hydrologic model uses land use from models that are not appropriate for an ecological understanding of the system. This project provides a land cover description of the watershed that can be used in these models to improve predictions of nutrient storage, flow, and export.

- Connecting urban land cover to decisions and actions at the individual household scale.

Forestry Opportunity Spectrum (FOS). Developed a framework and open source GIS tools for identifying urban and community forestry opportunities and developing strategic and action plans for urban foresters and planners to use.

Lawn C stocks and fluxes. Complied spatial datasets for Baltimore based on pilot study in Burlington, VT and developed methods for choosing sites appropriate for testing hypotheses about the relative strengths of different controls on lawn C stocks and fluxes.

Soil ecology. We are discovering how native and non-native soil invertebrates affect decomposition and nutrient cycling in anthropogenic environments. The work requires species focus to unravel processes instead of the traditional functional grouping, because different species have different natural histories. In addition to gaining insight into the functioning of urban soil communities, such studies also reveal how redundant soil systems are, a fundamental question of ecology and conservation biology. We focus mainly on invasive species, which is a global environmental issue.

- *Computer science and engineering.* We are currently testing and calibrating soil temperature, soil moisture and CO2 sensors. We are also connecting the temperature and moisture sensors to the sensor boards. Wireless sensor networks provide a novel way to acquire environmental data. This type of monitoring is especially necessary in soil ecology, where conditions vary at different spatial and temporal scales. Our understanding of soil organism dynamics and the role these organisms play in important ecosystem processes is limited due to the complexity of this environments and lack of continuously collected abiotic data.

- *Digital Geology Map of Gwynns Falls Watershed.* A GIS layer was created for the purpose of characterizing the geology of the Gwynns Falls watershed. Four Maryland Geological Survey geology map quadrangles (Baltimore West, Ellicott City, Cockeysville, and Reisterstown) were scanned to TIFF format. The digital images were then georeferenced using high-resolution orthophotography. Geologic boundaries were then digitized and attributed using geographic information system software.

- *Ground and Structure DEM for Gwynns Falls Watershed.* This project was undertaken in order to characterize topographic, built, and vegetative structure in the Gwynns Falls. One-meter resolution digital elevation models (DEM) were interpolated from ground and first-pulse LIDAR data. The DEMs were created for use in various applications such as topographic analysis, hydrologic modeling, and vegetation analysis.

- *Center for Urban Environmental Research and Education (CUERE).* Cuere serves as host to the field operations of the Baltimore Ecosystem Study, providing lab, office, and meeting space to BES Co-PIs and students. CUERE's GIS Laboratory provides spatial data analysis services to BES researchers as needed. In addition, CUERE provides BES with an academic link to UMBC, whereby several of the BES PIs serve as adjunct faculty at UMBC, and UMBC faculty and students work on BES-related projects.

  CUERE has been instrumental in leveraging the presence of the BES on campus to increase related research activities. In 2004, CUERE was selected to receive a NSF CLEANER planning grant, which has as its goal evaluation of the BES as an engineering field facility. CUERE, in collaboration with the UMBC IS Department, submitted a proposal for the NSF Science and Engineering Information Integration and Informatics program using the BES as a test-bed for novel approaches for the integration and mining of ecological data. This was not funded but will be revised and resubmitted in November 2005. In 2005, CUERE in partnership with the UMBC Department of Civil and Environmental Engineering, obtained an NSF MRI grant to purchase an ICP-MS and an IC, which will both be used in analysis of soils and water for heavy metals. CUERE also took the lead on submission of an IGERT preproposal to NSF on the theme of "Water in the Urban Environment," which was invited for a full proposal submission, and on which numerous BES researchers are Co-PIs. There is no doubt that the partnership with the BES LTER has been a key element in these successes.

  CUERE was also instrumental in UMBC's winning bid to move the MD-DE-DC District Office of the USGS Geological Survey to campus in 2006 under a long-term cooperative agreement. Part of the attraction for USGS to move to campus was the presence of the BES and related research opportunities. USGS' presence on campus should further strengthen the relationship between the USGS, BES, and CUERE.

Contributions to education and human resources

- *Contributed to a youth forestry program for summer employment.* Building Resources and Nurturing Community Health & Environmental Stewardship (BRANCHES). Seven youth from underserved communities were trained in exotic species identification and removal. Worked with the Baltimore City Department of Recreation and Parks to identify suitable sites for exotic species removal and appropriate techniques and monitoring of success. The seven undergraduates supervised teams of high school youth in the exotic species removals in seven Baltimore City parks.

- *Developed curricular materials for schools*

    - Assisted a high school teacher in the development of curriculum on neighborhood evolution (social and environmental) in Baltimore.
    - "Habitat restoration and water quality improvement project for Baltimore City Public Schools in Watershed 263." Baltimore, MD.
    - "Baltimore breaths." Western Technical High School, Baltimore, MD.
    - Harvey, J., K. Szlavecz, R. Pouyat and I. Yesilonis. 2004. Investigations in Urban Soils. Draft 2. Baltimore Ecosystem Study – Investigating Urban Ecosystems program. J. Gordon and A.R. Berkowitz, editors. Institute of Ecosystem Studies, Millbrook, NY.
    - Saven, J., A.R. Berkowitz, J. Gordon and J. Coffey. 2005. Schoolyard Hydro-Ecology Teachers' Handbook. Draft 2. Baltimore Ecosystem Study – Investigating Urban Ecosystems program. J. Gordon and A.R. Berkowitz, editors. Institute of Ecosystem Studies, Millbrook, NY.
    - Schmidt, M., P. Groffman, L. Band, G. Fisher and N. Law. 2004. Exploring Watersheds in Baltimore. Draft 1. Baltimore Ecosystem Study – Investigating Urban Ecosystems program. J. Gordon and A.R. Berkowitz, editors. Institute of Ecosystem Studies, Millbrook, NY.

- *Workshops.*

    - "Schoolyard worms and soil," presented for middle school science teachers in Baltimore, MD.
    - Baltimore Ecosystem Study LTER research organization and field safety. Baltimore Ecosystem Studies Safety and Awareness workshop, Youth Unlimited, Baltimore, MD.
    - "Urban hydro-ecology," presented for teachers in Baltimore, MD.
    - "Exploring watersheds," presented for teachers in Baltimore, MD.
    - "Urban hydrology and the schoolyard." Workshop at Morgan State University, Baltimore, MD.
    - "Exciting research findings about the Baltimore Ecosystem: results and teaching ideas from the Baltimore Ecosystem Study (BES)." Workshop at Maryland Association for Environmental and Outdoor Education. Ocean City, MD.

- "Environmental education and community stewardship." Synergy Workshop: Baltimore's Ecosystem and Community Decision Making, Baltimore, MD.
- "A new kind of after school program: the KidsGrow model." Maryland Association for Environmental and Outdoor Education, Ocean City, MD.
- "Urban micrometeorological flux observations and surface characterization." Helsinki Urban Modeling Workshop, Helsinki Mesoscale Testbed, Vaisala Oyj and the Finnish Meteorological Institute, Helsinki, Finland.

- *Training and research opportunities*

  - We continue to involve many undergraduate students in our projects. Several received (Provost Undergraduate Research Awards (PURA) for their participation.
  - Teaching plant identification and microbial techniques.
  - Use of plants for delineating ecosystems and land use.
  - Identifying microbial communities using DNA fingerprinting methods.
  - Trained graduate and undergraduate students in database development, GIS development and spatial analysis. (Data used for two graduate theses.)
  - Trained students in archival research, historic GIS development and remote sensing techniques.
  - Two research support specialists enrolled in graduate program; one focused on urban watersheds.
  - Trained graduate and undergraduate student interns in a pilot street tree inventory and methodology development for citywide street tree inventory.
  - BES Annual Staff Field Safety and Community Awareness Training Workshop; trained twenty people from IES, US Forest Service, and Parks and People.
  - Community training: Community Grants program opportunities; capacity building and leadership development in Watershed 263; community greening training in planning and carrying out community restoration projects.
  - Teacher training – soil moisture, infiltration measurements. Baltimore Ecosystem Study, Baltimore, MD.

- *University graduate courses*

  - "Managing Urban Greenspace" was developed and taught at Ohio University. The curriculum included relevant information from the study and a field trip to Baltimore.
  - Graduate courses at Yale University: "Seminar in Ecosystem Management: Social Ecology, Community Forestry and the Future of Place Based Environmentalism" and "Monitoring and Evaluation Techniques, Theory and Methods Applied to Ecosystem Rehabilitation/Community Revitalization Interventions," introducing students to tools and methods for evaluating interventions in urban systems and the impact of those interventions on the social and ecological health of the system.
  - "Advanced Spatial Methods," NR 245, used BES as a case study to teach advanced spatial statistical methods to graduate and undergraduate students. Students used BES data sets for lab exercises in which they learned spatial and statistical analysis methods. University of Vermont.

- "Stakeholder Involvement in Environmental Problem Solving," Undergraduate course ENVS 4002, incorporated BES materials into course work. University of New Brunswick, Fredericton, NB, Canada.
- "Nature, society and social ecology." Graduate Course, ENVS 6001, incorporated BES materials into course work. University of New Brunswick, Fredericton, NB, Canada.

- We have developed a collaborative enterprise involving Ph.D. researchers, graduate and undergraduate students working as a team at both UMBC and Princeton, with field activities concentrated at UMBC in summer. New students are recruited into the project through class activities or through contacts with colleagues at other institutions. Our project receives no funding from the core BES grant and the project ends this year.

Contributions to institutional and information resources for science and technology

Highlights for the past year include:

- Successfully submitted a proposal to the Biocomplexity, coupled human-natural systems competition at NSF connecting HERCULES to hydrologic modeling, nitrate export into the Chesapeake Bay, vegetation management strategies and opportunities and urban design.

- Contributed to a successful proposal to the Ecosystems Division of NSF to investigate the drivers of and controls on carbon storage and flux in residential lands.

- The BES spatial database creation and data development activities have greatly supported BES by centralizing and standardizing data and making many formerly unusable layers useable through quality enhancement and metadata development. We have also made this standardized data available on the web. Finally, we have created new layers through analysis techniques.

- We have developed software tools primarily for our own use to convert between formats of the different software packages we are using. We are developing databases of topographic data and modeling results at our field sites but these are still in multiple versions and no definitive versions are available while we are still engaged in the modeling process.

- The LiDAR data collected by CUERE with funding from EPA and partial funding from BES as well as additional funding from a separate NSF award are stored on the CUERE server and are made available to nonprofit, educational or agency groups as requested. The data sets are too large to be served out over the web.

- Provided funding for development of an inexpensive GLOBE type CO_2 instrument—a prototype for non-dispersive infrared NDIR for field and student use.

Contributions to public welfare beyond science and engineering

Highlights of the past year are these:

- Engaged U.S. Forest Service State and Private Forestry to conduct research and write a report outlining management and funding of urban forestry operations in ten large U.S. cities.

- Developed a Forestry Opportunity Spectrum framework for urban foresters and environmental planners and developed GIS tools for implementing the FOS framework.

- The Forestry Opportunity Spectrum framework and tools, which were developed as a prototype for Baltimore, are now being tested in other cities such as New York City, Boston, Wilmington, DE, and Burlington, VT. The FOS framework for assessing capacity and neighborhood needs to receive urban forestry and greening assistance. The associated GIS tools are extremely useful to urban foresters and environmental planners in Baltimore as well as other test site cities.

- Importance of key decisions of the past in land use and development. Theses of two graduate students uncovered the decision regarding the location of Leakin Park and its significance to the preservation of the Gwynn's Falls stream valley; and the urban renewal process undertaken in Bolton Hill which enabled its reemergence as a desirable neighborhood and was the defining event to reintroduce its residents to the benefits of embracing street trees in their neighborhood.

- The relationship of the vegetation throughout the watershed to geomorphic and hydrologic processes as they have been changed by people. The effect of historical events on vegetation distributions. Understanding the spread of invasive species, both exotic and native. Understanding vegetation patterns important for stream restoration – including buffering.

- A study Co-PI is one of the founding editors of a new electronic journal specifically for urban ecology: Cities and the Environment, to be launched in Winter 2005-2006.

- A study Co-PI is co-chair of a research working group for the Urban Ecology Collaborative (UEC) which aims to increase cross city collaborations, and make the comparative ecological information available to managers, communities, and decision makers.

- NIH Proposal, 2005. Yonkers, NY. Walking Rx Project: Linking Health, Urban Parks and Lifestyles to Mobilize Minority Residents to Counter Overweight and Physical Inactivity Through Exercise Programs. A study Co- PI, along with other persons from a variety of disciplines–Public Health, Architecture, Medicine, etc.

- SANREM Planning Grant. 2005. “Assessing the linkages between Conservation, Entrepreneurial and Governance Skills–Lessons Learned from 3 Decades of Nepal Forest User Groups.” (Sustainable Agriculture and Natural Resource Management. Collaborative Research Support Program. Promoting stakeholder empowerment and improved livelihoods through knowledge-based sustainable agriculture and natural resource management systems.) Applications of the Human Ecosystem Model for community based natural resource management, e.g. extension from BES back to Rural Development in poor countries. Begins in Nepal and North India, then Thailand, Sri Lanka and Bangladesh.

- Improved operational efficiency and effectiveness of relationships with local partners and the Greater Baltimore Community.

- Increased the body of practical knowledge of how urban residents develop an understanding of the metropolis as an ecological system to improve the quality of their environment and daily lives.

- Increased understanding of participatory approaches to long-term integrated urban ecological research as it relates to public agencies and non profit organizations.

- Strengthened relationships in Watershed 263 between community leaders and BES scientists; built Watershed 263 Stakeholder Council to serve as community voice in watershed restoration project.

- Participated in East Coast Urban Ecology Collaborative. Information is being exchanged, joint funding proposals developed and joint projects implemented in the cities of: Boston, New Haven, New York, Baltimore, Pittsburgh, and Washington, DC. Helped develop survey tools and work plan to evaluate minority interest and participation in urban forestry through MERGE project.

Publications and Products

Journal Publications

Agardy, T., J. Alder, P. Dayton, S. Curran, A. Kitchingman, M.A. Wilson, A. Catenazzi, J. Restrepo, C. Birkeland, S. Blaber, S. Saifullah, G. Branch, D. Boersma, S. Nixon, P. Dugan and C. Vörösmarty. *Accepted.* Coastal systems and coastal communities. Millennium Ecosystem Assessment: Condition and Trends Assessment.

Bain, D.J. and G.S. Brush. 2005. Placing the pieces: Reconstructing the original property mosaic in a warrant and patent watershed. Landscape Ecology 19:843-856.

Bain, D.J. and G.S. Brush. *In revision.* Early chromite mining and agricultural clearance: Opportunities for the investigation of agricultural sediment dynamics in the Eastern Piedmont (USA). American Journal of Science.

Bart, D., S.T.A. Pickett, A.P. Vayda and J.-M. Hartman. *Submitted.* Human roles in plant invasions: Causation and the perils of undue aggregation. Oikos.

Buckley, G.L., R.F. Bailey and J.M. Grove. *Submitted.* The Patapsco Forest Reserve: Establishing a “city park” for Baltimore, 1907–1941. Historical Geography.

Burch, W.R., Jr. 2004. Leadership for sustainable development: Lessons from Tao to Mao. Journal of Sustainable Forestry. 17(4):3-23.

Cadenasso, M.L. and S.T.A. Pickett. *In preparation*. Spatial heterogeneity in urban ecosystems: Reconceptualizing land cover classifications. Frontiers in Ecology and the Environment.

Cadenasso, M.L., S.T.A. Pickett and J.M. Grove. *Revised*. Dimensions of ecosystem complexity: Heterogeneity, connectivity, and history. Ecological Complexity.

Cadenasso, M.L., S.T.A. Pickett and J.M. Grove. *In review.* Integrative approaches to investigating human-natural systems: The Baltimore Ecosystem Study. Natures, Sciences, Sociétés.

Cadenasso, M.L., S.T.A. Pickett, M.J. McDonnell and R. Pouyat. *In press*. Forest vegetation along an urban-rural gradient in the New York City metropolitan area: Patterns and relationships to ecosystem processes. Transactions of the Linnean Society of New York.

Casey, R.E., A.N. Shaw, L.R. Massal, J.W. Snodgrass. 2005. Multimedia evaluation of trace metal distribution within stormwater retention ponds in suburban Maryland, USA. Bulletin of Environmental Contamination and Toxicology 74:273-280.

Chen, Z., A. Gangopadhyay, G. Karabatis, M. McGuire and C. Welty. 2005 *In revision.* Semantic integration and knowledge discovery for environmental research. Special issue on Defining, eliciting and using data semantics for emerging domains. Journal of Database Management.

Cook, W.M., D.G. Casagrande, D. Hope, P.M. Groffman and S.L. Collins. 2004. Learning to roll with the punches: Adaptive experimentation in human-dominated systems. Frontiers in Ecology in Environment. 9:467-474.

Dalton, S.E. *In progress.* Redefining the terrain: Power and performance among public agencies and non-profit organizations in urban natural resource management.

Dalton, S.E. *In progress.* Social network analysis: A useful quantitative tool for measuring the structure of natural resource management regimes.

Davis, M.A., J. Pergl, A.-M. Truscott, J. Kollmann, J.P. Bakker, R. Domenech, K. Prach, A.-H. Prieur-Richard, R.M. Veeneklaas, P. Pyšek, R. del Moral, R.J. Hobbs, S.L. Collins, S.T.A. Pickett and P.B. Reich. 2005. Vegetation change: A reunifying concept in plant ecology. Perspectives in Plant Ecology, Evolution, and Systematics. 7:69-76.

Faeth, S.H., P.S. Warren, E. Shochat and W. Marussich. 2005. Trophic dynamics in urban communities. BioScience 55(5):399-407.

Felson, A.J. and S.T.A. Pickett. *Submitted.* Designed experiments: New approaches to studying urban ecosystems. Frontiers in Ecology and Environment.

Gaylard, A., M.L. Cadenasso and S.T.A. Pickett. *Submitted.* Heterogeneity shaped by African elephants in semi-arid savannas: The significance of space and scale. BioScience.

Gragson, T.L. and J.M. Grove. *Accepted.* Social science in the context of the Long-Term Ecological Research Program. Society & Natural Resources.

Groffman, P.M., J.S. Baron, T. Blett, A.J. Gold, I. Goodman, L.H. Gunderson, B.M. Levinson, M.A. Palmer, H.W. Paerl, G.D. Peterson, N.L. Poff, D.W. Rejeski, J.F. Reynolds, M.G. Turner, K.C. Weathers and J. Wiens. *In press.* Ecological thresholds: The key to successful environmental management or an important concept with no practical application? Ecosystems.

Groffman, P.M., R.V. Pouyat, M.L. Cadenasso, W.C. Zipperer, L.E. Band and G.S. Brush. *In preparation*. Nitrogen cycling in urban forests. Ecosystems.

Groffman, P.M., A.M. Dorsey and P.M. Mayer. *In press.* Nitrogen processing within geomorphic features in urban streams. Journal of the North American Benthological Society.

Groffman, P.M., N.L. Law, K. Belt, L.E. Band and G.T. Fisher. 2004. Nitrogen fluxes and retention in urban watershed ecosystems. Ecosystems. 7:393-403.

Grove, J.M., M.L. Cadenasso, W.R. Burch, Jr., S.T.A. Pickett, J.P.M. O'Neil-Dunne, K. Schwarz, M.A. Wilson, A.R. Troy and C. Boone. *Accepted.* Data and methods comparing social structure and vegetation structure of urban neighborhoods in Baltimore, Maryland. Society & Natural Resources.

Grove, J.M., M.L. Cadenasso, W.R. Burch, Jr., S.T.A. Pickett, K. Schwarz, M.A. Wilson and C.G. Boone. *Submitted*. The social ecology of prestige: Group identity and social status of ecological structure and its implications for urban watershed dynamics in the Baltimore Metropolitan region, Maryland. Society & Natural Resources.

Grove, J.M., A.R. Troy, J.P.M. O'Neil-Dunne, W.R. Burch, Jr., M.L. Cadenasso and S.T.A. Pickett. *In press*. Characterization of households and its implications for the vegetation of urban ecosystems. Ecosystems.

Grove, J.M., A.B. Cumming, M.F. Galvin, G.W. Hager, J.P.M. O'Neil-Dunne, A.R. Troy, F. Rodgers, F. Spero, E. Svendsen and A.E. Draddy. *Submitted.* Integrating urban forestry research and applications: A forest opportunity spectrum framework and its application to Baltimore, Maryland. Journal of Forestry.

Heisler, G.M., R.H. Grant, W. Gao and J.R. Slusser. 2004. Solar ultraviolet-B radiation in urban environments: The case of Baltimore, Maryland. Photochemistry and Photobiology. 80(3):422-428.

Herberlein, T.A., M.A. Wilson, R.C. Bishop and N.C. Schaeffer. 2005. Rethinking the scope test as a criterion for validity in contingent valuation. Journal of Environmental Economics. 50(1):1-22.

Higgins, J.A., K.T. Belt, J.S. Karns, J. Russell-Anelli and D.R. Shelton. 2005. Tir- and stx- positive *Escherichia coli* in stream waters in a metropolitan area. Journal of Applied and Environmental Microbiology. 71(5):2511-2519.

Higgins, J.A., K.T. Belt, R. Russell-Anelli, J.S. Karns, and D.R. Shelton. *Submitted*. Prevalence and molecular characterization of Enteropathic *Escherichia coli* in stream waters in a metropolitan area. Proceedings of the National Academy of Science.

Hohn, C., D. Goens, K.T. Belt, and J.A. Higgins. *Submitted.* Survey of lotic freshwater eukaryote microorganisms using 18S rRNA gene sequencing.

Howarth, R.B and M.A. Wilson. *Accepted.* A theoretical approach to deliberative valuation: Aggregation by mutual consent. Land Economics.

Johnston, C.A., P.M. Groffman, D.D. Breshears, Z.G. Cardon, W. Currie, B. Emanuel, J. Gaudinski, R.B. Jackson, K. Lajtha, K. Nadelhoffer, D. Nelson, Jr., W.M. Post, G. Retallack and L. Wielopolski. 2004. Carbon cycling in soil. Frontiers in Ecology and Environment. 10:522-528.

Katti, M. and P.S. Warren. *In press*. Research focus: Tits, noise, and urban bioaccoustics. Trends in Ecology and Evolution.

Katz, R.W., G. Brush and M.B. Parlange. *In press*. Statistics of extremes: Modeling ecological disturbances. Ecology.

Kaushal, S.S., P.M. Groffman, G. Likens, K.T. Belt, L.E. Band and G.T. Fisher. *Submitted.* Changing land use and the anthropogenic salinization of inland waters. PNAS Science.

Kaye, J.P., P.M. Groffman, N.B. Grimm, L.A. Baker and R.V. Pouyat. *Submitted.* A distinct urban biogeochemistry? Trends Research in Ecology and Evolution.

Kinzig, A.P., P.S. Warren, C. Martin, D. Hope and M. Katti. 2005. The effects of human socioeconomic status and cultural characteristics on urban patterns of biodiversity. Ecology and Society 10(1):23. [online] http://www.ecologyandsociety.org/vol10/iss1/art23/

Law, N.L., L.E. Band and J.M. Grove. 2004. Nitrogen input from residential lawn care practices in suburban watersheds in Baltimore County, MD. Journal of Environmental Management 47(5):737-755.

Law, N.L., L.E. Band, P.M. Groffman, K.T. Belt and G.T. Fisher. *In press*. Water quality trends and determinants in developing urban-suburban watersheds. Hydrological Processes.

McGrath, B. and G. Shane. *In press.* Sensing the 21st century city. AD, Architectural Design.

McGrath, B. and D. Thaitakoo. 2005. Tasting the Periphery: Bangkok's agri- and aquacultural fringe. AD, Architectural Design. 75(3):43-51.

Morimoto, J., M.A. Wilson, H. Voinov and R. Costanza. *Submitted*. Accounting for watershed biodiversity: An empirical study of the Chesapeake Bay, Maryland, USA. Environmental Modeling and Software.

Nowak, D.J. *In review.* Institutionalizing urban forestry as a means to improve environmental quality. Urban Forestry and Urban Greening.

Nowak, D.J., M. Kurodo and D.E. Crane. *In press*. Urban tree mortality rates. Urban Forestry and Urban Greening.

Nowak, D.J., D.E. Crane and J.C. Stevens. *Submitted*. Air pollution removal by urban trees in the United States. Nature.

Pickett, S.T.A. and M.L. Cadenasso. *In Review*. Advancing urban ecological studies: Frameworks, concepts, and results from the Baltimore Ecosystem Study. Austral Ecology.

Pickett, S.T.A., M.L. Cadenasso and J.M. Grove. 2005. Biocomplexity in coupled natural-human systems: A multidimensional framework. Ecosystems 8:225-232.

Pickett, S.T.A., M.L. Cadenasso and J.M. Grove. 2004. Resilient cities: Meaning, metaphor, and models for integrating the ecological, socio-economic, and planning realms. Landscape and Urban Planning. 69(4): 369-384.

Pickett, S.T.A., J.M. Grove, P. Groffman, L.E. Band, C.G. Boone, G.S. Brush, W.R. Burch, Jr., M.L. Cadenasso, J. Hom, J.C. Jenkins, N.L. Law, C.H. Nilon, R. Pouyat, K. Szlavecz, P.S. Warren, and M.A. Wilson. *Submitted*. Beyond urban legends: Improved ecological management for cities and suburbs. Science.

Pouyat, R.V., P. Groffman and J. Russell-Anelli. *In press*. The characteristics of soils in urban landscapes: Chemical and physical properties. Journal of Environmental Quality.

Pouyat, R.V., I.D. Yesilonis and D.J. Nowak. *Submitted*. Soil chemical and physical properties in an urban landscape. Journal of Environmental Quality.

Pouyat, R.V., I.D. Yesilonis and J. Russell-Anelli. *Submitted*. Carbon storage by urban soils in the USA. Journal of Environmental Quality.

Redman, C., J.M. Grove and L. Kuby. *In press*. Integrating social science into the Long-Term Ecological Network: Social dimensions of ecological change, ecological dimensions of social change. Ecosystems.

Schweik, C.M., T. Evans and J.M. Grove. 2005. Open source and open content: A framework for global collaboration in social-ecological research. Ecology and Society. 10(1):33. [online] http://www.ecologyandsociety.org/vol10/iss1/art33/

Schweik, C.M., A. Stepanov and J.M. Grove. 2005. The open research system: A web-based metadata and data repository for collaborative research. Computers and Electronics in Agriculture. 47:221-242. Available at: http://www.sciencedirect.com/science/journal/01681699

Shelton, D.R., J.A. Higgins, J.S. Van Kessel, Y.A. Pachepsky, K.T. Belt, J.S. Karns. 2004. Estimation of viable Escherichia coli O157 in surface waters using enrichment in conjunction with immunological detection. Journal of Microbiological Methods. 58:223-231.

Shelton, D.R., J.S. Karns, J.A. Higgins, J.S. Van Kessel, M. Perdue, K.T. Belt, J.R. Russell-Anelli and C. Debroy. *Submitted.* Prevalence and diversity of water-borne *Escherichia coli* 0157 in an urban/suburban watershed. Science.

Snodgrass, J.W., W.A. Hopkins, B.P. Jackson, J.A. Baionno and J. Broughton. 2005. Influence of larval period on responses of overwintering green frog (*Rana clamitans*) larvae exposed to contaminated sediments. Environmental Toxicology and Chemistry. 24(6):1508-1514.

Song, Y., G. Wang, W.R. Burch, Jr., M.A. Rechlin. 2004. From innovation to adaptation: Lessons from 20 years of the SHIFT forest management system in Sanming, China. Forest Ecology and Management. 191:225-238.

Szlavecz, K., S.A. Placella, R.V. Pouyat, P.M. Groffman, Cs. Csuzdi and I. Yesilonis. *In press*. Invasive earthworms and nitrogen cycling in remnant forest patches. Applied Soil Ecology.

Tague, C.L., L.E. Band. 2004. RHESSys: Regional hydro-ecologic simulation system—An object-oriented approach to spatially distributed modeling of carbon, water, and nutrient cycling. Earth Interactions. 8:1-42.

Tenenbaum, D.E., L.E. Band, C.L. Tague and S.T. Kenworthy. *In press.* Analysis of soil moisture patterns in forested and suburban catchments using high resolution photogrammetric and LIDAR digital elevation datasets. Hydrological Processes.

Tenenbaum, D.E., M.L. Cadenasso, L.E. Band and S.T.A. Pickett. *Submitted.* ArcTrCS - ARCView transect characterization system. Journal of Geographical and Environmental Modeling.

Troy, A.R., J.M. Grove, J.P.M. O'Neil-Dunne, M.L. Cadenasso and S.T.A. Pickett. *Submitted*. Predicting patterns of vegetation and opportunities for greening on private urban lands. Landscape and Urban Planning.

Voinov, A., R.M.J. Boumans, C. Fitz, and R. Costanza. *Submitted*. Modular ecosystem modeling. Environmental Modeling and Software.

Wang, H. and E.C. Ellis. *In press.* The effect of image misregistration on feature-base change measurements. Photogrammetric Engineering & Remove Sensing.

Walsh, C.J., A.H. Roy, J.W. Feminella, P.E. Cottingham and P.M. Groffman. *In press.* The urban stream syndrome: Current knowledge and the search for a cure. Journal of the North American Benthological Society.

Warren, P.S., M. Katti, M. Ermann and A. Brazel. *In press.* Urban bioacoustics – It's not just noise. Animal Behaviour.

Warren, P.S., C.H. Nilon, J.M. Grove, A.P. Kinzig, C. Martin and M. Cox. *In preparation.* Human socioeconomic factors and avian diversity: A cross-site comparison. Journal of Environmental Management.

Wilson, M.A., R. Costanza, R. Boumans and S. Liu. *In press*. Integrated assessment and valuation of ecosystem goods and services provided by coastal systems. Biology and the Environment: Proceedings of the Royal Irish Academy.

Yesilonis, I., R. Pouyat, and J. Russell-Anelli. *Submitted*. The distribution of anthropic heavy metals in an urban landscape. Journal of Environmental Quality.

Yesilonis, I., B.R. James, R. Pouyat, and B. Momen. *Submitted.* Lead forms in forest and turf grass soils. Soil Science Society of America.

Zipperer, W. 2005. Species composition and structure of regenerated and remnant forest patches within an urban landscape. Urban Ecosystems. 6(4):271-290.

Zipperer, W. *Submitted*. Ecological consequences of fragmentation and deforestation in an urban landscape. Urban Forestry and Urban Greening.

Zipperer, W., and R. Pouyat. *Submitted*. Rehabilitating urban woodlands: A problem for managers and researchers. Restoration Ecology.

Books and Book Chapters

Band, L.E. and C. Tague. 2005. Feedbacks and coupling between water, carbon and nutrient cycling at the Hillslope Scale. 4.10. *In:* A. Bronstert, J. Carrera, P. Kabat, S. Lütkemeier, Eds. Coupled models for the hydrological cycle—Integrating atmosphere, biosphere, and pedosphere. Springer-Verlag, New York.

Band, L.E., M.L. Cadenasso, C.S.B. Grimmond, J.M. Grove and S.T.A. Pickett. *In Press.* Heterogeneity in urban ecosystems: Pattern and process. *In:* G. Lovett, C.G. Jones, M.G. Turner, and K.C. Weathers, Eds. Ecosystem function in heterogeneous landscapes. Springer-Verlag, New York.

Boone, C.G. and A. Modarres. *Accepted and in production.* City and Environment. Temple University Press, Philadelphia, Pennsylvania.

Buckley, G.L., *In preparation.* Cradle of conservation.

Burch, W.R., Jr. *In press.* Identity, resilience and boundaries of biophysical and sociocultural patches in urban ecosystems–a preview. *In:* J.M. Grove, M.L. Cadenasso, S.T.A. Pickett, and W.R. Burch, Jr., Eds. Human ecosystems in the first urban century: Patch dynamics for ecology and social science. Yale University Press, New Haven, Connecticut.

Burch, W.R., Jr. *In press.* An ecosystem approach for planning and managing 21st century urban challenges. Ch. *In:* Ecology and cities in Asia. UN University Press, Tokyo, Japan.

Burch, W.R., Jr.and J.M. Grove. *In press.* Developing social perspectives and methods for understanding urban ecosystems. *In:* X. Bai, Ed. Studies in urban ecology theory, methods and applications. Yale University Press, New Haven, Connecticut.

Cadenasso, M.L. and S.T.A. Pickett. *In press*. Boundaries as structural and functional entities in landscapes: Understanding flows in ecology and urban design. *In:* B. McGrath, M.L. Cadenasso, J.M. Grove, V. Marshall, S.T.A. Pickett and J. Towers, Eds. Designing urban patch dynamics. Princeton Architectural Press, Princeton, New Jersey.

Cadenasso, M.L., S.T.A. Pickett, J.M. Grove, and C.G. Jones. *Submitted*. Looking forward: Frameworks for the study of ecosystems in heterogeneous landscapes. *In:* G. Lovett, C.G. Jones, M.G. Turner, and K.C. Weathers, Eds. Ecosystem function in heterogeneous landscapes. Springer-Verlag, New York.

Carreiro, M.M., R. Pouyat and C. Tripler. *Submitted*. Nitrogen and carbon cycling in forests along urban-rural gradients in two cities. *In:* M.J. McDonnell, A. Hahs, and J. Breuste, Eds. Comparative ecology of cities and towns. Springer-Verlag, New York.

Grimmond, C.S.B. *In press*. Understanding urban climates. *In*: B. Warf, D. Janelle and K. Hansen, Eds. WorldMinds:100 Geographic Solution. Kluwer.

Grimmond, C.S.B. *Submitted*. Variability of urban climates. *In:* H. Bridgeman and J. Oliver, Eds. The global problem climate system: Patterns, processes and teleconnections.

Grove, J.M., W.R. Burch, Jr. and S.T.A. Pickett. 2005. Social mosaics and urban forestry in Baltimore, Maryland. *In:* R.G. Lee and D.R. Field, Eds. Communities and forests: Where people meet the land. Oregon State University Press, Corvalis, Oregon.

Grove, J.M., W.R. Burch, Jr., M.A. Wilson and A.W. Vemuri. *In press*. The mutual dependence of social meanings, social capital, and the design of urban green infrastructure. *In:* B. McGrath, M.L. Cadenasso, J.M. Grove, V. Marshall, S.T.A. Pickett, and J. Towers, Eds. Designing urban patch dynamics.

Grove, J.M., M.L. Cadenasso, S.T.A. Pickett, W.R. Burch, Jr. and G.E. Machlis. *In Preparation*. Patch analysis for the study of human ecosystems in the first urban century: Ecology and social science. Yale University Press, New Haven, Connecticut.

Grove, J.M., M.L. Cadenasso, S.T.A. Pickett, and W.R. Burch, Jr. *In Preparation*. Human ecosystems in the first urban century: Patch dynamics for ecology and social science. Yale University Press, New Haven, Connecticut.

Kolasa, J. and S.T.A. Pickett. 2005. Changing academic perspectives of ecology: A view from within. pp 50-71. *In:* M.J. Mappin and E.A. Johnson, Eds. Environmental Education and Advocacy. Cambridge University Press, Cambridge, UK.

McGrath, B., M.L. Cadenasso, J.M. Grove, V. Marshall, S.T.A. Pickett and J. Towers. *In press*. Designing urban patch dynamics. Columbia books on urban design. Princeton Architectural Press, Princeton, New Jersey.

Nowak, D.J. and J.F. Dwyer. *In press.* Understanding the benefits and costs of urban forest ecosystems. *In:* J. Kuser, Ed. Urban and community forestry in the Northeast. Plenum Publishers. New York.

Perevelotski, A., M. Shachak, and S.T.A. Pickett. 2005. Management for biodiversity: Human landscape effects on dry environments. pp 286-304. *In:* M. Shachak, S.T.A. Pickett, J. Gosz and A. Perevelotski, Eds. Biodiversity in dry lands: Toward a unified framework for research and management. Oxford University Press, New York. [Mellon Publication]

Pickett, S.T.A. and M.L. Cadenasso. 2005. Vegetation succession. pp 178-198 *In*: E. van der Maarel, Ed. Vegetation Ecology. Blackwell, New York.

Pickett, S.T.A. and M.L. Cadenasso. *In press*. Patch dynamics as a conceptual tool to link ecology and design. *In*: B. McGrath, M.L. Cadenasso, J.M. Grove, V. Marshall, S.T.A. Pickett and J. Towers, Eds. Designing urban patch dynamics. Princeton Architectural Press, Princeton, New Jersey.

Pickett, S.T.A., M.L. Cadenasso, M.J. McDonnell, and W.R. Burch, Jr. *Submitted*. Frameworks for urban ecosystem studies: Gradients, patch dynamics, and the human ecosystem. *In*: M.J. McDonnell and A. Hahs, Eds. Comparative ecology of cities and towns. Cambridge University Press, Cambridge, UK.

Pouyat, R., M.M. Carreiro, P. Groffman, and M. Zuckerman. *Accepted*. Approaches to comparative studies of carbon and nitrogen dynamics in urban ecosystems. *In:* M.J. McDonnell, A. Hahs, and J. Breuste, Eds. Comparative ecology of cities and towns. Springer-Verlag, New York.

Pouyat, R.V., K.T. Belt, D.E. Pataki, P.M. Groffman, J. Hom and L.E. Band. *In press.* Urban land-use change effects on biogeochemical cycles. *In:* P. Canadell, D. Pataki and L. Pitelka, Eds. Terrestrial ecosystems in a changing world. Global change and terrestrial ecosystems synthesis book. Canberra, Australia.

Schweik, C.M., T. Evans and J.M. Grove. 2004. The open source paradigm and the production of scientific information: A future vision and implications for developing countries. *In:* J.M. Esanu and P.F. Uhlir, Eds. Open access and the public domain in digital data and information science. National Academies Press, Washington, D.C.

Shachak, M., J.R. Gosz, S.T.A. Pickett and A. Perevelotsky, Editors. 2005. Biodiversity in dry lands: Toward a unified framework for research and management. Oxford University Press, New York. 346 pp. [Mellon Publication]

Shachak, M., J.R. Gosz, A. Perevelotski and S.T.A. Pickett. 2005. Introduction: A framework for biodiversity studies. pp 3-12. *In:* M. Shachak, S.T.A. Pickett, J. Gosz and A. Perevelotski, Eds. Biodiversity in dry lands: Toward a unified framework for research and management. Oxford University Press, New York. [Mellon Publication]

Shachak, M. J.R. Gosz, A. Perevelotski and S.T.A. Pickett. 2005. Toward a unified framework in biodiversity studies. pp 320-336. *In:* M. Shachak, S.T.A. Pickett, J. Gosz and A. Perevelotski, Eds. Biodiversity in dry lands: Toward a unified framework for research and management. Oxford University Press, New York. [Mellon Publication]

Shachak, M. S.T.A. Pickett and J.R. Gosz. 2005. Plant species diversity and ecosystem processes in water limited systems. pp 153-166. *In:* M. Shachak, S.T.A. Pickett, J. Gosz and A. Perevelotski, Eds. Biodiversity in dry lands: Toward a unified framework for research and management. Oxford University Press, New York. [Mellon Publication]

Watson, F.G.R., L.E. Band and C.L. Tague. *In press*. The state-of-knowledge in integrated hydro-ecological modeling of forested and mixed watersheds. *In*: R.A. Vertessy and H.E. Elsenbeer, Eds. Forests and water. International Union of Forest Research Organizations.

Wilson, M.A., A. Troy and R. Costanza. 2004. The economic geography of ecosystem goods and services: Revealing the monetary value of landscapes through transfer methods and geographic information systems. pp 69-94. *In:* Dietrich and Van Der Straaten, Eds. Cultural landscapes and land use. Kluwer Academic Publishers, London

Abstracts, Proceedings and other one-time publications

Band, L.E., C. Tague, P. Groffman, S. Kenworthy and D. Tenenbaum. 2004. Geomorphic controls of catchment scale linkages between hydrologic and nitrogen cycling. Abstracts of the 2004 Fall Meeting of the American Geophysical Union, San Francisco, CA. December 13-17.

Belt, K.T., G. Heisler, J. Stubbs and L. Olszewski. 2004. The effect of urban land use on stream temperature regimes in the Gwynns Falls and Jennifer Branch (Cub Hill) watersheds. Talk (presented by J.Stubbs) at Annual Mid-Atlantic Ecology Conference, Franklin & Marshall College, Lancaster, PA. March 27-28. Abstracts published on the (MAC) ESA website.

Belt, K.T., R.V. Pouyat, W.P. Stack, G. Heisler, P.M. Groffman, U. Ghosh, A. Taylorson and J. Zhou. 2004. Watershed 263 small headwater storm drain catchment hydrology: Preliminary water quality results. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Berkowitz, A.R., M.L. Cadenasso, C.G. Boone, L.E. Band, N. Law, P.M. Groffman and S.T.A. Pickett. 2004. Opportunities and challenges for ecology in the Baltimore ecosystem. "Human Dominated Ecosystems: Opportunities and Challenges" session, organized by Marina Alberti and Jeff Hepinstall. Abstracts page 43. 89th Annual Meeting of the Ecological Society of America. Portland, OR. August 1-6.

Brush, G., J.M. Smith and J. Burke. 2005. Historical land use and vegetation gradients along a rural to urban riparian zone. Abstract. Annual Meeting of the Ecological Society of America, Montreal, Canada. August 7-12.

Cadenasso, M.L. and S.T.A. Pickett. 2004. Differential plant performance on the edge: Tissue nutrients in dominant woody species across contrasting riparian-upland boundary types in the Shingwedzi drainage, Kruger National Park, South Africa. 89th Annual Meeting of the Ecological Society of America. Portland, OR. August 1-6.

Claessens, L., C. Tague, L.E. Band, P.M. Groffman and S.T. Kenworthy. 2004. Hydro-ecological linkages in urbanizing watersheds: The role of small streams in controlling nitrogen export. Abstracts of the 2004 Fall Meeting of the American Geophysical Union. San Francisco, CA. December 13-17.

Cox, M. 2004. MERGE – Methods for engaging residents in grassroots and the environment. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Doebber, R. and F. Spero. 2004. BRANCHES summer youth Forestry project. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Friday, G. 2004. Greening - Strengthen communities, pathways to change. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Ford, M.E. and A.R. Berkowitz. 2004. Teaching ecology in urban settings: Schoolyards and gardens as ecosystems of study. Abstracts page 161. 89th Annual Meeting of the Ecological Society of America. Portland, OR. August 5.

Ghosh, U., P. Chumble, J. Zhao, R. Pouyat and K. Belt. 2004. Use of Caffeine to identify and quantify wastewater contamination in urban streams. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Grimmond, C.S.B. 2005. Progress in measuring and observing the urban atmosphere. *Theoretical and Applied Climatology*. DOI: 10.1007/s00704-005-0140-5

Groffman, P. 2005. The bio-geo-socio-chemistry of urban watersheds. Abstracts of the Conference on Emerging Issues Along Urban/Rural Interfaces: Linking Science and Society. Atlanta, GA. March 13-16.

Groffman, P., L. Band, K. Belt and G. Fisher. 2004. Long-term stream data in BES. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Grove, J.M., W.R. Burch, M. Cadenasso, S.T.A. Pickett, M. Wilson, C. Boone and A.R. Troy. 2004. An ecology of prestige and its implications for the social-ecological structure and function of urban ecosystems. Proceedings of the Eleventh International Symposium on Society and Resource Management (ISSRM): Printed abstract. Past and Future. Keystone, CO. June 2-6.

Hager, G. and Stack, W. 2004. Recent happenings in the neighborhoods of watershed 263 and project update. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Higgins, J., C. Hohn and K. Belt. 2004. Profiling bacterial populations in BES streams with DNA sequencing. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Hom, J., M. Patterson, S. Grimmond, B. Crawford, Q. Holifield, I. Yesilonis, D. Golub, B. Offerle, D. Nowak, G. Heisler, R. Pouyat, W. Zipperer. 2005. Studies on carbon dioxide concentration and carbon flux in a forested region in suburban Baltimore. p.120. Third USDA Symposium on Greenhouse Gases & Carbon Sequestration in Agriculture. Baltimore, MD. March 21-24.

Hornung E., K. Szlavecz and M.Dombos. 2004. Life history characteristics of *Trachelipus rathkei* and *Cylisticus convexus* (Crustacea, Isopoda, Oniscidea) in a North American urban forest. Sixth International Symposium on the Biology of Terrestrial Isopods, Aveiro, Portugal. July 12-15.

Juhaszova, K., K. Szlavecz and P. Groffman. 2005. Invasive terrestrial isopods and soil nutrient cycling. Ecological Society of America, Mid-Atlantic Ecology Conference, Baltimore, MD. March 12-13.

Kaushal, S.S. and P.M. Groffman. 2004. Ecosystem restoration and denitrification in a coastal stream. Abstracts of the 2004 Fall Meeting of the American Geophysical Union, San Francisco, CA. December 13-17.

Kaushal, S., P.M. Groffman and S. Findlay. 2004. Ecosystem restoration and denitrification in an urban stream. Abstracts of the 89th Annual Meeting of the Ecological Society of America, Portland, OR. August 1-6.

Kaushal, S.S., P.M. Groffman, S.E. Findlay and D.T. Fischer. 2005. The effects of land use on the dynamics of organic carbon, nitrogen, and phosphorus exported from coastal watersheds. Abstracts of the 2005 Joint Assembly Meeting of the American Geophysical Union, New Orleans, LA. May 23-27.

Mayer, P.E. Striz, E. Doheny, R. Shedlock, and P. Groffman. 2004. Geomorphic controls on carbon and nitrogen processing in a degraded urban stream. Abstracts of the 89th Annual Meeting of the Ecological Society of America, Portland, OR. August 1-6.

McGuire, M.P. 2004. Using DTM and LIDAR data to analyze human induced topographic change. Proceedings of the American Society of Photogrammetry and Remote Sensing (ASPRS) Fall Conference, Kansas City, MO. September 12-16.

Miller, A.J., J.A. Smith, C. Welty, K.N. Esleman, M. Piasecki, K.L. Prestegaard, K.L. Brubaker, M.A. Palmer, P.T. Imhoff, P.R. Wilcock, T.M. Scanlon, G.T. Fisher, R.J. Shedlock, A.C. Gellis, P.M. Groffman, K. Belt, L. Toran, R. Traver and T. Jordon. 2004. The Potomac River basin and western shore Chesapeake Bay drainage as a proposed CUAHSI Hydrologic Observatory. Abstracts of the 2004 Fall Meeting of the American Geophysical Union, San Francisco, CA. December 13-17.

Pickett, S.T.A. and M.L. Cadenasso. 2004. *Submitted.* Connecting ecology, landscape, and design. A. Beamish, and B. Parmenter, Eds. Proceedings of the Symposium on Connectivity and Landscape Change, Austin, TX. January 30-31.

Saffer, R.W., A.J. Tallman and R.H. Pentz. 2005. Water resources data, Maryland and Delaware, water year 2004. U.S. Geological Survey Water-Data Report MD-DE-04-01.

Schulman, A., M.L. Cadenasso, A.R. Berkowitz and M.E. Ford. 2004. The structure and composition of schoolyards along an urban-to-rural gradient: A case study in the Gwynns Falls watershed, Baltimore, Maryland. Abstracts page 458. 89th Annual Meeting of the Ecological Society of America. Portland, OR. August 5.

Szlavecz, K. 2004. Disturbance and soil faunal community dynamics: Lessons from American and European cities. 89th Annual Meeting of the Ecological Society of America, Portland, OR. August 1-6.

Szlavecz, K. 2004. Urban biodiversity: Challenges in a heterogeneous landscape. Annual meeting of the Entomological Society of America, Salt Lake City, UT. November 11-14.

Szlavecz, K., R.P. Pouyat, I. Yesilonis, P. Groffman and Q. Holifield. 2005. The suburban landscape: Patterns and processes in the soil. Ecological Society of America Mid-Atlantic Ecology Conference, Baltimore, MD. March 12-13.

Szlavecz, K., A.S. Szalay, W. Hong and D. Wertheimer. 2004. The use of wireless sensor networks in soil ecology. Abstracts of the 2004 Fall Meeting of the American Geophysical Union, San Francisco, CA. December 13-17.

Vemuri, A., M.A. Wilson, M. Grove and W.R. Burch. 2004. Environmental and social indicators of well being: The case of Baltimore, MD. Baltimore Ecosystem Study Annual Meeting, Baltimore MD. October 21-22.

Wilson, M.A. and T. Christopher. 2004. Accounting for ecosystem services in Baltimore, Maryland: The ecovalue project website. Baltimore Ecosystem Study Annual Meeting, Baltimore, MD. October 21-22.

Report to Agency or Organization

Hanley, L. 2004. This park is a magnet: How the refurbishing of Patterson Park has affected the residential property values of the Patterson Park neighborhood. MA Thesis submitted to the Department of Geography, Ohio University, Athens, Ohio.

Koenig, M.J. 2004. Baltimore's changing neighborhoods: A case study of Federal Hill, Little Italy, Washington Village/Pigtown, and Penn-North 1970-2000. MA Thesis submitted to the Department of Geography, Ohio University, Athens, Ohio.

Korth, C.A. 2005. Frederick Law Olmsted, Jr. and the creation of Gwynns Falls/Leakin Park. MA Theses submitted to the Department of Geography, Ohio University, Athens, Ohio.

Merse, C.L. 2005. Historical geography of urban forestry and roadside tree planting in Baltimore. MS Thesis submitted to the Department of Geography, Ohio University, Athens, Ohio.

Michaud, M. 2005. An analysis of conserved land, green space and neighborhood characteristics in the Baltimore Regions. Masters Thesis submitted to the University of Vermont, Burlington, Vermont.

Park, S. 2005. The soil microbial community associated with an invasive plant, *Polygonum cuspidatum* (Japanese knotweed). MS thesis submitted to Johns Hopkins University, Baltimore, Maryland.

Smith, J.M. 2005. Influence of channel morphology on riparian vegetation in the Gwynns Falls watershed. MS thesis submitted to Johns Hopkins University, Baltimore, Maryland.

Throneburg, M. 2004. From agriculture to urbanization: An historical approach to stream channel change in a Maryland Piedmont watershed. MS thesis submitted to Johns Hopkins University, Baltimore, Maryland.

Wells, J. *In process.* Carroll Park: The ethnic origins of an urban park. Thesis to be submitted to the Department of Geography, Ohio University, Athens, Ohio.

Other Products

Developed a system that mirrors the data in Open Research System (ORS) making BES data easily searchable by web searchers such as Google.

ArcGIS geodatabase at the University of Vermont Spatial Analysis Lab. Spatial data for BES stored in a standardized GIS-enabled database framework.

Bird database. We continue to maintain an online database of our bird monitoring which is undergoing some system improvements.

Water-resources data are provided in both provisional (working) and final (approved) form from 41 stream gaging stations in the BES study area, including six with full or partial NSF funding. Data are disseminated through the USGS-BES web link and through the USGS National Water Information System (http://nwis.waterdata.usgs.gov/nwis).

StreamStats (http://water.usgs.gov/osw/streamstats) implementation began in 2005 for the Patapsco-Gunpowder Hydrologic Units, which includes the BES study area. StreamStats is a GIS-based system for estimating basin characteristics and streamflow statistics at any point in a stream network. StreamStats provides a basic infrastructure for analysis and interpretation of hydrologic data, scaling, and regional transferability.

Novel land cover classification specifically developed for urban landscapes.

Developed the HERCULES land cover classification database for the Gwynns Falls watershed and the Baisman Run reference watershed.

Created a data set of forest patches in the Gwynns Falls watershed from 1938, 1957, 1971, 1999, and 2004 imagery.

Educational Aid: Pollinator Identification Guide. Laminated, pictorial keys of bee and butterfly species that are likely to be encountered in New York City community gardens were placed beside pollinator-conservation areas in 10 gardens located in Harlem or the Bronx.

Forest inventory data for Baltimore reservoirs, Frederick, MD, reservoirs, and Cylburn Arboretum.

Working BES urban flux tower for displays at conferences, meeting and forums.