Project 1G: Final Report

Habitat conservation and provision of ecosystem services

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Addendum: Results under Project Extension

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Introduction

In November 2007 we submitted the final report on this project, highlighting the key results of our project at that time. At the same time, we requested a no-cost extension to finish a few lingering tasks and to further refine the conservation planning toolkit that was the main focus of our project. In this addendum to that final report, we itemize further products of our efforts. These include further refinement of the toolkit, a summary of research reports and articles in preparation or review, and an update on our on-going collaborations in related work. This document is intended as a postscript to our final report, and updates but does not subsume that report.

Project Updates

During the past few months, we have codified and refined tools related to biodiversity support potential and habitat connectivity, and also extended our tools to model changes in watershed services resulting from land use change. We also have begun to incorporate a tool for evaluating carbon sequestration potential into our larger toolbox. These efforts are described in the following sections.

Toolkit Refinements and Extensions

Conservation Assessment Tools

In our November, 2007, final report we documented a toolkit that included tools to evaluate biodiversity support potential, habitat patch geometry, and the larger spatial context of habitat patches. While each of these tools was functional at the time, we have since made further progress on two fronts. First, we have verified that the biophysical proxies used to index biodiversity support potential are indeed capturing real differences in the physical environment (based on field surveys) and that these indices (“environmental zipcodes”) can serve as a useful guide to site prioritization. This effort was a substantial part of the Master’s Project for Jesse Leddick, who was partially supported by this project.

We also completed the geospatial database for evaluating habitat connectivity for the entire state of North Carolina, finishing a task that was at proof-of-concept stage when we submitted our final report. This database, instantiated for forest patches, allows us to assess the role of each habitat patch in serving as a potential "stepping stone" to connect otherwise disconnected regions throughout the state. The database links more than 600,000 forest patches to ~450 connected regions (subnetworks) across NC. The tools for generating this database and assessment are general and can be applied to other types of habitat patches or other regions as desired. This tool, we believe, represents the first such analytic capability to be developed for applications at the spatial extent of an entire state.

Watershed Services Tools

We have extended the evaluation of watershed services by developing proof-of-concept applications to illustrate the changes in ecosystem services implied by land use change. In both illustrations we have focused on the Upper Neuse watershed in central NC. In one application, we developed a scenario for future development pressure in the Falls Lake subbasin; the scenario is hypothetical but based on changes in land cover observed over the past decade (inferred from the National Land Cover Dataset) along with projections by local governments. The toolkit provides a means for updating the land use data used to drive the watershed assessment model pySPARROW (described in our final report), and then runs pySPARROW to estimate the nitrogen loading from each catchment contributing to a user-specified target water body. To evaluate land use change scenarios, we run the baseline case, change the land covers to reflect the land use scenario, rerun the model, and difference the results relative to the baseline case. In this illustration, the model highlights the complexity of watershed response to land use change: some catchments show lower nitrogen loadings while others show increased loadings. In part, this is because forested catchments are degraded by development, while agricultural lands actually are improved in terms of nitrogen loadings—although there are compensating changes in other attributes not modeled by pySPARROW (such as increases in peak stormflows, sedimentation, and pollution). We have not yet estimated the economic implications of this scenario. This modeling study was the basis for the Master's Project for Emily Chambliss, who was partially funded by this project.

In a second illustration, we developed a scenario to explore the implications of increased demand for agricultural products and the possibility that this might lead to the removal of some agricultural lands from the Conservation Reserve Program (CRP). In this scenario, we used the entire Upper Neuse basin but at lower spatial resolution (14-digit HUCs). We used Ag Census statistics to find the land area per county in CRP, and distributed this area randomly over the basins in each county (thus introducing some imprecision into the scenario, a problem that could be fixed with more highly resolved data). The scenario consisted of four steps: (1) model baseline nitrogen loadings, (2) alter the land cover database to reflect the reversion of CRP lands back to agriculture (mostly grasslands, but a small amount of forest), (3) rerun pySPARROW and find the changes in N loadings; and (4) apply the benefits transfer model to estimate the economic value of these changes, based on a travel-cost model for recreation. The modeling is documented in our final report and in Jenkins et al. (in prep., see below). In this example, the economic implications are not very large, but the scenario provides a useful illustration of the application of the evaluation tools. In particular, the spatial pattern of nitrogen loadings—the production of the ecosystem service—can be rather different from the spatial pattern of the consumption of those services (in this case mediated by travel cost considerations). This issue of accounting for the different spatial patterns of the production of ecosystem services and where these benefits are consumed is perhaps one of the most challenging tasks in the emerging field of ecosystem services.

Carbon Sequestration Potential

Under separate EPA funding, we previously developed a web-based tool to estimate the carbon sequestration potential of changes in land use (e.g., planting 40 acres of agricultural fields to loblolly pine). This is the Reforestation/Afforestation Project Carbon On-line Estimator (RAPCOE version 1), available on-line at http://ecotools.env.duke.edu/RAPCOE_v1). Over the past few months we have ported the tool to work with our other tools, to make it easier to evaluate candidate sites for management. For example, given a set of candidate sites that are equivalently valuable for conservation (e.g., biodiversity support) and watershed protection, one might use relative carbon sequestration potential to further inform land use siting decisions. Similarly, this tool might be applied to siting decisions about allocating carbon offsets as part of a larger mitigation strategy.

Joint Production and Bundling of Services

From the outset, our approach has been to devise tools so that we could ultimately assess the joint production of ecosystem services simply by overlaying the results of analyses with different tools. For example, the bundling of watershed protection and biodiversity support could be indexed by intersecting the production function maps for these two targets. For ecological evaluations, this is relatively straightforward. For economic evaluations, the task becomes more complicated, as the flow of benefits stemming from ecological services might not correspond to the production sites. More importantly, current methods for estimating the value of these benefits typically do not allow for spatial mapping of the flow of benefits. This is largely a reflection of the conventional methods used for valuation; for example, in a travel cost study one might ask a survey respondent how far s/he traveled or how much s/he spent on the trip, but rarely is the respondent asked *where* s/he traveled from. In cases where this information is collected, the spatial resolution is lost when the results are extrapolated via benefit transfer functions. Reconciling the spatial resolution of the production and consumption of ecosystem services is a methodological challenge we are currently working to resolve.

Products

Student Support and Training

This research over the past few months has supported two Master's Projects for students in the Nicholas School's Master's of Environmental Management program:

Emily Chambliss, *Modeling land use patterns and water quality: an evaluation of the pySPARROW model.* Master's Project, Global Environmental Change Program, Nicholas School of the Environment, Duke University. Graduation: May 2008.

Jesse Leddick, *Assessing the Biodiversity Support Value of Habitat Patches in North Carolina.* Conservation and Ecosystem Management Program, Nicholas School of the Environment, Duke University. Graduation: December 2008.

In addition, the project has supported two student research assistants: Yoanna Kraus Elsin (water quality valuation) and David Bollinger (pySPARROW development), along with four students who worked part time on data development over the course of the study.

Presentations and Publications

Papers and presentations generated by this project include the following:

Goodall, J.L., J.P. Fay, and D. Bollinger. An object-oriented model for regional-scale water quality management. In preparation for Water Resources Planning and Management.

Jenkins, W. Aaron, Randall A. Kramer, Dean Urban, John Fay, and Jon Goodall, Benefit transfer and ecosystem services: linking water quality and recreation in North Carolina. Selected for a paper presentation at the 2008 UCOWR/NIWR Conference to be held July 22-24 in the Durham, North Carolina. A related article in development to be submitted to Water Resources Research.

Kraus Elsin, Yoanna, Randall A. Kramer, and W. Aaron Jenkins. Water quality as ecosystem service: a benefit transfer approach for drinking water treatment in the Neuse Basin. Selected for a paper presentation at the 2008 University Council on Water Resources/The National Institutes for Water Resources (UCOWR/NIWR) Conference to be held July 22-24 in the Durham, North Carolina. A related article is ready for submission to Journal of Water Resources Planning and Management.

Urban, D.L. Landscape change and the provision of ecosystem services. Invited seminar to be delivered to EPA (simulcast nationally), May 12, 2008.

Urban, D.L., J.P Fay, J. Goodall, R. Kramer, and L. Olander. Integrating ecological and economic tools for evaluation ecosystem services. In preparation for Ecological Applications.

Urban, D.L., J.P. Fay, and B. Best. Multi-scale analysis of habitat connectivity for conservation planning. In preparation for Conservation Biology.

Collaborations

As part of this project, we continue to collaborate with the NC Department of Environment and Natural Resources (DENR), on their *One NC Naturally* project, an integrated conservation plan for the state. This is a perfect opportunity and test case for our project, as DENR intends to develop one master plan that addresses conservation, water resources, agriculture and forestry, parks and recreation, and wildlife (in effect, subsuming the state Wildlife Action Plan). We have been working for DENR for several months, helping to incorporate our tools into the state's analysis and planning approach. DENR is hosting a graduate internship to continue work on this collaboration during summer 2008.

In addition, we continue to pursue the collaborations detailed in our final report.

Tool Dissemination

The toolkit for ecosystem service evaluation is currently packaged for *beta* release, which we intend for active collaborators on similar projects in other regions. We are providing the tools as a WinZip archive that contains the tools as packaged for use as a Toolbox in ArcGIS version 9.2 (ESRI, Redlands, CA). Agencies who have expressed an interest in collaborating include The Nature Conservancy, The Conservation Fund, and researchers at the University of Maryland who are working with the National Park Service. As each of these groups has some expertise in this kind of research but no experience with these tools, we hope that our collaboration will help revise and refine the tools to be more robust and user-friendly. At that point, we will "go public" with the toolbox and distribute them through the Landscape Ecology Laboratory at the Nicholas School (lelserver.nicholas.duke.edu).

Conclusion

This project has pushed the state-of-the-art in the evaluation of ecosystem services in several ways. The conservation tools, especially the tools for biodiversity support potential based on biophysical proxies (envirionmental zipcodes) and habitat connectivity, represent the first tools of their kind that can be implemented readily in the industry-standard software package, ArcGIS. Similarly, the porting of SPARROW to pySPARROW and its implementation in ArcGIS, with interactive modeling and mapping of watershed impacts, is a significant advance in watershed assessment. The development of these tools supports our early contention that environmental assessment tools need not be simplistic in order to be widely accessible; these are quite sophisticated tools and yet they are readily accessible to client users who are comfortable working with ArcGIS.

Significant challenges remain in evaluating the ecological and economic value of ecosystem services. Most of these challenges concern reconciling disparate disciplinary conventions for data collection and modeling. Especially, reconciling the different currencies of valuation—whether ecological or economic—presents a major hurdle if we are to make progress in evaluating the joint production of services. Similarly, finding new ways to map the flow of benefits from ecosystem services, from where they are produced to where they are consumed, will also invite new methods for data collection and modeling. We intend to continue to work to find these solutions.