Report as of FY2006 for 2006NY81B: "Assessing the ecosystem services of open space for water resource protection in the Moodna Watershed, NY"

Publications

- Conference Proceedings:
  - Ramsey, Molly, Karin Limburg, and Valerie Luzadis, 2006, Modeling urbanization effects on water resources in Moodna Creek Watershed, NY: Developing a tool for community watershed management, IN Annual Meeting proceedings of the New York State Chapter of the American Fisheries Society, Thayer Hotel, West Point, NY, February 2006.
- unclassified:
  - Ramsey, Molly, Karin Limburg and Valerie Luzadis, 2007, Urbanization and the Sustainable Management of Water and Land Resources in the Moodna Creek Watershed, NY: An Ecological Economics Approach, In conference proceedings for the US Society for Ecological Economics, New York City, NY, June 23-27, 2007. Abstract prepared.

Report Follows

1. Title.

Assessing the Ecosystem Services of Open Space for Water Resource Protection in the Moodna Watershed, NY

4. Duration.
March 1, 2006 – February 28, 2007

5. Federal Funds requested.
$20,000

6. Non-federal funds requested.
$25,000 (match)

7. Principal Investigators.

Karin Limburg, SUNY-ESF; co-PI Valerie Luzadis, SUNY-ESF; Collaborators Simon Gruber, Coordinator, Moodna Watershed Coalition; William Schuster, Director, Black Rock Forest Consortium; James Beaumont, Executive Director, Orange County Water Authority; and David Church, Commissioner, Orange County Department of Planning.

8. Congressional District.
District 25 (includes Syracuse), District 19 (includes Orange County)

9. Statement of critical regional or state water problems.

Orange County is currently the fastest-growing county in NY State and management of water quality and quantity is a major concern in terms of drinking water, biodiversity, erosion and flood control, and other priorities. The Hudson River/Moodna Creek is identified in the county's Open Space Plan as one of four Selected Priority Watersheds, and the New York State Coastal Management Program has designated areas along the Moodna Creek as "irreplaceable" Significant Coastal Fish and Wildlife Habitats. Water *quality* is impacted by urbanization in the Moodna watershed, and these sites show symptoms of nutrient enrichment and other pollution (Nolan, 200). Water *quantity* is also impacted by urbanization, as large portions of the Moodna basin are dependent on groundwater for drinking water. Certain areas, including the Village of Washingtonville, use wells directly connected to Moodna Creek. During a dry spell in 2005, the Village was forced to tap emergency wells and implement water conservation requirements due to low water levels; yet, this dry spell was not considered a real drought. Ongoing development is expected to exacerbate the potential for water shortages both by increasing water demand and creating new impervious surfaces. Several municipal water districts in the Moodna basin (including Cornwall-on-Hudson and New Windsor) use water from NY City's Catskill Aqueduct, and a proposed new pipeline could lead to increased withdrawals from the City's system to serve areas in and adjacent to the Moodna basin. Unless a more sustainable approach for managing water resources is adopted, these pressures are only likely to increase over time. Land use planning and site design strategies can help to mitigate these problems; these include: open space protection, low impact development approaches for clustering, minimizing impervious surfaces, and optimizing treatment and infiltration of runoff. Acceptance and implementation of these strategies is, however, dependent on demonstrating the future impacts of current practices and comparing them to the potential benefits of alternative planning and design scenarios. Such information needs to be communicated to elected and appointed officials, regulatory agencies, developers, and other stakeholders. ***This proposal addresses the first two priority topics in the RFA.***

10. Statement of results or benefits.

The results of this project will provide:

- An understanding of how future land use scenarios impact the water balance, including water availability and water quality, of the Moodna sub-watersheds.
- Data on areas to target protection initiatives for key recharge areas, wetlands, stream corridors, steep slopes and other sensitive areas.

- Data for the Moodna Watershed Management Plan about strategies addressing open space conservation, municipal water resource supplies, and land use planning.
- Opportunities for public dialogue about potential land use scenarios for the Moodna watershed, and the value of open space and water resources.
- Community visions of future land use for development and conservation in the Moodna watershed.
- An enhanced public understanding of computer models and their use in environmental decision-making.

11. Nature, scope, and objectives

Human activities generate the economic demand for land that has resulted in an increasingly urbanized landscape with serious impacts to the ecosystem services (Daily 1997) provided by the natural environment. As human populations grow, the economic demand for land and the pressure for greater conversion of forests, wetlands, meadows and fields to residential and commercial development increase. This urbanization is a major reason for the degradation of key watershed and freshwater ecosystems (Carpenter et al. 1998, Postel 2000, Nilsson et al. 2003, Limburg et al. 2005 in press). Decisions about development and land conversion are typically made in piecemeal fashion, rather than by some concerted effort such as regional planning. Kahn (1966) referred to “the tyranny of small decisions” which describes the evolution of unintended economic consequences of decisions made on the basis of short-term, marginal gains. While the intention of environmental impact assessments is to prevent the negative environmental effects of human activities, these are carried out on a project-by-project basis. Thus, the cumulative effects of open space being converted to urbanized areas not anticipated. While many people are concerned about the loss of open space for aesthetic reasons, another widespread concern is the effect on drinking water quality and availability. Alternative approaches for development and land use planning decisions (Tidwell et al. 2004, Hulse et al. 2004) are more spatially broad, e.g. watershed-scale or bio-regional scale, and are more participatory, bringing together scientists, engineers, land use planners, business community leaders, environmentalists, and other stakeholders in an interactive way to discuss and evaluate future land use scenario and understand impacts to ecosystem services.

Open space areas provide key ecosystem services for the freshwater streams and groundwater flows of a watershed. Forests, meadows, fields, and wetlands provide sites for groundwater recharge, infiltration, and uptake of nutrients, thus reducing runoff rates, maintaining base flows and water quality, and regulating temperature (Daily 1997). With the conversion of land comes a hardening of the surface with concrete, reducing the connection of precipitation with groundwater recharge, and accelerated discharge of runoff water, sediment, and chemicals into recipient streams and rivers. It is recognized, that of the many aspects of urbanization, impervious surface is likely to have some of the most adverse effects on stream ecosystems (Klein 1979; CWP 2003). In small catchments (3rd order or less), an impervious surface cover > 10% is often associated with degradation of stream quality, with severe alterations when impervious surface exceeds 25% of the catchment area (CWP 2003).

Within the middle reaches of the Hudson Valley of New York, the pace of open space loss is rapid (Orange, Ulster, and Dutchess counties). In the Moodna watershed (466 km^2) of Orange County, development and new impervious surfaces have led to the filling of floodplains and wetlands, and the reduction of infiltration and base flows. Water availability is a serious concern, as wells are influenced by the level of the Moodna Creek. During the dry summer months of 2005, drinking water had to be shipped in from neighboring counties. In response to the environmental problems of development, Moodna (under the auspices of the Orange County Water Authority) watershed stakeholders have put several initiatives into place including the development of a watershed management planning proposal funded by the Hudson River Estuary Program (HREP). The stakeholders involved include the Orange County Water Authority, the Moodna Watershed Coalition, municipal leaders, and other county departments (e.g. Orange County Planning Department, Soil and Water Conservation District). This watershed management plan includes the development of water quality protection, long-term water quantity, habitat and open space protection, and long-term watershed management goals and opportunities. A key component of this work is envisioning future land use change and estimating the impacts of the potential development on water resources. ***We propose to study how development may alter the delivery of hydrologic ecosystem services provided by open spaces within the Moodna Creek watershed in Orange County, NY. For this project, we propose to coordinate with the Moodna Creek Watershed Steering Committee to help develop the watershed management plan by modeling present and projected distributions of water (surface and groundwater) and water quality as land use changes through development. The modeling will be an iterative, participatory process with future land use scenarios being developed by the steering committee members and the intern. We also propose to communicate these findings to local stakeholders, to aid in policy development.***

12. Methods, processes, and facilities.

To evaluate the effects of potential development on the Moodna water resources, two models will be implemented that simulate potential land use change and the effects of land use on water quantity and quality.

The water balance of the Moodna watershed with present and potential land uses will be simulated using the Generalized Watershed Loading Function model (Haith and Shoemaker 1987). The GWLF model is an event-based, hydrologic model that simulates water (including stream water flow, infiltration, runoff, and storage; groundwater will be estimated by difference) and loading of sediments and nutrients to receiving watersheds. Although the model is not spatially explicit, spatial approximations can be made by breaking up the watershed into sub-catchments and running the model separately in each of these. The model can be used to represent multiple land uses including forest, wetland, meadow, and urban with varying degrees of imperviousness. The effect of land use change on water resources will be evaluated using this model by running it with different development scenarios. Changes in water quantity, infiltration rates, and runoff rates will be compared between development scenarios. Some scenarios will represent development efforts that conserve open space; others will represent more intense development. How these different land use patterns affect water in the Moodna will reveal the importance and manner for conserving open space.

A coupled land use change – ecosystem health model (Polimeni 2002, Limburg et al. 2005, Hong and Limburg, in preparation) originally developed for Dutchess County, NY will be used to simulate urbanization effects on water quality in the Moodna. The land use model is a binomial logit regression that uses tax parcel data (locations, sizes, assessment values, land classification, number of houses permitted per parcel, etc.), demographic data (population change, income distribution change) and geographic factors (e.g., distance to business centers) to generate probabilities of unoccupied parcels (undeveloped land) being converted to occupied parcels (developed land). Restrictions, such as regulations for zoning or protecting steep slopes, hydric soils, or wetlands, can be imposed to prevent land conversion. The output of the model is a simulated land use map. (The land use data from the model can be input to the GWLF.) The % land use change from the simulated land use map is then fed into the ecosystem health component of the model. The ecosystem health model is a multiple linear regression model dataset that predicts how watershed urbanization affects a large suite of water quality and biological variables. The % land use change and coefficients representing relationships between land use composition and water quality are the inputs to this regression model. The coefficients for the multiple linear regression model are derived from data extracted from the USGS NAWQA (United States Geological Survey National Water Quality Assessment Program), restricted to the NY/NJ/PA area so that sufficient data sets could be analyzed without compromising specific characteristics of the region (Hong and Limburg, in preparation). The results of this modeling effort will be used to forecast water quality conditions for various land use change scenarios in the Moodna basin.

The modeling effort will be an iterative, participatory process involving the Moodna Watershed Steering Committee and the general public of the Moodna watershed communities. These individuals will partner with us to develop the different land use scenarios used in the models. The Moodna watershed-planning project funded by the HREP will include creation of a Watershed Steering Committee composed of local officials, business leaders, planning and design professionals, organizations, water suppliers, scientists, outdoor recreation groups, builders, cultural and arts organizations, and others. The Steering Committee will be invited to participate in planning the research and modeling process. The stakeholders from the Moodna Watershed Steering Committee include municipal leaders, members of the Moodna Watershed Coalition (citizens from watershed communities interested in planning issues), and experts with the Orange County Planning Department and the Soil and Water Conservation District. The intern will work with our collaborators (Gruber, Schuster, Beaumont, and Church) and the Moodna Watershed Steering Committee to develop future land use scenarios and to review the land use change/ecological health and hydrologic model results. Interaction with the Moodna watershed communities will occur during public meetings where the Moodna Watershed Steering Committee will also be describing the results of the watershed management plan development. Feedback from these public meetings can be used to evaluate and refine the future land use scenarios of the model results. The watershed management planning process will benefit from the modeling project beyond the specific implications of the model results. The participatory nature of the modeling project will result in a more in-depth dialogue between citizens about land use, open space, and water resource issues as well as an awareness of the potential serious impacts of urbanization.

Facilities and resources available for this project include SUNY-ESF, Orange County Planning Department, Orange County Water Authority, and the Black Rock Forest Consortium. The Orange County Planning Department and Water Authority will provide GIS data support for the intern. The intern will be based at SUNY-ESF and will complete the majority of the modeling, analysis and synthesis there. Meetings with stakeholders will be held at the Black Rock Forest Science and Education Center and at municipal offices in watershed communities. A final watershed summit where the project results will be disseminated to local officials and other stakeholders in the Moodna will be held at the Black Rock Forest Center.

Timeline of Project Intern

Spring 2006:	Planning and Background Work including working with the Moodna Watershed Coalition to convene the Steering Committee (the watershed stakeholders that will be involved in the modeling process and other aspects of the Watershed Plan)
Spring/Summer 2006:	Work with Watershed Steering Committee to develop land use change scenarios
Summer/Fall 2006:	Intern gathers data, parameterizes and executes models, does analysis, meets with stakeholders
Winter/Spring 2006/2007:	Intern updates and refines data, executes models and analysis; Communicate model results to stakeholders
Spring 2007:	Communicate project results to scientific community – public presentation(s) and begin to draft an article for a peer-reviewed journal

13. Related work.

The use of computer models to simulate hydrological effects of land use change is well documented (Kite 2001, Fohrer et al. 2002, Bhaduri et al. 2000, Burges et al. 1998). Recent efforts include a GIS coupled to a hydrologic model to estimate surface and groundwater resource conditions affected by land use change and climate change in Jordan (Al-Abed et al. 2005), a distributed hydrologic model (RHESSys) that estimated streamflow based on vegetation patterns in a semiarid shrubland in California (Tague et al. 2004), a rainfall-runoff model to estimate effects of land use on surface water runoff in multiple watersheds of the Rhine basin (Hundecha and Bardossy 2004), and a distributed watershed model (LISFLOOD) to simulate frequency and intensity of floods with changes in flood control measures and land use change in the Oder Basin in Poland, Germany and the Czech Republic

(DeRoo et al. 2003). In this project, we propose to use the hydrologic model Generalized Watershed Loading Function model (GWLF; Haith and Shoemaker 1987) to model the water balance of the Moodna sub-watersheds with varying land uses. The model has been used for similar purposes, although more emphasis on the simulation of sediment and nutrient loads, including the Hudson River (Swaney et al. 1996), the Choptank River (Lee et al. 2000, 2001), the Cannonsville watershed in New York (Schneiderman et al. 200), and the Susquehanna River (Chang et al. 2001).

Using stakeholder guidance to develop and model land use scenarios has been implemented in several projects including the Willamette River Basin Alternative Futures project (Hulse et al. 2004, Dole and Niemi 2004), the Middle Rio Grande, New Mexico system dynamics model for community-based water planning (Tidwell et al. 2004), and the future land use scenario analysis for northern Wisconsin (Peterson 2003a and 2003b). The stakeholder participation component of the project provides the advantages of greater scenario variation and political plausibility due to the unique and diverse perspectives of the stakeholders versus the standard approach of using scientist's input only (Peterson 2003b; Hulse et al. 2004). In a similar project where stakeholders developed land use scenarios for a rural area in northern Wisconsin, the participation of stakeholders strengthened community understanding of the potential environmental effects of tourism and second home development on the ecosystem services of the freshwater lakes in the watershed (Peterson et al. 2003a, 2003b). The stakeholder participation for predicting future land use scenarios in these studies is similar to that proposed in our study. However, our project is unique in that we intend to use the information on land use scenarios to simulate the land use change on water resources. In the models described above, models were used to estimate future water demands and did not simulate land use impacts on water quanitities.

Past and ongoing environmental research in the Moodna watershed is extensive and will provide water quality data that can be used to calibrate and validate the ecological health model. Water quality surveys on streams in undeveloped areas of the Black Rock Forest, a state park in the upland region of the watershed were conducted several years ago and are currently being published. Other water quality studies include a baseline study on streams in the Hudson (Stevens et al. 1994) and county wide bio-monitoring stream studies (Nolan 2004). The Orange County Water Authority has conducted several groundwater and surface water studies and produced GIS of water resource sites in the county.

14. Investigator's qualifications.

See attached CV's for Limburg (PI) and Luzadis (co-PI).

15. Training potential.

The project is specifically designed to train an intern, Ms. Molly Ramsey. Ms Ramsey is a second-year doctoral student at SUNY-ESF who has great interest in the linkages between land use, environmental quality, and how societal decisions affect these. The project will give the intern the opportunity to learn the skills necessary for scientific watershed assessment and communications with stakeholders. Results of this project will be shared with students and faculty of academic institutions through the Black Rock Forest Consortium, a membership organization of educational institutions; and, through the recently-formed Highlands Environmental Research Institute and the Highlands Coalition, respectively a scientific initiative and a coalition of environmental organizations, both interested in questions about water resources, open space, and development in the Highlands region, which includes part of the Moodna basin.

16. Principal findings or significant results.

To date the significant results of the project include the development of model scenarios to run in the watershed computer simulation model, GWLF (the Generalized Watershed Loading Function Model). The scenarios were developed at a meeting with the Moodna Watershed Coalition in July 2006. The scenarios represent the concerns and interests of the coalition. Two scenarios test worst and best-case scenarios, i.e. 100% impervious surface vs. 100% forested land cover. The other two scenarios represent specific development projects that are of concern to the watershed stakeholders. These scenarios are in sub-watersheds of the Moodna and the model will be run at the sub-watershed scale instead of the entire watershed.

17. Notable achievements.

Presentations to the Moodna Coalition, the watershed stakeholder group for the Moodna Creek watershed, were held in May and July 2006. These presentations gave an overview of the WRI project and developed the land use change scenarios for the watershed simulation model. Interests and concerns of the coalition members about the project were discussed and considered in the future development of the project and goals for the second year of the project (WRI grant 2007). Final results from the work done for the WRI 2006 project (watershed simulation modeling using GWLF) will be presented at a watershed summit meeting that will be held in October 2007 in Cornwall, New York (this meeting is being organized by the Moodna Watershed Coalition).

A second year of funding through the WRI was secured in December 2006. The second year of the project (2997-2008) will build upon the first year of the project with the installation of a stream gage on the Moodna and the calibration and validation of a spatially-explicit, water routing model.

Two professional oral presentations were given on the watershed modeling project – one to the New York chapter of the American Fisheries Society in February 2007 and another to the United States Society of Ecological Economics Conference in June 2007.

18. Student support (including names of students and area of study).

Academic and research support was provided for Molly Ramsey during the fall and spring semesters (2006-7), a doctoral student in the Environmental Science Department at SUNY-ESF, Syracuse, NY. Financial support included tuition, salary, and travel expenses.

Travel funds were used to attend several meetings of the Moodna Watershed Coalition at Black Rock Forest, Cornwall, New York and at the Orange County Office of Planning in Goshen, New York. Travel funds were also used to the 2006 3rd National Conference on Coastal and Estuarine Habitat Restoration "Forging the National Imperative" in New Orleans, LA. The national conference was held December 9 – 14th. The conference focused on coastal restoration issues including the human dimensions of restoration, education, and outreach, best practices, measuring and communicating results. The conference brought together academics, professionals, and citizen stakeholders involved in restoration research on terrestrial and coastal watershed and estuarine research. The conference was a great experience to hear and speak with scientists, government agencies, and NGO's involved in collaborative partnerships related to watershed planning. Case studies of projects similar to my own included the Hudson, Chesapeake Bay, Mississippi River, and Puget Sound. This was a very beneficial experience that helped provide a context for my own work, definitive and appropriate venues for future presentations about this project, and contacts for shared feedback from scientists, government agency, and NGO workers at the national-scale. I had several opportunities to discuss the WRI project with fellow conference attendees during several social events, question and answer periods following oral presentations and during my own poster presentation of an ecological economic project on the rebuilding of New Orleans. Seeing the positive feedback from others particularly related to public communication piece of this poster developed my current plans to organize a similar public workshop in the Moodna Creek Watershed that is the focus of my project for the WRI grant.

19. Publications generated to date (journal articles, theses, conference proceedings, etc. even those in press or submitted).

Publications include abstracts in two conference proceedings. An abstract for an oral presentation is published in the proceedings for the annual meeting of the New York state chapter of the American

Fisheries Society held in February 2006. The title of the presentation was *"Modeling urbanization effects on water resources in Moodna Creek Watershed, NY: Developing a tool for community watershed management."* An abstract for an oral presentation is published in the conference proceedings for the United States Society for Ecological Economics Conference, June 23 – 27, 2007, New York City, NY. The title of the presentation is the "*Urbanization and the Sustainable Management of Water and Land Resources in the Moodna Creek Watershed, NY: An Ecological Economics Approach*" by Molly Ramsey, Karin Limburg, and Valerie Luzadis of SUNY College of Environmental Science and Forestry.

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