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Harnessing the Hydrologic Disturbance Regime: Sustaining Multiple Benefits in Large River Floodplains in the Pacific Northwest

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Large river floodplains in the Pacific Northwest are the most ecologically and economically productive lands in the region. This research project has integrated a study of thermal patterns in the Willamette River, developed a model of hyporheic influence on water temperature, and created dynamic visualizations of technical concepts and research results. This information and informatics tools have been used to work with regional decision makers and state agencies to simultaneously derive water temperature reductions, terrestrial and aquatic habitat enhancements, increased recreation, and improved nonstructural flood storage in large river floodplains, while meeting the requirements of the Clean Water Act Total Maximum Daily Load (TMDL) for elevated temperature as a water quality limiting factor and federal Endangered Species Act concerns for elevated stream temperature effects on listed salmonids and other native riverine species. We have worked with municipalities, state and federal agencies, and non-governmental organizations to find solutions to comply with regulations while maximizing and sustaining the benefits to their constituencies. We have developed empirical water temperature data, models of hyporheic exchange, tools for geographic prioritization, and interacted with citizens and agencies to find socially plausible solutions.

The spatial distribution of cold water habitats has been mapped in the upper Willamette River between Albany and Eugene, Oregon. We used our maps of channel and floodplain complexity in the Willamette River in 1850, 1895, 1932, and 1995 to develop a typology of thermal reach types based on associations of thermal characteristics and channel morphology and floodplain vegetation. Based on these typologies, spatially explicit representations of the likely thermal patterns of the Willamette River have been developed. These typologies were used to project priorities for future floodplain restoration in response to land use changes, human population increase, and regional climate change.

Two simulation models of thermal dynamics have been developed in surface and hyporheic flows of floodplain rivers to predict thermal patterns that might result from alternative channel configurations, flow patterns, and floodplain vegetation. The first model was developed for the Oregon Department of Environmental Quality to explore floodplain application of wastewater. In summer 2006, we conducted field studies of hyporheic properties of three study sites. A simulation model of hyporheic exchange was developed for the three sites, and the relative contribution of the major determinants of water temperature was evaluated. This model is being used to develop a thermal credit trading framework for the Willamette River and to design restoration efforts in the Willamette River.

We used the field study results and preliminary modeling as a basis to discuss spatially explicit restoration efforts with regional agencies and citizen groups. Four workshops were held in 2006-2007 with the Oregon Department of Environmental Quality, citizen groups, and municipalities in the Willamette Valley. We identified approaches for achieving and sustaining multiple benefits, including but not limited to thermal modification, in prioritized locations. We also worked with the Willamette Partnership to develop market-based approaches to accomplish these goals. The meetings facilitated discussions between the state and major water users and have resulted in provisions with TMDL permits that encourage floodplain restoration. We are working with the Metropolitan Wastewater Management Council to design floodplain restoration to meet their TMDL wasteload allocations. These projects will form the initial demonstrations of the credit trading system, WillamEx, which is being developed by the Willamette Partnership and U.S. EPA and will be implemented by December 2008.

The Oregon Watershed Enhancement Board has used this project and previous research supported by a U.S. EPA STAR Grant and U.S. EPA National Health and Environmental Effects Research Laboratory, Western Ecology Division, in Corvallis, Oregon, to develop a Special Investments Program for restoring the mainstem of the Willamette River. Oregon has dedicated $6 million in the next biennium for restoration and is collaborating with partners to match the investment from non-state funds. A total of $24 to $50 million will be committed to restoration of the mainstem of the Willamette River by 2014. Research on cold water refuges from this project will provide a significant component of the technical foundation for this collaborative program to restore and conserve multiple ecosystem services for a large, floodplain river.

Multi-Objective Decision Model for Urban Water Use: Planning for a Regional Water Reuse Ordinance

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Project Goal and Objectives: The overall goal of this research project is to promote reuse as part of long-term sustainable water resources planning in northeast Illinois. Specific objectives of this project are to evaluate potential future water shortages, assess barriers and incentives to treated wastewater reuse, and develop and apply a multi-objective decision model for optimizing urban and suburban water use in northeast Illinois.

Approaches: One of the first project tasks was to assess current and projected water supply and demand in the Chicago metropolitan area to identify potential water supply shortages. We also estimated hydrologic footprints for 50 large-volume water discharging industries to quantify the wide range of water use efficiencies relative to economic output. Reuse of treated municipal wastewater effluent can help to address potential future water shortages. To better understand that role, we examined the technological, economic, societal, and environmental incentives and barriers to wastewater reuse. Because economics plays such a critical role, an optimization model also was developed to minimize the costs of water use in this region. The model includes costs for additional treatment, system maintenance, and especially the cost of installing new pipelines.

Significance of Findings: Water use in northeast Illinois has not been consistent with the concepts of sustainable growth. For example, the Chicago diversion from Lake Michigan has exceeded the limit specified by the U.S. Supreme Court decree of 1967, and most of the water is used in applications that do not demand high-quality water. Furthermore, the water and wastewater treatment processes dissipate a substantial amount of energy. Wastewater reuse in the Chicago metropolitan area could reduce the costs of municipal (drinking) water treatment, reduce the costs of wastewater treatment, reduce the amount of water diverted from Lake Michigan, and result in significant energy savings. We believe that a successful approach in northeast Illinois could find applications throughout the Great Lakes region.

Future Prospects for the Work: The Chicago Metropolitan Agency for Planning (CMAP) is adapting methodology developed in this study for water resources planning in the 11-county region that comprises northeast Illinois. As part of their role as facilitator for the Regional Water Supply Planning Group, CMAP plans to classify clusters of industry (existing as well as planned industrial parks) based on their proximity to municipal wastewater treatment plants. With that information, they can compare supply costs for treated wastewater effluent and for conventional municipal water. Results from their efforts will be included in the Regional Water Supply Plan that CMAP develops. In addition, CMAP will work with its Business, Industry, and Power and Wastewater/Non-Municipal Water Suppliers stakeholder groups to communicate the findings and find implementation strategies for recommendations emerging from the study.

Sustainable Sandhills: A Plan for Regional Sustainability

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Project Goal and Objective: The goal of this research project is to integrate sustainability planning into the day-to-day operations of the governments and communities in the Sandhills. The Sandhills region is defined as an eight-county area in southeast North Carolina. For this project, an additional three counties were added so that the project footprint matched that of the Base Realignment and Closure Regional Task Force initiative.

The objective of this project is to foster a coordinated approach to economic development, cultural and natural resource preservation and enhancement so that the quality of life in the region is improved. Using these suitability maps, decision-makers can identify, visualize, and assess relative values of land use to understand and communicate opportunities and constraints.

Approaches: This project created six geographic information systems-based models of land suitability. The results can be used singly or in a variety of combinations. The best available data across the region were identified. Stakeholder meetings and focus groups provided input into the modeling process. Project leaders used an iterative approach to find out what makes an area suitable for a particular land use activity. Rule-based criteria were applied to factors identified as assets and constraints.

Significance of Findings: The release of results has just begun. A planner who assessed the relevance of the results in her jurisdiction found the maps very relevant. The maps illustrated aspects of the landscape of which she was unaware. This new perspective altered a proposed land use plan and provided additional affirmation on zoning changes. She expects to use the combination maps as an educational and interpretative tool at public hearings.

Some members of the development community who participated in developing the tools expect the maps to assist in obtaining more coherent and consistent application of land use regulations and changes. The maps will assist them in communicating with planners and vice versa, and will assist both parties in presentations to local elected officials.

Future Prospects for the Work: The future for this project is assured through several agencies for different reasons. The North Carolina Department of Commerce will periodically update the data, rerun the models, and assist Sustainable Sandhills in redistributing the results. This will ensure that planners and other users have access to current data.

A regional organization, the BRAC-RTF, is already using its own money to add a predictive feature on top of the existing project models. In addition, the planner for the BRAC-RTF is charged with developing a growth management plan for the 11-county region covered by these sustainability maps. The maps are one of the inputs in this analysis of data. Funding for refining the models themselves based on a year's usage may become available through organizations that are using these models and data in their own projects.

Sustainability of Land Use in Puerto Rico

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The primary goal of this research project is to develop a scientific model using geographic information systems (GIS) with a land use sustainability index to provide a scientifically reliable tool to measure and monitor the impacts of the progression of the urban built environment on the quality and availability of land, ecosystems, and water in Puerto Rico for long-term sustainability. At present, Puerto Rico faces the challenge of a small tropical island (surface area is 8,874 km^2) with a high population density (429 inhabitants per square kilometers) and no island-wide land use plan. In addition, the island is divided into 78 municipalities (equivalent of townships in the United States), and each of these has the authority to prepare its own individual land use plan. The model to be developed will produce a land use index from 23 selected indicators, which will provide accessible and reliable information for key public and private stakeholders on the sustainability of their land use activities.

The initial process for the development of the model used four municipalities in Puerto Rico as case studies by examining the following: (1) site characterization and assessment, and the construction of the conceptual model; (2) collection and analysis of information and metadata for reliability, relevance, and accessibility; (3) analysis of GIS maps, aerial photographs, and satellite data; (4) selection of possible indicators based on the results of steps 2 and 3; (5) assignment of appropriate weight to each selected indicator, dividing them into stressors or relievers; (6) selection and validation of benchmarks and/or planning objectives for the indicator; (7) data integration for sustainability index (composite index model); and (8) analysis, reevaluation, and validation of outcomes.

The initial results revealed that all four municipalities scored quite low on sustainability—a mirror of the widespread unsustainable land use practices on the island. Now all benchmarks and planning objectives initially selected will be double-checked and validated, taking into consideration the challenges faced in the development that included: (1) the methodology and source of some data (metadata) were hard to verify and/or not readily available at the agencies and municipalities; (2) there are no clear and agreed upon benchmarks for many indicators (a scientifically proven threshold, a locally accepted public policy goal, or internationally agreed upon goal); and (3) the municipalities, as territorial units, pose difficulties in data collection and analysis when the scope and origin of the land use activity have a regional character. These challenges will be addressed at this final stage of the project by the research team and the External Advisory Committee to validate locally accepted land use planning goals.

Upon completion of this model, additional funding will be sought to fine tune some of the indicators and expand some to a regional scale using watersheds and/or municipal regional economic initiatives as territorial planning units. This research project is foreseen as spearheading the development of Puerto Rico's State of Land Use for Sustainability Report and serving as a tool to rank the municipalities according to their land use "eco-efficiency."

Cuyahoga Sustainability Network

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In northeast Ohio, as in most of the nation, market-driven land development decisions, modulated by hydrologic design for site development and stormwater management, shape the cumulative stressors that drive aquatic and terrestrial ecosystem responses. Yet the gaps between current decision making, and our emerging understanding of land use-hydrologic-ecosystem interactions pose some of the greatest challenges to sustainable development in the nation's urban-suburban metroplexes. These challenges also represent timely opportunities to enrich and rationalize decision making by matching science and technology applications to key information gaps that inform a systems approach to land transformation decisions. To address this timely challenge, the Center for Urban Environmental Research and Education (CUERE) at the University of Maryland Baltimore County (UMBC) has undertaken the Cuyahoga Sustainability Network (CSN). CSN cultivates a systems-oriented application of science and engineering to sustainable development, focusing on land transformation decisions and an ecosystem that serves at the urban-suburban fringe.

The CSN integrates regional partnerships and interdisciplinary expertise spanning the environmental, economic, and social dimensions of sustainable decision making, focused at the intersection of land transformation decisions and their consequences for urban ecosystems. Collectively, the proposed program elements address essential information needs coupling the multi-scale effects of land transformation decisions with ecosystem responses in urbanized systems. With a regional focus on the Cuyahoga River Valley and its built environments, the CSN cultivates a portfolio of collaborative science and technology applications to support sustainable decision making at the intersection of natural systems, engineered systems, and human social and institutional systems.

Significant Findings: Hedonic analysis of property sales shows no significant penalty in prices or appreciation rates for properties developed with conservation design, or in municipalities with riparian setback zoning.

- Pervious concrete demonstrations and workshops supporting technology transfer, education, and outreach, continue to contribute to the information needs of research and practitioner communities in northeast Ohio. New pervious concrete placements in the City of Seven Hills, Lakewood, University Circle, and downtown Cleveland at Cleveland State University reflect the continued incremental growth in understanding and acceptability of this technology in northeast Ohio.

- Preliminary analysis of urban infiltration data quantify limited infiltration on disturbed and compacted pervious land uses, with significant implications for landscape-scale distributed infiltration.

- Initial estimates of Cleveland's urban forest services exceed $3 million in annual benefits from improved air quality alone.

Future Prospects: Our partners are supporting a demonstration of low impact development (LID) on a private site, incorporating pervious pavement, bioretention, bioswales, and long-term monitoring. Our pre-development site assessment will provide baseline data to evaluate pre- and post-development site performance.

- No-mow and low-mow lawn mixes are under evaluation with the Cleveland Botanical Gardens at reclaimed properties in the City of Cleveland. Cleveland's urban greening creates parcel-scale urban test plots to evaluate alternate lawn mixes as well as site preparation and treatments for compaction effects and infiltration performance.

- We anticipate developing urban forest service estimates for the Cuyahoga County Greenprint, the Cleveland Metroparks, and Cleveland's street tree database, targeting a community-based volunteer survey of the regions' urban forests.

- Our research-training-outreach model for pervious concrete technology transfer is being leveraged in the Chesapeake Bay Watershed.

Framework for Sustainable Watershed Management

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Description: This research project takes place in the Pocono Mountains where the existing environmental resources are the region's largest economic multiplier. The area also is experiencing the state's second highest rate of population growth. Local concerns about sustaining water resources instigated an interdisciplinary effort to design a sustainable framework based on sound science that protects ***streamflows*** (baseflows) in high-quality streams threatened by rapid development. By using wild trout (populations) as an indicator species to gauge ***the effect of development on streamflows*** (baseflows), strategies that protect the wild trout habitat will help sustain the Creek's water resources. This effort integrates science, policy making, community outreach, and public education through a unique iterative planning process.

Status: The technical stage is an assessment of the effects of groundwater withdrawals and land use changes on brown trout, with brown trout being an indicator species for habitat, baseflows, and water quality. This stage is near completion. Major components completed are:

- Water monitoring
- Development of a Groundwater Model (U.S. Geological Survey [USGS])
- Development of a Watershed Hydrology Model (U.S. Environmental Protection Agency Office of Research and Development [EPA-ORD], Cincinnati, OH)
- Population and land use projections (Monroe Comprehensive Planning Commission [MCPC])
- Build-out scenarios (MCPC)
- Water quality monitoring data collected and analyzed (EPA-ORD, Edison, NJ)
- Current water use (Delaware River Basin Commission [DRBC])
- Hydroecological Stream Classification (USGS, Fort Collins, CO).

Due to insufficiency of data, the original intent to use the groundwater and hydrology models for inputs into the PA IMIF Model was not possible to complete. Instead, the DRBC contracted with the USGS Science Center in Fort Collins, Colorado, to complete a hydrological classification of the Pocono Creek Watershed's streams, develop flow standards and characterize hydrologic alteration—2000 baseline and 2020 "build out." The stream classifications were completed in October 2007.

Objective: Building on the foundation of an earlier pilot study of Pocono Creek, the need to ensure long-term sustainability of the creek's water resources became a primary concern. EPA responded by providing the means to develop a framework that integrates a watershed planning process with scientific, policy, and educational outreach products to implement strategies for sustainable watershed management.

This project is to be completed in three phases: (1) Technical; (2) Policy Development; and (3) Community Watershed Event. The Technical Phase involves collecting data, and building a groundwater model and a ***watershed hydrologic*** **(**hydraulics) model. These tools will be used to analyze ***projected land use change scenarios,*** producing outputs (i.e., surface water/groundwater interface, streamflows, projected impact of development on watershed hydrology [and land use scenarios]) that will be inputs to the third model that will calculate the flow regime necessary to support the wild trout habitat. The Policy Development Phase will use the technical information to devise strategies that will protect the conditions necessary to ensure that the wild trout habitat will be sustained. The Community Watershed Event is the concluding event that will roll out the strategies to key decision makers through a process that fosters collaboration and strategy implementation.

A. Project Organization: Organizational functions were assigned to an administrative Steering Committee and support "teams" for the technical, policy, and outreach phases of this project. This project's reiterative nature calls for a flexible scope, which is assessed regularly to meet the needs of the changing local

conditions and changes in process and/or methodologies when necessary. The transition from the Technical Phase into the Policy Development Phase has begun by identifying the skills needed to develop sustainable strategies, those that have those skills, and their recruitment.

A "Memorandum of Understanding" has been sent to all partners, and a request for a "no-cost" extension has been made to move the project deadline from September 30, 2006, to June 2007. Communications between the Technical Team and Steering Committee and among the Technical Team members will continue to take place on an as-needed basis.

Two grant(s) applications for the final implementation of watershed strategies were submitted to the Pennsylvania Department of Environmental Protection's Growing Greener in March 2005 and EPA's Assessment and Watershed Protection Program Grant in June 2005.

B. USGS Groundwater Flow Model: A calibrated three-dimensional Groundwater Flow Model capable of simulating groundwater/surface-water interactions in the Pocono Creek Watershed was successfully developed. The Groundwater Flow Model can evaluate the effect of groundwater withdrawals on stream baseflow and the corresponding impact on stream habitat. Also, it can estimate the potential reduction in stream baseflow caused by reduction in recharge from urbanization.

The model includes an upper layer representative of the unconsolidated surficial glacial deposits that are directly connected to the stream system and a lower layer representing fractured bedrock. The surface-water divide between the Pocono Creek Watershed and adjacent watersheds were considered to be a no-flow boundary. The model used the USGS MODFLOW computer program (Harbaugh and McDonald, 1996) with the Ground-Water Modeling System (GMS) as the interface (Environmental Modeling Systems, Inc., 2004). Aquifer-stream interactions were simulated using the stream-aquifer package of Prudic (1989). The model is capable of simulating groundwater discharge to Pocono Creek with various recharge and pumping rates.

Bedrock geology were imported into the model from the digitized (Geographical Information System [GIS]) geologic map of Berg and others (1980). Thickness of the bedrock aquifer was determined by statistical analysis of available depth of water-bearing zone data. Hydraulic conductivity of the bedrock aquifer was estimated based on analysis of available aquifer-test and specific-capacity data.

Surficial glacial geology was imported into the model from the digitized (GIS) surficial geology maps of Berg and others (1977), Bucek (1971), and Epstein (1969, 1973, and 1990) that were provided to the USGS by EPA. The thickness of glacial deposits was estimated based on casing depths from the USGS Ground-Water Site Inventory (GWSI) database and the Pennsylvania Topographic and Geologic Survey Pennsylvania Ground Water System (PaGWIS). Hydraulic conductivity of the glacial deposits will be estimated from available data and literature values.

A seepage study, consisting of stream baseflow discharge measurements made with current meters at selected locations, was conducted in October 2005. Water levels in wells in the watershed were measured at the same time as the seepage measurements were made.

Eight wells in the watershed were equipped with transducers and continuous measurement data loggers. This will provide data on aquifer response to precipitation and seasonal and annual water-level fluctuations. Water levels were measured from September 2004 to June 2006.

Model calibration was based on available hydraulic data and data from the aquifer test, the seepage studies, groundwater-level monitoring data, the USGS Pocono Creek streamflow-measurement station (01441495), and water budgets for the Pocono Creek Watershed (Sloto and Buxton, 2005).

The model is calibrated to hydrologic conditions at the time of the seepage study that corresponded closely to long-term average conditions. Long-term average conditions were determined by correlating discharge at the Pocono Creek streamflow measurement station with discharge at a long-term streamflow-measurement sta-

tion in an adjacent watershed underlain by the same geologic units. Model inputs were recharged; output from the model is the groundwater discharge to the Pocono Creek. A steady-state simulation approximates long-term average conditions in the Pocono Creek Watershed.

The effect of groundwater withdrawals on stream baseflow were simulated by using hypothetical pumping wells in selected subbasin**s**. This establishes the link between groundwater withdrawals and streamflow depletion. The maximum reduction in stream baseflow was determined for each scenario by using steady-state simulations. The reduction in streamflow that causes a 5 percent habitat loss will be provided by the Pennsylvania Fish and Boat Commission using the Pennsylvania Instream Flow Model (Denslinger and others, 1998). This model will be used to determine the groundwater withdrawal rate that would cause a streamflow loss corresponding to a 5 percent habitat loss.

The effect of reduction in recharge on stream baseflow caused by increased impervious area due to urbanization also was simulated by using the reduction in recharge provided by EPA from the results of their surface-water-model simulations. The same scenario was simulated, one with no reduction in recharge and one with reduced recharge, and compared to estimate the effect on stream baseflow.

C. Data Collection: A monitoring program has been ongoing. EPA-ORD's Edison, New Jersey, office supplied in-stream equipment and training to support the collection of flow information The program records water temperature in Pocono Creek and several tributaries. Automated logging equipment (YSI 6600 sondes) also records dissolved oxygen, pH, conductivity, water depth, and turbidity at three locations throughout the basin. In two locations, installed flow meters (American Sigma 950) record the depth and flow velocity that is used to estimate the flow rate in subwatersheds. Tipping bucket rain gauges are installed at two locations to monitor and document the total rainfall and spatial heterogeneity.

D. The Distributed Hydrologic Model: A Soil and Water Assessment Tool (SWAT) Model was developed by EPA. Adapted to be used as a watershed hydrologic model, it is able to quantify the impact of land use changes on peak runoff during storm events and low flows during baseflow periods. The goal is to identify a relationship between land use changes (increased imperviousness) on the frequency of peak runoff and low and high flows, and identify areas in the watershed that may contribute mostly to anticipated changes.

Run on a Graphical User Interface (GUI) within a GIS, the SWAT has a process-based runoff, channel, and baseflow components; operates on a daily time step; and combines Digital Elevation Maps (DEMs), soil, and land use maps, as well as channel characteristics with excess runoff and channel flow simulators.

The model was calibrated based on a database supplied by the DRBC. The data include DEM, land use maps, GIS soil data, and streamflow measurements obtained from a USGS gauge station located upstream from the mouth of the watershed. Climate data, including precipitation measurements, are obtained from the nearest NOAA gage stations. Next Generation Radar Rainfall (NEXRAD) also is evaluated as an alternative source for spatio-temporal precipitation.

The model is calibrated and verified, and its predictive uncertainty is quantified to examine forecast capability through time-series analysis and Monte Carlo simulation. The model can simulate hypothetical scenarios of land use changes (increased imperviousness) with stochastically generated rainfall events. The model results will quantify potential impacts of land use changes on groundwater recharge, and frequencies of low and high flows.

E. Hydroecological Integrity Assessment Process (HIP): As part of the Technical Phase, the USGS Fort Science Center and the Pennsylvania Fish and Boat Commission cooperatively conducted a study that establishes environmental flow standards and a streamflow alteration assessment for seven sub basins in the Pocono Creek watershed. The Hydrologic Model's (Mohamed Hantush—EPA-ORD) outputs (i.e., surface water/groundwater interface, streamflows, projected flow alteration due to water and land use development on watershed hydrology) were utilized to conduct the streamflow alteration assessment and to compare the assessment to environmental flow standards. The HIP developed by the USGS was used to conduct a

hydrologic classification of the Pocono Watershed's streams, establish environmental flow standards, and assess past and proposed hydrologic alterations on streamflow and other ecosystem components. Because HIP has not been developed for Pennsylvania, no stream classification for the entire state is available. Therefore, after rejecting use of the New Jersey Hydrologic Assessment Tool, USGS at Fort Collins opted to use the National Hydrologic Assessment Tool (NATHAT) that uses a national classification of streams (six types). The first run of HIP was completed in October 2007. All streams in the watershed were of the same class, "Flashy/Runoff," as established by the NATHAT.

The next task began in November 2007, and will apply the generic approach presented in the article titled "The Challenge of Providing Environmental Flow Rules To Sustain River Ecosystems" in the *Journal of Ecological Applications* (Arthington, A.H., Bunn, S.E., Poff, N.L., Naiman, R.N. The Challenge of Providing Environmental Flow Rules To Sustain River Ecosystems. 2006;16(4):1311-1318). The approach incorporates essential aspects of natural flow variability-based, specific hydrologic indices, and a stream class validation procedure using empirical biological data. In this case, using the selected stream type described above, existing biological data will be examined to determine how it can be used to develop flow relationships with wild brown trout population parameters. This sub-task will be dependent on the availability of streamflow data and wild brown trout population for streams that belong to the same class as the streams in the Pocono Creek Watershed. If applicable population data are not available, an attempt would be made to use applicable literature-based information. Also, additional criteria for sustainability were identified. Development of information on the effects of build-out and withdrawals on various streamflow statistics (EPA-ORD) and other "Indicators of Impact" measures are to be integrated into the technical reports.

Currently, the Technical Team is preparing report presentations for the Steering Committee and the Management Strategy Development Team. Three members of the Education and Outreach Team are attending the EPA Region 3 training on social marketing, an innovative approach to program development that uses com-mercial marketing techniques to address environmental issues.

F. Innovative Watershed Community Outreach and Education Effort: The Brodhead Watershed Association is implementing their innovative community watershed event, through the installation throughout the watershed of 25 66-inch fiberglass trout that will be painted by artists. The "Trout Trails and Tales" project will have a discovery trail of trout throughout the greater watershed community. Each trout will have a tale to tell about the inter-relationships among land use, streamflows, and sustaining healthy trout population. The community response is very strong, and participation is expected to be very high.

Next Steps: The development of watershed management strategies will use the technical findings to develop ways to retain the existing high-quality conditions while balancing the need for growth in the watershed. The strategies may include regulatory as well as technical measures, involving multiple levels of government and various water resource disciplines.

The Education and Outreach Team strategy involves: (1) converting the technical report's scientific terminology into common language; (2) identifying target audiences and their roles in utilizing the management strategies; (3) further developing the innovative program that effectively presents management strategies to the targeted audiences; and (4) implementing the education and outreach effort, "Trout Trails and Tales."

The USGS Groundwater Model and EPA-ORD Distributed Hydrologic Model have been developed, and final reports are expected in August. The models have established existing conditions and projected outcomes from withdrawals and development impacts. Using a 20-year framework and build-out scenarios, the impacts from withdrawals on baseflow and from development on flow were determined.

Moving Toward Sustainable Production

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For more than 15 years since the passage of the Pollution Prevention Act, manufacturers and government agencies have consistently faced the challenge of poor information systems for evaluating pollution prevention (P2) opportunities. Successful pollution prevention is based on an entity's ability to understand and improve its choice and use of materials and the associated financial impacts.

Northeast Waste Management Officials' Association (NEWMOA) and the Massachusetts Office of Technical Assistance (OTA) for Toxics Use Reduction are currently collaborating to develop and pilot test a materials use and profitability software tool called Energy & Materials Flow & Cost Tracker (EMFACT). This research project will build on the current application of environmental management accounting as a critical aspect of sustainable production and P2.

The primary beneficiaries of this project will be those companies and organizations that implement this environmental management accounting tool to aid them in setting P2 priorities, identifying value-added opportunities for sustainable production, and implementing other materials and energy efficiency improvements. State and local environmental and technical assistance programs as well as private-sector consultants will benefit by having the tool to help their client companies identify P2 opportunities and quantify the benefits and costs.

NEWMOA has contracted with SYS Technologies to develop the EMFACT tool and to provide training support. SYS Technologies was selected by NEWMOA and the Massachusetts OTA after a lengthy procurement process and competition among a number of highly qualified vendors. NEWMOA anticipates that a beta version of EMFACT will be available by the end of 2007 and hopes to post the final tool for free download on its Web site by late spring 2008.

Bringing Global Thinking to Local Sustainability Efforts: A Collaborative Project for the Boston Metropolitan Region

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Project Goals and Objectives: Although there is widespread implicit recognition of the global nature of sustainability, global considerations generally have not been incorporated and acted on in local/regional sustainability efforts. Moreover, local sustainability initiatives are typified by the absence of science-based methods and do not emphasize global drivers, impacts, and opportunities for action.

The objective of this research project was to support sustainable regional planning by providing tools and methods that promote preventative planning in an integrated social-economic-environmental systems framework. Short-term goals were to: (1) develop scenarios using the latest science that considers the social, environmental, and economic elements of sustainability from a global perspective; (2) inform citizens and policy-makers, including the ongoing MetroFuture regional planning process, concerning sustainability and alternative pathways for the region; and (3) promote networking of existing planning efforts taking place at different scales in the region.

Approach: Long-range planning for sustainability poses the challenge of indeterminacy—ignorance, surprise, and human volition. A scenario approach offers a powerful way to examine the forces shaping our world, the uncertainties that lie ahead, and the implications for tomorrow of trends and actions today. Building on the rich data already developed by our partners at the Metropolitan Area Planning Council, The Boston Foundation, and others, this project used Tellus Institute's *PoleStar* decision-support system to explore the sustainability of three alternative long-range scenarios for the Boston metropolitan region: Business-As-Usual (BAU), Policy Reform, and Deep Change. The scenarios assess alternative futures to 2050 in both qualitative and quantitative terms for a range of dimensions, including: demographics, economic activity, equity, transportation, agriculture and food, energy use, and CO_2 emissions. This project relied on inputs from the MetroFuture visioning process and a diverse Project Advisory Committee. To impact the public dialogue about the future trajectory of the region, the scenario results were shared with the MetroFuture regional planning effort, the Project Advisory Committee, and others.

Preliminary Findings: This project demonstrated the value of creating normative scenarios with sustainability targets and backcasting to identify plausible pathways for achieving desired futures. The Deep Change scenario was a powerful alternative that helped reframe the MetroFuture long-range regional planning process and impacted other initiatives in the region. It also showed that technological and policy initiatives were necessary but insufficient to reach certain sustainability targets (e.g., 80% CO_2 reduction), and that lifestyle changes also were required.

Significance of Findings: This project demonstrated a model approach for linking regional sustainability initiatives with global considerations through a combination of engagement, visioning, integrated sustainability scenarios, backcasting, and tracking of sustainability indicators. The analytical tools, data, and lessons learned in this project are readily transferable to other planning efforts. The further development of *PoleStar* has upgraded the key analytical tool used in this project, and improved its usability by other localities, regions, and states.

Next Steps: The results of the Boston regional scenarios will continue to be used by Tellus Institute and collaborators to inform policy and planning processes, including MetroFuture, regional transportation efforts, and state sustainability and climate change initiatives. In addition, the project team will document the project through a final report, and disseminate the project approach, tools, and lessons through the project Web site, published articles, and other means.

Using Market Forces To Implement Sustainable Stormwater Management

Dan Vizzini, Dave Kliewer, Gordon Feighner, Jim Middaugh, Craig Shinn, and Mary Wahl
Bureau of Environmental Services, City of Portland, Portland, OR

Objective of the Research: Portland recognizes the need to move beyond regulation, utility rates, and public infrastructure to achieve long-term sustainability goals. The City's sustainability agenda must include strategies that animate and direct market and social forces, expand public awareness, establish a green economy, increase private stormwater investments that produce multiple watershed benefits, and foster sustainable private behaviors at home, work, and play. Markets are the "place" where the social, economic, and ecological principles of sustainability are integrated and leveraged.

This research project was begun in July 2006, to test the feasibility of using market mechanisms to achieve city stormwater, watershed, and sustainability goals. The study is organized into three phases:

1. Phase I was completed in July 2007, and identified the costs and capacity of building public stormwater management infrastructure in the city's combined sewer basins; the cost and effectiveness of alternative structural and nonstructural stormwater management practices (BMPs); and the feasibility of using market mechanisms to increase private investments and reduce public investments.

2. Phase II will produce in-depth evaluations of the feasibility of market mechanisms, leading to the selection of one or two mechanisms for testing and evaluation.

3. Phase III will implement pilot projects in the city's combined sewer basins to assess the performance of the selected market mechanisms.

Progress Summary/Accomplishments: Phase I concluded in July 2007, and produced the following work products:

- Updated cost estimates to design, install, maintain, and operate 20 different stormwater BMPs.
- Updated effectiveness measures for each BMP focused on volume, flow rate, and water quality including sediment, zinc, pathogens, and phosphorous.
- BMP evaluations of ecosystem services, including air quality, carbon, flooding, terrestrial and aquatic habitats, heat island effect, and quality of life.
- Factors that constrain the use of individual BMPs, including land uses, soils, slope, and depth to groundwater.
- An evaluation tool to determine the most effective mix of BMP investments to achieve a variety of system, policy, regulatory, financial or sustainability goals within the city's combined sewer basins.
- Several runs of the tool to determine the feasibility of market mechanisms to achieve stormwater, watershed, and ecosystem goals.

Phase I produced the following findings: (1) There are enough potential suppliers to support a market-place. (2) There is a sufficient differential in the price of stormwater BMPs to realize savings from a marketplace, or achieve higher levels of stormwater management and ecosystem benefit for the same investment. (3) Portland can stimulate demand and animate a market by targeting public investments, incentives and regulations; however, the costs of a credit trading system may far exceed its benefits. (4) The city is well positioned to stimulate a local green economy, use reverse auctions, and employ creative marketing strategies to increase private investments in stormwater facilities. These strategies should be integrated into the city's stormwater and sustainability initiatives. (5) Additional work on the stormwater evaluation tool is needed to support the targeting of market strategies and pricing of public incentives. (6) Effective sustainability policies require much more work on the valuation of ecosystem services associated with stormwater BMPs and other investment strategies.

Ecological Sustainability in Rapidly Urbanizing Watersheds: Evaluating Strategies Designed To Mitigate Impacts on Stream Ecosystems

Margaret A. Palmer[1], Meosotis Curtis[2], Keith VanNess[2], Amy Hennessey[3], and Kevin Kelly[3]
[1]University of Maryland at College Park, College Park, MD; [2]Montgomery County Government (Maryland), Department of Environmental Protection, Rockville, MD;
[3]Environmental Systems Analysis, Annapolis, MD

Project Goals and Objectives: Urbanization has profound impacts on the hydrology and ecology of streams via alteration in water temperatures, peak and base flows, and nutrient, sediment, and contaminant inputs. Storm water management (SWM) is commonly used to reduce these impacts; however, comprehensive watershed-scale studies to determine the effectiveness of SWM designs in reducing ecological impacts are scarce. With the continuing trend of urbanization, there is an urgent need to more fully understand which SWM designs are most effective and why, so that policymakers are better equipped to address the sustainability of water resources.

In 2000, the State of Maryland adopted new SWM criteria to address the impacts of urbanization on stream ecosystems. Montgomery County (Maryland) Department of Environmental Protection initiated a project in 2002 to evaluate the effectiveness of new SWM practices. Our partnership significantly expands the scientific scope of that project to determine the effectiveness of SWM on mitigating the impact of urbanization on receiving streams. Critical questions will be answered using an empirical research design that focuses on multiple stream reaches within three watersheds currently being developed with the most advanced SWM technologies; one watershed developed using older SWM designs; and a largely forested (control) watershed. The timing of this study also allows us to collect data during the construction phase of development, prior to the conversion of sediment-trapping devices to SWM controls.

Approaches: This research project evaluates the structural and functional responses of stream ecosystems to new SWM designs using a variety of metrics, including: discharge, rainfall-to-runoff ratios, channel geomorphology, bed particle size and mobility, suspended sediment loads, water quality, macroinvertebrate community composition, nutrient uptake, and whole stream metabolism. Data collection occurs at various time scales ranging from daily (hydrological metrics), to seasonally (water quality, functional metrics), to annually (geomorphological and community metrics).

Significance of Findings: This project is unique because of the opportunity to strengthen and expand a county effort, because it is scientifically comprehensive (structural and functional responses evaluated at watershed-level scales before, during, and after urban development); replicated (multiple watersheds for each SWM design with multiple study reaches within each watershed); and controlled. Because the conversion of sediment-trapping devices to SWM structures has been slower than expected, much of the current data reflect the impacts of the construction phase on receiving streams (including dramatic responses by macroinvertebrate communities and channel morphology). Additionally, some of the results have indicated that "treatment" effects (i.e., SWM) are masked by larger local phenomenon such as local geology and potentially land use history. This study will have implications for the development and maintenance of SWM well beyond our region becasuse Maryland's SWM program is used as a model for many states and will provide feedback regarding the impacts of active development on stream ecosystems.

Future Prospects: Future work includes the continued monitoring of our five study watersheds as the conversions to SWM structures are completed and expanded to examine the interplay between larger preexisting regional scale conditions (geology, land use history, etc.) and SWM treatments.

Integrating Water Supply Management and Ecological Flow Water Requirements

Mark P. Smith[1], Colin Apse[1], Brian Joyce[2], Yongxuan Gao[3], Richard Vogel[3], Stacey Archfield[3], and Jack Sieber[2]

[1]The Nature Conservancy, New Paltz, NY; [2]Stockholm Environment Institute, Stockholm, Sweden; [3]Department of Civil and Environmental Engineering, Tufts University, Medford, MA

This research project provides an approach for defining "sustainable yield" for water supply reservoirs. We define the term "sustainable yield" for water supply reservoirs as "the amount of water that can be reliably supplied to meet human needs while meeting key downstream ecological flow requirements." This study builds on the growing literature regarding the relationship between storage, streamflow needs, and demand management to offer an approach for incorporating ecological flow requirements into water supply reservoir management operations. The trade-offs of different reservoir release policies were quantified on the water yield for human uses, the trade-off between different types of reservoir release policies and the ability to achieve different ecological objectives, and how the relative size of the reservoir affects these trade-offs. In addition, a series of modifications to these release policies were identified that improve the ability to maintain or restore certain key ecological flow components while maximizing the water available for human use. Finally, how the use of various drought management and demand management policies, in addition to the reservoir release policies, further maximize the ability of water resource managers to meet both human and ecological needs were quantified. By examining a spectrum of typical release and demand management policies, we are able to demonstrate that a "sustainable yield" for a water supply reservoir can be quantified, and that this yield is often 35 to 80 percent of the yield predicted by more traditional definitions of "safe yield" that include no ecological flow requirements.

Appendices

U.S. Environmental Protection Agency (EPA)
Collaborative Science and Technology Network for Sustainability (CNS) Workshop
Final Workshop for 2004 Grantees

November 8-9, 2007

Four Points by Sheraton
1201 K Street, NW
Washington, DC

AGENDA

Thursday, November 8, 2007

7:00 a.m. – 8:00 a.m. **Registration**

8:00 a.m. – 8:10 a.m. **Welcome - EPA's Sustainability Research Strategy**
Alan Hecht, Director for Sustainable Development, EPA, Office of Research and Development (ORD)

8:10 a.m. – 8:15 a.m. **Introduction to the Meeting**
Leanne Nurse, EPA, ORD, National Center for Environmental Research (NCER)

8:15 a.m. – 10:15 a.m. **CNS Project Presentations**

- Harnessing the Hydrologic Disturbance Regime: Sustaining Multiple Benefits in Large River Floodplans in the Pacific Northwest
  Stanley Gregory, Oregon State University
-
- Multi-Objective Decision Model for Urban Water Use: Planning for a Regional Water Reuse Ordinance
  Paul Anderson, Illinois Institute of Technology
- Sustainable Sandhills: A Plan for Regional Sustainability
  Susan Pulsipher, Sustainable Sandhills
- Sustainability of Land Use in Puerto Rico
  Juan Lara, Universidad Metropolitana
  Carlos Padin-Biblioni, Universidad Metropolitana
- Cuyahoga Sustainability Network
  Stuart Schwartz, University of Maryland–Baltimore County

10:15 a.m. – 10:30 a.m. **Break**

Thursday, November 8, 2007 (continued)

10:30 a.m. – 12:30 p.m. **CNS Project Presentations (continued)**

- Sustainable Watershed Management in the Delaware River Basin
  Charles App, Delaware River Basin Commission

- Moving Toward Sustainable Manufacturing Through Efficient Materials and Energy Use
  Terri Goldberg, Northeast Waste Management Officials' Association (NEWMOA)

- Bringing Global Thinking to Local Sustainability Efforts: A Collaborative Project for the Boston Metropolitan Region
  James Goldstein, Tellus Institute

12:30 p.m. – 2:00 p.m. **Lunch (on your own)**

2:00 p.m. – 5:00 p.m. **Program Meetings at EPA**

EPA program offices are hosting interactive conversations with CNS grantees and other federal, state, and local sustainability leaders.

Participants will report on action items from last year's CNS workshop. Grantees will briefly review their project findings and consider future actions that can support EPA's sustainability goals.

Session I: Sustainability, Water, and Ecological Services
EPA Host: Jamal Kadri, EPA, Office of Water
Location: EPA, ORD Offices, 1025 F Street, NW, Washington, DC, Room 3220 (Call-in Number: 1-866-299-3188, Code 2023439815#)

- Harnessing the Hydrologic Disturbance Regime: Sustaining Multiple Benefits in Large River Floodplains in the Pacific Northwest
  Stanley Gregory, Oregon State University

- Multi-Objective Decision Model for Urban Water Use: Planning for a Regional Water Reuse Ordinance
  Paul Anderson, Illinois Institute of Technology

- Integrating Water Supply Management and Ecological Flow Water Requirements
  Stacey Archfield, Tufts University

- Using Market Forces To Implement Sustainable Storm Water Management
  Dan Vizzini, City of Portland

Thursday, November 8, 2007 (continued)

Session I: Sustainability, Water, and Ecological Services (continued)

- Ecological Sustainability in Rapidly Urbanizing Watersheds: Evaluating Strategies Designed To Mitigate Impacts on Stream Ecosystems
  Laura Craig, University of Maryland
  Keith Van Ness, Montgomery County Department of Environmental Protection

- Sustainable Watershed Management in the Delaware River Basin
  Charles App, Delaware River Basin Commission

- Cuyahoga Sustainability Network
  Stuart Schwartz, University of Maryland–Baltimore County

- Integrating Water Supply Management and Ecological Flow Water Requirements
  Stacey Archfield, Tufts University

Session II: Geographic Information, Future Scenarios, and Land Development

EPA Host: John Thomas, EPA, Office of Policy, Economics and Innovation, Smart Growth Program

Location: EPA, ORD Offices, 1025 F Street, NW, Washington, DC, Room 3321 (Call-in Number: 1-866-299-3188, Code 2023439699#)

- Sustainable Sandhills: A Plan for Regional Sustainability
  Susan Pulsipher, Sustainable Sandhills

- Sustainability of Land Use in Puerto Rico
  Carlos Padin-Biblioni, Universidad Metropolitana
  Juan Lara, Universidad Metropolitana

Session III: Industrial Ecology and Lean Manufacturing

EPA Host: Mitch Kidwell, EPA, National Center for Environmental Innovation, Lean Manufacturing Team

Location: EPA West Building, 1301 Constitution Avenue, NW, Room 4119 (*Meeting onsite only;teleconferencing not available – notes will be posted on NCS site.)*

- Moving Toward Sustainable Manufacturing Through Efficient Materials and Energy Use
  Terri Goldberg, Northeast Waste Management Officials' Association (NEWMOA)

Thursday, November 8, 2007 (continued)

5:00 p.m. – 6:30 p.m.	**Dinner (on your own)**
6:30 p.m. – 8:00 p.m.	**Guest Speaker: George Hawkins, Director, District of Columbia Department of the Environment** "Sustainability and the Future of Distributed Environmental Decision Making" Discussion facilitated by Theresa Trainor, National Estuary Program Leader, EPA, Office of Water

Friday, November 9, 2007

8:00 a.m. – 8:15 a.m.	**Welcome** *Leanne Nurse, EPA, ORD, NCER*
8:15 a.m. – 9:45 a.m.	**Panel 1: Water Resource Protection** *Audrey Levine, EPA, ORD, National Program Manager, Drinking Water* *Bonnie Thie, EPA, Office of Water, Policy, Communications and Resource Management* *Stuart Schwartz, University of Maryland–Baltimore County (CNS Grantee – Cuyahoga Sustainability Network)*
9:45 a.m. – 11:15 a.m.	**Panel 2: Clean Energy and Climate Change** *Robert Ritter, U.S. Department of Transportation, Federal Highway Administration, Planning Capacity Building Team* *Graham Pugh, U.S. Department of Energy, Office of Policy and International Affairs, Climate Change, Policy and Technology* *Hannah Campbell, U.S. Department of Commerce, NOAA Climate Program Office* *Sherri Hunt, EPA, ORD, NCER*
11:15 a.m. – 11:30 a.m.	**Break**

Friday, November 9, 2007 (continued)

11:30 a.m. – 1:00 p.m. **CNS Project Presentations (continued)**

- Integrating Water Supply Management and Ecological Flow Water Requirements
  Stacey Archfield, Tufts University
  Richard Vogel, Tufts University

- Using Market Forces To Implement Sustainable Storm Water Management
  Dan Vizzini, City of Portland

- Ecological Sustainability in Rapidly Urbanizing Watersheds: Evaluating Strategies Designed To Mitigate Impacts on Stream Ecosystems
  Laura Craig, University of Maryland
  Keith VanNess, Montgomery County Department of Environmental Protection

1:00 p.m. – 3:00 p.m. **Group Lunch/Networking (individually paid)**
Ristorante Luigino, 1100 New York Avenue, NW, Washington, DC
(202) 371-0595

3:00 p.m. **Adjournment**

U.S. Environmental Protection Agency
Collaborative Science and Technology Network for Sustainability Workshop

November 8–9, 2007

Four Points by Sheraton
1201 K Street, NW
Washington, DC

PARTICIPANTS LIST

John Abraham
U.S. Environmental Protection Agency

Paul Anderson
Illinois Institute of Technology

Charles App
U.S. Environmental Protection Agency

Stacey Archfield
Tufts University

Diana Bauer
U.S. Environmental Protection Agency

Hannah Campbell
U.S. Department of Commerce

Russell Conklin
U.S. Department of Energy

Tina Maragousis Conley
U.S. Environmental Protection Agency

Laura Craig
University of Maryland

Terri Goldberg
Northeast Waste Management Officials' Association

James Goldstein
Tellus Institute

Stanley Gregory
Oregon State University

David Guest
U.S. Environmental Protection Agency

Sally Gutierrez
U.S. Environmental Protection Agency

George Hawkins
District of Columbia Department of the Environment

Alan Hecht
U.S. Environmental Protection Agency

Sherri Hunt
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Maria Juncos-Gautier
Universidad Metropolitana

Jamal Kadri
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Juan Lara
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Audrey Levine
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Leanne Nurse
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Carlos Padin-Bibiloni
Universidad Metropolitana

Graham Pugh
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Susan Pulsipher
North Carolina Department of Commerce

April Richards
U.S. Environmental Protection Agency

Robert Ritter
U.S. Department of Transportation

Ellen Rubin
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Christopher Saint
U.S. Environmental Protection Agency

Adam Sarvana
Inside Washington Publishers

Stuart Schwartz
University of Maryland Baltimore County

Anne Sergeant
U.S. Environmental Protection Agency

Bernice Smith
U.S. Environmental Protection Agency

Greg Susanke
U.S. Environmental Protection Agency

Bonnie Thie
U.S. Environmental Protection Agency

John Thomas
U.S. Environmental Protection Agency

Keith Van Ness
Montgomery County Government, Maryland

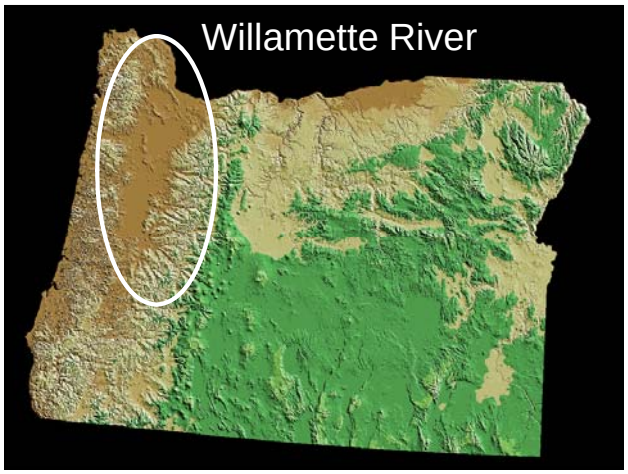
Contractor Support
Maria Smith
The Scientific Consulting Group, Inc.

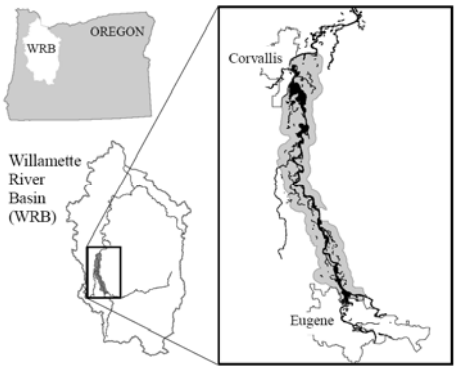
Mary Spock
The Scientific Consulting Group, Inc.

Harnessing the hydrologic disturbance regime: Sustaining multiple benefits in large river floodplains in the Pacific Northwest

Dr. Stan Gregory, Oregon State University
Prof. Dave Hulse, University of Oregon
Dr. Roy Haggerty, Oregon State University

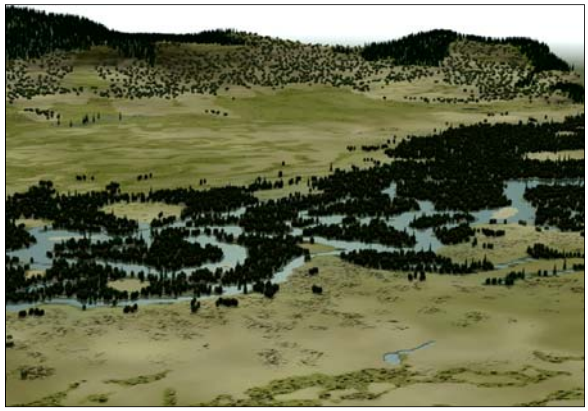
This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program
Grant # X3-83220501-0





Baker et al. 2004 Ecological Applications

1995



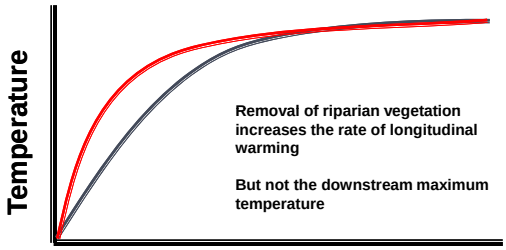
Baker et al. 2004 Ecological Applications

1850

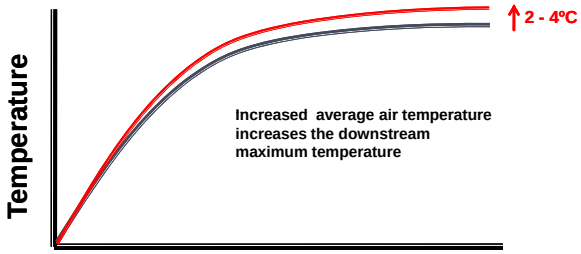
Climate Changes in Pacific Northwest

- Warmer climate
- Decreased summer precipitation
- Changes in temperature appear more certain than changes in precipitation.

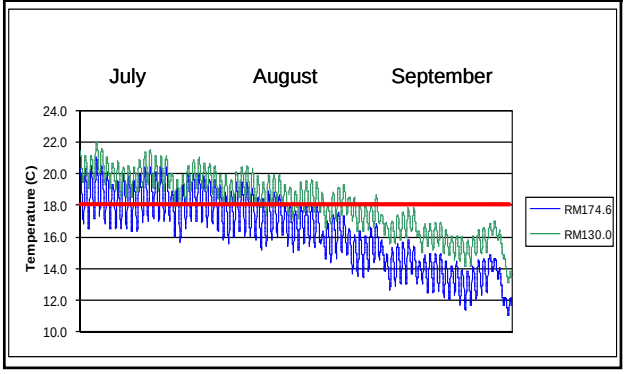
Longitudinal Warming



Longitudinal Warming

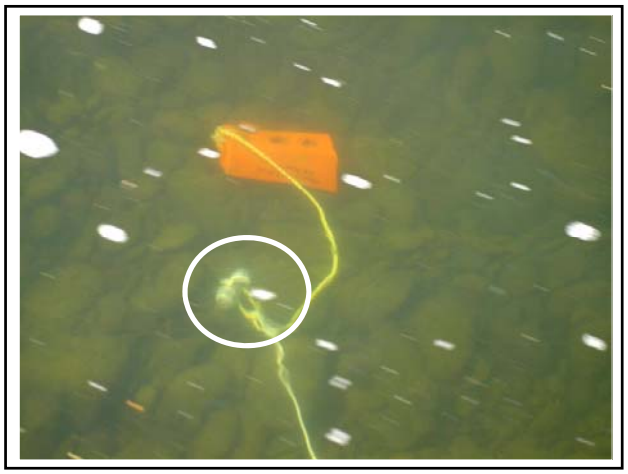


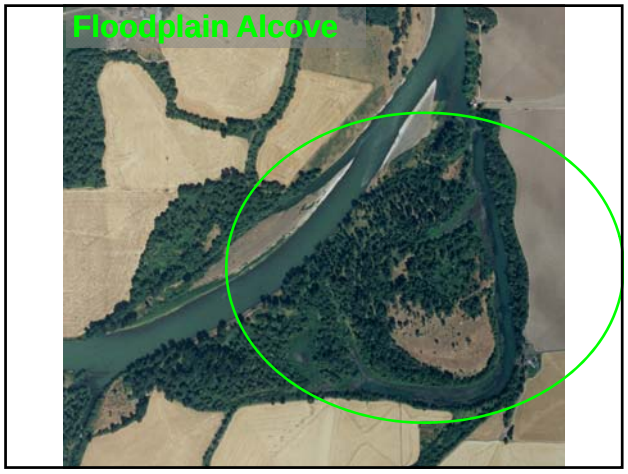
Longitudinal Profile



Approaches being considered to meet TMDL requirements:

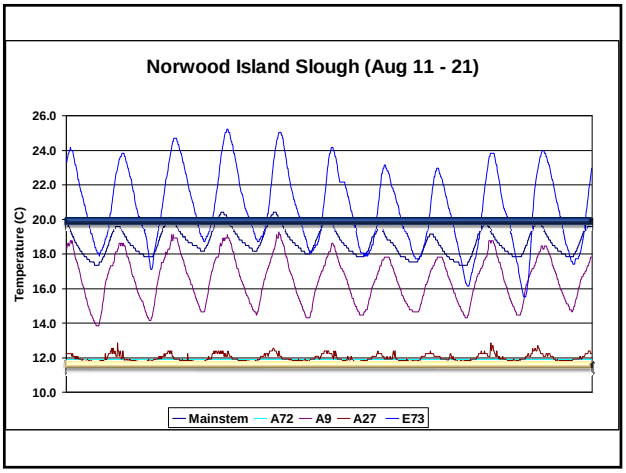
- Refrigeration ..... higher certainty
- Shade ..... ●
- Flow augmentation ..... ●
- Floodplain restoration ..... greater benefits




Floodplain Alcove


Bar Alcove

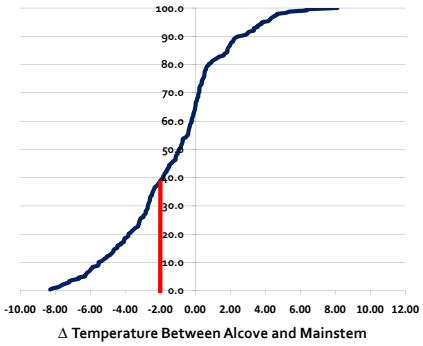

Side Channel



Floodplain Alcoves

65% of sites colder than mainstem

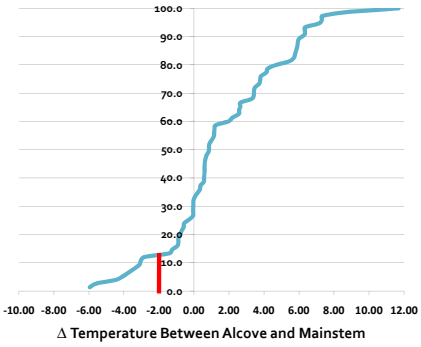
39% more than 2°C colder than mainstem



Alcoves on Gravel Bars

27% of sites colder than mainstem

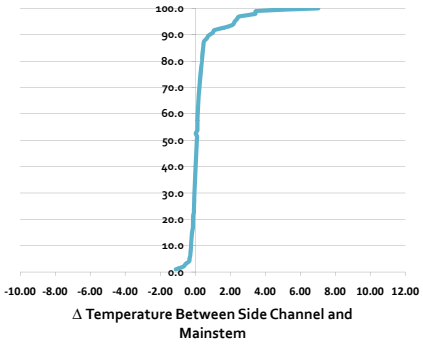
13% more than 2°C colder than mainstem



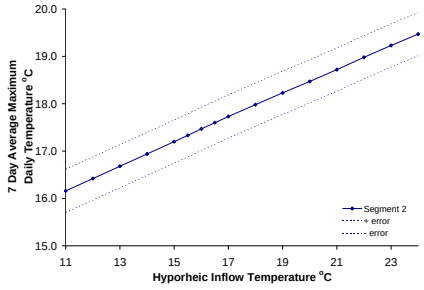
Side Channels

25% of side channel sites were colder than mainstem

None of the side channels were >2°C colder than mainstem

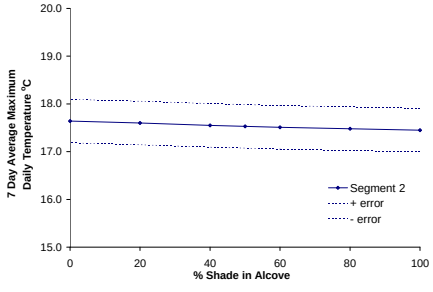


Influence of Hyporheic Inflow on Temperature

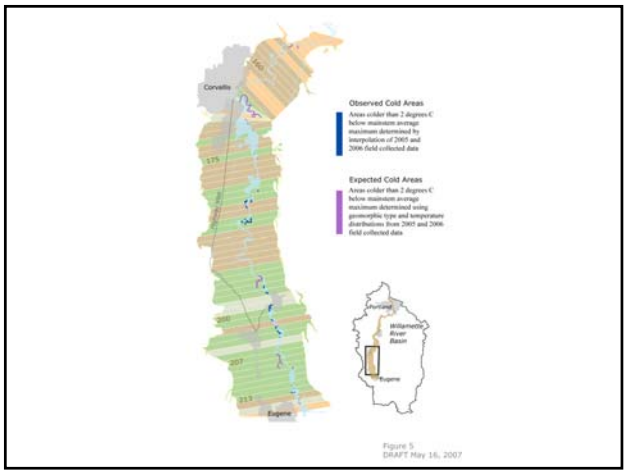


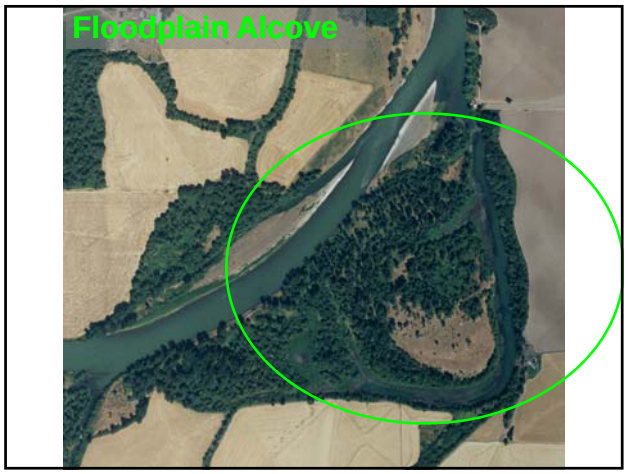
Changes in 7 Day Average Maximum Daily Temperatures in a small alcove for range of possible hyporheic inflow temperatures

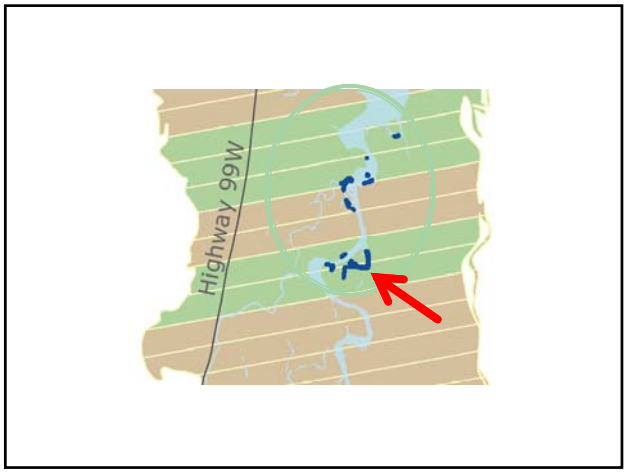
Influence of Shade on Temperature

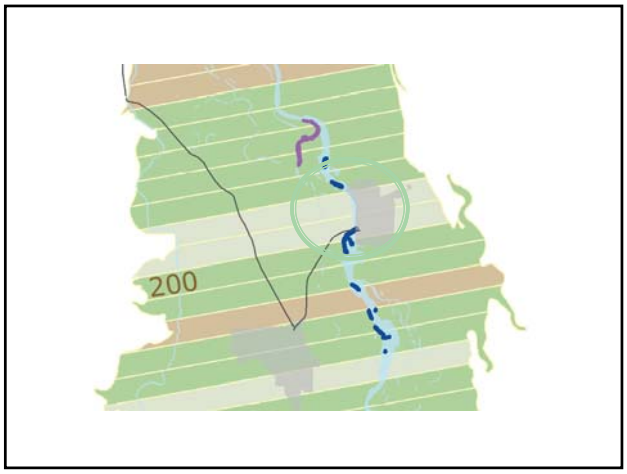


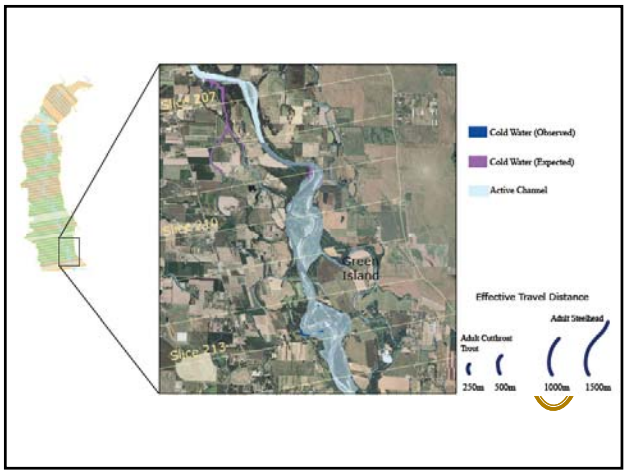
Changes in 7 Day Average Maximum Daily Temperatures in a small alcove for range of possible shade cover


Observed Cold Areas
Expected Cold Areas
Corvallis
Portland
Willamette River Basin
Eugene
Figure 5
DRAFT May 16, 2007

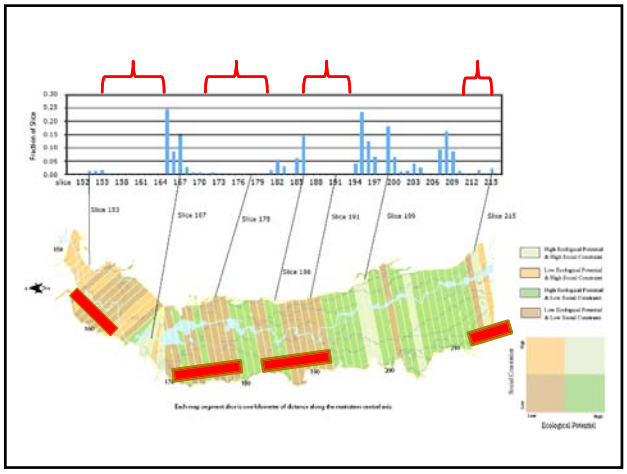

Floodplain Alcove

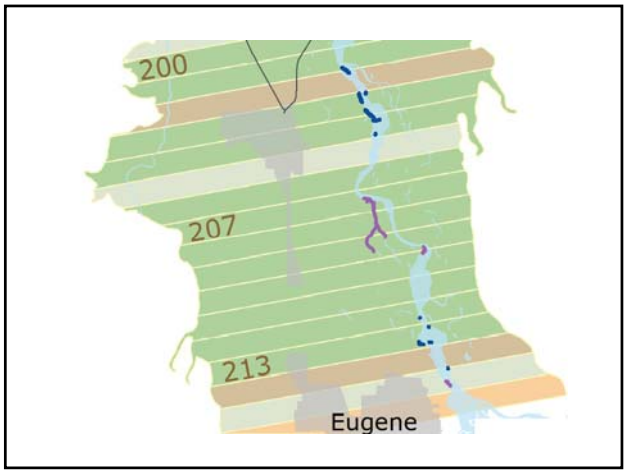

Highway 99W


200


Cold Water (Observed)
Cold Water (Expected)
Active Channel
Green Island
Slice 213
Effective Travel Distance
Adult Steelhead
Adult Cutthroat Trout
250m
500m
1000m
1500m


Highway 99W




200
207
213
Eugene


Green Island

Assessment Tools for Past, Present, and Future Ecological Trajectories

- Dynamic visualizations of trajectories of ecological change and demonstration of hyporheic processes
- Prioritization system for river conservation and restoration

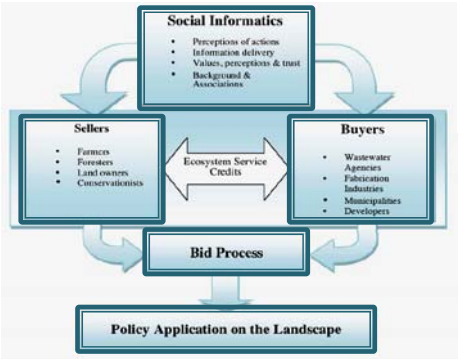
Assessment Tools for Past, Present, and Future Ecological Trajectories

- Assessment of thermal patterns and strategies for restoration of cold water refuges
- Development of an ecological credit trading system

Trading Credits in Willamette Exchange

- Thermal credits
- Wetlands credits
- Carbon credits

Market-Based Trading System



Future Directions

- Oregon Watershed Enhancement Board has funded a 3-yr study of fish use of cold water refuges to determine whether the restoration of cold water habitats would have a positive effect on designated beneficial uses under the Clean Water Act.

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program
Grant # X3-83220501-0

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Grant # X3-83220501-0

Future Directions

- Measure composition of fish assemblages in habitats colder and warmer than mainstem river
- Implant temperature loggers and radios in cold water species

- Determine movement rates between cold water refuges

Credit Trading Sequence Willamette Partnership

- Technical assistance provided by cooperators
  - Agencies, NGOs, Extension agents
- Evaluate site potential
- Plan restoration actions
- Identify regulatory requirements
- Register credits with Willamette Exchange
- Sell to credit buyer or aggregators
- Seller tracks and reports performance

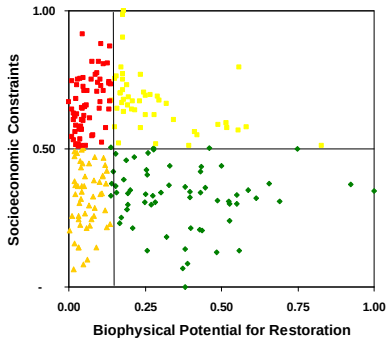
Application of Research

- Willamette Explorer Website for public, watershed councils, and students
- Conservation and restoration opportunities template adopted by state of Oregon
- Southern Willamette basin communities developed Region 2050 Plan for water resources based on alternative futures

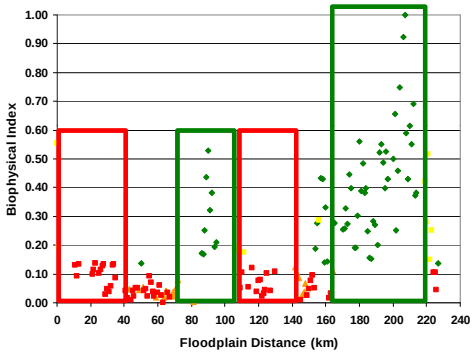
Application of Research

- Green Island Restoration Project incorporates research and concepts in designing and monitoring restoration
- Willamette Exchange credit trading system based on thermal research
- Oregon Sustainability Investments Program will use Willamette River prioritization approach to locate and design major restoration efforts

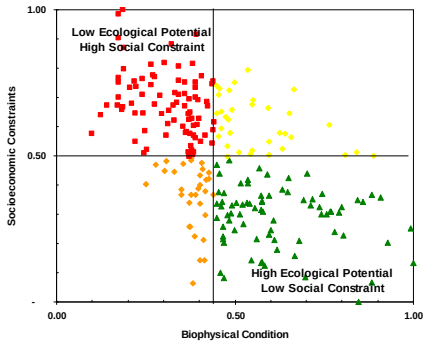
Restoration Priorities



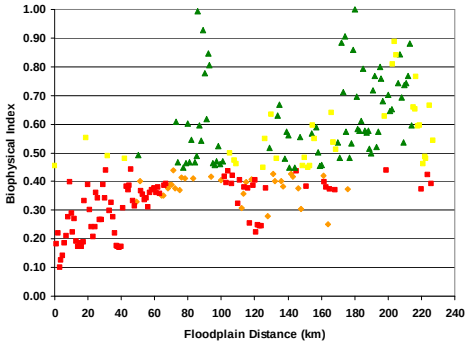
Restoration Priorities



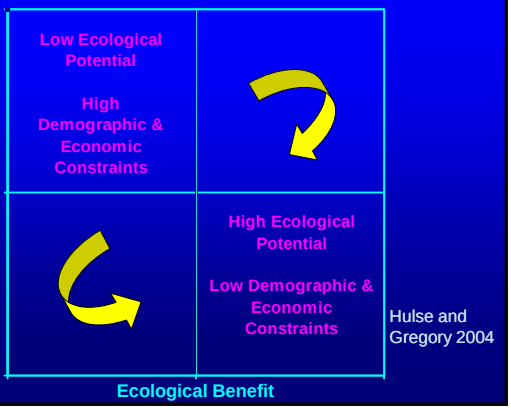
Conservation Priorities



Conservation Priorities

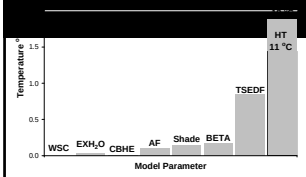


Relative Potential for Restoration

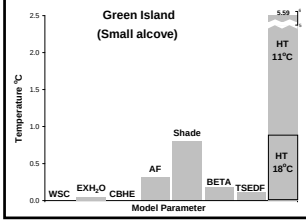


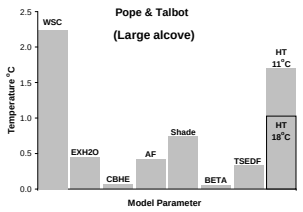
Hulse and Gregory 2004

Max ΔT_{max}



EXH2O=Light Extinction from Water
CBHE=Coefficient of Bottom Heat Exchange
AF=Alcove Flux
Shade=Topographic and Vegetative Shading
BETA=Solar Radiation Absorbed at Surface
TSEDF=Sediment Reflection of Solar Radiation





Conclusions

- Alcove size and flux largely determines meteorological impact
  - Large alcoves more affected by meteorological conditions (shade, wind, etc.) because of large surface area and long residence times
  - Small alcoves more affected by advection and residence time (and therefore by hyporheic processes) because of small surface area and short residence times

Conclusions – Small Alcoves

- Hyporheic temperature (or the temperature of any subsurface inflow) is the main driver of small alcove temperature
- Lag time of hyporheic flow determines its temperature
  - Lag time of hours to days can produce water that is out of phase with mainstem but with the same avg. temperature
  - Lag time of months or longer will have lower avg. temp than mainstem. However, long lag times are also associated with low hydraulic conductivity and therefore low total flow.

Conclusion – Restoration

- Features conducive to subsurface flow (i.e., gravel bars) must be continuously formed and maintained
- This process is impaired by altered flow regimes and bank hardening

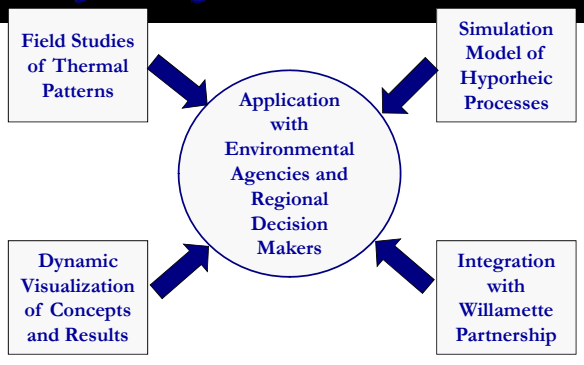
Contribution to Sustainability

- Provides the scientific basis for meeting thermal TMDL goals by restoring coldwater refuges in a large river through a market-based collaborative system.
  - Identifies locations of coldwater refuges
  - Models hyporheic influence on temperature
  - Creates dynamic visualization of complex information for stakeholders
  - Provides spatial framework for decision makers
  - Works directly with stakeholders and environmental agencies to solve environmental challenges

Contribution to Sustainability

- Restoration projects that have been initiated by this research will provide multiple ecosystem services:
  - Cold water
  - Nutrient uptake
  - Floodplain function
  - Riparian forest restoration
  - Channel and habitat complexity
  - Wildlife habitat
  - Recreation and aesthetic values for communities

Project Organization



Surprising Results

- Coldwater refuges (3-8˚C lower than mainstem) were found in all study reaches.
- Alcoves on floodplains exhibited the coldest thermal environments.
- Alcoves on gravel bars exhibited temperature both colder and warmer than the mainstem.
- State environmental agencies have officially accepted floodplain restoration to create coldwater habitats as part of TMDL permits.
- Willamette Partnership used the project results and dynamic visualizations to develop a market-based system for restoration of the Willamette River corridor.

Collaborators and Partners

- **Oregon State University**
- **University of Oregon**
- **Willamette Partnership**
- **EPA Corvallis NHEERL, Western Ecology Division**
- **Oregon Department of Environmental Quality**
- **Metropolitan Wastewater Management Commission**
- **City of Eugene, Oregon**
- **McKenzie River Trust**
- **Oregon Department of Fisheries & Wildlife**
- **US Department of Agriculture**
- **US Fish & Wildlife Service**
- **National Marine Fisheries Service**

Water reuse: An integral part of sustainable water resource planning

Collaborative Science and Technology Network for Sustainability Workshop

November, 2007

Acknowledgments

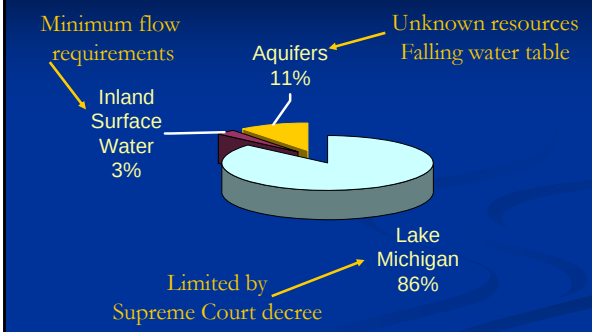
- Partners
  - Illinois Institute of Technology
  - Illinois Waste Management and Research Center
  - Chicago Metropolitan Agency for Planning
- Sponsor
  - US EPA Science to Achieve Results Program
- Work conducted by
  - Yi Meng
  - Shihui Luo
  - Feng Huang

Decision support for sustainable growth

What do decision-makers need to know?

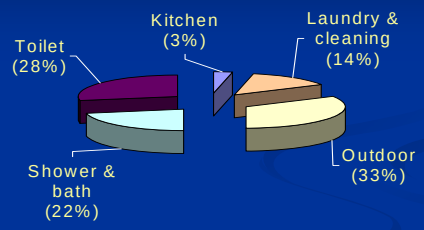
- Demonstrate need for efficient water use
- Water reuse education
- Identify potential barriers and incentives
- Provide tool for economic assessment

NE Illinois: Limited water sources



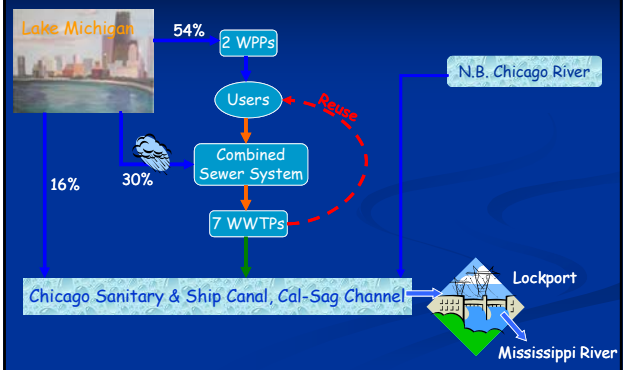
Northeastern Illinois regional non-cooling water source allocation (NIPC, 2001)

We don't use water very efficiently

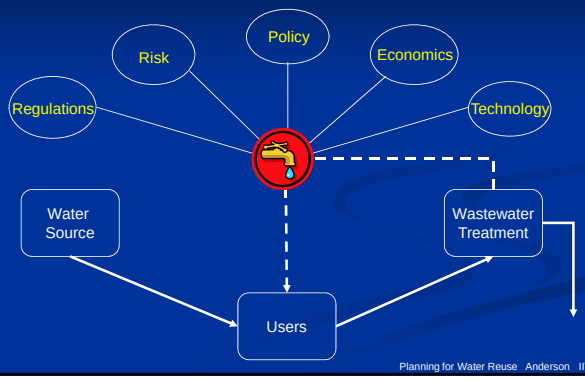


Domestic water use (USEPA, 2006)

The Illinois Diversion



Water reuse: Barriers & Incentives



Water reuse regulations

- Federal
  - There are no water reuse regulations
  - *Guidelines for Water Reuse* (USEPA, 2004)
- States (2004 data)
  - 25 states have regulations
  - 16 states have guidelines
  - 9 states without regulations or guidelines

Illinois reuse regulations

- State level
  - IEPA (land application)
  - Dept. of Public Health (cross-connections)
- Regional (CMAP)
  - "…recommended alternative is to evaluate a no-discharge system, such as land application."
- Municipal
  - Chicago's Water Agenda 2003
  - Village of Richmond Reuse Ordinance

Water reuse risks

- Human health risks
  - Pathogenic organisms
    Bacteria, viruses, protozoa
  - Chemical contaminants of concern
    - Pharmaceuticals
    - Pesticides, herbicides
    - Disinfection by-products
- Ecosystem risks
  - Chemical contaminants of concern
  - Nutrients

"…there have not been any confirmed cases of infectious disease resulting from the use of properly treated reclaimed water in the U.S."
USEPA (2004)

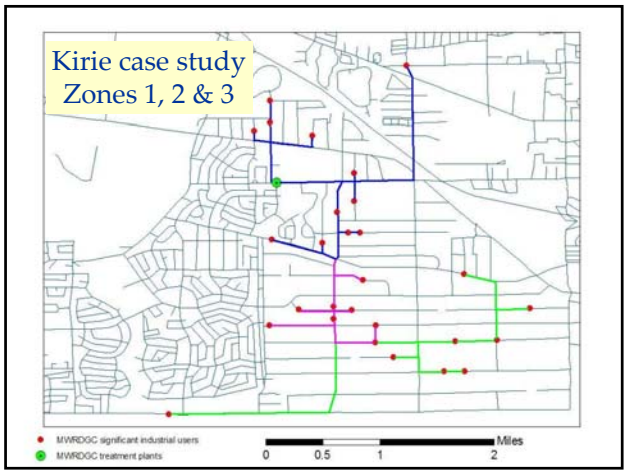
- Are there unconfirmed cases?
- What about non-infectious disease?
- How long does it take to see effects?
- What about ecosystem risks?
- What about incidental reuse?

Water reuse policy

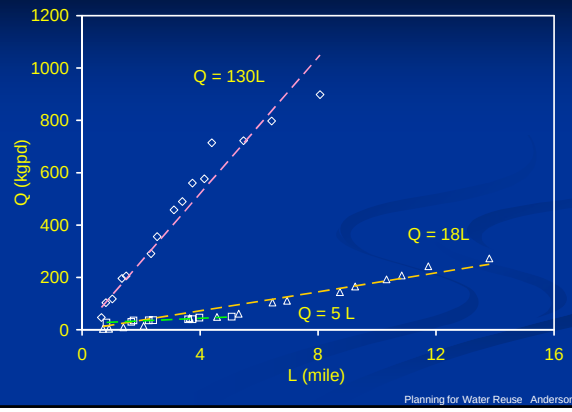
- IL Executive Order 2006-1
  - Governor orders water supply study
- The mission statement
  - "To consider the future water supply needs of northeastern Illinois and develop plans and programs to guide future use that provide adequate and affordable water for all users, including support for economic development, agriculture and the protection of our natural ecosystems."

Water reuse economics

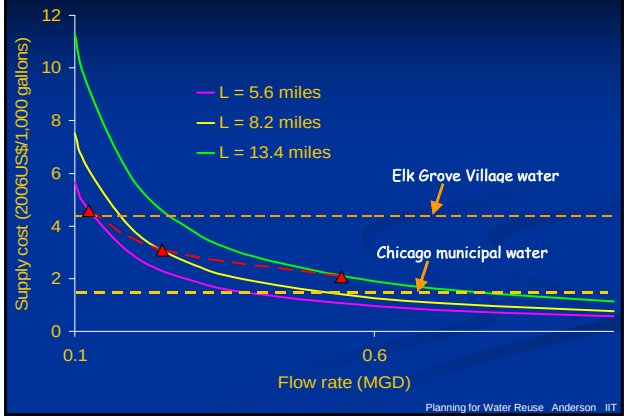
- Objective:
  - Minimize cost
- Constraints:
  - Demand
  - Mass balance
  - Capacity
  - Water withdrawal
  - Water quality



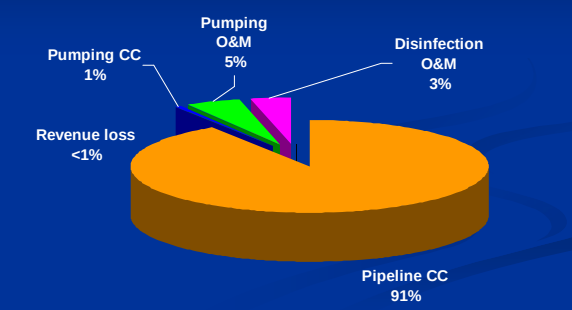
User clusters determine demand



Cost depends on volume & distance



Pipeline costs dominate



Surprises

- Water use data are limited
  - Quantity and quality
- Chicago is different
  - Water is cheap
  - WRD is revenue-neutral
- System inertia
  - Change is hard

Feedback and response

- Feedback
  - Chicago is an unusual case study
- Response
  - Partnership in Aurora, IL
  - Rationale
    - Rapid growth in western suburbs
    - Recent drought and watering restrictions
    - Limited water sources

Collaborative efforts

- Regional Water Supply Planning Group
  - NE Illinois water resources planning
  - Facilitated by CMAP
- Reuse workshops
  - Commerce & industry
  - Golf course & park district irrigation
  - Facilitated by ILWMRC

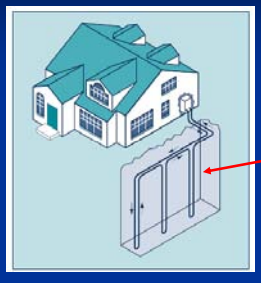
Future efforts

- CMAP's regional planning tool
  - Identify potential reuse sites
- Great Lakes regional water reuse
  - Growth in SE Wisconsin
- Can we get more value from water?

Geothermal heat pumps

- "…the most energy efficient, environmentally clean, and cost-effective space conditioning systems available." (USEPA, 1993)
- Benefits (USDOE, 1998):
  - Less energy consumption
  - Lower operating costs
  - Reduced carbon emissions

Domestic geothermal heat pump

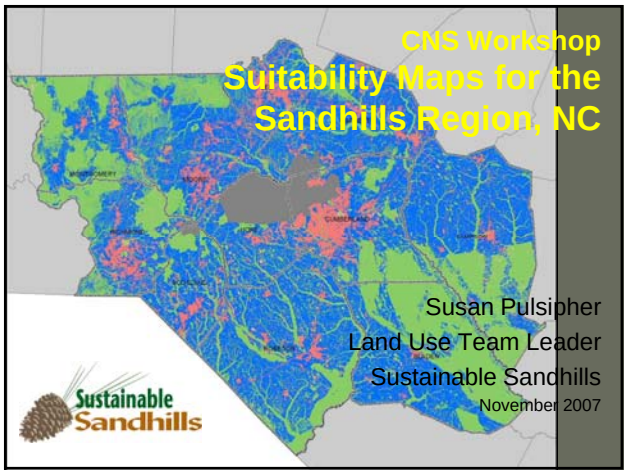


Ground loop represents about 60% of initial costs

USDOE (1998)

Dual-purpose distribution system

- Integrated infrastructure
  - Non-potable water supply
  - Ground loop for heat pump system
- Issues
  - Economics
  - Regulations
  - Technology
  - Risk
  - Policy



CNS Workshop

Suitability Maps for the Sandhills Region, NC

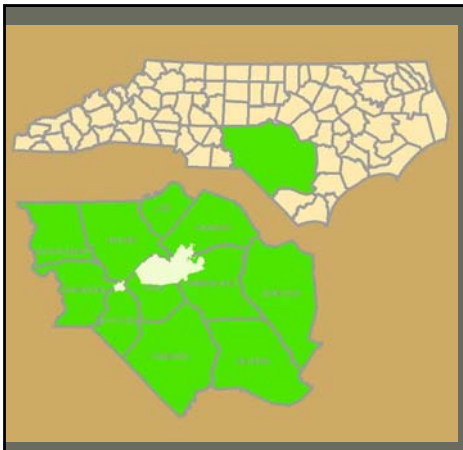
Susan Pulsipher
Land Use Team Leader
Sustainable Sandhills
November 2007

Presentation Outline

- Who are we?
-
-
-
-
-

Sustainable Sandhills promotes consensus, cooperation, shared visions and collaborative actions.

Sustainable Sandhills is a model for regional sustainability planning that preserves natural resources and enhances economic development, improving the quality of life in the region for current and future generations.



North Carolina counties in project

Bladen
Cumberland
Harnett
Hoke
Lee
Montgomery
Moore
Richmond
Robeson
Sampson
Scotland

CORE TEAM

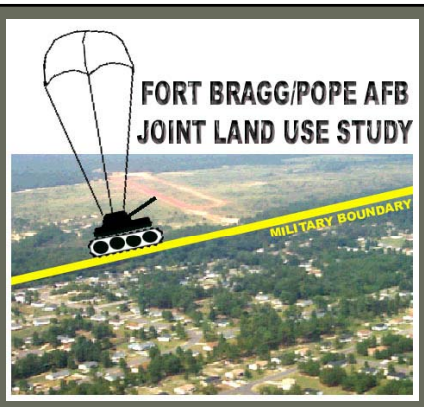
- Jon Parsons, Sustainable Sandhills
- Jeff Brown, CGIA
- Susan Pulsipher, DCA
- Pete Campbell, US F&WS

List of all participants on Sustainable Sandhills website
http://www.sustainablesandhills.org/

Participants

- Land Use Team, Sustainable Sandhills (volunteers from many agencies)
- Concerned citizens
- Local jurisdiction officials and staff
- Experts on suitability factors for different landscapes

-
- What is the problem?
-
-
-
-

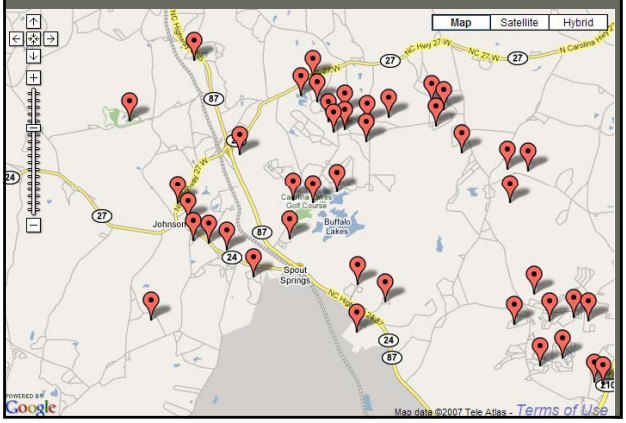


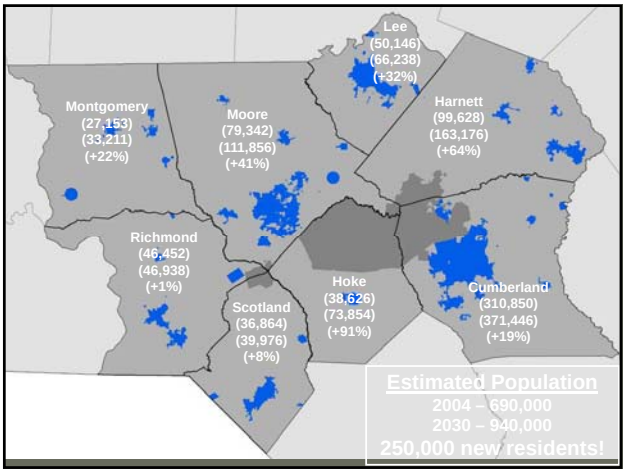
RLUAC lead agency on JLUS

No longer able to drop tanks from planes on this drop zone.

Houses are too close.

Subdivision sprawl – just north of base





Base Realignment & Closure

- Relocation of Forces Command (FORSCOM) & U S Army Reserve Command (USARCOM) to Fort Bragg
  - Military, DoD civilians, family members, defense contractors
  - Older military personnel, already have degrees
  - 25,000 plus people
- Additions to regular troops

BRAC-RTF lead agency on military realignment effects

Sustainability in the Sandhills

- Sustaining Fort Bragg as a viable military installation
  - Also important to economic health of surrounding communities
- Sustaining the local ecosystem so that people continue to enjoy living here
- Managing population and economic growth to sustain (and improve) existing environment

- Solutions

Industrial Development
Uwharrie Lumber, Troy

What Are Land Suitability Maps?

- Suitable = potential to have sustainable value for a type of use
- Based on criteria
- Relative values / low to high
- All locations rated

What Are Land Suitability Maps?

- Not current land use
- Not predicting land use
- Suitability for different uses
- Competing values

- Best available data
- Simple and transparent models

Sandhills Objectives

- Best available data
- Simple and transparent models
- Relative values now
- Alternative futures next
- Maps and statistics
- Tools for supporting decisions

Criteria for Suitability

- Framework (previous projects)
- Workshops and score cards
  - What makes an area suitable?
  - How do we represent it on a map?
  - Relative importance?
- Focus groups
  - How near is near?
  - Ratings 1 to 9

Suitability models

⇐ Commercial
Working Forest ⇒

⇐ Residential
Farm land ⇒

⇐ Industrial
Natural Values ⇒

Meeting needs

Created a set of tools that

- Graphically illustrate the competing potential uses of land from a variety of viewpoints
- give developers and planners a way to assess a lot of factors quickly before spending a lot of time and money on a piece of land or project
- Can be used in public hearings to inform the public of relationships and possibilities
- Provide elected officials, developers & planners with the same set of base data to work from when assessing how land is best utilized for the well-being of a community and region

Project timeline

Refresh GIS Data, Rerun Models

Gather Feedback, Revise Models

Distribute Other Stakeholders

Review with other Stakeholders

Oct Dec 2007 Deliver Grids to Planners, Training

Sept 2007 Regional Planners Meeting

Sept 2007 GIS Models Revised

Feb to June 2007 Expert Focus Groups

Jan 2007 Suitability Models Complete

May to Oct 2006 Stakeholder meetings

Sept 2005 Kickoff Meeting

Aug 2005 EPA Grant Awarded

- Technical side

Industrial Development
Uwharrie Lumber, Troy

Some of the data layers used

	Industrial	Commercial	Residential	Natural Areas	Farm Lands	Working Forest
City limits	A	A	A	C	C	C
Parcel size	A	A	A			
Value land				C	C	C
Primary roads	A	A	A	C	C	C
Active rail	A					
Wetlands	C	C	C	A		
Public sewer	A	A	A	C	C	C
Woodland soils						A
School rating			A			
100 yr flood	C	C	C			

A ASSET C = CONSTRAINT

Modeling process

- Data – obtained & merged
- Criteria buffers created from feature classes
- Converted to grid on 30-meter cell size
- Used ModelBuilder for as much of data preparation and manipulation as possible
- Map algebra

Constructing a suitability map

- Industrial
- Commercial
- Residential
- Natural areas
- Working farmland
- Working forests

Commercial Development
Downtown Rockingham

Rule-Based Criteria

- Markets and infrastructure (satisfying all four is highest rating)
  - Near urban density and higher income
  - Near primary road
  - In or near public water service area
  - In or near public sewer service area

Rule-Based Criteria

- Land constraints (any one of four lowers the rating)
  - Steep slope
  - In floodplain
  - Soils are wet (hydric)
  - In wetlands

Rule-Based Criteria

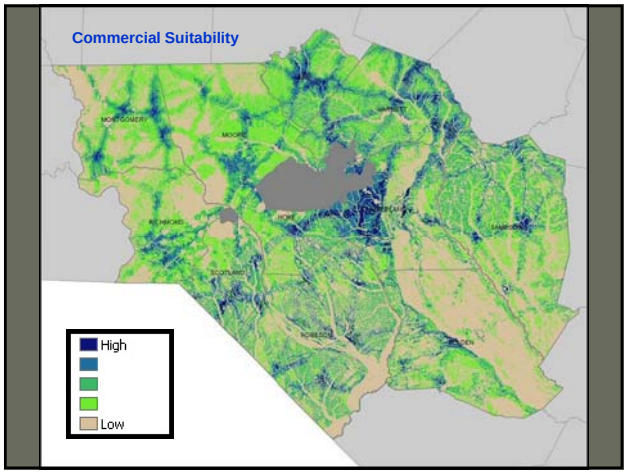
- Out of bounds for development (not counted in map results)
  - Conservation lands
  - Water supply watershed critical and protected areas
  - In large water bodies
  - Inside military installations

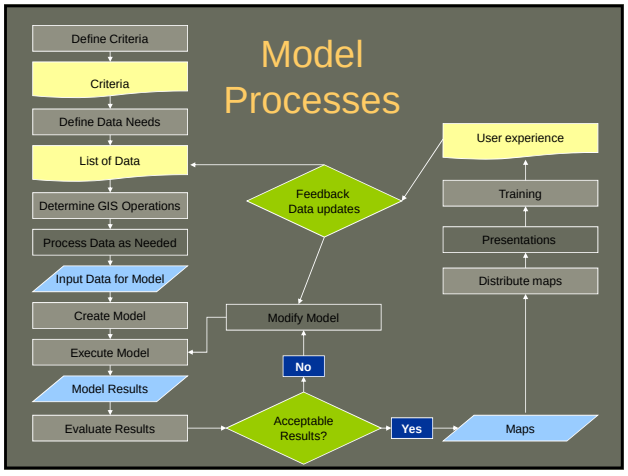
Layer values or location related to ratings Commercial

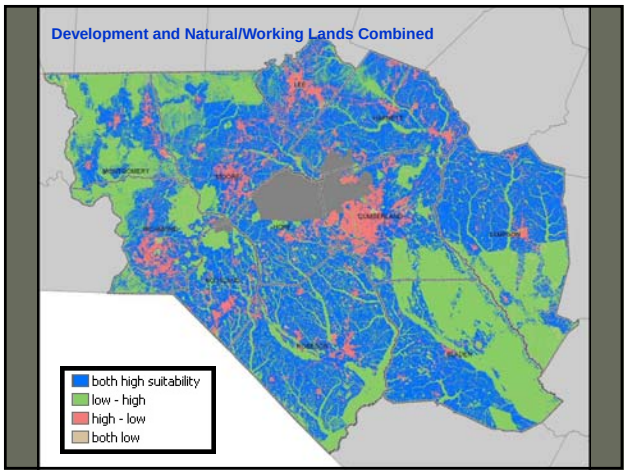
	A	C	D	E	F	G	H	I	J	K
1	Commercial Development					——Criteria and Rating——				
2		Lowest Value				Neutral				Highest Value
3	Markets and infrastructure -- Group 1	1	2	3	4	5	6	7	8	9
4	Population density	rural-lower-income	rural-mid-income	rural-upper-income		transition-lower-income	urban-lower-income	transition-mid-income	urban-mid-income and transition upper	urban-upper income
5	Primary roads		<5000 ft			4000- 5000 ft	3000-4000 ft	2000-3000 ft	1000-2000 ft	< 1000 ft
6	Public sewer service			>4000 ft		3000-4000 ft		2000-3000 ft	1000-2000 ft	<1000 ft
7	Public water service			> 5000 ft		4000- 5000 ft	3000-4000 ft	2000-3000 ft	1000-2000 ft	<1000 ft
8	Total Group 1									
14		Lowest Value				Neutral				Highest Value
15	Land factors -- Group 3	1	2	3	4	5	6	7	8	9
16	Slope (percent)	>25%				15-25%		10-15%	4-10%	<4%
17	Soils (hydric)			hydric A				hydric B		not hydric
18	Floodzone 100 year	100-yr		future 100-yr				500-year		outside zone
19	Wetlands			inside						outside

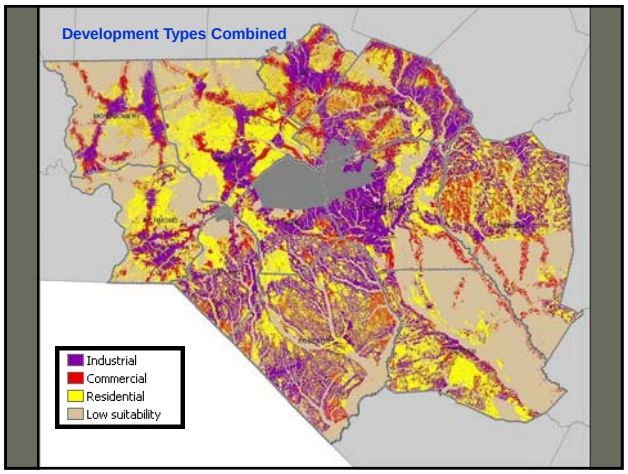
Operations to combine the Commercial layers; assumptions noted

	A	C	D	E	F	G
1	Commercial Development		--Relative Weights--			
2			Workshop Score	Assigned Weight	Percent Weight	Comments
3	Markets and infrastructure -- Group 1	Operation	1 to 5	1 to 5		
4	Population density	Group 1 Overlay	4.1	8	27.6	Population density by block (3 classes) and median household income (3 quantiles) by block group (Census 2000) were grouped to represent market areas.
5	Primary roads	Group 1 Overlay	4.3	8	27.6	Assume cost advantages for projects closer to US and NC highways. Distances based in part on analysis of distance to nearest primary road using point locations of businesses in the Sandhills.
6	Public sewer service	Group 1 Overlay	4.5	4	22.2	Assume cost advantages for projects within or near public wastewater service areas
7	Public water service	Group 1 Overlay	4.5	4	22.2	Assume cost advantages for projects within or near public water service areas.
8	Total Group 1			18	100.0	
14			Workshop Score	Assigned Weight	Percent Weight	
15	Land factors -- Group 3		1 to 5	1 to 5		
16	Slope (percent)	Map Algebra A (minimum of group)	3.3			Assume cost advantages for gentle slopes and constraints on steep slopes
17	Soils (hydric)	Map Algebra A	3.7			Wet (hydric) soils are less suitable for development
18	Floodzone 100 year	Map Algebra A	4.0			Floodzones are less suitable for development or would be a cost disadvantage
19	Wetlands	Map Algebra A	4.3			Wetlands are problematic for commercial development
20	Lands managed for conservation & open space			0		Out of bounds for development
21	Water supply watershed critical protection area			0		Rules restrict development
22	Lakes and ponds			0		Water out of bounds for development
23	Military bases			0		Long-term public ownership and restricted use









Feedback

- Modeling process designed to obtain feedback which was immediately used to modify models
- Model design steps, documentation, and presentation methods monitored and altered by members of Sustainable Sandhills Land Use Team
- Beta version distributed to two planners for detailed analysis against local knowledge. Feedback incorporated into models and documentation
- Workshop with regional planners designed to obtain feedback. Feedback incorporated into data utilized for creation of Release 1; into release schedule and approach with different stakeholder groups

Surprising Results / Lessons

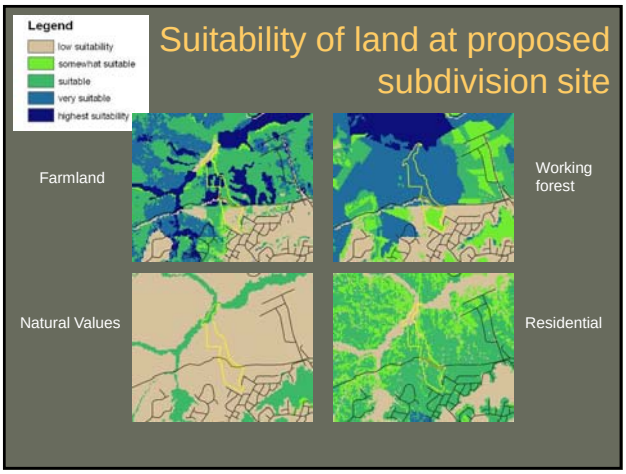
- Enthusiasm of representatives from different stakeholder groups
- Frustration of local data holders and regional transportation planners with GIS-based state level transportation data; people KNOW their local road systems
- Delight when first planner to use maps tried the maps on projects on her desk and the information was relevant and informative

- Application examples

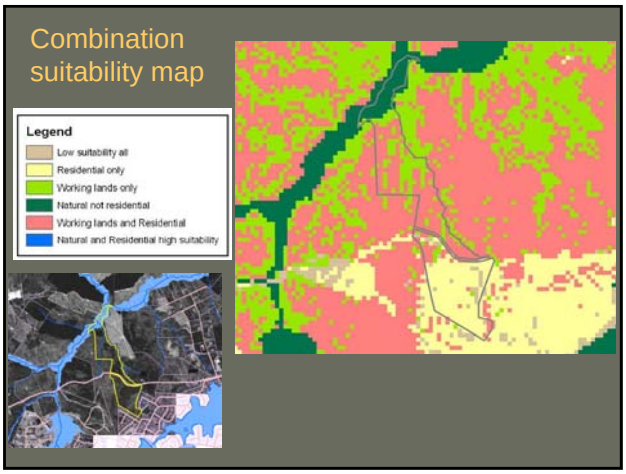
Industrial Development
Goodyear Plant – Fayetteville

Example 1 – subdivision proposal

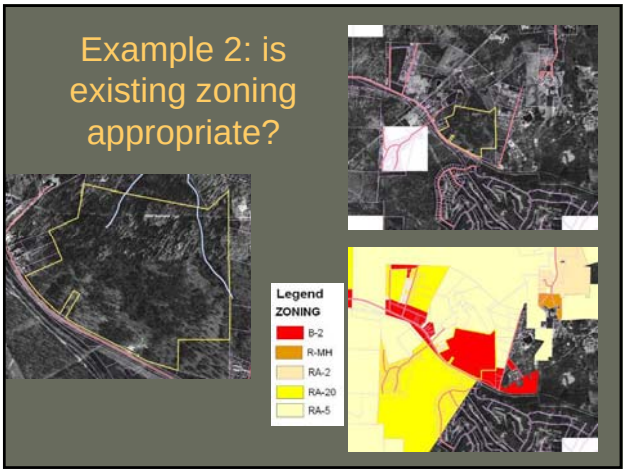
Suitability of land at proposed subdivision site

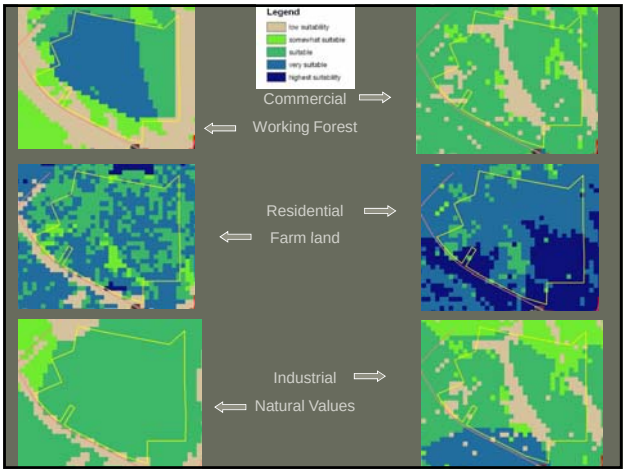


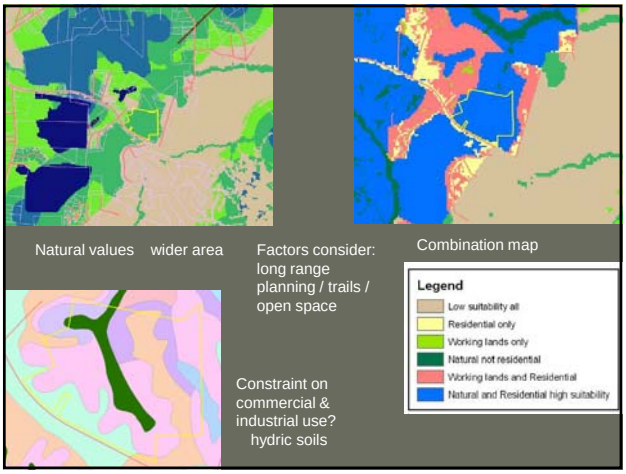
Combination suitability map



Example 2: is existing zoning appropriate?







SUSTAINABLE SANDHILLS EPA GRANT PROJECT

Lead organization on this regional land use planning project.

RESULTS WILL BE: used in 2008 JLUS update (5 mile study area)

RESULTS WILL BE: incorporated into Comprehensive Regional Growth Plan

Additions to project

- From BRAC-RTF
  - Added data for 3 new counties
  - Predictive modeling
  - New data layers for Release 2 (under review)
- From NC DOT
  - cultural data
  - Revise models for Release 2

Collaboration

- Development of suitability models involved many individuals from different stakeholder groups
- Feedback on beta version obtained from planners at workshop in September; Release 1 run
- Now distributing grid maps to planning offices
- Preparing presentations for developers and related groups
- Providing information on project to elected officials by short presentations at their regional meetings
- Future
  - formal presentations to agricultural community & elected officials
  - feedback gathered for future Release 2

Other collaboration & spin-offs

- Results being used in 2008 Joint Land Use Study update (by RLUAC) of five mile area around Fort Bragg
- Results will be incorporated into the Comprehensive Regional Growth Plan of the BRAC-RTF
- Both RLUAC and BRAC-RTF participating in suitability map development & assisting with meeting logistics
- SS project & models forming basis for military funded land use modeling project covering another 13 counties in SE NC (SECCURE, part of SERPPAS)
- Original plan was to include the location of cultural resources in model; data not available; grant just funded; new partner - NC Dept of Transportation
- Forming a Cultural Resources Team

Future

- Use by planners, conservation groups, all types of developers, extension agents, & elected officials to inform decision-making
- Release 1 findings incorporated into 2007 JLUS and BRAC-RTF growth management plan
- Annual update of data and redistribution of maps (grid & PDF formats)
- Development of Release 2 with cultural data and predictive modeling added; feedback on data layers & weighting incorporated

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Sustainability of Land Use in Puerto Rico

Center for Sustainable Development Studies

School of Environmental Affairs

UNIVERSIDAD METROPOLITANA

November 8, 2007

WASHINGTON, D.C.

Aim of our Project

Sustainability of Land Use in Puerto Rico

The original and primary aim of our project is to develop a model using geographic information systems (GIS) with a land use sustainability index to provide a scientifically reliable tool to measure and monitor the impacts of the progression of the urban built environment on the quality and availability of land, ecosystems, and water in Puerto Rico for long term sustainability.

Urban Sprawl: Suburban expansion in the San Juan Metropolitan Area

How does your work meet the needs of environmental decision making for sustainability?

Expected contribution:

- Our work will provide an easy-to-use index model with indicators that are fed with accessible and reliable information to evaluate municipal land use plans towards sustainability.
- The model will also provide a sustainable status of municipal land use activities for public policy decisions.
- Four municipalities are being used as case studies and the outcomes will be transferable to the other municipalities.
- The model could be transferable to other islands.

Sustainability challenges for land use decision making in Puerto Rico:

Why is the municipality (equivalent to township) the territorial unit for the project?

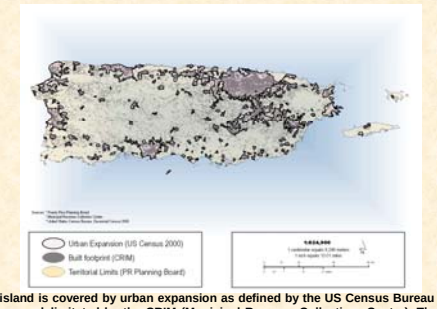
- There are 78 municipalities in Puerto Rico's relatively small surface area (8,870 km²) and the local Autonomous Municipality Act requires them to have a land use plan although there is no an island-wide land use sustainable framework to guide them at present (an island-wide land use plan is still in process).

- Municipalities are required to revise their land use plans every 8 years.

Also:

- Puerto Rico is an island with a high population density (429 inhabitants per square kilometers), topographical limitations, and a serious combination of natural hazards.

Sustainability challenges for land use decision making in Puerto Rico



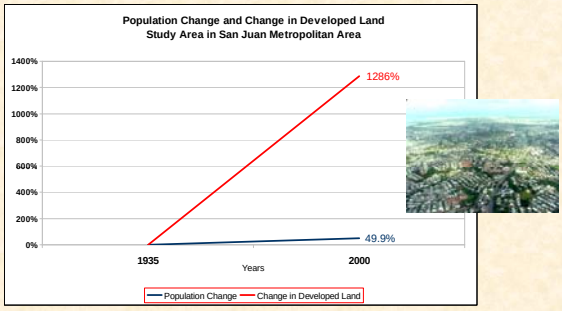
22% of the island is covered by urban expansion as defined by the US Census Bureau 2000, plus built-up areas as delimitated by the CRIM (Municipal Revenue Collection Center). The impact of low density development, based on the scattered patterns of the built up areas outside the official urban areas defined by the U.S. Census, is significant and demonstrates the sustainability challenge for land use in Puerto Rico.

Sustainability challenges for land use decision making in Puerto Rico

Puerto Rico Road System = **26,186.30 Km**

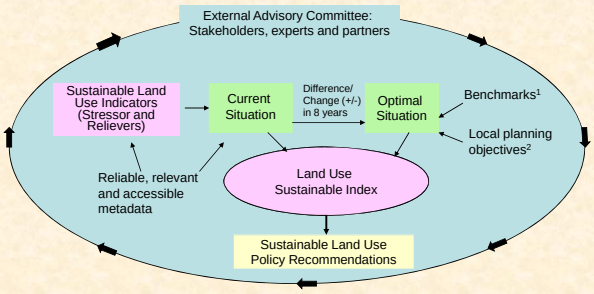
Contributes to low-density development widespread across much of the island outward from the urban centers in linear features following the extensive rural-road network and some of the highways and routes.

Sustainability challenges for land use decision making in Puerto Rico



Study area municipalities: Bayamón, Carolina, Cataño, Guaynabo, San Juan, Toa Alta and Trujillo Alto. Updated results from Universidad Metropolitana (2001), *Puerto Rico's Road to Smart Growth.*

Schematic overview of the project



1. **A locally accepted public policy goal, an internationally agreed goal or a scientifically accepted threshold.**
2. **When there is no benchmark, we use planning goals for Puerto Rico based on local stakeholder and expert opinions.**

Schematic overview of the project

Four primary components:

- Describe the current land use situation using selected indicators as stressors and relievers (an evaluation of how close or far is the municipality from sustainability of land use) based on available and reliable information.
- Establish a base optimal land use based on benchmarks or planning objectives for the selected indicators that will help measure positive or negative change through time.
- Provide a land use sustainable index to measure status and progress.
- Receive constant feedback and collaboration for the decision making process by stakeholders, experts and partners (External Advisory Committee).

In the last 25 years, 45% of built-up areas (mostly suburban low density growth) occurred in valuable agricultural lands.

Selection of indicators

1. Maturity (reliable metadata based on the best available information)
2. Relevant and functional for land use planning at the municipal level
3. Adaptable to different scenarios (78 municipalities)
4. Must be able to evaluate current situation and future tendencies
5. Have quantitative and qualitative value

A tentative group of indicators was selected by the Project Team with the input of the Advisory Committee composed mostly of local and federal government agencies and municipal officials (informed stakeholders and experts).

Tentative Selected Indicators (23)

Environmental
1. Percentage of houses without sewage connection from total housing units.
2.Development pressure in Rustic Land (change in housing density)
3. Percentage of officially protected land by federal, state and municipal governments.
4. Population living in urban areas at 15 minutes walking distance from parks and natural public open spaces.
5. Total solid waste generation per person per day.
6. Percentage of recycled solid non-hazardous waste from total annual waste generation.
7. CO^2 generation per passenger cars registered per year.
8. Percentage of houses in coastal hazard areas from total housing units
9. Water consumption per house per day
10. Energy consumption per house per day

Institutional
22. Approved land use plan by the Puerto Rico Planning Board
23. Fiscal Fragility Index

Socio-economics
11. Percentage of highly valuable agricultural lands
12. Percentage of active agricultural lands.
13. Percentage of residents that work in the same municipality.
14. Repopulation of urban areas (change in population density)
15. Total number of people living in zone prone areas.
16. Percentage of families that receive public assistance.
17. Socio-economic Index
Infrastructure
18. Percentage of change in the use by residents of public transportation to work.
19. Percentage of wards served by at least one public transportation service route to urban center.
20. Percentage of Public road's footprint from total municipal land.
21. Total wards with accessibility deficiencies to potable water.

The Project Team is preparing a Methodology Report for the indicators with information about the metadata.

Tentative Selected Indicators (23)

Methodology Report will include for each indicator:

1. **Measurement (what is being measured, description of the indicator)**
2. **Rationale/context for sustainability of land use**
3. **Recommended benchmark or planning objective and why**
4. **Calculation**
5. **Units**
6. **Data collection methods and sources**
7. **Data collection year**
8. **Data collection frequency or frequency of measurement**
9. **Temporal and spatial format / reporting format**
10. **Limitations**

Tentative Selected Indicators
Stressors

	Municipal Indicators	PONCE	CAGUAS	BARCELONETA	CAROLINA	Planning Objective or Benchmark for the Indicator	Benchmark for the Index	Suggested Weighing Scale 1 to 10
1	Total number of people living in flood prone zones.	2,699	3,337	1,023	816	0	0	**1.00**
2	Total wards with accessibility deficiencies to potable water.	3	2	1	2	-60%	1.00	**0.90**
3	Percentage of houses without sewage connection from total housing units.	34.0%	29.8%	46.1%	24.9%	-20%	20%	**0.80**
4	Solid waste generation per person per day (pounds).	4.2	5.9	7.5	3.2	3.4	3.4	**1.00**
5	CO_2 generation per passenger cars registered per year (tons).	584,900	514,471	84,192	661,358	-7%	500,000	**1.00**
6	Percentage of houses in coastal hazard areas from total housing units.	2%	N/A	6%	7%	-5%	5%	**0.80**
7	Precentage of public road's footprint from total municipal land.	9%	11%	9%	13%	0	13%	**0.80**
8	Fiscal Fragility Index	13.53	-9.51	0.22	0.06	0	20.00	**2.00**
9	Water consumption per house per day (gallons).	166	164	164	172	-25%	124	**1.00**
10	Energy consumption per house per day (kilowats).	5,754	6,222	4,049	7,508	-7%	5,500	**0.60**
11	Development pressure in Rustic Land (housing density).	54	133	91	98	0	100	**2.00**
12	Socioeconomic Index	95.83	109.15	82.78	132.55	100	100	**2.50**
13	Families that receive public assistance.	24%	16%	25%	11%	-10%	10%	**4.00**

With suggested objectives / benchmarks and weight.

Tentative Selected Indicators
Relievers

	Municipal Indicators	PONCE	CAGUAS	BARCELONETA	CAROLINA	Planning Objective or Benchmark for the Indicator	Benchmark for the Index	Suggested Weighing Scale 1 to 10
14	Percentage of officially protected land by federal, state and municipal governments.	33%	4%	53%	22%	30%	30%	**0.80**
15	Percentage of change in the use of public transportation for work.	-1.0%	-2.0%	0.0%	-2.0%	+5.0%	5%	**0.60**
16	Repopulation in urban areas (change in population density).	1,598	2,189	809	3,299	+10%	2,200	**2.30**
17	Approved land use plan by the PR Planning Board	1	1	1	1	1	1	**1.70**
18	Percentage of highly valuable agricultural lands.	14%	16%	55%	14%	0	variable	**1.70**
19	Percentage of active agricultural lands.	23%	15%	18%	18%	0	variable	**1.00**
20	Percentage of residents that work in the municipality.	86.0%	56.0%	56.0%	42.0%	60%	60%	**2.00**
21	Wards served by at least one public transportation service route to urban centers.	In process of development						**3.20**
22	Population living in the urban areas 15 minutes walking distance from parks and natural public open spaces.							**2.30**
23	Percentage of recycled solid non -hazardous waste from total annual waste generation.	2.9%	9%	1.5%	1.1%	35%	35%	**6.00**

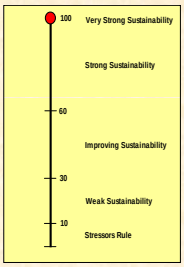
With suggested objectives / benchmarks and weight.

ISLA Composite Index Model

$$ISLA = \sqrt{\frac{RI}{SI}} \times 100$$

Relievers Index (RI) and a Stressors Index (SI)

ISLA ranges in value from 1 to 100, as do RI and SI individually. RI is calculated as a weighted geometric mean of individual reliever indicators, each of which has been divided first by a benchmark value. SI is calculated in the same manner, but using stressor indicators. In ISLA, the value 10 separates sustainability from non-sustainability. At 10, stressors and relievers cancel each other. Below 10, stressors outweigh relievers. For values higher than 10, relievers outweigh stressors.



Preliminary results

Preliminary results:

	Ponce	Caguas	Barceloneta	Carolina
ISLA Composite Index	**7.645**	**9.032**	**8.917**	**9.125**

When the ISLA composite index model was run for the first time, all 4 municipalities used as case studies came out very low in sustainability (lower than 10), a mirror of the unsustainable reality of land use trends in PR.

At this phase of the project, the research team is revaluating and validating with the Advisory Committee and local experts the parameters used in the model (benchmarks/planning objectives).

How have you responded to feedback from stakeholders?

Project integrates key public stakeholders through an Advisory Committee:

- **13 municipalities (4 as case study: Carolina, Ponce, Barceloneta, Caguas)**
- **4 local government agencies (PRDNER, PRPB, PREQB, PRDA)**
- **2 federal agencies (USFS, USDA)**

Also included in the Committee:

- **Puerto Rico Planning Society**
- **Estudios Técnicos, Inc. and Advantage, Inc., 2 locally economic and planning consulting firms.**

Municipalities in the Advisory Committee

Discussion meetings every two to three months:

Stakeholders provide feedback and present their evaluations of the different stages of the project at the meetings.

The Project Team incorporates stakeholders feedback in the decision making process: selection of indicators, weight and benchmarks for each indicator, and possible planning objectives.

Lessons Learned

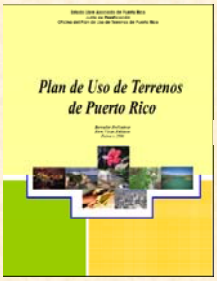
- Stakeholders' participation from the beginning resulted in successful collaboration and interest on the results of the project for decision making.
- Land use planning goals are being discussed and evaluated with stakeholders as alternatives when there are no clear and agreed upon benchmark for the indicators.
- The municipality as a territorial unit poses difficulties in data collection and analysis when the scope and origin of the land use activity has a regional character.
- The modeling method had to consider dissimilar conditions across municipalities.
- In Puerto Rico, reliability and availability of some data is a major challenge.

Update current/potential partners and potential clients who could learn from your project, and best collaboration stories.

The regional economic development operation INTENOR (North Region) composed of 15 municipalities, 3 universities (including ours) and several private organizations, has a Land Use Commission to establish a cohesive regional land use plan. Our composite index model could be used for policies and decision making. The University is also assisting in two other similar regional initiatives: INTECO (Central West Region) and INTENE (Northeast Region).

Update current/potential partners and potential clients who could learn from your project, and best collaboration stories.

The Puerto Rico Land Use Plan Act (2004) - enacted to develop an island-wide land use plan – also requires the development of a set of indicators to evaluate land use policies. This initiative is still not finalized and had been halted by the government due to pressure from different economic sectors and for political reasons. Nevertheless, agencies involved in developing the plan are members of the External Advisory Board and are awaiting the final results of our project.



Ways in which CNS funding and program have helped in enabling the University to be in involved with other collaborative efforts or spin-off efforts?

- **Universidad Metropolitana (UMET) has been invited to collaborate in the development of island-wide environmental indicators with the Puerto Rico Environmental Quality Board.**
- **UMET has also been invited to advise the regional initiatives INTENOR, INTECO, and INTENE.**
- **The Project Team was invited to present at the Puerto Rico Social Forum at the University of Puerto Rico (November 19, 2006).**
- **The project enhances ongoing education-related initiatives at UMET, especially the Puerto Rico version of ICMA and EPA's educational publication *Getting to Smart Growth: 100 Policies for Implementation.***
- **UMET has also been invited to participate in TV and radio programs.**

Where do you foresee this work going in the future?

- **Objective tool to evaluate performance for sustainability: Development of Puerto Rico's State of Land Use for Sustainability Report where municipalities will be ranked every four/eight years according to land use "eco-efficiency"**
- **Initiative to spearhead public policy: Use of the Report and the index for municipal ordinances and public policies (Example: The results of a previous EPA's sponsored project at UMET - *Puerto Rico' Road to Smart Growth* – helped enact three new Smart Growth and environmental-related acts. Specifically: Urban Center Revitalization Act, San Juan Ecological Corridor Act, and Puerto Rico Land Use Plan Act.**
- **Collaborative agreements: Support to municipalities for specific land use sustainability projects (educational, research and public policy related project).**
- **Further research based on lessons learned: Opportunities to fine tune some indicators due to lack of reliable metadata at the present moment. Includes the possibility to expand the indicators to a regional scale using watersheds or regional municipal economic initiatives as territorial planning units.**

Sustainability of Land Use in Puerto Rico

Questions and Feedback Welcome

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Cuyahoga Sustainability Network

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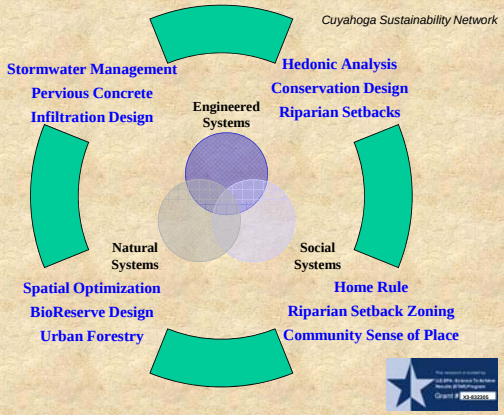
Allen Bradley	IIHR Hydroscience & Engineering University of Iowa
Brian Mikelbank	Levin College of Urban Affairs Cleveland State University
Terry Schwarz	Cleveland Urban Design Collaborative Kent State University

Contributions to Sustainable Decision Making:

Fill Key Information Needs to Foster and Support Sustainable Land Transformation Decision-Making

- Landscape Influences on Environmental Services
- Urban Hydrology and Sustainable Landscapes
- Economic Demand for Environmentally Sustainable Design
- Multiobjective Decision Making



Surprising Results:

- Suburban History - Ghosts of Landuse Past
- Pervious Runoff
- Planning & Development in a Home Rule State
- Hedonic Analysis – Price Signals for Environmental Design
- Pervious Concrete – Cold Weather Performance & Design
- Urban Forest Services

Economic Sustainability: Hedonic Price Analysis

Conservation Design

Riparian Setback Zoning

New Urbanism

Riparian Setbacks; Technical Information for Decision Makers

www.crwp.org/pdf_files/riparian_setback_paper_jan_2006.pdf

- Local Governments Commission
- Colorado League of Women Voters
- Chesapeake Bay Local Government Information Network
- Community Forest Resource Center
- Mass. Dept Fish and Game
- Arizona NEMO (*Nonpoint Education for Municipal Officers*)
- New Hampshire Fish and Game Department
- Maryland DNR
- Connecticut Association of Conservation and Inland Wetland Commissions Inc.
- Wisconsin DNR
- Maine DEP
- Montana Water Course
- Westchester County, NY Department of Planning.
- Association of State Wetland Managers

Cuyahoga Sustainability Network

Cleveland's Urban Forest

Annual Air Quality Benefits ~$3 billion

- Cuyahoga County Green Print
- Cleveland Metroparks
- City of Cleveland Street Trees

"Train the Trainer"

D. Nowak, R. Pouyat
U.S. Forest Service
Northern Research Station

baltimoresun.com

On a mission to add to greenery

Volunteers armed with computers collect data on Baltimore's trees

By Alia Malik Sun reporter July 28, 2007

Sun photo by Mauricio Rubio, July 18, 2007

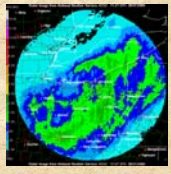
Cuyahoga Sustainability Network

Hydrologic Services:
Sustainable Landscapes & Pervious Concrete

Cleveland State University& Ohio Ready Mix Concrete Association

Cuyahoga Sustainability Network

Pervious Concrete Test Plot



Tropical Storm Katrina Storm Totals:

31Aug 2005 - 07:27 EDT

Cuyahoga Sustainability Network

Cuyahoga Sustainability Network

Hydrologic Services:
Quantifying Site Infiltration

IIHR Digital Infiltrometer Controller

CRWP

Cuyahoga Sustainability Network

LID Performance Monitoring

EPA National Community Decentralized Wastewater Demonstration Project

-Matt Morrison – EPA NRML

-USGS Ohio District

- **Rain garden: max water level**
- **Pervious pavement outflow**
- **Pervious pavement soil moisture (TDR nests)**
- **WQ: Temp & conductivity + TSS, TP, Cl, turbidity, total & dissolved metals**
- **Parking lot surface runoff: quantity and quality**

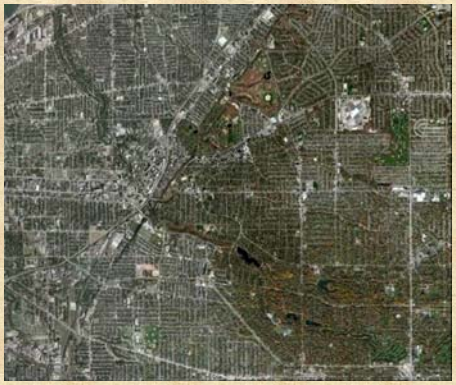
IR: 24.0 – 0.74 cm/hr

Cawrse & Associates — Chagrin River Watershed Partners

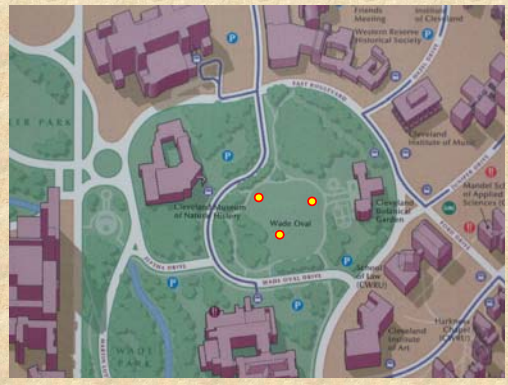
Suburbanization and Greenspace

Ghosts of Land Use Past

Cuyahoga Sustainability Network



Cuyahoga Sustainability Network

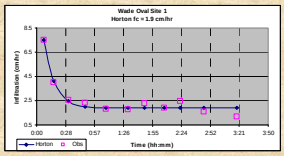


Wade Oval Infiltration

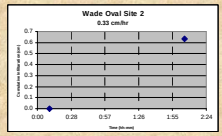
Cuyahoga Sustainability Network

Wade Oval Infiltration

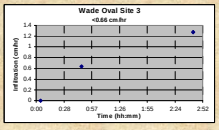
Cuyahoga Sustainability Network



1.8 cm / hr



0.33 cm / hr



< 0.3 cm / hr

Cuyahoga Sustainability Network

Beyond Impervious Area-

Rain Gardens - etc?

Cuyahoga Sustainability Network

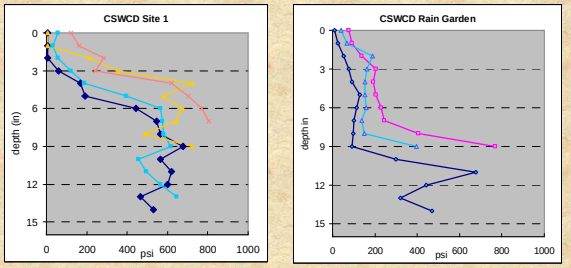
CSWCD Rain Garden

Infiltration and Soil Compaction

Cuyahoga Sustainability Network

CSWCD Rain Garden

Infiltration and Soil Compaction



Cuyahoga Sustainability Network

Cuyahoga Sustainability Network

"Engineered Topography"

Cuyahoga Sustainability Network

No-Mow Lawns

Cleveland Botanical Garden

City of Cleveland

No-Mow Lawns

Results from CNS Funding

Enabled New Collaborations & Technology Transfer:

-U.S. Forest Service Northern Research Station
Urban Forestry & Sustainable Landscapes

- Baltimore Ecosystem Study a NSF-LTER site
Urban Infiltration Studies –Cornell Infiltrometers

- Chesapeake Bay Trust – Pervious concrete Partnership with CSU, MD-SHA, County Engineers, MDE, MRMCA, MD-ASCE, MD-USGBC

Collaborator Updates

- CSU – Parker Hannifin Building – pervious concrete

- Chagrin River Watershed Partners – Cawrse Associates

- University Circle Corporation

- Cleveland Botanical Gardens – low-mow lawns

- City of Cleveland – Urban Street Trees

- Cuyahoga County Planning Commission – Greenprint

-Cuyahoga SWCD – compaction and lawn tillage

Future Work

- Community Tree Survey in Cleveland
- Urban Forest Services:
  - Cuyahoga GreenPrint; Cleveland Metroparks; Cleveland Street Trees
- Infiltration & Hydrologic Services:
  - Hydrologic function of rain gardens & urban pervious areas
  - Lawn treatment for infiltration
  - No-Mow lawns and lawn care – quality and function
- Pervious concrete partnerships in Chesapeake Bay
- Spatial Decision Models – New Color & IR Aerials and LIDAR

Social Sustainability

Ghosts of Land Use Past

Euclid Golf: Suburbanization & Greenspace

August 26, 1919

Dear Mr. Rockefeller:

… One of the most gratifying features of the enterprise is that real estate men look upon this Euclid Golf Allotment as a model development. Mr. Deming has had many visitors from all parts of the United States inspecting the place, and their universal comment has been that only "Mr. Rockefeller" could do such a fine piece of work. …

Very Truly,
Charles O. Hedyt

PA Lawns –
Pitt
Clavenger

Turf Amendment – Balousek 2003

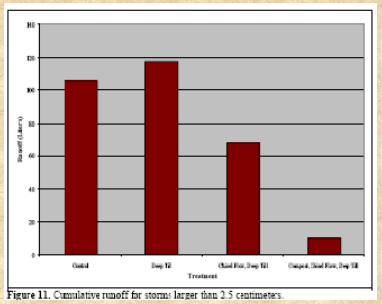


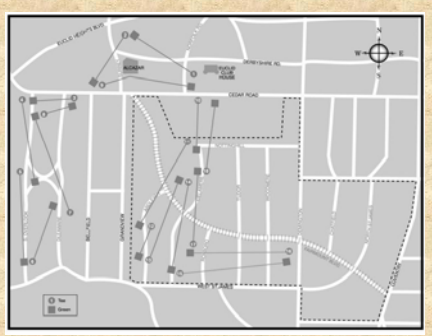
Figure 11. Cumulative runoff for storms larger than 2.5 centimeters.

Balousek 2003. "Quantifying Decreases in Stormwater Runoff from Deep Tilling, Chisel Plowing, and Compost Amendment."
http://www.countyofdane.com/landconservation/papers/quantifyingdecreasesinswrunoff.pdf

Feedback & Contacts

- Commoditizing Stormwater – Credits and Trading
- Automatically Derived Spatial (GIS/Remote Sensing) Metrics of Sustainable landscapes & design
- Landscape Influences on Hydroecology
- Urban BMP cost-effectiveness
- Riparian Setback / Riparian Buffer Technical Literature

Euclid Golf



Environmental Sustainability

- Hydrologic Services & Sustainable Landscapes
  - Pervious Concrete
  - Site Infiltration
  - Lawns & Green Spaces
  - Beyond Impervious Area

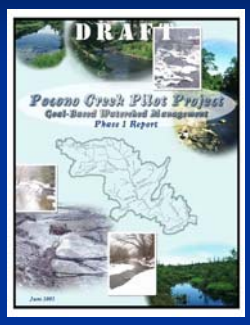
Social Sustainability
Ghosts of Land Use Past

- The Heights & Early Suburbanization
- Rockefeller, Ambler, Wade
- Euclid Golf
  - Deed Restrictions
  - Euclidean Zoning
  - *Euclid v. Ambler*
- Shaker Nature Center and the Lee-Clark Freeway

Framework for Sustainable Watershed Management

U.S. EPA GNS Workshop
Washington, DC
November 8-9, 2007
Pamela V. Gomez, Watershed Planner
DRBC

Pocono Creek Pilot Study 2000-2004



Major Water Resources Issues in Pocono Creek Watershed

- 1. Stream Flow
- 2. Water Quality
- 3. Stream Channel Stability
- 4. Aquatic Ecology

Pocono Creek Watershed

Pocono Creek is 18 Miles Watershed 46.5 sq. mi.
Tributaries are HQ & EV Cold Water Stream (PADEP) & Class A Wild Trout Stream (PF&BC)

Pocono Creek Watershed

Monroe County PA – 2nd in Growth

Tourism Based Economy

Population Increased > 50% in past decade

More than 50% Undeveloped

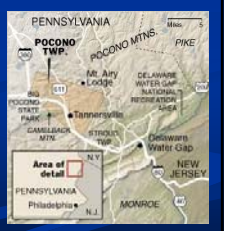
90 minute Drive from Philadelphia & NYC

Two Ecoregions

Appalachian Plateau
Ridge & Valley

Pocono Creek Watershed Goals

- **Maintain high quality water quality**
- Preserve stream corridors and floodplains
- **Coordinate watershed planning process with other levels of government**
- **Maintain existing stream flow**
- Develop using village centers and conservation design
- Establish an economy compatible with the environment
- Preserve open space



Water Quantity Goals

Maintain existing stream flows & Support natural ecosystems

Framework for Sustainable Watershed Management

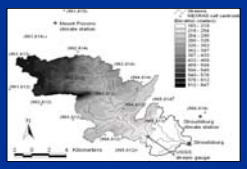
Manage the Water Resources to Meet Current and Future Needs

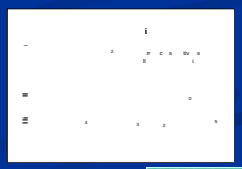
Sustainable Watershed Conditions

Water Resources to Support Human Needs & Ecological Habitat

Framework for Sustainable Watershed Management

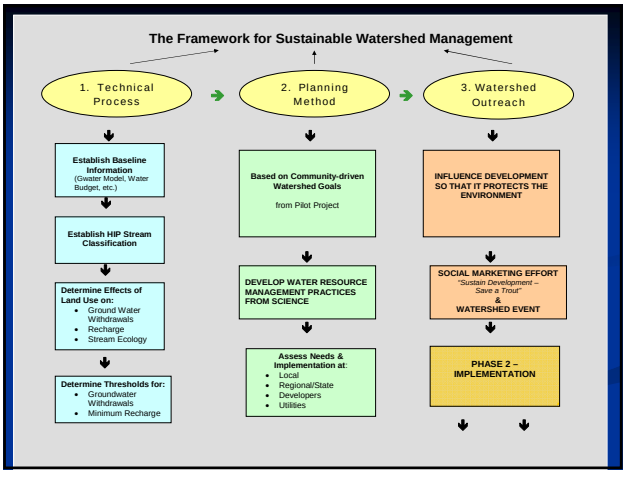
Approach: To use sound science to develop water resource management strategies and polices that local decision makers **a) adopt** and **b) implement**.



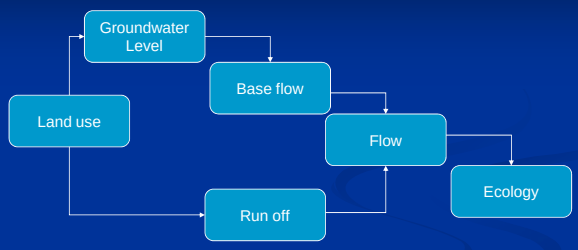


Framework for Sustainable Watershed Management

- Stage 1 – Technical & Scientific Research
- Stage 2 Development of Management Strategies & Planning Tools
- Stage 3 – Innovative Watershed Community Event



Models and HIP Process



Technical Stage

- Completed Baseline Studies for:

Existing Water Budget
Ground Water/Surface Water Interface
Streamflow Statistics
Hydrologic Conditions
Existing Water Demands

Characterize hydrologic relationships between baseflows and withdrawals

- Identify stressors for existing habitat
- Determine necessary conditions to maintain sustainable flows in Pocono Creek Watershed

EPA HYDROLOGY MODEL STUDY

RESULTS Based on Projected Build Out -

Recharge reduced in 26 out of 29 recharge areas

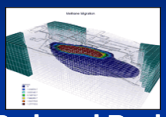
Daily Base Flow < 31%
Low Flow 7Q10 < 11%,
Monthly Median Daily Flow < 10%

Monthly Peak of Daily Flows > by 21%
Annual Maximum of Daily Flow > 19%

Watershed-averaged Groundwater Recharge < 31%

USGS MODFLOW-2000 Groundwater Flow Model

Measured Effects on Base Flow from



Ground-Water Withdrawals

&

Reduced Recharge from Land Use Change

- Three-dimensional model
- Entire Pocono Creek watershed
- Used EPA-ORD hydrology model recharge values for 2000 land use & 2020 land use.

USGS MODFLOW-2000 Groundwater Flow Model

2020 Build-out:

- Effects of withdrawals are related to drainage area
- Base flows < 38 to 100%
- Groundwater withdrawals and surface water withdrawals equally affect stream flow

In 2007 -

We Got HIP -

The Pocono Creek Hydroecological Integrity Assessment Process

and….

We Got HAT -

The Pocono Creek
Hydroecological Assessment Tool

Purpose of HIP

Links Streamflow and Stream Health in order to maintain healthy aquatic ecosystems

sustain or restore stream communities
sustain or restore stream integrity

Purpose of HAT

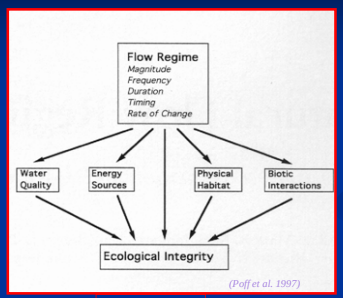
Establishes a hydrologic baseline to:

- Determine environmental flow standards, and
- Assess alternate (future) conditions

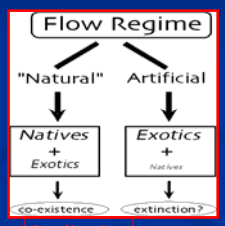
Fundamental Scientific Principle

- Ecological integrity of river ecosystems depends on their natural dynamic character (Poff and others 1997).
- Altering flow regimes affects stream biota in relation to the degree of alteration (Bunn and Arthington 2002).

Flow – "Master Variable"



Perspective



Implication

Dynamic Variables

9 FLOW COMPONENTS

Flow Conditions:	Ave., Low and High
Frequency of Flow Events:	Low Flow Events High Flow Events
Duration of Flow Events:	Low Flow Conditions High Flow Conditions
Timing	
Rate of Change in Flow Events	

"Table 3." Statistically Significant Stream Type Specific Indices (171)

	Stream Classification				
	Perennial	Flashy/Runoff	Snow & Rain	Snowmelt	Stable GW	All Streams
Magnitude of flow events Average flow conditions	$M_6$18, $M_8$39, M_{12}26, $M_8$37	$M_8$9, $M_8$15, $M_8$33, $M_8$32	$M_6$24, $M_8$11, $M_6$43, $M_8$40, $M_8$45	$M_8$39, $M_8$13, $M_8$44, $M_8$40, $M_8$9	$M_8$20, $M_8$37, $M_8$34, $M_8$40
Low flow conditions	$M_1$6, $M_1$13, $M_1$13, $M_1$16	$M_1$20, $M_1$4, $M_1$21, $M_1$16	$M_1$3, $M_1$19, $M_1$20, $M_1$3, $M_1$13	$M_1$20, $M_1$20, $M_1$13, $M_1$15, $M_1$21	$M_1$8, $M_1$19, $M_1$13, $M_1$15
High flow conditions	$M_0$5, $M_0$16, $M_0$20, $M_0$18	$M_0$24, $M_0$4, $M_0$18, $M_0$26	$M_0$14, $M_0$17, $M_0$12, $M_0$13, $M_0$16	$M_0$16, $M_0$2, $M_0$21, $M_0$3, $M_0$1	$M_0$20, $M_0$3, $M_0$20, $M_0$23
Frequency of flow events Low flow conditions	$F_1$3, $F_1$3, $F_1$1, $F_1$1	$F_1$3, $F_1$2, $F_1$1, $F_1$1	$F_1$1, $F_1$3, $F_1$3, $F_1$2, $F_1$3	$F_1$3, $F_1$1, $F_1$1, $F_1$2, $F_1$3	$F_1$3, $F_1$3, $F_1$1, $F_1$2
High flow conditions	$F_0$4, $F_0$3, $F_0$1, $F_0$9	$F_0$4, $F_0$10, $F_0$1, $F_0$10	$F_0$7, $F_0$3, $F_0$3, $F_0$4, $F_0$11	$F_0$3, $F_0$9, $F_0$5, $F_0$10, $F_0$11	$F_0$7, $F_0$3, $F_0$9, $F_0$2
Duration of flow events Low flow conditions	$D_1$4, $D_1$12, $D_1$16, $D_1$6	$D_1$15, $D_1$1, $D_1$16, $D_1$12	$D_1$16, $D_1$14, $D_1$5, $D_1$9, $D_1$17	$D_1$4, $D_1$16, $D_1$16, $D_1$11, $D_1$7	$D_1$3, $D_1$12, $D_1$16, $D_1$6
High flow conditions	$D_0$2, $D_0$13, $D_0$20, $D_0$8	$D_0$12, $D_0$2, $D_0$20, $D_0$24	$D_0$11, $D_0$14, $D_0$1, $D_0$9, $D_0$23	$D_0$14, $D_0$2, $D_0$17, $D_0$12, $D_0$23	$D_0$11, $D_0$2, $D_0$15, $D_0$8
Timing of flow events	T_A1, T_A1, $T_1$1, T_A3	T_A1, $T_0$2, $T_1$2, $T_0$3	$T_0$3, T_A1, $T_1$2, $T_1$1, T_A3	T_A1, $T_0$3, $T_0$2, T_A1, T_A2	TA1, TH2, TL3, TA1
Rate of change in flow events	R_A3, R_A7, R_A8, R_A5	R_A7, R_A1, R_A6, R_A2	R_A6, R_A3, R_A1, R_A2, R_A4	R_A7, R_A3, R_A8, R_A1, R_A6	R_A6, R_A3, R_A8, R_A2

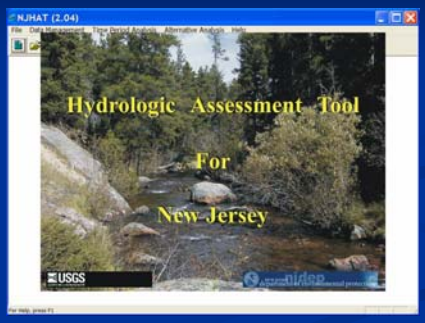
From Olden & Poff 2003

Pocono Creek HIP

USGS Task A –

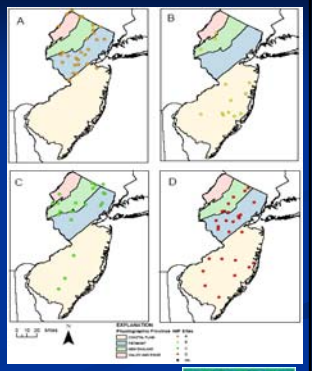
1) Classify streams – hydrologically & develop flow standards (NJSCT?)
2) Characterize hydrologic alteration – 2000 baseline & 2020 'build out' – (NJHAT or NATHAT?)

All Ready Done in NJ!



Distribution of Four NJ Stream Types

- All perennial
- Group B – GW influenced High base flow, low variability daily flow
- Group D – small DA, low base flow, highly variable daily flow (flashy)
- Groups A & C intermediate B/D, low to moderate daily flow variability, moderate baseflow, A small flood



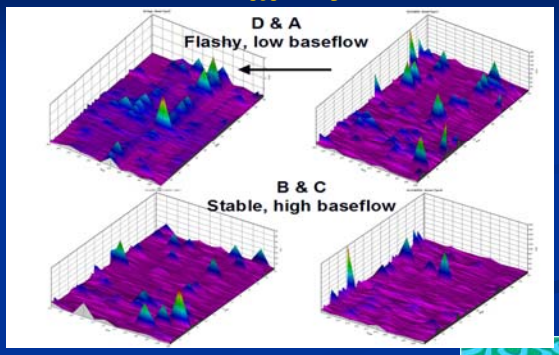
Hydrological Model's Sub – Basins Used

Task A: Objective (1) – Classify streams hydrologically

Used NJ Stream classification tool

NJ Stream Type	Pocono Sub Basins	Percent
A	6, 20	7
B	3, 18	7
C	5, 7, 9, 11, 12, 13, 15, 16, 17, 21, 24, 25, 28, 29	48
D	1, 2, 4, 8, 10, 14, 19, 22, 23, 26, 27	38

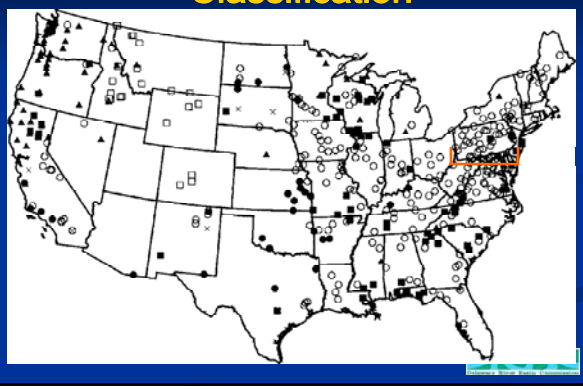
NJ Stream Classifications – "Bad Fit"



Start Again…..

Returned to National Classifications……

Olden & Poff National Classification



National Classifications

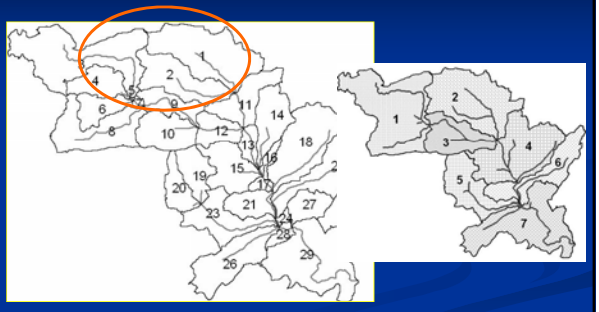
Poff 1996 – *Freshwater Biology*

- Unregulated gages 806 & 420 "best" Nat, 35 PA.
- 11 indices, 10 stream types Nationally, 2 PA.
- 34 Perennial runoff low flood seasonality, high seasonality of low flow.

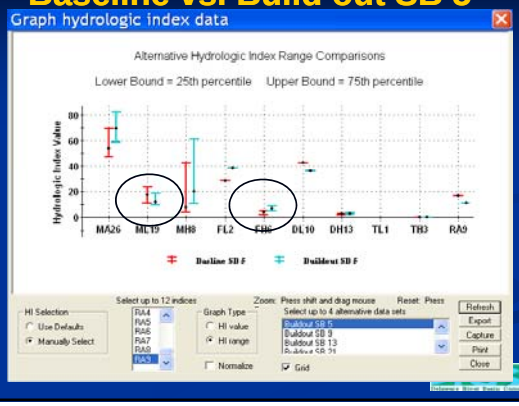
Olden & Poff 2006 – *River Research & Applications*

- 420 "best" unregulated, 24 PA.
- 171 indices, Six stream types Nationally, 2 PA.
- 23 of 25 Perennial flashy or runoff – low flood. seasonality, high seasonality of low flow.

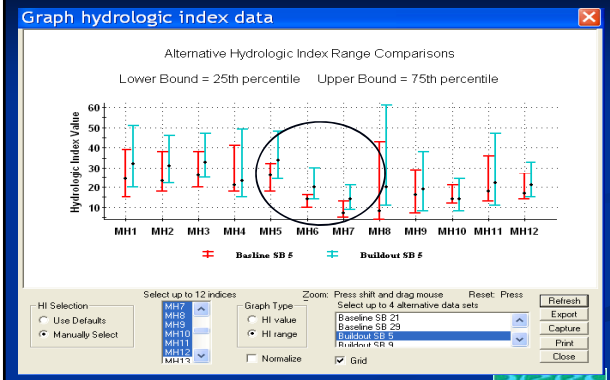
29 Sub Basins = 7 Clustered



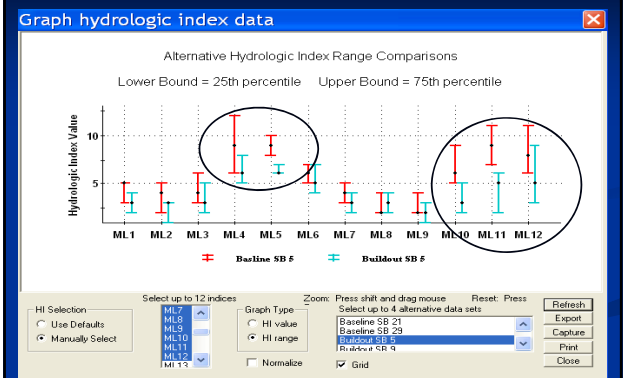
Flow Standards & Alteration Baseline vs. Build out SB 5



Median Monthly Maximum Flow



Median Monthly Minimum Flow



Conclusions……..in part

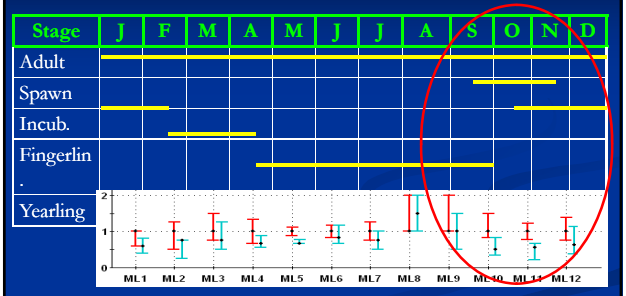
Index	Units	SB 5	SB 9	SB 13
ML1-12	Median monthly minimum % # of months	16-50 ↓ 11	14-57 ↓ 11	17-42 ↓ 10
FL1	<25%t - events/yr %	7 ↑ 175 ↑	4 ↑ 57 ↑	4 ↑ 44 ↑
DL16	Mean days/yr %	10 ↓ 57 ↓	3 ↓ 26 ↓	3 ↓ 33 ↓
MH1-12	Median monthly maximum % # of months	9-150 ↑ 11	14-90 ↑ 11	-4 ↓-90 ↑ 12
FH5	>25%t - events/yr %	5 ↑ 46 ↑	4 ↑ 31 ↑	6 ↑ 40 ↑
DH15	Mean days/yr %	3 ↓ 35 ↓	2 ↓ 25 ↓	1 ↓ 20 ↓

Pocono Creek HIP

Task B objectives –

- If …"Flow/trout data suitable for developing testable hypotheses for flow/trout relationship?
- Test hypotheses.
- Results?
- Develop flow standards

General Periodicity Chart Brook and Brown Trout



Median Monthly Minimum Flow

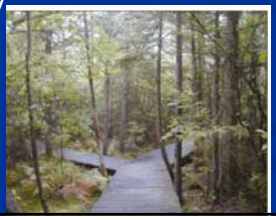
October 31, 2007 Discussion

- Which sub basins? All 29 or 7?
- Establish environmental standards and document 'violations' or…
- Test flow/'trout' (change in abundance) relationship.
- Or both?
- Time frame?

Next Steps…..

By May 2007
- Management Strategies
- Watershed Community Event

Phase II
- Local Adoption
- Local Implementation
- State Policy Revised



IMMEDIATE FUTURE DIRECTION

Through the "Seven Doors" Social Marketing

adapted from Les Robinson, Social Change Media.

- 1. Knowledge/awareness Planning
- 2. Vision Creates Desire
- 3. Skills Make it Easy
- 4. Optimism Promote Benefits of Alternatives
- 5. Facilitation Implementation
- 6. Stimulation Watershed Community shares event => Galvanizes action
- 7. Feedback and reinforcement

COLLABORATIVE INNOVATIVE WATERSHED COMMUNITY EVENT

"Both science and art have the capacity to help us see much further than our everyday economy requires."

(Holmes Rolston III, Philosophy Gone Wild).

November 14, 2007

"DEVELOP RIGHT- SAVE A TROUT!"

Linking Sustainability Message to Watershed Community

New Watershed Partners!

- Chamber of Commerce
- Corporations
- Arts League
- University
- Media
- Local Officials
- Residents
- Tourists

PHASE II

FUTURE DIRECTIONS:

A. Local Protection Measures

- Developed
- Adopted
- Implemented

EPA TRUE PARTNER

GOAL MADE POSSIBLE:
To Establish a Collaborative Community Process to Develop Sustainable Watershed Practices Based on Sound Science.

EPA Funded Project: USGS and DRBC

EPA ORD Edison NJ and Cincinnati OH: Developed tools that will be useful in other watersheds; Provided training, equipment, and technical support.

EPA ORD, EPA Region 3 and EPA ORD CNS: Excellent support and collaboration, No-Cost Extension, networking opportunities, patience and good humor.

New Linkages with **PA DEP, USGS** Scie[illegible]enter, Ft. Collins CO

Pamela V'Combe, Watershed Planner
Delaware River Basin Commission
pvcombe@drbc.state.nj.us
(609) 883-9500 x226

Energy & Materials Flow & Cost Tracker (EMFACT)

Terri Goldberg
Northeast Waste Management Officials' Association

Overview

- Background
- Purpose & Scope
- Development Process
- Big Picture
- Example
- Features
- Status

2

EMFACT Objectives

To assist small & medium-sized businesses in the U.S. to:

- → Better track & understand the use & flow of fuel, water, & materials through their facility
- → Better understand the actual costs of poor resource efficiency & subsequent waste management
- → Improved business decision-making & environmental performance
- → Implement a cycle of continuous improvement via continuous tracking

3

EMFACT Products

- → An easy-to-use, well-documented tool to assist small & medium-sized enterprises in tracking:
  - fuel, water, & materials use
  - generation of air emissions, wastewater, & solid/hazardous waste
  - associated costs
- → User's guidance & training materials
- → Training for technical assistance providers
- → Online downloadable free access to the software application & support materials

4

EMFACT Team

- → US EPA *(funder)*
- → Northwest Waste Management Officials' Association (NEWMOA)
- → Massachusetts Office of Technical Assistance (Mass OTA)
- → SYS Technologies
- → EMARIC
- → Advisory Group (includes EPA)

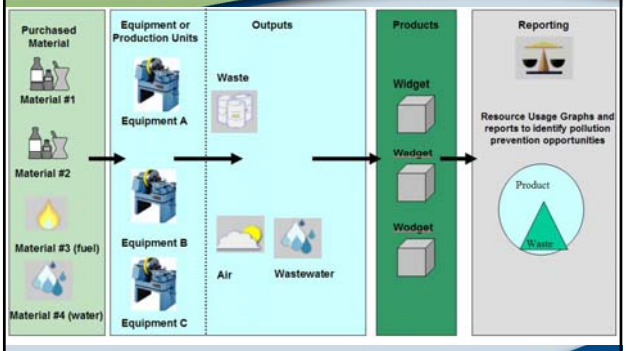
5

Development Process

- Engaged Advisory Committee, TURPAs, example companies, & NEWMOA's Board
- Developed a Draft Request for Proposals (RFP)
- Held a vendors' meeting – Comments on Draft
- Issued final RFP – Held bidder's conference
- 5 proposals submitted
- Formed review committee
- Selected SYS Technologies
- Developed contract
- Developed systems & data requirements

6

Data Flow



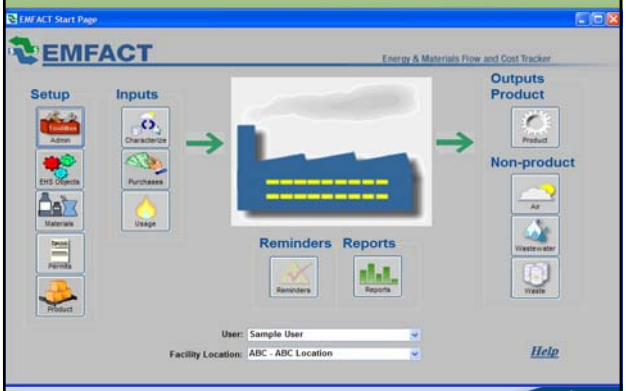
7

EMFACT Approach

- → User has the option to define:
  - Organization (e.g., departments)
  - Site & buildings
  - Equipment, including waste management equipment
  - Inputs (fuel, water, materials, chemical constituents)
  - Intermediate & final products
  - Non-product outputs (air, water, waste)
- → Link the components together
- → Populate with data, e.g., physical quantities, costs, emission factors
- → Analyze & report

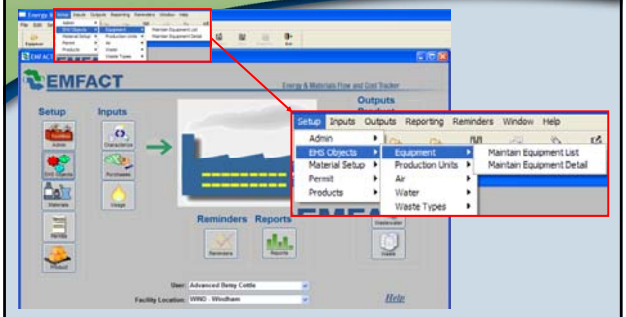
8

EMFACT Dashboard



9

EMFACT Navigation



Menu paths are provided for all windows.

Clicking an icon, button, or menu path will open a new window for the indicated functionality.

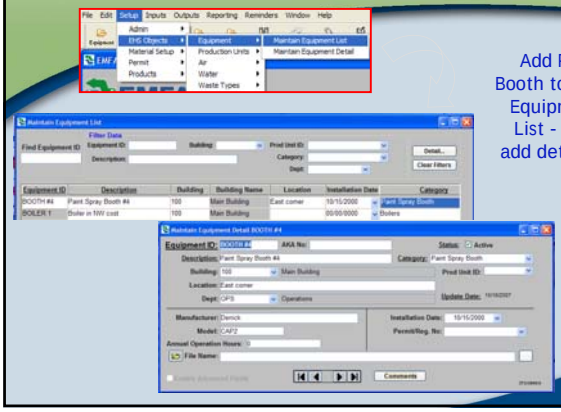
10

EMFACT Example

Air Emissions from a Paint Booth

11

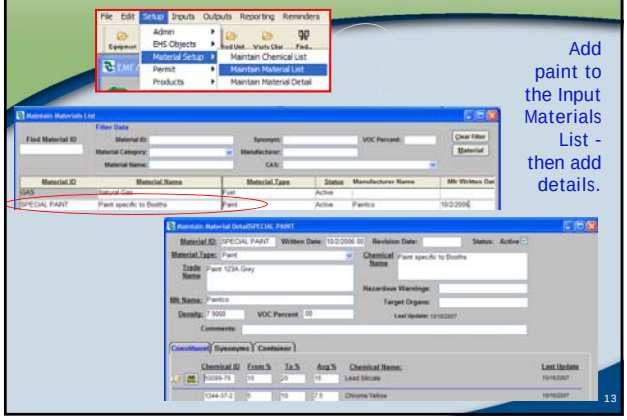
Define Process Equipment



Add Paint Booth to the Equipment List - then add details.

12

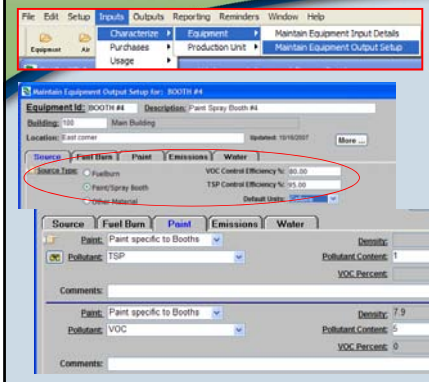
Define Input Materials



Add paint to the Input Materials List - then add details.

13

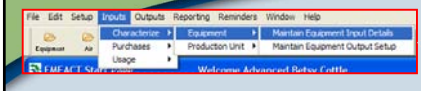
Define Non-product Outputs



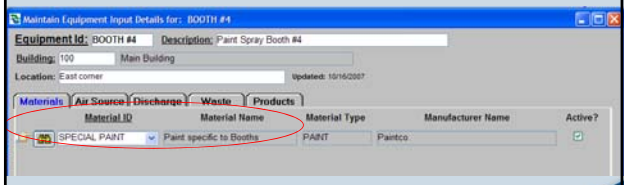
In the case of air emissions, determine emission factors for different pollutants.

14

Link Equipment, Inputs, & Outputs

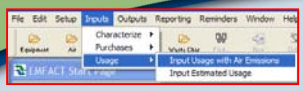


Link the Paint Input Material to the Paint Booth Equipment.

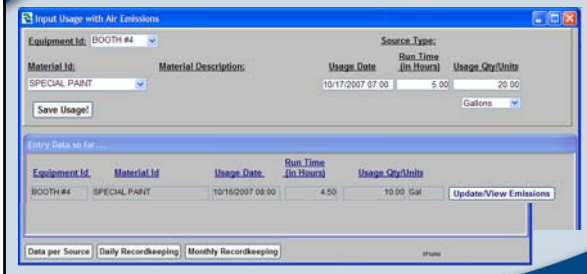


15

Inputs – Enter Usage Data

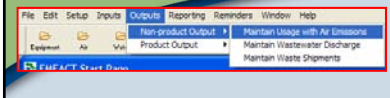


Enter paint usage data.

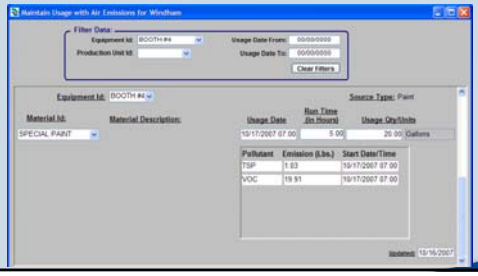


16

Outputs – Auto Calculated *(in this case)*

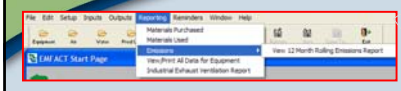


Emissions are automatically calculated in this case. Outputs will be manually entered in other cases, e.g., solid waste.



17

Report



Review paint usage with computed emissions by month & 12-month rolling totals.

18

Cost Data

→ EMFACT will also allow collection of relevant cost data; this feature is in an early stage of development.

→ Examples include:

- Materials purchase costs
- Waste management & disposal costs
- Others

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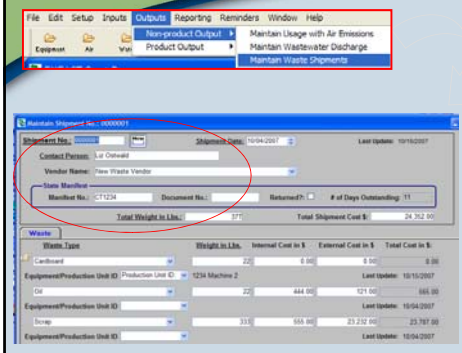
Waste Shipments & Costs



The Waste Shipment screen allocates back to the source, *tracks cost data*, & tracks other waste shipment information (date, manifest, vendor, etc.).

20

Compliance Information

→ A survey of potential users told us – regulatory compliance must be a component of EMFACT

→ So, EMFACT incorporates lists of regulated chemicals; tool can flag & report on these chemicals:

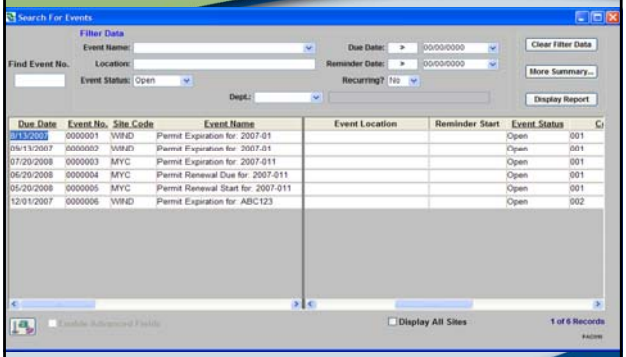
- SARA 313
- Hazardous Air Pollutants (HAPs) – federal & state
- Ozone Depleting Substances – Classes I & II

→ EMFACT also provides

- Ability for users to create their own chemical lists
- Screens to list/describe permits
- A calendar with event reminders (e.g., permit renewal)

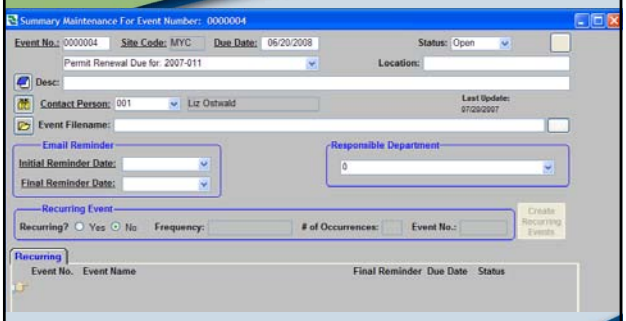
21

Examples of Reminders



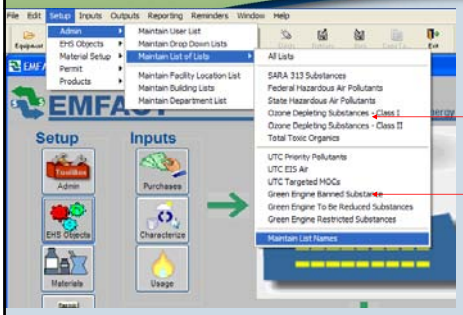
22

Reminder Details



23

Lists of Regulated Chemicals



Preloaded lists

User-defined lists

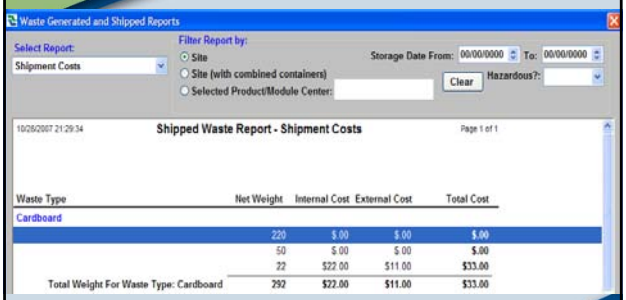
24

What Kinds of Reports?

- → Lists of equipment & of materials/chemicals
- → Materials Use &/or Non-Product Output *per unit of product, per equipment, per production unit, for entire facility*
- → Materials Use - *incorporated into product vs. into non-product output*
- → Various cost reports
- → SEARCH window will enable searching by a variety of fields - output can be printed or saved to Excel

25

Example–Solid Waste



26

Example–Solid Waste

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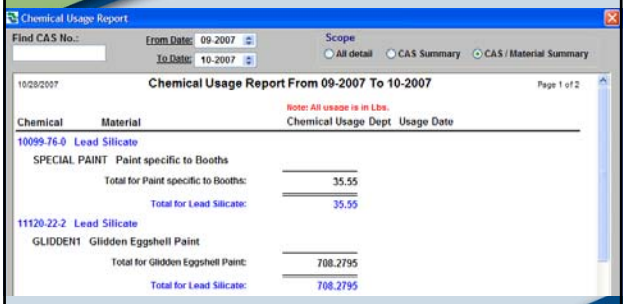
Example—Chemical Usage



28

User Flexibility

- → Two user levels: basic & advanced
- → Can have multiple users
- → Can start small or big - for a single process or product line, or for the entire facility
- → Can do grouping
  - Group individual pieces of equipment into "production units"
  - Group similar pieces of equipment into equipment "categories", e.g., paint booths

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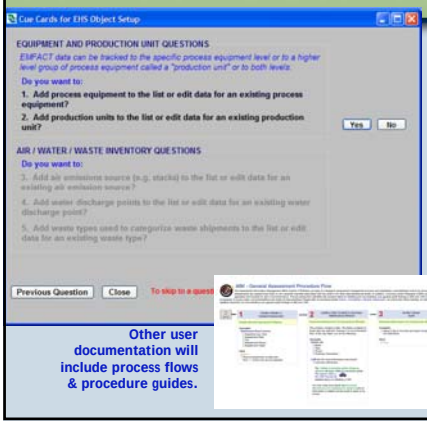
EMFACT Help Features



"Cue-card" type menus will be provided for the basic user to guide them through a logical series of windows.

Other user documentation will include process flows & procedure guides.

30

EMFACT Development Status

- → Development will continue for another 2-4 weeks
- → Early (team) testing is ongoing
- → Formal testing start target is November – includes pilot training at facilities
- → Launch v1 in March 2008 *(downloadable for free!)*

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For More Info…

http://www.newmoa.org/prevention/emfact

- → Terri Goldberg (NEWMOA): *tgoldberg@newmoa.org*
- → Rick Reibstein (MASS OTA): *rick.reibstein@state.ma.us*

32

Bringing Global Thinking to Local Sustainability Efforts:
A Collaborative Project for the Boston Metropolitan Region

James Goldstein
Tellus Institute
Boston, MA

U.S. EPA Collaborative Science and Technology Network for Sustainability Final Workshop

November 8-9, 2007

Project Purpose

- Support sustainable regional planning by providing tools and methods that promote an integrated long-term systems approach.
  - Develop alternative scenarios for Boston region, including a normative scenario consistent with sustainability and global responsibility
  - Inform stakeholders about sustainability and alternative pathways for the region
  - Promote networking of existing planning efforts taking place at different scales in the region

Project Collaborators and Partners

- Tellus Institute
- Metropolitan Area Planning Council (MAPC) (convener of MetroFuture project)
- The Boston Foundation (Indicators Project)
- The Massachusetts State Sustainability Program
- Project Advisory Committee & Work Groups

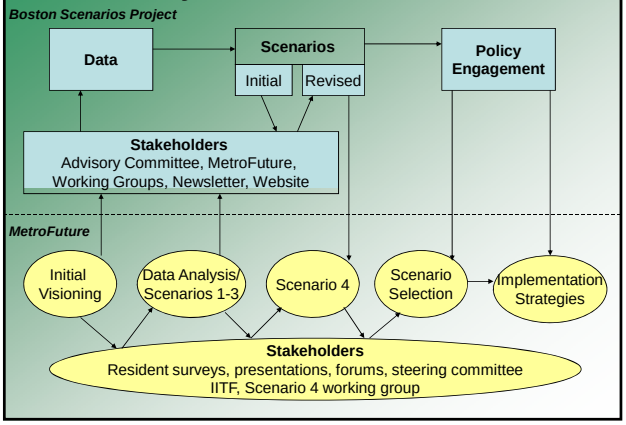
Scope of Work

- Review and coordinate with MetroFuture process
- Stakeholder consultation
- Data collection, review and synthesis
- Enhance PoleStar scenario building tool
- Develop scenarios: BAU, Policy Reform, Deep Change
- Identify policy & other engagement opportunities

MetroFuture Planning Process

- Coordinated by MAPC, regional planning agency
- 3-phase process:
  - Stakeholder visioning
  - Data analysis and scenario development
  - Implementation strategies
- Tellus coordinating closely with MAPC
  - Provide modeling assistance
  - Serve on MetroFuture Steering Committee, Technical Advisory Group & Inter-Issue Task Force
  - MAPC participates in our project advisory group

Systems Overview

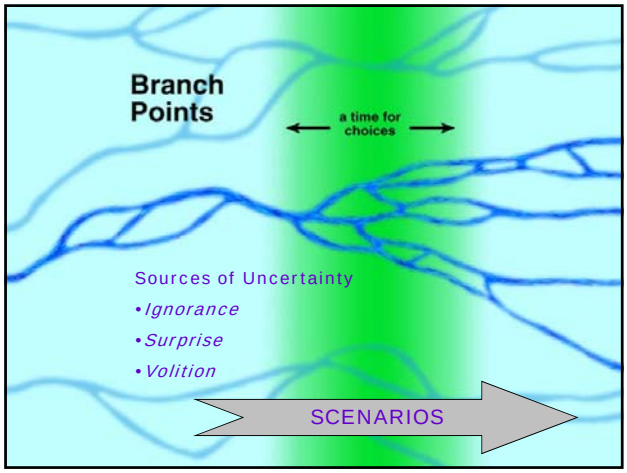


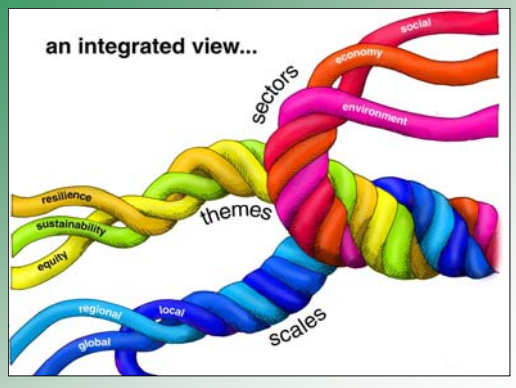
Stakeholder Consultation

- Established and met with 25-person Advisory Committee
- Developed project website and e-discussion group: www.bostonscenarios.org
- Build on input to MetroFuture process
  - Analyzed 3,000 visioning statements for elements of sustainability
  - Participated on Steering Committee and others, & public forums

Data Collection, Review & Synthesis

- Gather recent and current data (iterative)
  - demographics
  - economic activity
  - industry
  - transportation
  - air quality
  - energy
  - employment and income
  - income
  - land use
  - water quantity and quality
  - solid waste
  - food and agriculture
- Rely on existing sources (MAPC, Indicators Project, state)
- Refine as appropriate as better data becomes available



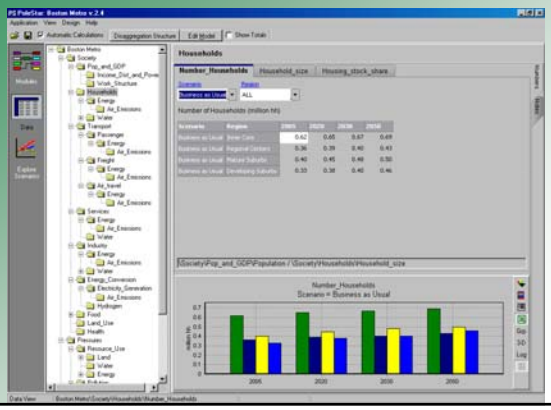


POLESTAR

A Tool for Sustainability Studies

- Decision support system for sustainability studies, local to global
- Developed by Tellus in early 1990s
- Not a rigid model, but an open framework to build integrated scenarios plus a database
- Allows user to identify driving forces, address critical uncertainties and explore alternative futures

Polestar Application



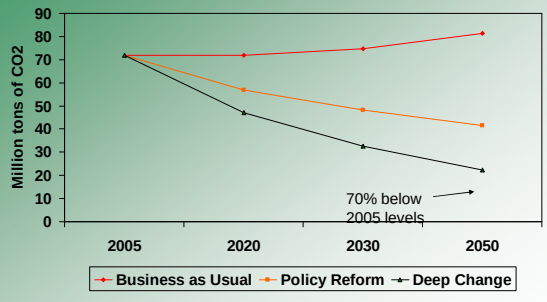
Scenarios for Boston Region

- Iterative process with collaborators and stakeholders: Three scenarios being developed:
  - **Business-As-Usual** (BAU): little change in production and consumption patterns; equity not addressed
  - **Policy Reform**: technological and policy measures emphasized to moderate ecological destruction and social inequality
  - **Deep Change**: changes in values lead to changes in lifestyles and institutions (along with technology innovations) to achieve sustainability with global responsibility

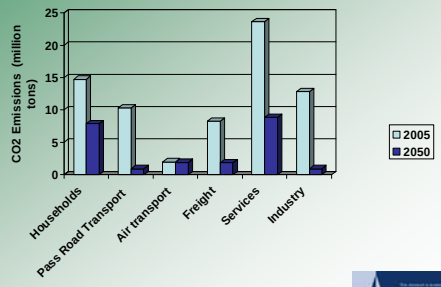
Deep Change Endorsed

- Deep Change scenario strongly endorsed by Advisory Group, sectoral working groups, and project participants
- Consistent with the objective of sustainability with global responsibility
- Significant challenges acknowledged

Meeting CO2 emissions target requires Deep Change



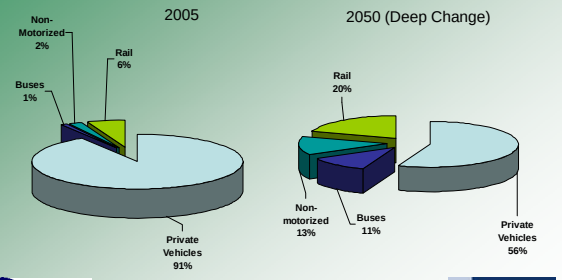
Sources of emissions reductions in Deep Change



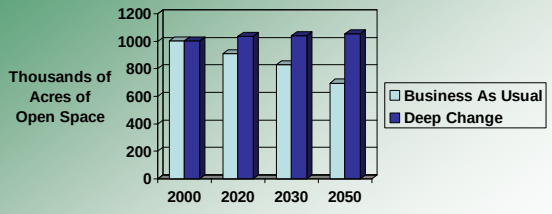
CO2 reductions in Deep Change

- **GDP**: Reduction in workweek → lower overall GDP by 25%
- **Households**: Smaller houses, more multi-family, reduced rate of appliance growth, increased efficiency & renewables
- **Passenger transport**: More compact communities → less driving & air travel, mode shifts, efficiency and renewables
- **Freight**: Reduced demand for goods, increased efficiency and renewables
- **Services**: Reduced consumption → reduced commercial floor space, increased efficiency and renewables
- **Industry**: Reduced output (less demand for "stuff"), increased efficiency, renewables
- **Electric generation (impacts all of the above)**: Reduced consumption, increased efficiency, renewables

Major Shift in Travel Mode Shares across the Region



Deep Change Commitment to Preserving Open Space



Engagement Opportunities

- MetroFuture
- Brief new administration (Gov. Patrick)
- Educational curriculum: BC, UEI, BU
- MA State Sustainability Program
- MPO Regional Transportation Plan
- MA Climate Action Plan & RGGI
- Boston Indicators Project
- MA Green Budget
- Other NGO initiatives

Impact on Partners

- MetroFuture adopted sustainability as overall criterion for scenario evaluation
- Introduced new, more visionary scenario ("Imagine") to MetroFuture process
- Though not selected, it altered the dialogue about desirable and possible futures
- Key elements added to preferred scenario (e.g., energy & CO_2, more integrated approach)

Contributions to Environmental Decision Making for Sustainability

- Infusion of science based systems approach, integrating sustainability and local & global concerns into a regional planning effort and stakeholder process
- Raised awareness among policymakers & citizens of the need to examine the role of values and lifestyle in social, environmental and economic elements of sustainability
- Promote integration of existing planning efforts in the region to incorporate long-term goals for sustainability and global responsibility

Lessons Learned

- Need technology plus values/lifestyle changes for sustainability
- Long-range scenarios with normative visions have potential for significant impact
- Difficult to involve all relevant parties in stakeholder engagement process
- Data collection at metro regional level is challenging
- Relationships among sectors are complex to model
- Importance of local partners, knowledge and data

EPA's CNS Support

- Improved tool (PoleStar) for long-range sustainability scenario development
- Enhanced our standing with:
  - MAPC
  - EPA
  - Boston Scenarios Project advisory committee
- Strengthened Tellus links with sustainability leaders in region (e.g., academics, local and state agencies, MA Smart Growth Alliance)

Response to Feedback

- Advisory Committee input helped shape alternative scenarios, espec. Deep Change
- Accepted invitation to get deeply involved in MetroFuture
- Committee and sector working groups identified and prioritized policy engagement opportunities (education, transportation)

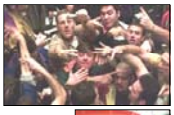
Future Work

- PoleStar now being used to update global scenarios (11 regions)
- Assist other regions in creating long-term scenarios of alternative futures
- Disseminate scenario approach and Deep Change in educational materials
- Ongoing involvement in Boston region policy efforts (transportation, energy, etc.)

Portland's Stormwater Marketplace

Using Market Forces for Sustainable Stormwater Management

Collaborative Science and Technology Network for Sustainability
Progress Workshop



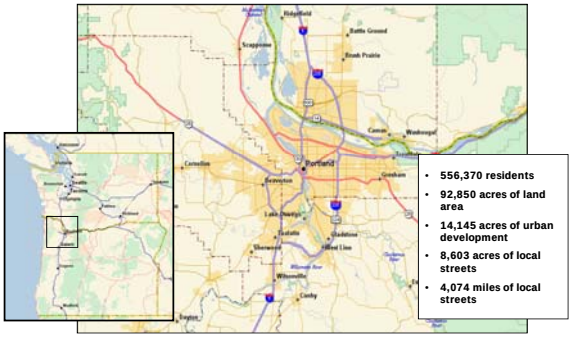

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program
Grant #
X3-83220701-0

Washington, DC – November 8-9, 2007

Ecotopia

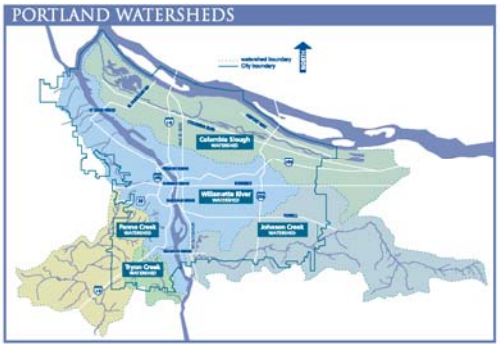
Portland and the Left Coast



- **556,370 residents**
- **92,850 acres of land area**
- **14,145 acres of urban development**
- **8,603 acres of local streets**
- **4,074 miles of local streets**

Watershed Focus

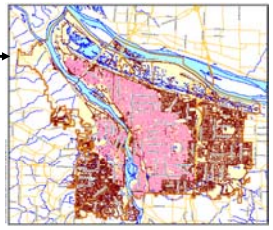
Five diverse urban ecosystems



Multiple Stormwater Management Systems

Systems based on Age and Geography

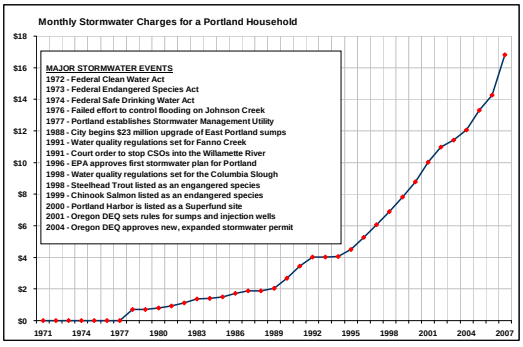
- **861 miles of combined sewers (pink)**
- **932 miles of separated sanitary sewers (red)**



- **568 miles of separated storm sewers, storm channels, ditches and culverts (green)**
- **9200 sumps (blue)**

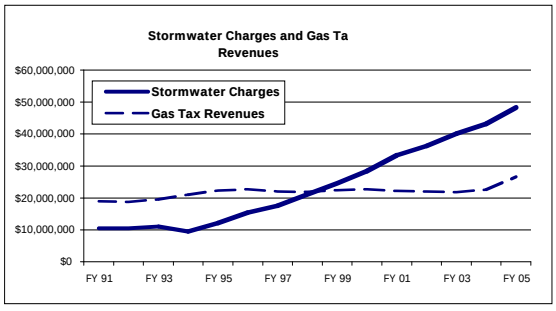
Financial Reliance on Utility Rates

Utility investments and rates driven by City response to environmental regulations



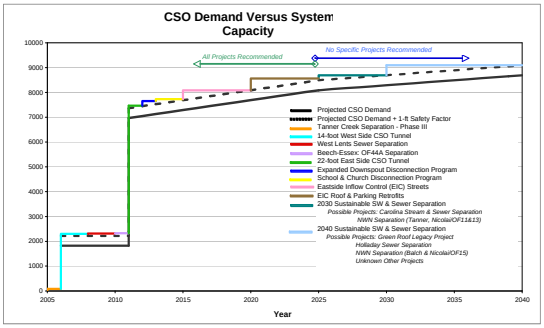
Shifting Financial Burdens

Street system drainage costs shifted to stormwater ratepayers



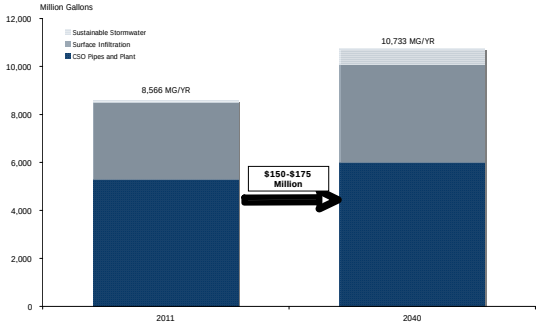
CSO Control Strategies

Planned Strategies to maintain CSO controls from 2011 through 2040



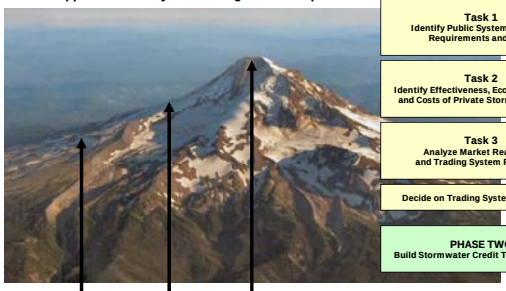
Challenge beyond 2011…

Increased density with add 2.2 billion gallons of runoff by 2040



Grant Proposal

Phased Approach to Analysis and Program Development



PHASE ONE

Task 1
Identify Public System Capacity, Requirements and Costs

Task 2
Identify Effectiveness, Ecosystem Values and Costs of Private Stormwater BMPs

Task 3
Analyze Market Readiness and Trading System Feasibility

Decide on Trading System Feasibility

PHASE TWO
Build Stormwater Credit Trading System

Phase One Feasibility Decision Complete by Jul 07

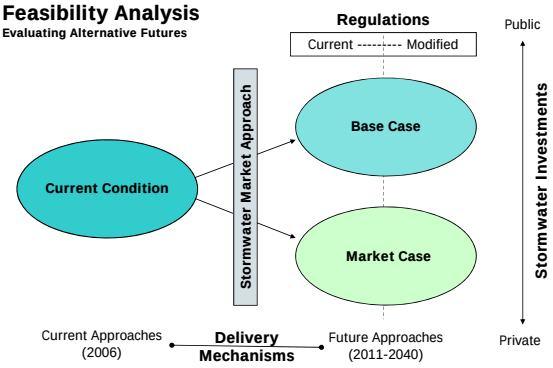
Phase Two Build System Prototype Complete by Jul 08

Phase Three Test the Marketplace Complete by Dec 09

PHASE THREE
Demonstrate System Feasibility

Feasibility Analysis

Evaluating Alternative Futures



Market Cases

Engaging Private Investments – Expanding Ecosystem Benefits

Alternative 1
- Optimize Cost and Volume Control
- Increase Private Investments

→ Cost; Volume Control; Private Investment – Regulatory; Private Investment - Voluntary

Alternative 1b
- Optimize Cost and Volume Control
- Increase Private Investments
- Increase Street System Investments

→ Cost; Volume Control; Public Investment – Public Property; Private Investment – Regulatory; Private Investment - Voluntary

Alternative 2
- Optimize Water Quality Controls

→ Water Quality Control

Alternative 3
- Optimize Ecosystem Services

→ Ecosystem Services

Evaluation Tool

Weighing Costs and Benefits

Activity Types
Public Investment – Public Property
Public Investment – Private Property
Private Investment – Regulatory
Private Investment - Voluntary

BMP Characteristics

Cost
Capital, Design and O&M
Unit Cost per 1000 Gallons of Volume Control

Volume Control
Gallons of Volume Control per Acre per Year

Water Quality Control – BMP Effectiveness
Flow
Sediment (TSS)
Zinc
Pathogens
Phosphorous

Ecosystem Services – BMP Effectiveness
Air Purification
Carbon Sequestration
Flood Storage
Terrestrial Habitat
Aquatic Habitat
Urban Heat Island Effect
Aesthetics/Quality of Life

Evaluation Tool

BMP Characteristics

BMPs	Costs			Life Span	Annual Stormwater Volume	
	Capital	Design	O&M	(years)	% Removed	% Overflow
Ecoroof	286,000	85,800	935	30	40%	60%
Drywell						
Drywell	21,552	2,155	25	25	100%	0%
Sump w/ Sed. Manhole	90,000	27,000	130	30	100%	0%
Flow-Through Planter - Roof Areas	100,000	30,000	2,287	30	25%	75%
Infiltration Planter						
Roof Area	85,000	25,500	2,000	30	50%	50%
Streets	100,000	30,000	2,287	30	50%	50%
Curb Extension	70,144	21,000	2,287	30	50%	50%
Pipe Separation	524,750	157,425	850	100	50%	50%
Porous Pavement						
New Construction	218,000	65,400	4,000	20	50%	50%
Retrofits	308,000	92,400	4,000	20	50%	50%
Sand Filter	56,100	16,830	1,100	30	0%	100%
Downspout Disconnection						
School/Church	18,000	3,000	25	30	40%	60%
SF Residence	23,100	2,900	25	30	40%	60%
Tree Planting	43,500	2,175	50	50	10%	90%
Other BMPs						
Flow Restrictor	15,000	4,500	130	10	0%	100%
Soakage Trench	110,000	33,000	550	15	100%	0%

Evaluation Tool

BMP Characteristics

BMPs	Tier 2 Effectiveness				
	Flow	Sediment	Zinc	Pathogens	Phosphorus
Ecoroof	60%	40%	28%	40%	40%
Drywell					
Drywell	100%	0%	0%	0%	0%
Sump w/ Sed. Manhole	100%	66%	2%	0%	2%
Flow-Through Planter - Roof Areas	85%	85%	90%	14%	50%
Infiltration Planter					
Roof Area	50%	50%	50%	50%	50%
Streets	50%	50%	50%	50%	50%
Curb Extension	95%	85%	90%	10%	70%
Pipe Separation	100%	0%	0%	0%	0%
Porous Pavement					
New Construction	77%	64%	35%	87%	25%
Retrofits	77%	64%	35%	87%	25%
Sand Filter	25%	42%	95%	93%	63%
Downspout Disconnection					
School/Church	40%	40%	40%	40%	40%
SF Residence	40%	40%	40%	40%	40%
Tree Planting	10%	42%	35%	0%	25%
Other BMPs					
Flow Restrictor	10%	0%	0%	0%	0%
Soakage Trench	100%	0%	0%	0%	0%

Evaluation Tool

Identifying Market Investments based on Objectives, Price, Effectiveness and Constraints

Strategies	Market 1 Optimize Cost Effectiveness	Market 1b Add Green Streets	Market 2 Optimize Water Quality	Market 3 Optimize Ecosystem Svcs
Marketplace Investments – Millions of Gallons Managed				
Downspout Disconnection	328	328	0	0
Tree Planting/Watershed Revegatation	71	71	0	266
Vegetated Filter Strip	290	290	325	354
Wet Pond	89	89	0	458
Drywell	883	883	227	449
Soakage Trench	555	555	227	227
Infiltration Planter	1,103	1,103	2,380	306
Ecoroof	52	52	185	222
Flow-Through Planter	227	227	382	227
Swale - Grassy and Vegetated	1,170	825	1,244	1,614
Porous Pavement	0	0	812	0
Vegetated Infiltration Basin	957	957	1,112	957
Total - Marketplace Investments	**5,725**	**5,380**	**6,894**	**5,080**

Evaluation Tool

Trading Direct Public Investments for Marketplace Trading

Investments	Base Case	Market 1 Cost Effectiveness	Market 1b Green Streets	Market 2 Water Quality	Market 3 Ecosystem Services
Pipe Separation	3,222	3,222	3,222	3,222	3,222
Sustainable Stormwater	172	172	172	172	172
NW Neighborhoods	4,145	4,145	4,145	4,145	4,145
Green Roof Legacy Project	149	148	148	148	148
Eastside School Disconnects	299	299	299	299	299
Eastside Church Disconnects	142	142	142	142	142
Eastside Inflow Controls	3,708	0	0	0	0
Redevelopment with SWMM	1,665	0	0	0	0
Green Streets	0	0	346	0	0
Public - Public	0	691	346	691	691
Public - Private	0	1,591	1,591	1,591	1,591
Private - Regulatory	0	832	832	832	832
Alternative SWMM	0	1,018	1,018	1,463	784
Private - Voluntary	0	1,593	1,593	2,317	1,182
Totals - Million Gallons Managed	13,502	13,853	13,854	15,022	13,208

Evaluation Tool

Comparing Marketplace Results to Portland's Base Case for Stormwater Management

	Base Case	Variance from Base Case			
		Market 1 Cost Effectiveness	Market 1b Green Streets	Market 2 Water Quality	Market 3 Ecosystem Services
Stormwater Management Costs					
Total Cost ($millions)	$263.90	($47.13)	($47.13)	$32.16	$36.29
Unit Cost per 1000 Gallons Managed	$19.55	($3.90)	($3.90)	$0.16	$3.18
Market Credit Price per 1000 Gallons Managed	$19.55	($9.84)	($9.84)	$5.72	($5.44)
Managed Stormwater Volume per Year (MG)					
Public - Public	8,313	482	137	506	506
Public - Private	3,524	(1,909)	(1,909)	(1,933)	(1,933)
Private - Regulatory	1,665	(833)	(833)	(833)	(833)
Private - Alternative to SWMM		1,018	1,018	1,463	784
Private - Voluntary		1,593	1,939	2,317	1,182
Total Managed Volume (million gallons)	13,502	351	352	1,520	(294)

Evaluation Tool

Relative Gains and Losses – Variance of Market Alternatives to the Base Case

	Variance from Base Case			
	Market 1 Cost Effectiveness	Market 1b Green Streets	Market 2 Water Quality	Market 3 Ecosystem Services
Stormwater Management Costs				
Total Management Costs	-17.9%	-17.9%	12.2%	12.5%
Cost per 1000 Gallons Managed	-19.9%	-19.9%	0.8%	16.3%
Market Credit Price per 1000 Gallons Managed	-50.3%	-50.3%	29.3%	-27.8%
Impervious Area Managed				
Roof Areas	15.6%	15.6%	9.0%	12.5%
Parking Areas	-17.3%	-17.3%	9.8%	-13.0%
Streets	0.0%	0.0%	0.0%	0.0%
Total Imperious Area Managed	0.0%	0.0%	-0.1%	0.2%
Volume Control	2.6%	2.6%	11.2%	-2.2%

Evaluation Tool

Relative Gains and Losses – Variance of Market Alternatives to the Base Case

	Variance from Base Case			
	Market 1 Cost Effectiveness	Market 1b Green Streets	Market 2 Water Quality	Market 3 Ecosystem Services
Tier 2 - Water Quality Controls				
Flow	2.9%	2.9%	1.3%	-8.9%
Sediment	-18.6%	-18.6%	4.5%	0.8%
Dissolved Zinc	-23.4%	-23.4%	-7.6%	2.3%
Pathogens	37.1%	37.1%	107.3%	101.5%
Phosphorous	-16.8%	-16.6%	7.1%	-1.8%
Tier 3 - Ecosystem Services				
Air Purification	0.0%	0.0%	0.0%	0.0%
Carbon Sequestration	-23.0%	23.0%	-17.8%	1.2%
Flood Storage	-4.3%	-4.3%	-17.2%	6.7%
Terrestrial Habitat	-12.6%	-12.6%	-12.6%	28.6%
Aquatic Habitat	0.0%	0.0%	0.0%	0.0%
Urban Heat Island	152.5%	152.5%	122.8%	593.1%
Aesthetics/Quality of Life	152.5%	152.5%	122.8%	593.1%
Composite Score	26.5%	25.6%	17.8%	65.8%

Phase I - Lessons Learned

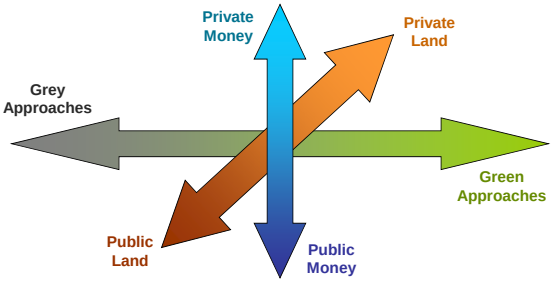
- There appears to be an adequate supply (sellers) for a stormwater marketplace
- There may be sufficient relative price differences to consider credit trades and auctions at the BMP level for selected comparisons, and across a package or "portfolio" of BMPs
- Refined inputs and sensitivity analyses are needed to be sure
- There are substantial opportunities to develop and deploy market mechanisms to animate demand (buyers), including heightened regulations and the effective use of City investments
- The costs of implementing a credit trading system may exceed the potential benefits unless the City can find partners to share the legal, administrative and technical burden

Phase I - Lessons Learned

- Evaluation and decision-making tools hold out great promise as aids to planning, program development, and decision-making
- More work is required...
  - Refine BMP cost and effectiveness information
  - Develop values for ecosystem service effectiveness
  - Integrate the "Tool" with systems modeling and asset management efforts
    Expand the "Tool" to allow for site-specific and watershed-specific analysis
  - Use the "Tool" to make effective marketing and investment decisions

Phase I - Lessons Learned

We have a better idea about where we've been, where we are now, where we might want to go, and how to get there



Portland's Stormwater Marketplace

Current Examples of Market-Oriented Initiatives

Development Density Bonuses
Discounted Utility Charges
Downspout Disconnection Program
Watershed Stewardship Grants

Development Density Bonuses

- Targets new developments in the Central City
- Developers receive a square foot of floor area bonus for each square foot of roof garden
- The ecoroof bonus ranges from 1:1 to 3:1 depending on the extent of the roof coverage
- Developers must record covenants to retain and maintain the green roofs... permanently
- The bonus has produced an estimated $225 million in additional private development at 11 participating sites
- The program has spurred ecoroof developments outside of the target area... Portland has more than 120 ecoroofs in place and more are on the way

Downspout Disconnection Program

- Targets to homes and small businesses in combined sewer areas on the east side of the Willamette River
- Great opportunity for public education about stormwater and CSOs
- Property owners and community volunteers do the work after the City surveys each site and approves each disconnection
- Property owners receive $53 per disconnected downspout... Community groups earn $13 per disconnected downspout
- Since 1994, the program has reached 56,000 properties, 1.2 billion gallons of stormwater per year from the combined sewer system

Discounted Utility Charges

- Itemizes the stormwater bill into on-site and off-site stormwater management services
- Offers up to 100% discount of the on-site portion ... 35% of the total stormwater bill
- First discount comes with a retroactive credit worth as much as 12 months of the stormwater discount
- Discounts are calculated based on the extent and effectiveness of private facilities to control flow rate, pollution and disposal
- Since October 2006, the City has processed more than 33,000 registrations
- Full participation may reach 110,000 of the 176,000 stormwater ratepayers

Clean River Rewards
contain the rain

Watershed Stewardship Grants

- Grants up to $5,000 to community groups
- Focused on community-initiated projects to improve watershed health
- Fosters community partnerships and provides technical assistance, financial support and training to volunteers
- Projects have included ecoroofs, parking lot swales, habitat restoration and downspout disconnections
- Between 1995 and 2005, the program awarded 108 grants, engaging more than 27,000 citizens who donated nearly 140,000 volunteer hours
- Nearly $450,000 in City grants have attracted more than $1.9 in matching funds

Portland Responds to Baseline Questions

Contribution to Sustainability
Surprising Results
Update on Collaborators
How has CNS Helped?
Desired Feedback

Contribution to Sustainability

Observations from 2006...

- Actors are able to quantify benefits derived from site-level investments
- Actions are more accountable since prices are linked directly to costs
- Improved accounting links individual actions to community and public goods
- Incentives create a "bias for action" independent of regulation
- Dispersed, small-scale facilities increase the resiliency of the overall system

Observations from 2007...

- Markets provide the "place" where the social, economic and ecological principles of sustainability are integrated and leveraged
- Markets increase the likelihood of sustainable investments by providing easy access to research, technical assistance, financing, incentives, supply chains and maintenance services
- Markets improve the sustainability of public investments and utility finances by shifting responsibility and costs to private actors and personal behavior

Surprising Results

Observations from 2006...

- Actors are able to quantify benefits derived from site-level investments
- Actions are more accountable since prices are linked directly to costs
- Improved accounting links individual actions to community and public goods
- Incentives create a "bias for action" independent of regulation
- Dispersed, small-scale facilities increase the resiliency of the overall system

Observations from 2007...

- Market forces are ever-present, awaiting animation and direction
- Public understanding of sustainability is increasing, approaching a tipping point
- Public understanding of the role of markets needs to catch-up
- Social networks and marketing strategies can play a critical role
- Sophisticated and expensive trading systems might need to follow more accessible and grass roots marketplace structures and strategies
- Institutional inertia is the most significant obstacle to any paradigm shift

Update on Collaborators

Observations from 2006…

- Inquiries are focused obstacles- permitting, regulation and transaction costs
- Coordination with regional marketplace initiative is essential
- Regulators (state and federal) are very interested
- Collaboration will increase in future phases

Observations from 2007…

- The project is moving from internal deliberations to a community conversation
- Project stakeholders and partners are interested and supportive
- Uncertainty remains when it comes to regulators and organized special interests
- The next phase will engage social networks to determine the ways and means of animating and directing market forces
- New initiatives will target the green economy, sustainability professionals and the supply chain of goods and services to serve individuals and communities

How CNS Has Helped?

Observations from 2006…

- Provided the necessary funding to get the work started
- Increased visibility, interest and knowledge of ecosystem services
- Provided the initiative for internal collaboration within Environmental Services
- Provided networking opportunities around the US and in DC

Observations from 2007…

- Created the occasion for a coming together of federal and state stakeholders from the Pacific Northwest
- Brought Dr. Garrett Louis into the project.. and his thoughtful inquiry into our methods of engaging stakeholders and decision-makers
- Increased our credibility in conversations with Congressional committees

Desired Feedback

Observations from 2006…

- Help document and check our assumptions and reduce our level of uncertainty
- Suggest ways to increase regulatory acceptance and flexibility
- Suggest ways to simplify a complicated subject and increase its accessibility to the public
- Help us see identify threats and risks, as well as opportunities facing our project

Observations from 2007…

- Help organize collaborative research and development programs to advance the following practical prerequisites of sustainable stormwater markets:
  - Methods and models for monitoring the effectiveness of sustainable stormwater facilities
  - subjective and objective values for ecosystem services
  - configurable software to operate credit trading registries
  - integration of local, regional, national and international marketplaces for ecosystem credit trading

Principal Investigators

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CH2M-Hill

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- Ken Carlson - 503.235.5000 - ken.carlson@ch2m.com

Ecological Sustainability in Rapidly Urbanizing Watersheds: Evaluating Strategies Designed to Mitigate Impacts on Stream Ecosystems

Keith Van Ness
Montgomery County DEP

Laura Craig
University of Maryland

Collaborative Science and Technology Network for Sustainability
Progress Review Workshop
November 8-9, 2007 Washington DC

Lead Principal Investigator:
Margaret Palmer
University of Maryland
Co-Principal Investigators:

Meosotis Curtis, Keith Van Ness
Montgomery County DEP

Amy Hennessey, Kevin Kelly
Environmental Systems Analysis

Questions:

When compared to pre-2K SWM strategies, are post-2K strategies better at mitigating the effects of urbanization on stream ecosystems?

How does watershed development affect receiving streams?

University of Maryland

Montgomery County DEP

Environmental Systems Analysis

Collaborators

Ecosystem Function

Water Quality

Hydrology

Geomorphology

Community Ecology

Selected Metrics

N removal & retention
Stream metabolism

Carbon availability
Nutrient concentrations

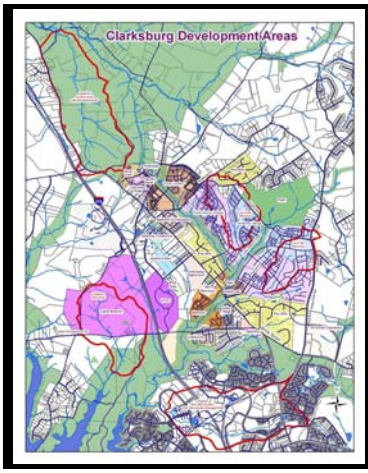
Peak Q
Baseflow Q
Rainfall:Runoff

Channel morphology
Particle size distribution

Biodiversity

Study System:
1 pre-2K control watershed
1 forested watershed
3 post-2K watersheds

Valuable Tools:
5 USGS stream gages
2 rain gages
LiDAR imagery



BACI Approach

2 Control drainages
3 Test areas

5 USGS stream gages
2 rain gages

LiDAR overflights

Meeting the needs of environmental decision-making for sustainability

- Documenting ecosystem response/recovery to long term and significant landscape changes
- Documenting effectiveness of sediment and erosion control and SWM best management practices
- Providing feedback to decision-makers regarding development and SWM design
- Devising more focused research questions based on the needs of managers and decision-makers

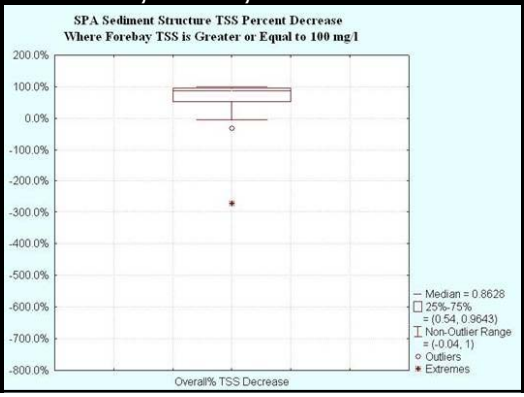
"Lessons Learned"

Questions and methods must be adaptable when studying large-scale treatments that you cannot control

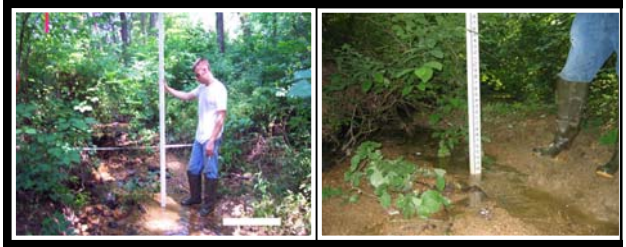
- Conversion of sediment control to SWM has been slower than expected
  - Building moratorium imposed on study area
  - Conversion can only occur when 100% of drainage area is controlled
- Speed of development has slowed over the course of the study
  - Slow down of housing market
- Treatment" effects may be masked by larger local effects
  - Cut and fill
  - Loss of natural drainage patterns
  - Influence of local geology and physiography

The Long Construction Phase

Sediment and erosion control devices are, at best, 86% efficient



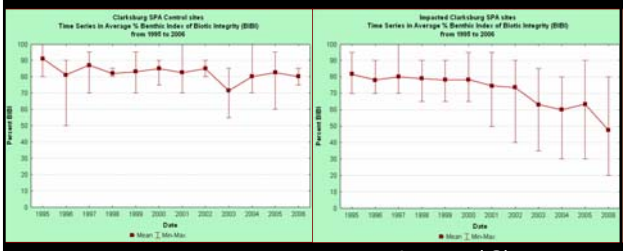
Development results in changes to in-stream habitat



2002 2005

Construction phase profoundly changes benthic macroinvertebrate community composition

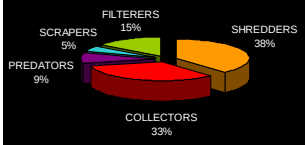
Benthic Macroinvertebrate IBI Scores



Control Sites Impacted Sites

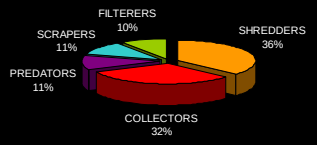
Changes in Benthic Macroinvertebrate Community Composition (Control Sites)

1996-2000



Dominant Taxa:
Amphinemura= 33% Shredder
Chironomidae= 21% Collector
N= 24, Total # of Stations = 7

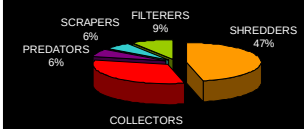
2003 2006



Dominant Taxa:
Amphinemura = 34% Shredder
Orthocladiinae= 13% Collector
N 17. Total # of Stations = 7

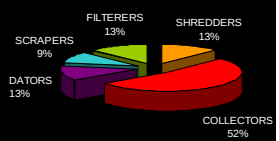
Changes in Benthic Macroinvertebrate Community Composition (Impacted Sites)

1996-2000



Dominant Taxa:
Amphinemura= 43% Shredder
Chironomidae= 20% Collector
N= 35, Total # of Stations = 9

2003 2006



Dominant Taxa
Orthocladiinae = 24% Collector
Chironimini= 13% Collector
N 31, Total # of Stations = 9

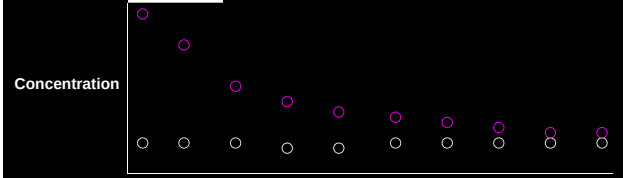
In-stream NO_3 uptake cannot be detected in Clarksburg study watersheds

Measured NO_3 uptake at each site:

Summer and Fall 2005

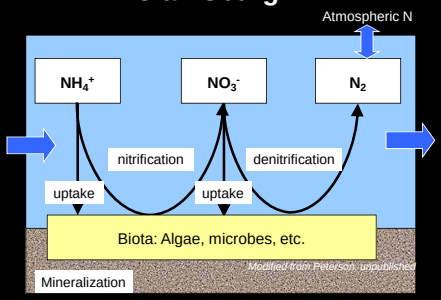
Spring, Summer, and Fall 2006

Summer 2007



Nutrient concentrations do not change with distance downstream!

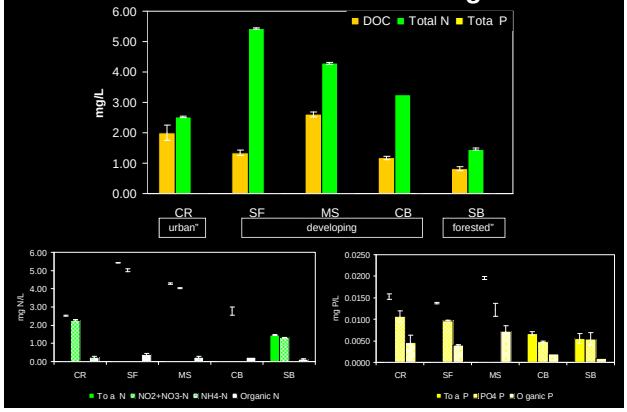
Why can't we measure NO_3 uptake in Clarksburg??



Streams are N saturated / Other nutrients are limiting

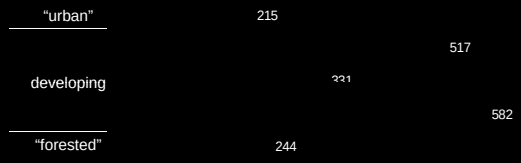
Nitrification is producing NO_3 (masking effects of removal)

Are streams N saturated? Are other nutrients limiting?



Are streams N saturated? Are other nutrients limiting?

DIN:SRP is a strong predictor of N saturation (Earl *et al.* 2006)



Study streams appear N saturated

C and P may be limiting uptake by benthos

Local conditions mask treatment effects!

Ways the CNS Funding & Program have Helped Us

- Creation/recognition of the Clarksburg Integrated Ecological Study Partnership has increased the number contacts from potential collaborators
- Helped leverage funding and in-kind services
- Provided a level of legitimacy to the county s efforts to understand effects of land use change to receiving streams and biota
- Networking has provided increased access to information, people, and equipment
- Research funded by CNS has led to new and interesting research questions regarding the effects of land use on stream ecosystems.

Update on Collaborators and Partners

S. Taylor Jarnagin, EPA-EPIC
Mapping landscape change and channel morphology using LiDAR

Dianna Hogan, USGS-Reston
Direct measurement of SWM BMP effectiveness

John W. Jones, USGS-Reston
Land use change and climate

Yusuf M. Mohamoud, EPA-NERL
Modeling urban development with HSPF

Kaye Brubaker, Vince Gardina, University of Maryland
Accuracy of LiDAR in different canopy densities

Gary Fisher, WRD, USGS
Collaborator on 5 USGS stream gages

M NCPPC Park Managers and Ecologists

Response to feedback from partners, CNS grantees, and others

Expanded partnerships with collaborators and the generation of additional data related to our original questions.

- Multi-year LiDAR coverage captures landscape and stream changes (Jarnagin)
- Accuracy assessment of LiDAR (Jarnagin)
- Creation of ARCMAP coverages (Hogan)
- Creation of BMP database (Hogan)

Discussions with other grantees at last year s meeting provided insight regarding data and inspired follow up experiments

Motivated the upgrade of the USGS gauge at our urban site to "real-time" allowing for public access

The Future of "Ecological Sustainability in Rapidly Urbanizing Watersheds"

Continued monitoring to gain a long-term understanding of the effects of land use change and SWM on geomorphological and ecological metrics as funding allows

Continued collaborative efforts

Pursue interesting "spin-off" questions

Publication of results (DEP releases and peer-reviewed journals)

Questions?

Comments?

Feedback?

Integrating Water Supply And Ecological Flow Requirements

EPA Grant # X3-83238601-0

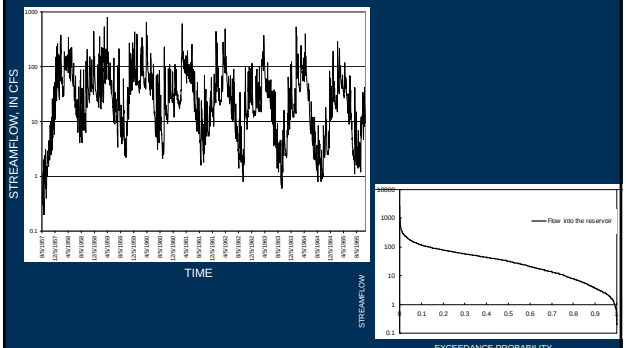
Collaborative Science and Technology Network for Sustainability Workshop

Washington, DC
November 8-9, 2007

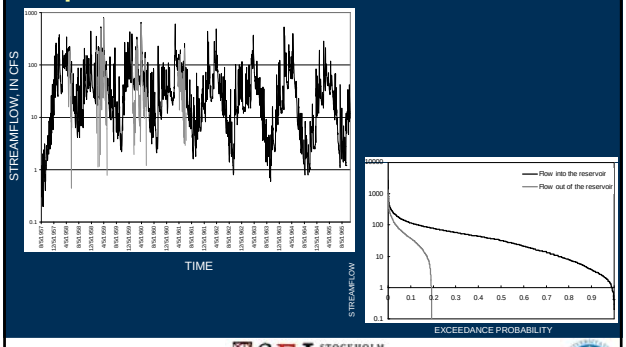
Experiment Objectives

- Examine trade-offs between human and ecological demands for water for a wide range of reservoir-release policies and reservoir sizes
- Quantify effects of demand management on this tradeoff
- Apply results to real-world case studies
- Communicate results through publication

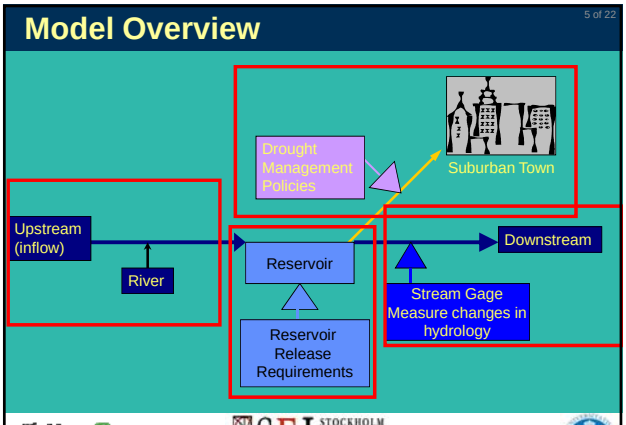
Inflows to the reservoir



Downstream Flow with No Release Required



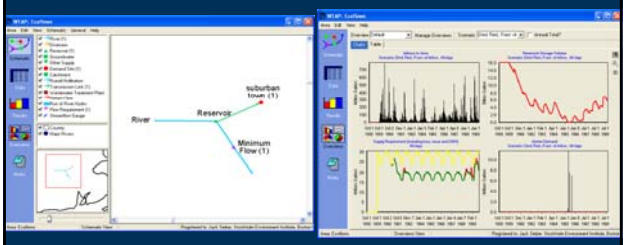
Model Overview



Model Platform

Water Evaluation and Planning model (WEAP)

- Developed by Stockholm Environment Institute



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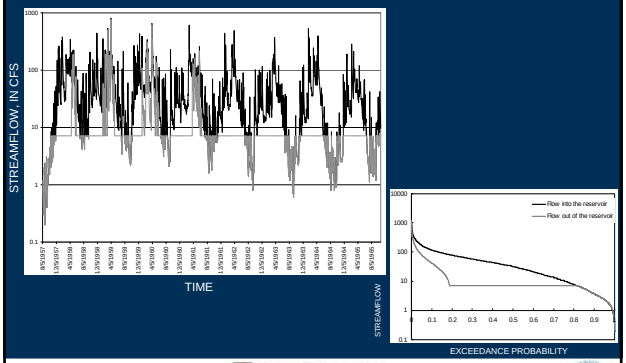
Release Policies Simulated

- No Release Required
- Minimum flows
- Seasonal minimum flows
- Seasonal minimum flows with high pulses
- Adaptive seasonal minimum flows
  - based on reservoir level
- Fraction of inflow
- Fraction on inflow with low flow protection

8 of 22

Flow Policy: Minimum release



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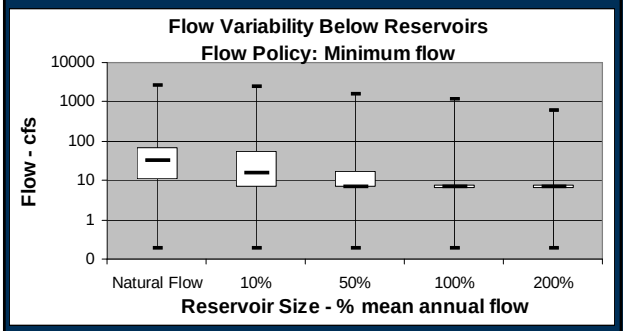
Reservoir Size



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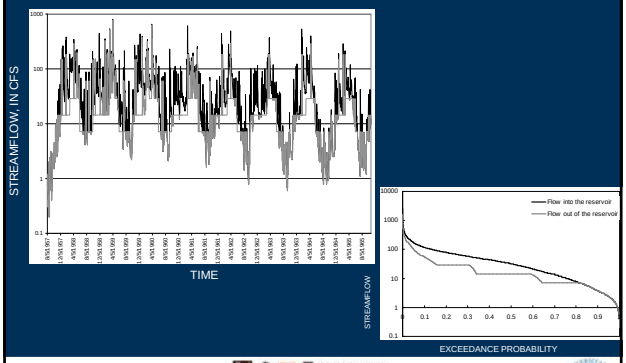
Flow Policy: Seasonal min with pulses



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Flow Alteration Metrics

Flow statistic	# Days Pre (avg/yr)	# Days Post (avg/yr)	Change (percent)	Impact Score range	Score
High Flows					
≥ 0.02	7.3	2.4	-66.6%	0 – 3	2
≥ 0.10	37.1	10.4	-72.1%	0 – 3	2
Mid Flows					
≤ 30% MAF	120.9	315.4	155.3%	0 – 3	3
Low Flows					
≤ 0.90	36.5	296.9	712%	0 – 3	3
≤ 0.98	7.3	295.4	3903%	0 – 3	3
			Total	0 - 15	13

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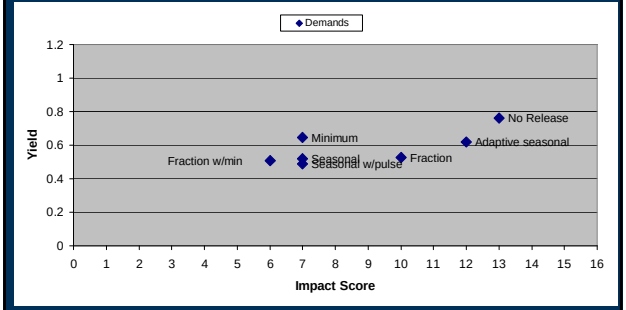
Yield and Impacts



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Drought Management Policies

Reservoir Level (% full)	Demand Reduction
60-100%	0
40-59%	20%
0-39%	40%

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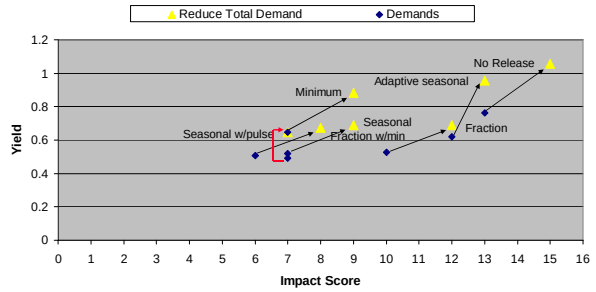
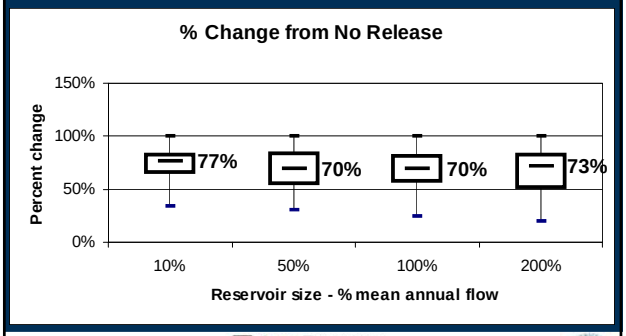
Yield and Impacts
Drought Management



15 of 22

Release rules can reduce reservoir yields by 24-30%



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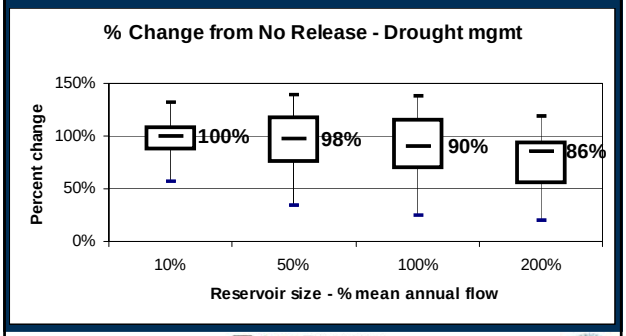
Drought management can allow for comparable yields to no releases



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Results and Lessons Learned

- Environmental sustainability of water supplies can be improved through the use of integrated reservoir release policies and drought policies
- Reduced yields as a result of reservoir release policies can be largely offset by drought management measures:
  - Release rules can reduce reservoir yields by 24-30%
  - Drought management can allow for yields comparable to no-release yields and pre-reservoir flow conditions
- Increased supplies from drought management can be used to support environmental flows
- Release policies that are effective for small reservoirs may not be effective for large reservoirs

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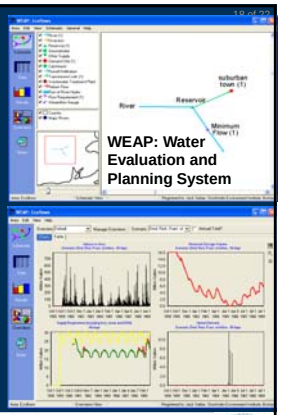
Project Collaboration

- Case study in support of Connecticut Department of Environmental Protection's effort to develop a streamflow-protection regulation
  - Tool will be used to: a) evaluate draft reservoir release and direct withdrawals policies (standards), and b) be compared to a similar but less robust model being developed by CT Institute for Water Resources



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Response to feedback

- We are starting to apply our results to case studies; therefore, we have just begun to receive feedback from partners in a specific way
- We also have received strong interest in this tool from state-agency personnel in the New England states

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Ways in which CNS funding has helped

- CNS funding has enabled our research team to communicate results through publication and at conferences and workshops around the world:
  - American Society of Civil Engineers, World Environmental and Water Resources Congress (Anchorage, AK)
  - National Center for Environmental Research Subcommittee on Water Availability and Quality (Arlington, VA)
  - International River*Symposium* and Environmental Flows Conference (Brisbane, Australia)
  - EPA Region I Science Day (Boston, MA)
    - Presentation was direct result of being posted on the website
  - American Water Resources Association, Baltimore, MD
  - Article in American Water Works Association journal (October, 2007)

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Future Work

- Apply results to case studies
- Continue evaluation of tradeoffs between reservoir-release policies, reservoir yield and drought management
- Formulate optimization by determining a set of streamflow statistics most representative of change in the natural-flow regime due to reservoir operation
- Develop decision-support tool to optimize reservoir operations that maximize both human and ecological water needs

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Research Team

- The Nature Conservancy: Mark P. Smith and Colin A. Apse
- Stockholm Environment Institute: Brian Joyce and Jack Sieber
- Tufts University: Richard M. Vogel, Stacey A. Archfield, and Yongxuan Gao

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Meeting the needs of environmental-decision making for sustainability: Project goals

- Quantify trade-offs between competing water management objectives;
- Integrate a more precise definition of ecosystem flow needs into water supply management;
- Provide a tool for optimizing timing and use of drought management and water conservation techniques;
- Promote consensus-based decision-making to management of water resources.

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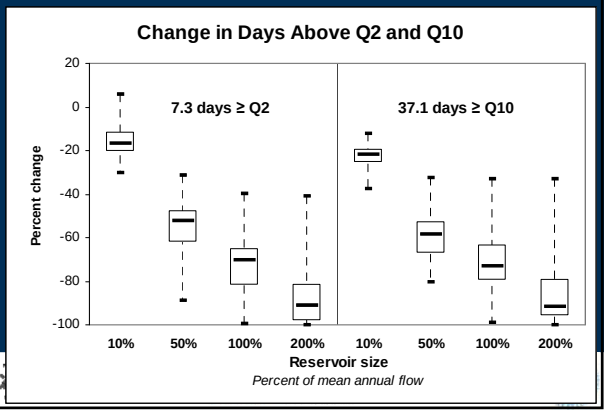
Changes in High Flow Events



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Reservoir Yields

Policy	Yield Fraction	mgd
No Release	0.76	26.5
Minimum	0.65	22.4
Adaptive seasonal	0.62	21.7
Fraction	0.53	18.7
Seasonal	0.52	17.7
Fraction w/min	0.51	17.0
Seasonal w/pulse	0.49	16.4

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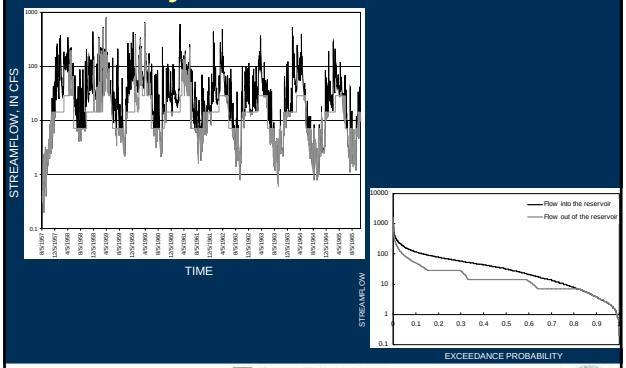
Flow Policy: Seasonal minimum flows



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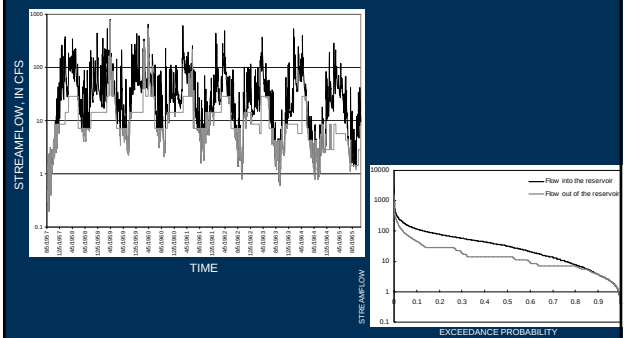
Flow Policy: Seasonal release based on reservoir level



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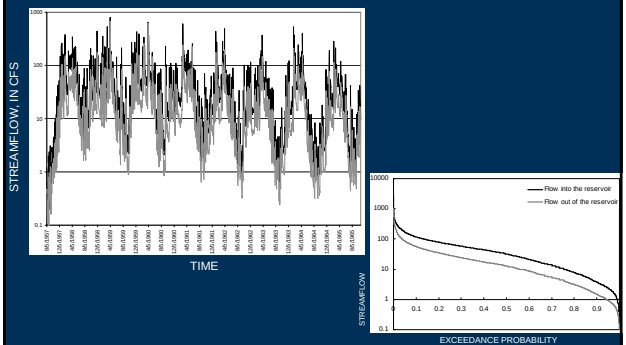
Flow Policy: Fraction of inflow



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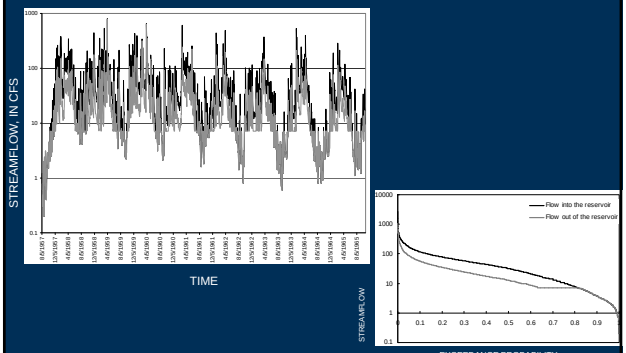
Flow Policy: Fraction with minimum



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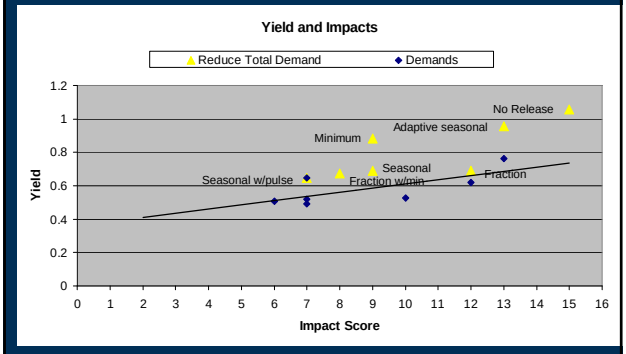
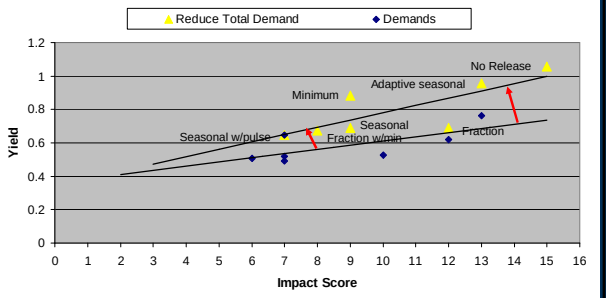
Yield and Impacts



Yield and Impacts

Effects of Drought Management



Integrating Water Supply And Ecological Flow Requirements

EPA Grant # X3-83238601-0

Collaborative Science and Technology Network for Sustainability Workshop

Washington, DC
November 8-9, 2007

Collaborative Research:

Richard Vogel – Tufts University
Stacey Archfield – Tufts University
Mark Smith – The Nature Conservancy
Colin Apse – The Nature Conservancy
Jack Sieber – The Stockholm Environment Institute
Brian Joyce – The Stockholm Environment Institute

Outline of Talk

Tufts University

- Historical Perspective on the Problem of Ecological Flow Protection
- Introduction to the Ecodeficit
- Optimal Balance of Water For Humans and Ecosystems
- Relationships Between Reservoir Storage, Yield and Instream Flow

Low Flow Conditions in Water Rich Massachusetts

Tufts University

Fish Brook, Boxford

Sudbury River, Hopkinton

Photos from MA Riverways Program website

Low Flows In Rivers Due to Human and Natural Causes Lead to Water Supply Deficits

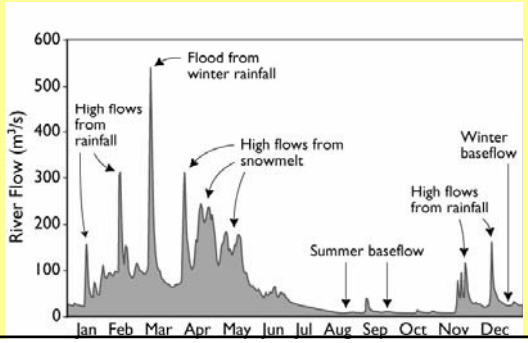
Tufts University

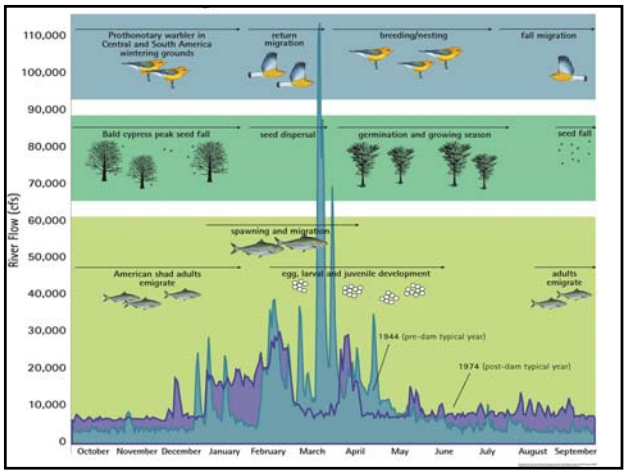
Middleton Pond, Massachusetts

Wenham Lake Massachusetts

Ecosystem Depends Upon Natural Variability

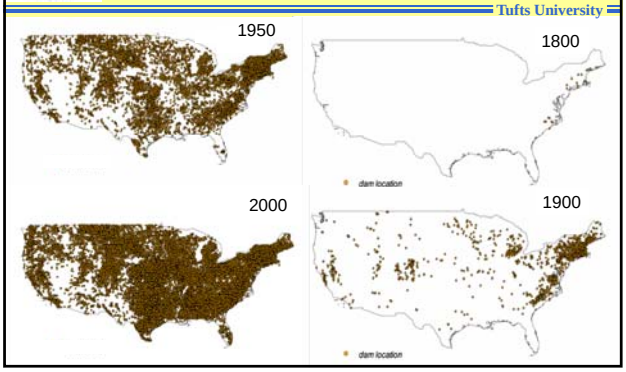
Tufts University





There are now over 75,000 dams Occurring on average every 70km On over 5.2 million km of river miles

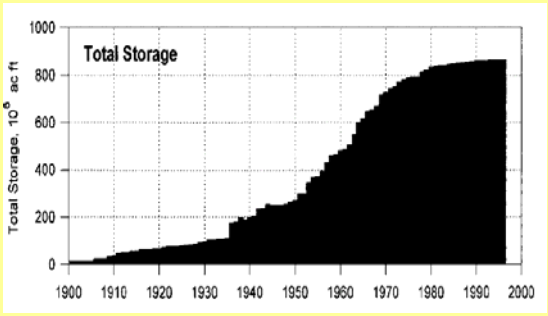
Tufts University



History of increasing total reservoir storage for the continental U.S.

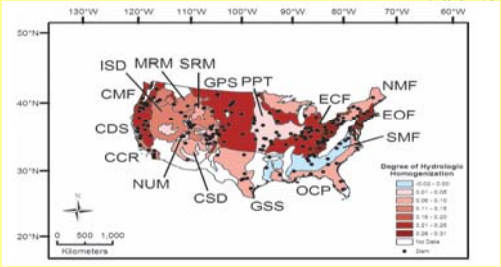
(from U.S. Army Corps of Engineers, 1996)

Tufts University



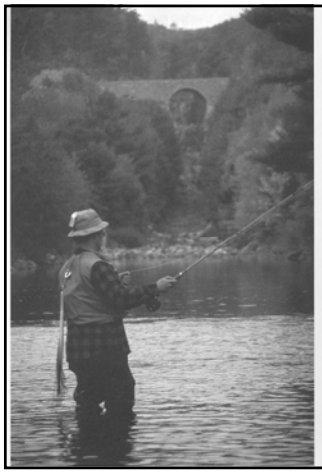
Dams 'flatten' the downstream flow regime

Tufts University



Shading denotes degree of homogenization in flow regimes due to dams

(from Poff et al. 2007, PNAS)



Its Not So Simple!

The Quabbin Reservoir Tailwater Region, Just Below the Spillway Attracts Fly Fisherman from All over the Region!

Dams Provide Many Benefits Including:

Tufts University

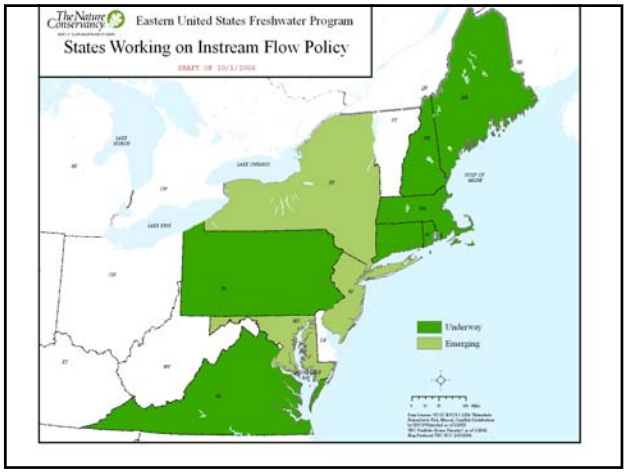
- Water Supply
- Hydropower
- Irrigation
- Recreation
- Cooling Water
- And …

2

The Setting and Problem

Tufts University

- The need to balance human and ecological flows results from our historical lack of attention given to ecological flows (instream flow) in water resource management
- There are dozens of texts and tens of thousands of articles on the management of reservoirs for human needs
- Until very recently, they only assign a minimum flow requirement for instream flows



The Setting and Problem

Tufts University

There is a sizable literature addressing each of the following problems:

- Instream Flow Needs
- Optimal Reservoir Management (for human uses)
- Water Resource Policy and Negotiations

However, there is very little literature integrating these three areas.

The Setting and Problem

Tufts University

- What causes ecological flow stress?
  - Increased human withdrawals (ground and surface)
  - Natural climatic variability
  - Climatic change
  - Land use changes (impact water quality and flow regimes)

The Setting and Problem

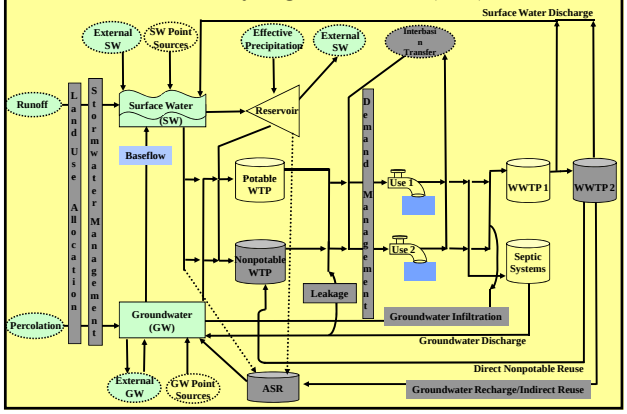
Tufts University

- How do we reduce ecological flow stresses?
  - Decrease human withdrawals (demand management, reuse, leak detection, …)
  - Stormwater recharge/management
  - Land-use management
  - Groundwater banking
  - **Improve environmental releases**

(topic of this talk)

3

A Watershed Systems Optimization Model Could be Used
From Zoltay, Vogel and Kirshen (2007)



Watershed Systems Approach: Management Options

Tufts University

Table 6. Management Recommendations with Increasing Management Options.

Management Options	Units	Current Allocation	Optimal Allocation	Near Term Optimization	Long Term Optimization with WW Export	Long Term Optimization without WW Export
Consumer's Rate Change	%	NA	NA	**10% (Max)**	**50% (Max)**	**50% (Max)**
DWTP Infrastructure Repair	% of Leaks	NA	NA	**100%**	**100%**	**100%**
WWTP Infrastructure Repair	% of Infiltration	NA	NA	NA	0	**100%**
Stormwater BMPs	# units	NA	NA	0	0	0
Land Conservation	Ha	NA	NA	NA	0	0
Nonpotable Distribution System	% of Consumers	NA	NA	NA	0	0
Additional Surface Water Storage	MG	NA	NA	NA	0	0
Additional Capacity:						
Surface Water Pumping	MGD	NA	NA	NA	**5.4**	**5.4**
Groundwater Pumping	MGD	NA	NA	NA	0	0
Drinking Water Treatment	MGD	NA	NA	NA	0	0
Wastewater Treatment	MGD	NA	NA	NA	0	**1.6**
Aquifer Storage & Recovery	MGD	NA	NA	NA	0	0

Watershed Systems Approach Ipswich River Example, From Zoltay, Vogel and Kirshen (2007)

Tufts University

Table 8. Management Recommendations with Increasing Instream Flow Requirement.

Management Options	Units	¼ ISF	½ ISF	Full ISF
Consumer's Rate Change	%	**50%**	**50%**	**50%**
DWTP Infrastructure Repair	% of Leaks	**100%**	**100%**	**100%**
WWTP Infrastructure Repair	% of Infiltration	**100%**	**100%**	**100%**
Stormwater BMPs	# units	0	0	**120**
Land Conservation	ha	0	0	0
Nonpotable Distribution System	% of Consumers	0	0	0
Additional Surface Water Storage	MG	0	0	0
Additional Capacity:				
Surface Water Pumping	MGD	**5.4**	**5.4**	**5.0**
Groundwater Pumping	MGD	0	0	0
Drinking Water Treatment	MGD	0	0	0
Wastewater Treatment	MGD	**1.6**	**1.6**	**1.6**
Aquifer Storage & Recovery	MGD	0	0	**18**
Water Reuse Facility	MGD	0	0	0
Net Benefit		**$3,084,187**	**$3,066,407**	**($9,530,879)**

ISF=Instream Flow; the fraction of instream flow met in scenario

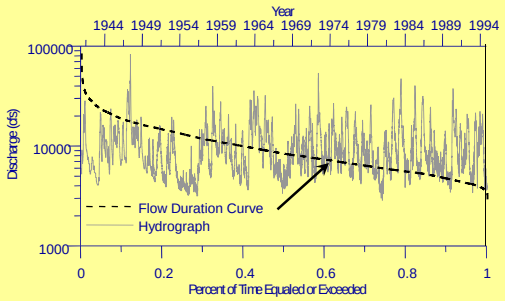
Historical Perspectives

Tufts University

- When the systems were designed the question was:
  - How much water can we reliably withdraw from the river?
- Today's question is:
  - How much water do we need to leave in the river?

Flow Duration Curves (FDC's) are Useful Tools for Ecological Flow Assessments

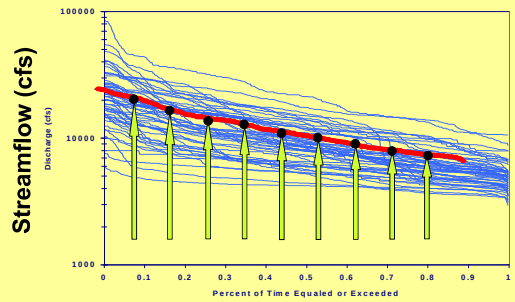
Tufts University



Suwannee River, Near Wilcox, FL

Annual FDC's and the Median Annual FDC

Tufts University

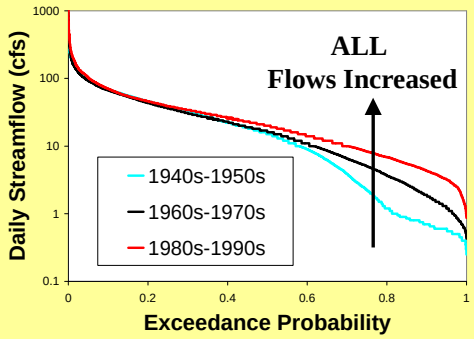


Exceedance Probability

4

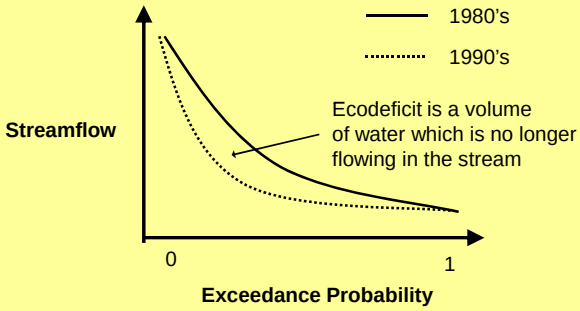
An Example of Use of FDC's for documenting hydrologic change – Aberjona River, MA

Tufts University



Definition of an Ecodeficit

Tufts University



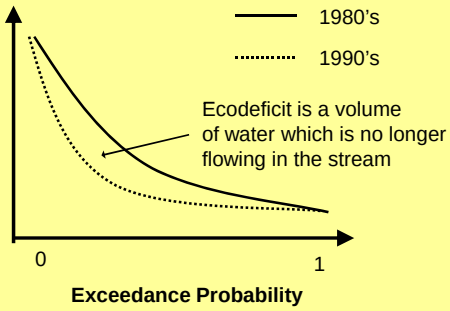
Ecodeficit can be defined in terms of streamflow or habitat

Tufts University

Streamflow

Or

Habitat Suitability Index



The Ecodeficit – An Example

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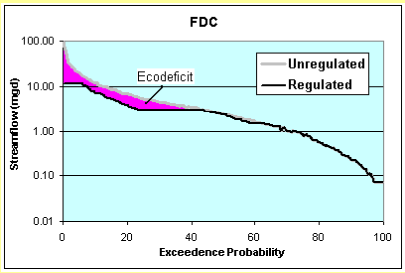

Here ecodeficit represents reduction in streamflow after river is regulated by withdrawals from a reservoir.

An Ecodeficit and Ecosurplus are Both Possible

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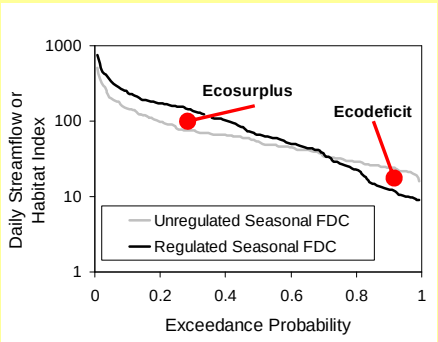

Advantages of Ecodeficit/Ecosurplus

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Can handle changes in seasonal, annual and decadal flow regimes

Summarizes entire flow regime from droughts to floods

Provides both graphical and quantitative summary

FDC's are already widely used in hydrology and habitat assessment

FDC's can be defined in terms of flow or habitat

Confidence intervals are easily obtained, leading to hypothesis tests

Competition for Water

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- When there's plenty of water, competition among flow needs is irrelevant
- Some standards exist for instream flow
  - Existing standards may not protect habitat
  - Existing standards are rarely adaptive
- Usually there are **NO** standards for water supply reliability

Tradeoff or Competition is a Multi-objective Optimization Problem

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Tradeoff or Competition is a Multi-objective Optimization Problem

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The biota now has a place at the negotiating "table"

Tradeoff or Competition is a Multi-objective Optimization Problem

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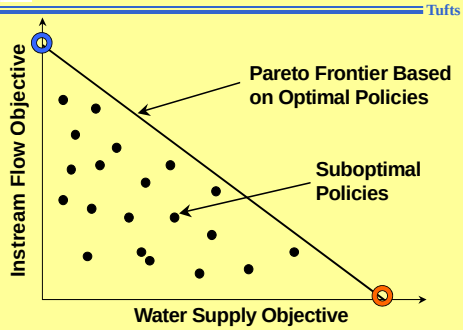

Most uniform instream flow policies lead to a zero-sum game

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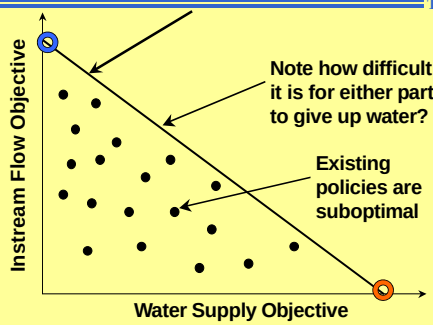

Research goal is to improve our ability to negotiate the Pareto Frontier

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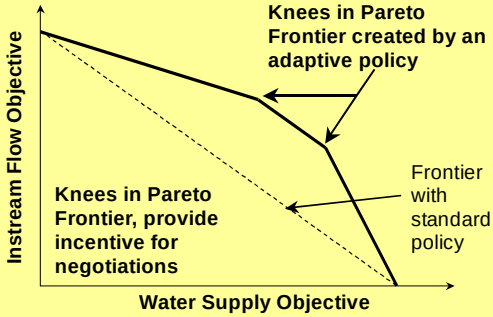

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The Traditional Water Supply Storage – Reliability – Yield Relationship

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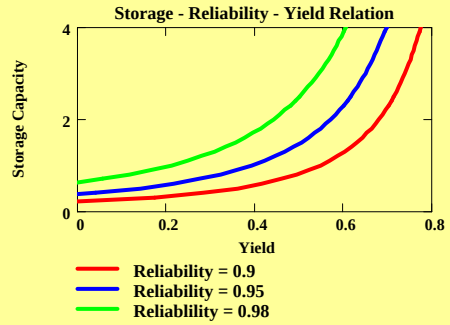

Little Attention Is Given to Properties of Instream Flow

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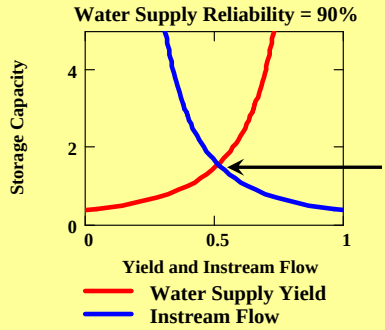

Large Storage favors water supply Yield

Smaller Storage favors instream flow

Exploring the Storage - Yield – Instream Flow Relationship

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Goal

Examine the impact of a range of release polices on the reservoir storage capacity S, water supply yield Y, and instream flow I.

Experimental Design:

- **Daily streamflows for Green river in Massachusetts (46 sq. mi)**
- **Storage ratios, S/μ range from 0-3, where**
  - **S=reservoir storage capacity**
  - **μ=mean annual inflow to reservoir**

Typical Storage Ratios Across the United States

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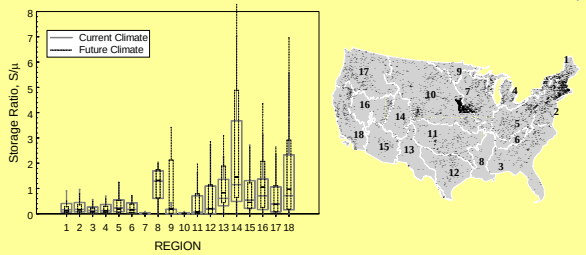

Storage Ratio is Number of Years of Water In Storage (From Vogel et al. 1999)

Reservoir Release Policies Considered

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- No instream flow release
- FOI - Release fraction of inflow to reservoir
- Fixed Minimum Release
- Flow components – releases to enhance floods and low flows
- FOI with demand (drought) management

Release Policies have an enormous impact on storage – yield relation

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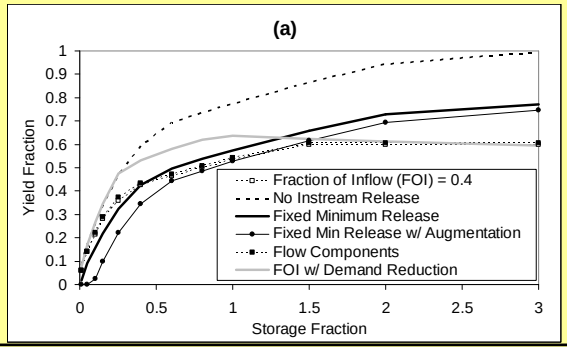

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Demand reduction has enormous impact on storage yield curve

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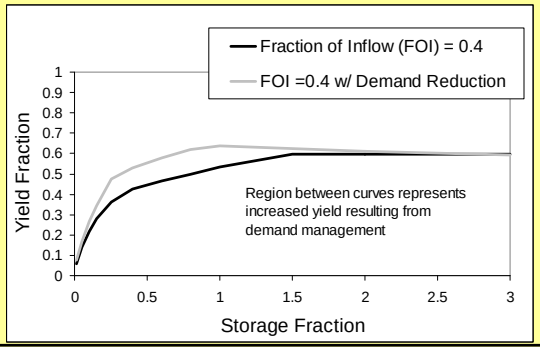

Fixed minimum release is good for small reservoirs but not large ones

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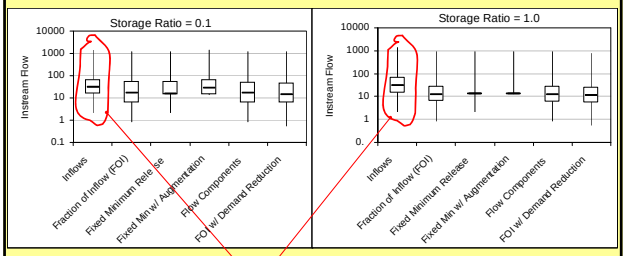

Inflows = Natural Flow Regime

Fixed minimum release is good for small reservoirs, but not large ones

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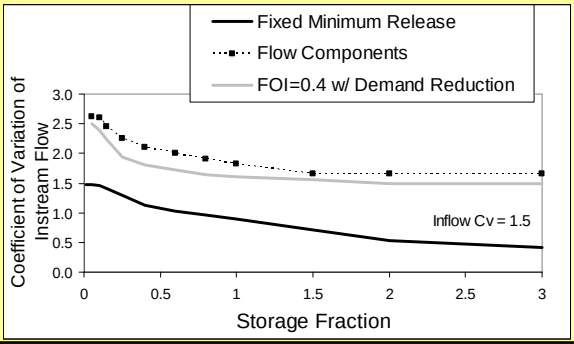

Summary

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Our Research Is:

- Quantifying trade-offs between competing water management objectives;
- Integrating a more precise definition of ecosystem flow needs into water supply management;
- Providing a tool for optimization of the timing and use of drought management, water conservation and other reservoir release strategies;
- Promoting a consensus-based decision-making approach to management of water resources.

8

U.S. Environmental Protection Agency
Collaborative Science and Technology Network for Sustainability
Final Workshop for 2004 Grantees

Four Points by Sheraton
1201 K Street, NW
Washington, DC

November 8–9, 2007

Executive Summary

NOVEMBER 8, 2007

Welcome – EPA's Sustainability Research Strategy
Alan Hecht, Director for Sustainable Development, EPA, Office of Research and Development (ORD)

Dr. Hecht welcomed attendees to the third year of the Collaborative Science and Technology Network for Sustainability (CNS) program. The cooperative grants program was one of the first programs ORD initiated when starting to work on sustainability. ORD needed a process by which stakeholders could achieve outcomes that were sustainable. Since the grants were awarded, grantees have submitted and reported on excellent projects. It is always a pleasure to listen to and learn from these projects. As part of the full sustainability campaign, ORD now has a sustainability strategy published on its Web Site at: http://www.epa.gov/sustainability/pdfs/EPA-12057_SRS_R4-1.pdf. Dr. Hecht thanked the participants for their work, and emphasized that the results of these projects will be very important.

Introduction to the Meeting
Leanne Nurse, U.S. EPA, ORD, National Center for Environmental Research (NCER)

Ms. Nurse welcomed attendees and expressed her appreciation to the ORD management for the opportunity to work on the CNS program. She is very encouraged with the progress the initial grantees have made. She shared a quote from one of her teachers, which stated that because of humanity's self-consciousness, "the mission of human beings is to contribute as conscious participants in the creative evolution of the universe." Though the work of CNS is practical and oriented toward providing solutions for sustainability for communities, from a loftier standpoint, each grantee is participating in the work of conscious evolutionary thinking. She added that the next days would be productive and interesting, and thanked the participants for attending.

CNS PROJECT PRESENTATIONS

Harnessing the Hydrologic Disturbance Regime: Sustaining Multiple Benefits in Large River Floodplains in the Pacific Northwest
Stanley Gregory, Oregon State University

Dr. Gregory's project studied the Willamette River Basin in Oregon, specifically the area upstream between Corvallis and Eugene. The river basin was surveyed in 1995 and previously in 1850, and the changes have been extraordinary. The loss of habitat had tremendous implications on the aquatic wildlife.

Dr. Gregory's project addressed the question: How can the Willamette River be restored using floods? Floods are the natural process by which rivers restore themselves, and the goal is to harness this process. Another variable studied is the climate change in the Pacific Northwest. The prediction is that the area will have a much warmer climate over the next decade, with a 2°C to 4°C increase over the next century. There also is a prediction for decreased summer precipitation, but this is less certain than the climate change. Removal of riparian vegetation increases the rate of longitudinal warming, but not the downstream maximum temperature, whereas increased air temperature will cause increased maximum stream temperature. This has huge implications for cold water species as well as for invasive species that are more tolerant of higher temperatures.

Municipalities are considering numerous ways to meet the Total Maximum Daily Load (TMDL) requirements, as the temperature of treated sewer effluent exceeds the allowed level. One option is refrigerating waste effluent, which will meet TMDL allocations, but it is a waste of energy. Another approach is flow augmentation. Dr. Gregory looked at flood plain restoration, which has less certainty in terms of meeting requirements, but has a lower cost. If the flood plain is restored, cold water refuges will be created by subsurface temperature exchange. This could restore cold water habitats and meet cold water refuge requirements. The Oregon Department of Environmental Quality (DEQ) will invest in floodplain restoration to meet TMDL waste load allocations, but will monitor this project, and if it is not working in 10 years, the project will end.

Dr. Gregory's group looked at hyporheic rivers, which act like a sewage treatment plant. Water flows through gravel bars and is cleaned by microbes. The researchers placed 150 dataloggers per kilometer on the bottom of the river. They studied floodplain alcoves, bar alcoves, and side channels. In one example, in the Norwood Island Slough, springs enter at 11°C, though the rest of the water is 20°C; this can be important in a warm environment. Dr. Gregory found that the floodplain alcoves studied were 65 percent colder than the mainstem, and 39 percent of them were more than 2°C, which under Oregon law makes the area a cold water refuge that has to be protected.

In the restoration process, levies will be moved back and areas will be flooded to restore exchange of surface and subsurface water. Willamette Exchange (Willamex) is selling thermal credits, which would pay landowners for maintaining or restoring floodplain function. Later, they may offer wetlands credits and carbon credits. The Oregon Watershed Enhancement Board has funded a 3-year study of fishes' use of cold water refuges to determine whether the restoration of cold water habitats would have a positive effect on designated beneficial uses under the Clean Water Act. The study will determine if fish are using the cold water habitats differently than they use the mainstem.

Dr. Gregory's project contributes to sustainability by: providing the scientific basis for meeting thermal TMDL goals by restoring coldwater refuges in a large river through a market-based collaborative system; identifying locations of coldwater refuges; modeling hyporheic influence on temperature; creating dynamic visualization of complex information for stakeholders; providing a spatial framework for decision makers; and working directly with stakeholders and environmental agencies to solve environmental challenges.

Discussion

A participant asked if the goal in restoring the floodplain, which creates the side channels and alcoves helpful for coldwater habitats, is not necessarily to change the temperature in the mainstem but to create habitat in side areas. Dr. Gregory confirmed that this is correct. The issue was a sticking point with the Oregon DEQ at first, because the department wanted to see temperatures lowered in the mainstem, but the cold water refuge narrative standard carries equal legal weight. It would not have been possible to raise the mainstem temperature significantly.

A participant asked if the restoration approach would be limited in a more developed setting. Additionally, on the thermal trading scheme, the value of lowering the temperature is very different depending on where the warm water gaps are filled in with coldwater habitat. How will the trading scheme account for that? Dr. Gregory explained that in terms of incentives, the details are just being developed. Landowners will get more credit if the area provides a stepping zone between functional habitats, and most credit might be on the interface of functional and less functional habitat. The Greater Miami River in Ohio has a thermal trading program as well. In terms of urban areas, there is less flexibility in restoration around the rivers. However, more people see projects in an urban area, and these projects can act as a classroom on sustainability.

A participant asked if there is a rain regime in the Willamette River Basin. Dr. Gregory responded that most of the rain occurs from October through March, so the warm season is also the low water season.

A participant asked Dr. Gregory to define the thermal measurement. Dr. Gregory answered that it varies depending on the velocity of water in the area. In most areas measured, the researchers found that at least one-half the depth is in the cool water zone. This can be predicted based on the permeability of the floodplain substrates, which is the most variable parameter in the environment.

A participant asked how much the measured river depths vary. Dr. Gregory responded that they vary from a quarter of a meter to 4 to 5 meters deep.

Water Resuse: An Integral Part of Sustainable Water Resource Planning
Paul Anderson, Illinois Institute of Technology

Dr. Anderson's research goal in studying water reuse was to provide the following key information to decision makers: a demonstration of the need for efficient water use (a new concept in the Great Lakes area), water reuse education, and identification of potential barriers and incentives. The biggest barrier seems to be economic, so another goal was added to provide a tool for economic assessment.

Lake Michigan provides 90 percent of the water supply for northeastern Illinois, and the water level there is falling. By law, no more than the current 90 percent of the water supply can be taken from Lake Michigan. In the region, and in the United States as a whole, water is not used very efficiently. A large fraction of the water used could be lower quality, because 60 percent of potable water is used for outdoor irrigation and flushing toilets. There is not another commodity that the United States puts as much money into only to throw it away. There are no federal water reuse regulations, though EPA issued guidelines in 2004. Based on 2004 data, 25 states have water reuse regulations.

The cost of water delivery depends on volume and distance, so the goal is to get the highest demand users closest to the source. (Chicago's water cost is already low, so it is not a particularly good example in this respect.) To create a secondary distribution system for lower quality water for uses that do not require potable water, the main cost would be putting in the pipeline. However, there are some human health risks inherent in water reuse, such as pathogens and chemical contaminants like pharmaceuticals and pesticides, and ecosystem risks including phosphorus and nitrogen in the wastewater. In 2006, the Illinois governor ordered a water supply study with the following stated mission: "To consider the future water supply needs of northeastern Illinois and develop plans and programs to guide future use that provide adequate and affordable water for all users, including support for economic development, agriculture and the protection of our natural ecosystems."

Current water use data are limited, and there are challenges in creating change to promote water reuse due to system inertia; communities are more accustomed to looking for new water sources instead of considering reuse. Because Chicago was an outlier in terms of cost, Dr. Anderson's group formed a

partnership in Aurora, Illinois, which is experiencing rapid growth, has higher costs for water, has limited water resources, and has recent experience with drought and watering restrictions.

Future efforts will involve identifying further methods to get more value from water. Geothermal water-source heat pumps offer low-cost heat with less energy consumption and reduced carbon emissions. The dual purpose water distribution system (potable and non-potable water) could have an integrated infrastructure that includes the non-potable water supply and a ground loop for the heat pump system. Key issues to overcome for the success of this project include economics, regulations, risk, and policy decisions; officials must decide that this concept is worth examining.

Sustainable Sandhills: A Plan for Regional Sustainability
Susan Pulsipher, Sustainable Sandhills

Ms. Pulsipher explained that Sustainable Sandhills is a small nonprofit organization in North Carolina that promotes regional sustainability planning. Ms. Pulsipher added that their project under the CNS grant created land-use suitability maps for 11 counties in the state, plus the Fort Bragg military base. The goals of the project were to sustain Fort Bragg as a viable military installation, sustain the local ecosystem so that it remains enjoyable for residents, and manage population and economic growth to sustain and improve the existing environment. Land suitability maps point out how appropriate certain land is, in terms of sustainability, for a certain type of use based on the best available data and using simple and transparent models. The researchers created a set of tools that graphically illustrate the competing potential uses of land from a variety of viewpoints. This gives developers and planners a way to assess a number of factors quickly before spending a lot of time and money on a piece of land or project. The maps also provide elected officials, developers, and planners with the same set of base data to work from when assessing how land is best utilized for the well-being of a community and region.

Land-use suitability criteria for commercial developments were considered highest if the land was near an area of urban density, in a higher income area, near a primary road, and in or near a public water and sewer service area. Land was considered of lower suitability for commercial use if any of the following constraints were found: a steep slope, location in a floodplain or wetlands, and the presence of wet soils.

Sustainable Sandhills received feedback on the beta version of their tools from planners at a workshop in September 2007, and now are distributing grid maps to planning offices. The results of the study will be used in a 2008 Joint Land Use Study update of a 5-mile area around Fort Bragg to be conducted by the Regional Land Use Advisory Committee (RLUAC), and will be incorporated into the Comprehensive Regional Growth Plan of the Base Realignment and Closure Regional Task Force (BRAC-RTF). Both RLUAC and BRAC-RTF are participating in the suitability map development. The CNS project and models will form the basis for a military funded land-use modeling project covering another 13 counties in southeast North Carolina. Ms. Pulsipher noted that the enthusiasm with which developers received the project was surprising, but very encouraging.

Discussion

Dr. Gregory noted that in his region, with some models, local planners wanted to have the controls (such as knobs and sliders) available to adjust the weightings themselves, and asked if the Sustainable Sandhills' program had this capacity for the user. Ms. Pulsipher responded that the level of sophistication that Dr. Gregory described would require more development funding.

Mr. Dan Vizzini asked if Sustainable Sandhills had received any negative feedback from property rights supporters. Ms. Pulsipher explained that the group had not yet received such feedback, but they currently were trying to keep a low profile. The group wants to get the tools in the hands of the planners, then into

the development community so builders can use them, because some do understand geographic information systems (GIS). It will gradually filter out into the general public and to the elected officials, but the researchers are letting the planners take the lead. Later in the month, she will present the tool to the long-range planning commission of Southern Pines, North Carolina, and to the elected officials of 11 counties. She imagines there will be some negative response from some stakeholders, but she had already responded to a planner who asked how these data will affect land values. The answer is that they should not have an effect.

Ms. Nurse mentioned that with the BRAC transition in St. Mary's County, Maryland, the local government was completely overwhelmed. It is a rural area with two or three Superfund sites, and the existing structure could not take the change. This is a BRAC example similar to Fort Bragg. Ms. Pulsipher stated that the Army may have learned a lesson from that, because the BRAC-RTF is funded by the military, and has an elected board with transportation, water, sewer, housing, and school working groups. They have consultants on these groups, and Sustainable Sandhills is sitting in on many of the groups. The region is trying to be proactive.

Dr. Gregory offered information for Sustainable Sandhills in terms of questions they may receive on property values. A recent study at Oregon State University on property values versus planning showed that zoning had no effect on property value. It does not change the land values, at least in the Northwest where the study was conducted.

Mr. Vizzini noted a study at Reed College in Portland, Oregon, that examined the effect of open areas near property in terms of property values, and owners benefit in this case. He asked if transfer of development rights, in which a landowner transfers building rights from one location to another, is available in North Carolina. Ms. Pulsipher responded that state laws restrict this kind of activity. Mr. Vizzini explained that such transfer of development rights created areas of heightened density and urbanization; a problem in Portland was that planners did not create enough receiving areas.

Sustainability of Land Use in Puerto Rico
Juan Lara and Carlos Padin-Bibiloni, Universidad Metropolitana, Puerto Rico

Dr. Padin-Bibiloni stated that the primary aim of this project is to develop a model using GIS with a land use sustainability index. This will provide a scientifically reliable tool to measure and monitor the impacts of the progression of the urban environment on the quality and availability of land, ecosystems, and water in Puerto Rico for long-term sustainability. Four municipalities are being used as case studies, and the outcomes will be transferable to the other municipalities in Puerto Rico. The model also could be transferable to other islands. There are 78 municipalities in Puerto Rico, all of which must have a land-use plan that must be revised every 8 years. The island has a high population density (429 inhabitants per square kilometer), topographical limitations, and a serious combination of natural hazards.

A great challenge when considering land sustainability in Puerto Rico is that no single resource on Puerto Rico remains unaffected by urban sprawl, and 22 percent of the island is urban. From 1935-2000, the population of the San Juan metropolitan area has increased by 49.9 percent, but the amount of developed land increased by 1,286 percent.

The project has several components. First, the researchers will describe the current land-use situation using selected indicators as stressors and relievers, which evaluate how close or far the municipality is from sustainability of land use based on available and reliable information. They will establish a base optimal land use for the selected indicators that will help measure positive or negative change through time. Using these indicators, they will provide a land-use sustainability index to measure status and

progress, and hope to receive constant feedback and collaboration on the decision-making process from stakeholders and advisors.

Dr. Lara explained that a tentative group of 23 indicators was selected by the project team with the input of an Advisory Committee composed mainly of local and federal government agencies and municipal officials. Indicators were chosen based on their relevance and functionality for land-use planning at the municipal level, adaptability to different scenarios in 78 municipalities, ability to evaluate both the current situation and future tendencies, and expression of a value that is both quantitative and qualitative.

Indicators were separated into stressors (SI) and relievers (RI), and each was weighted. ISLA (the index created using SI and RI) ranges in value from 1 to 100, as do RI and SI individually. RI is calculated as a weighted geometric mean of individual reliever indicators, each of which has been divided first by a benchmark value. SI is calculated in the same manner, but using stressor indicators. In ISLA, the value 10 separates sustainability from non-sustainability. At 10, stressors and relievers cancel each other. Below 10, stressors outweigh relievers, and for values higher than 10, relievers outweigh stressors.

When the ISLA composite index model was run for the first time, all four municipalities used as case studies came out very low in sustainability (lower than 10), a mirror of the unsustainable reality of land-use trends in Puerto Rico. At this phase of the project, the research team is re-evaluating and validating the parameters used in the model (benchmarks/planning objectives) with the Advisory Committee and local experts.

The researchers have discussion meetings with stakeholders every 2 to 3 months. Stakeholders' participation from the beginning resulted in successful collaboration and interest in using the results of the project for decision-making. Land-use planning goals are being discussed and evaluated with stakeholders as alternatives when there are no clear and agreed upon benchmarks for the indicators.

In the future, the researchers hope to use the index as the basis for an objective tool to evaluate performance for sustainability: development of Puerto Rico's State of Land Use for Sustainability Report, in which municipalities will be ranked every 4 to 8 years according to land-use "eco-efficiency." They hope to use this report for municipal ordinances and public policies, and to provide support to municipalities for specific land-use sustainability projects. The project team believes there will be opportunities to fine-tune some indicators that now suffer due to a lack of reliable data. Future research would include the possibility to expand the indicators to a regional scale using watersheds or regional municipal economic initiatives as territorial planning units.

Discussion

A participant noted that with a scale of 1 to 100, if the cut-off for sustainability is 10, that leaves little room to show a broad range of unsustainable activities. Dr. Lara responded that the Advisory Committee also raised this as a concern, because the information should not be summarized so much in the index that the details are missed. That is why the researchers realized that they needed a separate stressor index and reliever index, so they each could be examined individually as well as in the index. Because the two groups of indicators point in different directions, part of what the researchers want to capture is how they pull against each other. At number 10, there is a stalemate between stressors and relievers. This is not a scale that can be interpreted in uniform units because it is based on a square root.

Mr. Vizzini commented that this will have an effect on public policy because the math will drive the decisions. Policy will not necessarily focus on individual items, but on the composite of stressors and relievers. It will be interesting to see how this develops over time. He is interested in the way the researchers got to the benchmarks, because that is essentially a political discussion as much as an

economic or land use one. Dr. Lara explained that one of the difficulties the project team had was distinguishing benchmarks from policy objectives, and they still are not sure they understand the distinction very well. Dr. Padin-Bibiloni added that benchmarks come from various policies. The researchers also looked at other U.S. policies concerning certain indicators. For example, in determining the benchmark of pounds of solid waste per person, they used the lowest in Puerto Rico. Mr. Vizzini asked if the indicators resulted from a review of existing policies. Dr. Padin-Bibiloni said that this was correct. Mr. Vizzini noted that the idea of carrying capacity is more significant on an island than anywhere else, and asked if this topic arose in discussion. Ms. Maria Juncos-Gautier, another member of the project team, answered that this was a challenge to discuss with the Advisory Committee, because Puerto Rico's resources are not sustainable with the current levels of development. Dr. Padin-Bibiloni added that what the group was seeking with this indicator was a tool to help guide decision-making so the situation does not worsen.

Dr. Anderson asked if the weighting of indicators came from the Advisory Committee. Dr. Padin-Bibiloni answered that they had come from the Advisory Committee as well as state and federal agencies, planning commissions, and different stakeholders.

Dr. Gregory stated that some people would just see the index as a number that did not make any sense. Are there any other ideas for visualization in the works, such as urban footprints, for instance, as an indicator of how much land would be necessary for Puerto Rico to have to be sustainable at current levels? Dr. Padin-Bibiloni answered that a study showed that if Puerto Rico continued the same type of development it is now conducting, the entire island will be developed in 75 years. This research can be important in educating people in Puerto Rico. One political party's vision of Puerto Rico is a city island with the rural areas as parks, and this is what the project is working against.

Cuyahoga Sustainability Network
Stuart Schwartz, University of Maryland–Baltimore County

Dr. Schwartz's project tried to identify key information gaps and needs for sustainable decision-making in Cuyahoga County, Ohio. His project is centered at the intersection of natural systems, engineered systems, and social systems that constrain decision-making, and examines environmental, economic, and social sustainability. Dr. Schwartz studied landscape influences on environmental services, urban hydrology and sustainable landscapes, and the economic demand for environmentally sustainable design.

As part of the project, a pervious concrete installation at Cleveland State University was combined with a workshop, and this has been very successful. The installation now has been through two winters and survived without any problems. The new administration building at the university has a parking lot paved with pervious concrete, and the Wade Oval, part of the cultural center in Cleveland, has a pervious concrete performance stage.

Dr. Schwartz's project quantified site infiltration using an IIHR Digital Infiltrometer Controller to conduct infiltration tests. Two of the three sites studied had negligible infiltration. Wade Oval infiltration is poor, though it is a significant area of premier greenspace, and it produces significant runoff from storms. This has shaped a lot of the thinking about pervious lands. Researchers increasingly are embracing the idea that they need to ask why lawns are producing so much runoff instead of just seeing if a rain garden will help reduce the runoff. Another infiltration problem is due to the modern practice of land development that removes topsoil and its hydrologic surfaces. Cleveland Botanical Garden is experimenting with a "no-mow" lawn of native grasses and plants.

Hedonic analysis looked at price signals for environmental design. As an example demonstrating that economics is a key factor in sustainability, Cleveland's first published project in conservation design was not printed in sustainability literature but in an appraisal journal.

Dr. Schwartz's future work will involve conducting a community tree survey in Cleveland; urban forest services in conjunction with Cuyahoga GreenPrint, Cleveland Metroparks, and Cleveland Street Trees; further infiltration and hydrologic services, including a study of the hydrologic function of rain gardens and urban pervious areas; lawn treatment for infiltration, and the quality and function of no-mow lawns and lawn care; pervious concrete partnerships in Chesapeake Bay; and new spatial design models.

Framework for Sustainable Watershed Management
Charles App, EPA Region 3, Environment Assessment and Innovation Division

Mr. App gave this presentation for Pamela V'Combe of the Delaware River Basin Commission who was unable to attend the meeting. The research was conducted in the Pocono Creek Watershed, an area which is less than 50 percent developed, but which saw a population increase of more than 50 percent in the past decade due to the fact that it is 90 minutes from both New York City and Philadelphia. The population is expected to double during the next 20 years. Current residents do not want to lose their current resources, including the trout stream, when this development occurs. Sustainability goals for the watershed include maintenance of high-quality water, preservation of stream corridors and floodplains, development using conservation design, preservation of open space, and the establishment of an economy compatible with the environment. The researchers are trying to predict how the growth will affect the trout stream in terms of flow.

The project goal is to use sound science to develop water resource management strategies and polices that local decision makers can adopt and implement. Land use will drive what happens with the groundwater. More development will mean more impervious surfaces.

The researchers conducted a hydrology model study using a Hydroecological Integrity Assessment Process (HIP), which links stream flow and stream health to maintain healthy aquatic ecosystems. The results they found based on projected build out in the area showed that stream recharge would be reduced in 26 out of 29 recharge areas. They measured the effects on base flow from groundwater withdrawals and this reduced recharge from land-use change. The projected build out will change the nature of the stream in numerous ways. In each of the indicators (flow conditions, frequency of flow events, duration of flow events, timing, and rate of change in flow events), there is some significant effect from the build out. Groundwater withdrawals and surface water withdrawals have an equal effect on stream flow.

The researchers hope that there will be a flow/trout (meaning a change in abundance of trout) indicator relationship. If this is the case, then they will develop flow standards. HIP will be applied statewide to all the streams. The project team is conducting discussions with the fish and boat commission to see if the tool can be linked to the biological community that they are trying to protect. The group will seek funding for this project.

Discussion

Dr. Gregory noted that it was strange that brown trout would be protected because it is an invasive species. Mr. App responded that there was debate as to whether it is invasive, but in Pennsylvania it is highly valued.

Dr. Anderson asked how the researchers communicated the sophisticated models to stakeholders. Mr. App noted that there have been statistical measures for each of these models, but agreed that they are

difficult to explain. The watershed hydrologic model is sophisticated, as is the groundwater model; however, the HIP is easy to apply.

Moving Toward Sustainable Manufacturing Through Efficient Materials and Energy Use
Terri Goldberg, Northeast Waste Management Officials' Association

Ms. Goldberg explained that her project group developed the Energy and Materials Flow and Cost Tracker (EMFACT), a software program intended to assist small and medium-sized businesses in the United States. EMFACT will help users to: better track and understand the use and flow of fuel, water, and materials through their facility; better understand the actual costs of poor resource efficiency and subsequent waste management; and improve decision-making and environmental performance via continuous tracking.

EMFACT can be used to track fuel, water and materials use, generation of air emissions, wastewater, and solid hazardous waste, and associated costs. The tool will be available online at no cost. The user has the ability to define many options themselves, including the site, equipment, inputs, products, and non-product outputs. The components can be linked together and analyzed, and reports can be generated for further analysis. EMFACT was designed to be user-friendly, with menu paths provided for all windows.

Though this ability is in an early stage of development, EMFACT will have the capacity to collect relevant cost data for materials and waste management and disposal. When the project team surveyed potential users, regulatory compliance issues were raised as an important concern. Therefore, EMFACT incorporated lists of regulated chemicals, and can flag and report on them. Users also can create their own chemical lists, and EMFACT will note if permits are required for certain chemicals and will keep track of when these permits are due.

Development will continue for another 2 to 4 weeks, with the launch of version one scheduled for March 2008. The beta version will be available in December at the time of the groups' advisory meeting. Ms. Goldberg's hope is that users will be able to develop useful efficiency reports with EMFACT.

Bringing Global Thinking to Local Sustainability Efforts: A Collaborative Project for the Boston Metropolitan Region
James Goldstein, Tellus Institute

The purpose of Tellus Institute's "Boston Scenarios" project is to support sustainable regional planning by providing tools and methods that promote an integrated long-term systems approach. Currently, there is much pressure on the developing suburbs around Boston, Massachusetts. These areas are poorly served by public transportation. The project involves coordination with MetroFutures (another regional group involved in sustainability), consultation with stakeholders, and data collection, review, and synthesis. Tellus enhanced its PoleStar scenario building tool for the project. The institute developed scenarios that would occur under three circumstances: business as usual, policy reform, and deep change.

Although Boston Scenarios is EPA funded, MetroFutures is stakeholder-driven. Boston Scenarios relied on existing data sources for the scenarios created, and adopted MetroFutures "business as usual" scenario, under which there is little change in production and consumption patterns, and resource equity is not addressed. These scenarios are not predictions, but possibilities. Because they are predicted to 2050, they are necessarily vague. The deep change scenario would keep consumption within the region's equitable global share of resources. It requires changes in values leading to changes in lifestyles and institutions, along with technology innovations, to achieve sustainability with global responsibility. The middle-of-the-road scenario is policy reform, in which technological and policy measures are emphasized to moderate ecological destruction and social inequality.

The deep change scenario was strongly endorsed by Boston Scenarios' Advisory Group, sectoral working groups, and project participants, though the significant challenges inherent in this scenario were acknowledged. The advisory group was hand-picked from those in sustainability leadership roles in the region already, so it is not representative of the community at large.

The deep change scenario requires large carbon dioxide reductions that could be achieved through the following changes needed to increase efficiency and renewables: a reduction in the work week would lower overall GDP by 25; percent smaller houses and more multi-family houses would mean a reduced rate of appliance growth; more compact communities would mean less driving and air travel; reduced demand for goods would mean less freight is transported; reduced consumption of goods would mean reduced commercial floor space and reduced industrial output. There would be reduced electricity generation due to all of the above.

The Boston Scenarios project led to an infusion of science-based systems approaches, integrating sustainability and local and global concerns into a regional planning effort and stakeholder process. It also raised awareness among policymakers and citizens of the need to examine the role of values and lifestyle in social, environmental, and economic elements of sustainability.

Tellus' PoleStar is now being used in 11 regions to update global scenarios. The group's future work will involve disseminating the scenario approach, and the deep change scenario in particular, in educational materials, and an ongoing involvement in Boston's regional policy efforts, such as transportation and energy.

NOVEMBER 9, 2007

CNS PROJECT PRESENTATION

Integrating Water Supply and Ecological Flow Requirements
Richard Vogel and Stacey Archfield, Tufts University

Dr. Vogel explained that the project examined the water supply deficits from low flows in rivers due to human and natural causes, and tried to determine how a balance could be achieved between human and ecological requirements. The current need to balance human and ecological flows results from our historical lack of attention given to ecological flows (instream flow) in water resource management. There are dozens of texts and tens of thousands of articles on the management of reservoirs for human needs, but until very recently, they only assigned a minimum flow requirement for instream flows.

There is a sizable literature addressing each of the following problems: instream flow needs, optimal reservoir management for human uses, and water resource policy and negotiations. However, there is very little literature integrating these three areas. Ecological flow stress is caused by increased human withdrawals, natural climate variability, climate change, and land-use changes. Dr. Vogel's project examined reducing ecological flow stresses by improving environmental releases.

The watershed systems approach uses flow duration curves (FDCs) as a tool for ecological flow assessments. The ecodeficit is a volume of water no longer flowing in the stream, and in this project it represents reduction in streamflow after the river is regulated by withdrawals from a reservoir. Some standards exist for instream flow, but these may not protect habitat and are not adaptive. In most cases, reservoir release requirements are imposed. Ms. Archfield explained that the goal of the project was to examine the impact of a range of release policies on the reservoir storage capacity, water supply yield, and instream flow.

The reservoir release policies that were considered cover a range from no instream flow release to a fraction of inflow with drought management. There is a supply impact associated with each. How much yield is lost to gain a certain flow regime that supports fish in the stream? Demand reduction has an enormous impact on the storage yield curve.

The project team's research involves quantifying tradeoffs between competing water management objectives; integrating a more precise definition of ecosystem flow needs into water supply management; providing a tool for optimization of the timing and use of drought management, water conservation, and other reservoir release strategies; and promoting a consensus-based decision-making approach to management of water resources.

Discussion

Dr. George Vander Velde asked how many dams in the Northeast are hydroelectric, and what effect sedimentation has on the models. Dr. Vogel responded that quite a few are multipurpose reservoirs, and the research had not looked at sedimentation.

Dr. Gregory asked, concerning the 40 percent flow standard for the area, how the research deals with certain flows that are absolutely required for a certain species in a case where 40 percent would not meet the ecological objectives critical for an endangered species spawning habitat. Is there a variance from the 40 percent rule when it cannot meet a designated use? Ms. Archfield responded that the researchers had tried to incorporate that with one policy where there is a fraction inflow, but if that fraction is lower than some threshold the reservoir is forced to release to keep the threshold. The project looked at that situation for low flows, but not for the whole range of flows.

Dr. Gregory noted that considering the project's partnership with the Nature Conservancy, and using their multimetric index of flow as a surrogate for fishery services, the real operating tradeoff is the risk of water supply services and the risk of fishery or ecosystem services. Is the research planning to go beyond a flow metric as the deviation to the risk-based tradeoff? Dr. Vogel responded that the tradeoff is between the reliability of meeting both objectives. The researchers examined that tradeoff for different reliabilities of water supply, but have not assigned any risk-based or reliability-based metrics to the instream flow. This would be a good challenge. Dr. Gregory asked about moving from flow metrics to fishery metrics. Dr. Vogel noted that the group has other ongoing research: They are working with a data set of more than 200 basins with dams for which they have the downstream flow data for 20 years before and after the dam was constructed, and they are examining the effects on flow. Fisheries argue for dozens of statistics to determine suitability, but it can be boiled down to about three or four statistics. There are some tremendous gaps in this project. Hydrologists have not gotten involved in the debate on how much water the river needs; it has been fishery people who are involved. Dr. Gregory noted that with Western water rights law, all water demands are not equal under the law. Dr. Vogel responded that the study was East Coast centric, and employed a riparian philosophy. The Water Evaluation and Planning (WEAP) system was used because it is one of the only models with as much attention to detail on the demand as the supply. The group hopes another case study could be done on the West Coast.

Dr. Audrey Levine asked if the model takes water quality and climate change into account. Dr. Vogel answered that the natural flow regime is the target, and water quality is completely ignored. It is a balance between allowing more development and replacing flow downstream. Examining climate change will be the next step. The first requirement is to find out what is happening under a stationary climate.

Mr. Vizzini asked if the flow duration curves for the ecodeficit and ecosurplus had been used elsewhere. Dr. Vogel responded that the technique came out of this project, and he had not seen it used anywhere else. It came out of a struggle to figure out indicators that were representative when just dealing with

flows and the quantity of water. The researchers hope to be able to say how useful it is when compared with other indicators.

Dr. Anderson asked for clarification on the management approach's influence on the smaller reservoirs. Dr. Vogel answered that if only the minimum flow is released, it does not hurt the small reservoirs as much as the large ones, as a small reservoir has many releases already, so the flattening effect of the management is smaller. The group is trying to look at different strategies for different kinds of reservoirs.

PANEL 1: WATER RESOURCE PROTECTION

Panel Members:
Audrey Levine, EPA, ORD, National Program Manager, Drinking Water
Bonnie Thie, EPA, Office of Water, Policy, Communications and Resource Management
Stuart Schwartz, University of Maryland–Baltimore County (CNS Grantee, Cuyahoga Sustainability Network)

Dr. Levine explained that the research program she is trying to integrate and craft examines the kind of research support needed to ensure a safe drinking water supply. The Safe Drinking Water Act (SDWA) focused on making water safe from contaminants, but does not focus on water sustainability or quantity. There are primary and secondary drinking water standards that have maximum contaminant levels. The industry is forced to treat water for safe drinking water requirements, and there is a large infrastructure that distributes water from reservoirs, groundwater, and other sources, but the issues relevant to sustainability are water sources, not distribution. In the SDWA, there is a little bit of attention to source water protection, but it is not enforceable. All of the enforceable parts are at the distribution end. How can water resource protection and sustainability get into the dialogue? As land-use patterns change to make biofuels, the way water is used changes, as does the water quality. This affects drinking water source quantity and quality. It is challenging to get this into the drinking water paradigm because of the way the SDWA is crafted. A start would be to examine source waters and water treatments to determine if they are sustainable. A lot of focus now is on the infrastructure. Many pipes were designed for the early 20th century to ensure that there was enough water distributed. The infrastructure must be improved to promote sustainability, safety, and reliability of water programs. The main challenges are institutional barriers. Drinking water, wastewater treatment, water reuse, and wastewater management are disconnected in many parts of the United States. For example, in Florida, there is a lot of pressure to reuse wastewater for irrigation and other applications, but because water is a commodity, there is competition. Drinking water conservation means revenue lost to the water community, but gained by the water reuse community. It is challenging to determine ways to overcome institutional barriers. Another challenge is determining a way to measure success. It is obvious when there is not enough water, but how can it be shown that there is enough?

Ms. Thie stated that she is based in the Office of Water, Policy, Communications and Resource Management within EPA's Office of Wetlands, Oceans and Watersheds, which primarily focuses on protecting human health, but that her group focuses on habitat issues and how to protect the entire ecosystem. Sustainability brings these issues together. The watershed approach has been around for a long time, but her group is trying to mainstream this approach. The idea consists of three points: (1) it has a geographic focus, is hydrologically defined, and includes all stressors; (2) it includes all stakeholders, because not much progress would be made without this collaboration; and (3) it has a strategic focus on addressing water resource protection issues. One way her group is working toward this goal is through the targeted watershed grants. Since 2003, roughly $13 million a year has been available. Competitive grants are $500,000 to $1,000,000 each, and the group is very interested in establishing partnerships. Her office also gives larger grants, known as implementation grants. In the Cumberland River area in Tennessee and

Kentucky, EPA gave builders such grants to implement green buildings on the urban, suburban, and rural scale. This has been so successful that the builders were able to expand their work beyond the pilot project. She asked meeting participants to consider how to map successes and get them into use. How can EPA and grantees get people to change their behaviors? Another implementation grant went to the Christina Basin Clean Water Partnership in Delaware, which focuses on urban issues. Almost 50 percent of stream miles there are impaired due to industry, agriculture, sewage treatment plants, and urban and suburban runoff. They have developed control plans and smart yards, and have encouraged the use of native plants and habitats.

Dr. Schwartz's work supports sustainability by looking at the portfolio of joint services that results from cumulative processes on the landscape scale. Much of his work studies replacing or mitigating lost function. Hyperfunctionality occurs when function is lost across the whole area and a very highly functioning small area tries to make up for this lost function. There is a 40 percent flow goal in the Chesapeake Bay. Larger challenges in his research involve targeting key information needs. Mr. Hawkins, District of Columbia Department of the Environment, commented that his successes could be attributed to information at his hands when he went into discussions. Most of the developers are not out to destroy the land, and will do what is asked of them, but public officials do not know what to ask for in terms of sustainable practices. The key is getting them the information they need. There is a need to understand the cumulative effects of distributed best management practices (BMPs). Dr. Schwartz examines individual infiltration structures and rain gardens but researchers do not know the cumulative effect of putting in a thousand rain gardens in a 250-acre development. However, decisions still have to be made. With some of the recent work on the watershed scale, cumulative effects matter. Another of his group's approaches is trying to plant seeds of sustainability through partnerships, but with that comes the risk that germination rates are unpredictable and uneven. The idea of trying to commoditize sustainability by transforming sustainable technologies into boutique specialty items and services is simply an idea based on using good practices and good ways of doing business that also happen to have sustainability outcomes associated with them. He asked the group to think about ways to integrate reliability, sustainability, and efficiency. Part of the move towards efficiency or sustainability has to involve a consideration of the tradeoff with reliability. Part of planning for sustainability must consider resiliency and the effects of changing the load factor at which the system operates, and part of the challenge in this integration is to think about how to evaluate risk-based decisions.

Dr. Vogel questioned EPA's emphasis on watersheds. Watersheds are important, but there needs to be a change, and research will have to focus on hydrologic units (small parts of watersheds where decisions are made) as well. Once the profession works with models of that type, researchers will be able to answer the distributed decision-making questions that Dr. Schwartz is asking. These models are in their infancy, and have to be encouraged. The old data are more watershed-based, but now most data are actually grid-based and require grid-based modeling. This is a very different way of thinking about the watershed. For example, at the mouth of the Mississippi River, the hydrologic units are dominated by inflow, and the watershed becomes irrelevant in terms of management requirements.

Ms. Thie agreed that the participants had good points. She is aware that EPA and others are working on hydrologic units as well as the entire watershed.

Dr. Gregory noted the need for research to be explicit about the time required for certain outcomes. Quite often in watershed programs, researchers consider actions for land-use resource consumption and balancing restoration, but are not explicit about time. Has EPA been able to be more explicit in watershed programs about the timing of their actions, the degree of their impact, and when the outcomes will be achieved? He noted that stakeholders often expected instant gratification with these projects. Ms. Thie responded that the measurement pendulum is always swinging. However, looking for immediate to rapid

measurable results does tend to undercut the significance of the long-term measures that might happen more slowly.

Dr. Vander Velde said that for technology adoption to take place, there must be three kinds of knowledge: awareness is first. Unfortunately, a lot of government programs stop at this point. Second is technical knowledge. In watershed projects where technology has been implemented, bringing stakeholders in so they know and understand technical principles is important. Third is "how-to" and hands-on knowledge. His program invoked these three, and the results were phenomenal. They went from a typical approach, with adoption rates of 5 percent at best, to going through demonstrations with the stakeholders. They now do onsite training for the second type of knowledge, then highly recommend that the company do a pilot project. The pilot will answer the question: "Is it going to work for us?" Adoption rates now are up to 60 to 70 percent, but the work is more intensive and takes a longer period of time. How can other research get to this stage? Perhaps a plan to bring in parties from other geographic areas should be included in the research project. When they go back to their own area, they will be pioneers. That is the only way his group has been getting much higher implementation rates.

Ms. Thie noted that this is the kind of process that EPA has been more aware of for the last 3 years. The Agency has shifted from just developing tools. Education was a mantra, but they found that unless they took the next step of helping the organization walk through the process, people just would not adopt the tools. The idea of bringing other people from other locations into the research is a good one. The way to transfer knowledge is to bring people into the partnership.

Ms. Archfield stated that she was struck by Dr. Levine's comments about not looking at just water quality, but sustainable water quantity. The Massachusetts Department of Environmental Protection focuses on sustainable quality management of ground and surface water withdrawals. Are there more formalized programs in EPA looking at this?

Dr. Levine explained that a lot of the drivers are regulatory, and much is regulated at the state, not federal, level. However, this issue is really about awareness. There has not been a good mechanism to really educate people on this topic, and there will not be until the mindset changes and mechanisms for sustainability are brought in. She is optimistic that it will happen, but it is not happening yet.

Dr. Gregory made an observation on energy flow. From an ecologist's point of view, it is not the goal just to maximize efficiency; the energy flow has to be stable. In commercial fisheries, researchers learned that by increasing efficiency, they are having a bigger impact on the resource. Every time researchers talk about optimization routines and maximizing efficiency, they run the risk of losing the community simply because they emphasize a few winners and create a lot of losers.

Dr. Schwarz noted that when comparing industrial systems of water supply to ecological systems, something that is lost in partial interpretation is the idea that he was trying to capture: Researchers are missing the resilience or brittleness cost associated with efficiency. This is an inherent tradeoff.

Dr. Vander Velde explained that there is a project in Illinois that is relatively simple but expensive. The project turned levies into sieves so that the land that had been converted to farmland was returned to wetland. This outcome is not instant. However, one thing that it did immediately accomplish was to create a huge area in the flyway, and there was a large influx of migratory waterfowl into that area.

Dr. Gregory emphasized that this is a case of trying to be explicit about the timing and the degree of recovery. A sieve provides wetland, but the flood plain has many other functions as well. What does society want in terms of its landscape? Researchers must be more articulate about the degree of function and the amount of time that recovery will take.

Ms. Thie asked the group to consider how to translate research results into practice and use. How many of the grantees' projects include allocations for this?

Dr. Anderson responded that his project included outreach and education. The planning agency wants to adopt spatial economic tools that his group will develop. They also will hold conferences and a workshop.

Mr. App explained that he is working on the sustainability of a high-quality trout stream. Part of the project is assessing the effects of growth. EPA will be working on recommendations for the county, but he is concerned about going the next step. How is the county going to take those recommendations and will they be able to put them into practice? This is a small rural area. The residents have told EPA they alone could not have done what the Agency is helping them do. They were glad that EPA and the U.S. Geological Survey (USGS) offered assistance. This seems typical of a lot of small communities without expertise. They do not have the resources to do the right thing even though they would like to, and some help is needed.

Dr. Gregory stated that his group is working with some of the local non-governmental organizations on restoration of the river, and helping them design on-the-ground restoration at no cost to them, because his group would like to see the application of their work. They have been meeting with farmers to see what kind of restoration program they would find workable in their landscape. When interviewed, some of the farmers admitted to finding federal and state awards to be disincentives and embarrassments, while local awards were more of an incentive.

Dr. Vander Velde explained that he had done a tremendous amount of work with the city of Chicago. A large coalition was formed to work on highly polluted and economically depressed areas. The coalition, primarily of governmental agencies, developed an "ecotox" index. They were able to get accurate numbers from EPA on human health, but what about ecology and habitats? That fundamental information was lacking. In several of the parcels, resident species were unknown. His agency funded research in that area because there is a need to know what species are being protected. The outcome revealed an amazing species diversity in what was considered a slag area. There is a large amount of research that goes into restoration of these processes. His group has the luxury of an individual in their organization with expertise on sediment. There is a great deal of data on sediment in the Illinois River for the last 15 years. There used to be major fishery around Peoria, and that is now gone because the average water depth was 10 feet, and now is about 1.5 feet due to urban development and farming practices. His group was able to do research on that sediment, and took 110 barge loads to the city of Chicago for use as topsoil. The city is using the material to create a park on top of the slag.

Ms. Goldberg noted that there is a whole field of social marketing that addresses ways to change human behaviors. This is a key aspect of the way people communicate with each other. It involves understanding what is preventing them from making changes. It requires a lot of piloting and trial and error, and is fairly intensive. Often their projects do not have that next funding allocation.

Mr. Vizzini added that people reach a moment when they are ready to change. People at the bureau questioned his team when their engineering group implemented combined sewer overflow (CSO) patrols. No one knew how to have the kind of conversation with property owners necessary to achieve their goals. The idea is to get as much information out there as possible, and then be available to help.

Dr. Levine noted that social marketing is important in certain projects, especially with projects that are stopped due to a stigma attached to them. For example, EPA works hard to make drinking water safe, but many people drink bottled water, which does not have the same kind of protection. This is a ripe area for social marketing.

PANEL 2: CLEAN ENERGY AND CLIMATE CHANGE

Panel Members:
Robert Ritter, U.S. Department of Transportation (DOT), Federal Highway Administration, Planning Capacity Building Team
Graham Pugh, U.S. Department of Energy (DOE), Office of Policy and International Affairs, Climate Change, Policy and Technology
Sherri Hunt, EPA, ORD, NCER
Hannah Campbell, U.S. Department of Commerce, National Oceanographic and Atmospheric Administration (NOAA) Climate Program Office

Mr. Ritter said that his group at the DOT is working with state DOTs, and a single voice for their work can be found at the Center for Climate Change in DOT. Their Web Site URL is: climate.dot.gov. He highlighted an initiative the group completed in the Gulf Coast region. There is a significant likelihood of a sea level rise there, and the chance that a huge percentage transportation infrastructure will be underwater. There is a challenge ahead. His group also is planning environment linkages that are broader than climate change. They have been trying to create a connection between transportation projects and environmental issues, and to foster cooperation in long-range planning processes. They are talking to experts on environmental resources to identify needs for transportation systems and the goals for the environmental resources.

Mr. Pugh is part of the climate policy and technology office in DOE, which has a strategic plan for the climate change technology program available at the URL: climate.technology.gov. The goal is to understand greenhouse gas mitigation technologies. It is very easy to pick technology winners. However, with all the available energy technologies, how can they make a rational portfolio investment? How do they determine what will get more money; is there a rational way to do that? They use an integrative assessment model that is an energy and economic model of the world. It is mainly focused on U.S. impacts. Scenarios are dependent on a number of assumptions, including not only the technological maturity of all these technologies but also the potential these have to mitigate a certain number of carbon emissions. It is interesting to run some scenario analyses, because it is not intuitive. Another part of his group's work beyond energy research and development is understanding the technologies' barriers to market penetration. They have been conducting a study to examine and identify the barriers. There are three main messages. The first is to use a portfolio approach when planning. Do not pick winners based on popularity. Everyone has a limited amount of money: spend it for the biggest return on investment in terms of carbon mitigation for climate control purposes. Carbon is not everything, but for climate change purposes it is the focus. The second is to choose technology appropriate for the situation. For example, it is better to buy solar panels in Phoenix than in Portland. In Phoenix, they can offset peak flow and can be economical. Like biofuels, solar energy is more popular than deserved from a carbon standpoint. The third consideration is a lifecycle carbon approach. Choose technology that will be effective in the future regardless of climate change. Energy efficiency is the best investment in terms of carbon mitigation.

Ms. Hunt explained that she focuses on air and particulate matter, and also global change. Her group has been trying to understand the impact of climate change on air quality. They want to mitigate global change, but first need to understand its impact. If only the weather changes, how does that impact air quality? Carbon is not the only thing that is going to change. Additionally, her group is supporting programs on changes in emissions. Those projects are examining transportation planning and land use. If it is taken into account that the climate is changing, emissions would have to be reduced by another 10 percent to get today's air quality in 2050. There also is a lot of energy coming from buildings, so there is a push for green buildings. A city can bring in water from outside the area, but residents have to breathe the air that is in their city. She expressed an interest in some of the comments about technology transfer in

the earlier projects. There is a real opportunity to transfer the technology to other countries. Additionally, there are a few programs within the air group promoting behavioral change.

Ms. Campbell stated that the research division of the NOAA climate program offices has a Regional Integrated Sciences and Assessments (RISA) program that offers competitive research grants. These projects look at different regional sectors of climate variability and the impact of change. The projects mainly are based in universities. These have been some of the most effective programs using regional signals from climate variability and looking into climate change. It is an integrated model in terms of understanding this impact. How can they take that and work with stakeholders, such as water resource managers, coastal zone managers, and urban planners, to understand the work they are going to do? Her group has let this develop in each region. They are working with stakeholders to see what they want to achieve and how the climate information can best be used to help them do this. They are not only creating useful information, but also usable tools. However, do stakeholders understand the information? Are they using it, and if so, are they changing behaviors? It is important to evaluate the efficacy. Her group is trying to bridge the gap between the stakeholders and the scientific community. This is important in successful projects. It is not useful to overload stakeholders with climate data, but it seems to be what happens frequently. Better information on regional climate impact is needed. Where is the good regional information? A big question for stakeholders is what will happen in their region. Will the information they receive be trustworthy? If so, will they understand the information? It is much more expensive to build a bridge and have a dialogue with stakeholders than to push data at people, but it is more effective. This is a learning process.

Mr. Vizzini noted it was frustrating for a novice to try to find information on topics of sustainability. How can the agencies facilitate access to information and create dialog between researchers? The lack of access seems so inefficient, given all of the research that is being conducted. Any movement along that line by the federal government or universities would be very helpful.

Mr. Pugh responded that with energy technologies, there is definitely a private-sector role. Agencies have to focus on policies that move to the private sector to take the action to achieve their goals. It is very frustrating to be in a position where the potential technologies are evident, but they are not getting into the marketplace. Policymakers have to make the right decisions. He expressed even more appreciation for economics as the driver of all of this than he had when he worked in the private sector. The quality of the discussions has been much better over the past year. A lot of good information is out there, and a lot of good research from the private sector is available at http://www.climatechange.com.

Dr. Bauer noted that if the United States has to change its energy portfolio in a large way, this may lead to some unintended consequences. How can these issues be addressed?

Ms. Hunt responded that we must do as much research as possible to understand the impact of various technologies. Biofuels are negative from her standpoint, because though they produce less carbon, they produce more carcinogens. There is a real need to investigate the various technologies as deeply as possible. However, there is much pressure now to make decisions a lot faster. Dr. Bauer responded that not changing the course society is on also is a decision.

Mr. Pugh noted that research and development into impact goes through one model and land-use feedback goes through another. Both of these models focus on carbon now.

Mr. Ritter stated that regarding the question of models, there is a lot of variability. His group already has a hard time using a four-step modeling process to figure out how many vehicles will be using a certain roadway they might be considering in 20 years. If climate change facts are added to that, and the source

of energy the vehicles will be using also is a consideration, he does not believe DOT has the technology to begin to answer that question.

Dr. Vogel expressed uncertainty about how often decision trees were used. They are one of many decision tools, but are particularly easy for people to understand because they are graphical, they integrate uncertainty, impact, and science, and allow researchers to look at many alternatives and evaluate the broad context of the variables of decision-making for climate change. Are these tools something that EPA is considering?

Ms. Hunt responded that in the air program it is always a challenge to understand the model. They are using more complex models. States have to implement the plans.

Ms. Campbell mentioned that governors and urban planners had done a network analysis in the Southwest looking at water resources. This is one of the few groups looking at decision-making in an integrated way. Regarding the concept of resilience, if there is an increased capacity for variability, there will be more resilience. For example, when building a sewage treatment plant, making it possible to adjust the location of the outlet will make it more resilient.

Mr. Pugh explained that the way government funding works does not accommodate the flexibility that decision trees provide. There are fixed budget cycles, and the way the budget is reviewed is to allocate certain amounts of money in certain areas. For researchers to reallocate their budget based on a new piece of information is very difficult. The Office of Management and Budget must be convinced, it must be taken to Capitol Hill for approval, and so on. That nimble approach is not easy to get, but it is very important to try to build in the ability to plan under uncertainty, because that is what all researchers are doing. The curve for damages has a long tail towards the higher impact side, and when planning for uncertainty, researchers must take into account extreme events. There is a high chance that outcomes will be more severe than mild.

Mr. Ritter noted that it would seem that this would be true in transportation but it does not happen that way. Elected officials do not want to turn the decisions over to stakeholders, but want to be able to use their influence to change outcomes.

Dr. Vander Velde found it interesting that the DOT was looking at a 20-year horizon in terms of planning for new roads, but the known petroleum reserves will be gone in 43 years with current consumption rates. The timeframes are short.

Mr. Pugh agreed. People will find more oil shale, for example, but it will become more and more expensive to get and will have more and more of an impact on the environment. The transportation infrastructure will have to change. People will not change until that happens. Higher prices will make other technologies more competitive. As a society, we will have to keep some technology approaches off limits, and that will be very hard to do.

Ms. Pulsipher asked if there had been modeling on the local level of transportation if people lived closer to work and school. Dr. Vander Velde said there is some modeling, but it is in a genesis state. It does not look just at the energy efficiency of a building, but the transportation footprint of a building.

Dr. Bauer said that one 2006 CNS grantee at the program did a project on accessibility indicators, trying to create an overall model for some geographic regions.

Mr. Ritter agreed that there is starting to be a serious discussion on this in the transportation community. The National Academy of Sciences published a report, and one of the conclusions is that researchers need

models. The current models are incapable of handling some situations. For instance, they are not designed to address the effect of adding a toll to a road.

Ms. Sergeant mentioned that no one was saying much about conservation, but instead were talking about alternative energy sources and finding new technologies.

Mr. Pugh explained that what will drive this problem in the future is not just the United States, but developing countries. These countries have much lower per capita energy consumption now than the United States, even though they are rising at a rapid rate. A conservation message in the United States, though not politically popular, is warranted, but it would not be well-received internationally. It would be taken as the United States asking other countries to hold back their development. The goal would be to get them to develop in a less intense way than the United States did, but they are developing in a more intense way. China is learning the pollution lesson the United States learned decades ago. Pollution will probably create action long before climate change in a global arena.

Ms. Sergeant asked why the conservation message is not heard more often in the United States. Ms. Hunt responded that they can disseminate the information, but they have to show the public that conservation works. In Atlanta, for example, agencies can tell people not to drive their cars, but they will still drive their cars because it is part of the culture.

Ms. Sergeant noted that information is not enough, alternatives to driving have to be offered. Mr. Ritter answered that this has not worked. For a long time, DOT talked about conservation, and there has not been a lot of response. This does not mean the agency should give up as things change and become more economical. He believes conservation has to be part of the solution.

Dr. Gregory agreed that conservation is an old message, and it is not working. Per capita consumption has increased, not decreased, since the first Earth Day. The discipline of the market has not worked.

Mr. Vizzini noted that building codes no longer have a strong basis in energy conservation. Building codes in the 1970s did not allow the 10- and 12-foot ceilings being built in new homes. Those will be very expensive to heat in a few years. He agreed that a combination of land-use planning and regulation as well as economics must be used. However, buses running to Portland are very full, and are going to get more so. The cost of fuel is having an effect as well.

Dr. Vogel explained that it has to become common knowledge that good environmental decisions also are good economic decisions and vice versa. People need to understand the economic value. For instance, front-loading washing machines save a lot of money and also save water.

Mr. Pugh added that economics works in many respects, but in others it does not. Driving Hummers has allure despite the expense. Status symbols are powerful. Economics is one tool, but it has to be combined with regulations and incentives.

Dr. Anderson stated that it sounds like one of the strategies is to forget about the United States because it is too late to affect change here, but that we should try to influence China and other developing countries before they make the same mistakes.

Mr. Pugh explained that the European approach did try to affect other countries. With the concept of clean development, Europeans are buying projects in the developing world. Any sustainability action that the United States takes that is not international will be meaningless.

Dr. Vander Velde agreed that the message of conservation should not be abandoned, as his agency did a great deal of it.

One participant noted that consumers use efficiency as a rationalization to buy bigger cars. Mr. Pugh said that Americans are driving cars with engines that are more efficient than they used to be, but they are pulling more weight.

Ms. Pulsipher asked if the fast food industry should consider using china instead of disposable containers, which end up as waste in the environment, or if that would be detrimental to the water supply. Ms. Sergeant answered that when there was a severe water shortage in Charlottesville, Virginia, people were encouraged to use paper plates and plastic utensils, and drinking fountains were not turned on in schools. It depends on the severity of the water problem. She feared there would be china on the side of the road instead of paper trash if fast food restaurants started using it.

Dr. Vogel stated that the fast food trash issue is much bigger than just a water problem. To answer that question, a cradle-to-grave analysis of the scenarios would be necessary to make the right decision.

CNS PROJECT PRESENTATIONS

Using Market Forces for Sustainable Stormwater Management
Dan Vizzini, City of Portland

Mr. Vizzini explained that Portland, Oregon, has multiple stormwater management systems, and there is a financial reliance on utility rates to maintain them. The utility investments and rates are driven by the city's response to environmental regulations. However, the financial burden of street system drainage costs has been shifted to stormwater rate payers. There are planned strategies to maintain CSO controls from 2011 through 2040, but the challenge will be dealing with the additional 2.2 billion gallons of runoff caused by the increase in population density by 2040.

Mr. Vizzini's project consists of a phased approach to sustainable stormwater management analysis. Phase one, the feasibility decision, was completed in July 2007. Phase two involves building a stormwater credit trading system, and phase three will be the demonstration of system feasibility in the marketplace.

There appears to be an adequate supply (sellers) for a stormwater marketplace. There may be sufficient relative price differences to consider credit trades and auctions at the BMP level for selected comparisons, and across a portfolio of BMPs. Refined inputs and sensitivity analyses are needed. There are substantial opportunities to develop and deploy market mechanisms to animate demand (buyers), including heightened regulations and the effective use of city investments.

The costs of implementing a credit trading system may exceed the potential benefits unless the city can find partners to share the legal, administrative, and technical burden. Evaluation and decision-making tools hold great promise as aids to planning, program development, and decision-making.

Additional work is needed to: refine BMP cost and effectiveness information; develop values for ecosystem service effectiveness; integrate the tool with systems modeling and asset management efforts; expand the tool to allow for site-specific and watershed-specific analysis; and use the tool to make effective marketing and investment decisions.

Portland currently has a market-oriented initiative for developers who receive a square foot of floor area bonus for each square foot of roof garden. The bonus has produced an estimated $225 million in

additional private development at 11 participating sites. In another financial incentive program, discounted utility charges apply to the onsite portion of stormwater bills. This discount is calculated based on the extent and effectiveness of private facilities in controlling flow rate, pollution, and disposal. Similarly, the downspout disconnection program targets homes and small businesses in combined sewer areas on the east side of the Willamette River. Property owners receive $53 per disconnected downspout.

These financial incentives create motivation independent of regulation for citizens to take action to promote sustainability. Dispersed, small-scale facilities increase the resiliency of the overall system. Markets increase the likelihood of sustainable investments by providing easy access to research, technical assistance, financing, incentives, supply chains, and maintenance services.

Mr. Vizzini's research found that public understanding of sustainability is increasing, but public understanding of the role of markets needs to increase. Social networks and marketing strategies can play a critical role, but institutional inertia is the most significant obstacle to this and any paradigm shift. His project now is moving from internal deliberations to a community conversation. New initiatives will target the green economy, sustainability professionals, and the supply chain of goods and services to serve individuals and communities.

Agency help in organizing collaborative research and development programs on the following would be of great benefit to his project: methods and models for monitoring the effectiveness of sustainable stormwater facilities; subjective and objective values for ecosystem services; configurable software to operate credit trading registries; and integration of local, regional, national, and international marketplaces for ecosystem credit trading.

Discussion

Dr. Vogel noted that it is inspirational for someone coming from the Northeast to see the progress in integrated stormwater management in Portland. His group had an EPA grant that just ended that allowed his group to create a spreadsheet model evaluation tool on BMP effectiveness. It does not consider location but it does consider land use and soil types. He added that it would have been beneficial to hear about Mr. Vizzini's project 3 years ago.

Mr. Vizzini stated that the accumulated belief in the system is that facilities such as a properly designed rain garden or even curb plantings have other ecosystem benefits such as habitat benefits. The general belief is that the more green a facility becomes, the better. However, he does not know if his organization has accumulated all of the costs properly, and enforcement monitoring still has to be added.

Dr. Schwartz observed that it seems in all the trading systems that the key question is how to define the commodity. Units are annual volume per year, not just stormwater, because combined sewer overflows and their effects are what need to be controlled. These will vary spatially and temporally, and to get the market to work the commodity must be defined correctly. The thinking moving forward from the planning level should be on the annual volume per year.

Mr. Vizzini responded that this volume is at an aggregate level. In the next version of the project, the team hopes to focus on a parcel or some subset of the city. Combined sewer analysis performed on a property must take into account the amount of impervious area and the fate of water all the way to the river, which requires a very detailed model that must be fully integrated. At that point the group also can look at basement flooding, because individual properties have to get the water off the system or basements will flood. Some properties will be worth more in terms of incentives for stormwater removal than others based on system modeling that his group has completed. The pricing of the commodity is really the issue. Now it is based on annual volume, but this should be based on peak flow.

Ecological Sustainibility in Rapidly Urbanizing Watersheds: Evaluating Strategies Designed To Mitigate Impacts on Stream Ecosystems
Laura Craig, University of Maryland, and Keith Van Ness, Montgomery County Department of Environmental Protection

Ms. Craig and Mr. Van Ness focused their work on the benefit of mitigating impacts before and during development, and sought to answer these questions in their research: When compared to pre-2000 stormwater management strategies, are post-2000 strategies better at mitigating the effects of urbanization on stream ecosystems? How does watershed development affect receiving streams?

They studied one pre-2000 control watershed, one forested watershed, and three post-2000 watersheds. In the Clarksburg development area, they attempted to test areas using USGS stream gauges and rain gauges. The goals of their research were to document ecosystem response and recovery to long-term and significant landscape changes, and to document the effectiveness of sediment and erosion control and stormwater management (SWM) BMPs. This would allow them to provide feedback to decision makers regarding development and SWM design.

The researchers encountered some unexpected issues while conducting this project. Conversion of sediment control to SWM has been slower than expected, because there was a building moratorium imposed on the study area, and conversion can only occur when 100 percent of the drainage area is controlled. The speed of development, due to the slump in the housing market, has slowed over the course of the study. Additionally, the effects of their work were masked by larger local effects, such as loss of natural drainage patterns and the influence of local geology.

They found that: sediment and erosion control devices were, at best, 86 percent efficient; development results in changes to in-stream habitat; and the construction phase of new developments profoundly changes the benthic macroinvertebrate community composition. Mr. Van Ness noted that recovery at these sites would not be complete regardless of the SWM strategies used.

In-stream NO_3 uptake cannot be detected in the Clarksburg study watersheds. Nutrient concentrations do not change with distance downstream. The researchers could not measure the NO_3 uptake because the streams are nitrogen-saturated, and nitrification is producing NO_3 (masking the effects of removal).

CNS funding was beneficial because the creation of the Clarksburg Integrated Ecological Study Partnership has increased contacts with potential collaborators. In addition, the grant has provided a level of legitimacy to the county's efforts to understand the effects of land-use change on receiving streams.

Discussions with other grantees at last year's meeting provided insight regarding data and inspired follow-up experiments. The project also motivated the upgrade of the USGS gauge at their urban site to one with real-time monitoring, allowing for public access.

The researchers' future work will focus on continued monitoring to gain a long-term understanding of the effects of land-use change and SWM on geomorphological and ecological metrics as funding allows.

Discussion

Dr. Gregory asked whether the researchers had tested the phosphorus in the stream. Ms. Craig responded that she had done 12 6-hour phosphorus injections, but did not have the results yet.

Dr. Anderson wondered whether Mr. Van Ness' assertion that the area would not recover had to do with the fact that their project studied an already stressed system (e.g., a stream that was already nitrogen-saturated).

Ms. Craig responded that the nitrogen had been there all along and there was not a change in the composition of invertebrates in the control system, so she believes the nitrogen-saturation is a separate issue. Mr. Van Ness added that the issue was where the development was located. In the study case, development was close to headwater streams, which are very sensitive. This should be part of the dialogue for everyone considering development in watershed areas: what densities should be located near the best headwater streams? He had conducted another study on an area with an 8 percent pervious cap, and this area did see a recovery back to preconstruction levels. There must be an impervious cap on development.

Mr. Vizzini noted that it seems like it is better to pay more attention during the construction phase, not just to where the development is placed, but to the management technique during construction. Right now, developers are only taking stop-gap measures.

Mr. Van Ness responded that not just engineering, but many different variables, such as cut and fill sediment and erosion control, must be taken into account. In terms of drainage, this may work well during the rough construction phase because the ground is filtering larger particles. However, what will happen when the land is fine-graded and lots have been paved and compacted? The drainage will not be adequate.

Dr. Gregory said that the Oregon DEQ uses a modeling program to determine the source of degradation, for instance, whether sediment, flow magnitude, or habitat degradation was causing the problem.

Mr. Van Ness agreed that it was an important determination to make.

Ms. Nurse thanked the participants for attending, and gave special thanks to Dr. Bauer for her guidance on the CNS program. She congratulated grantees on the high quality of their work, and adjourned the meeting at 1:00 p.m.