Proceedings

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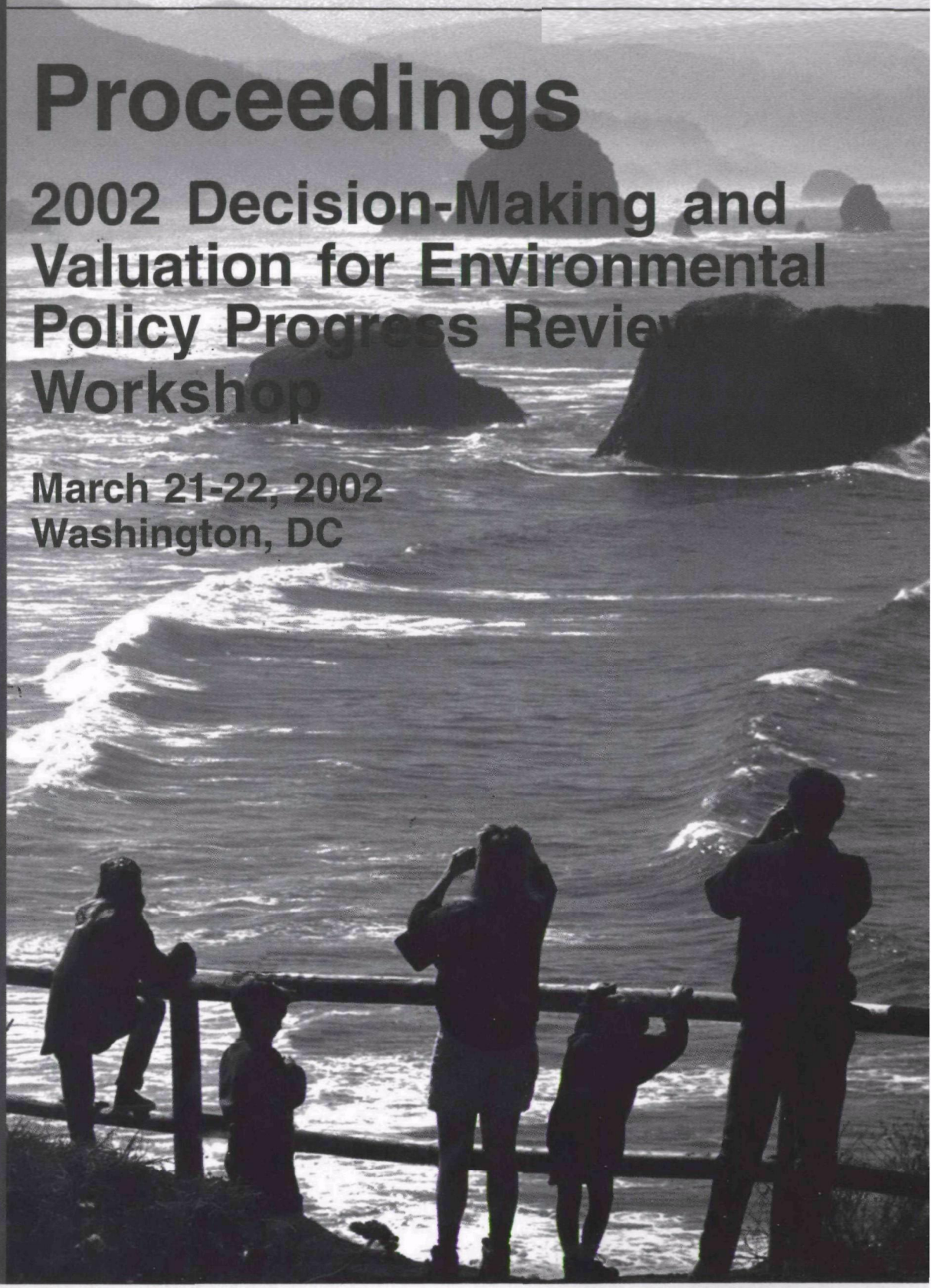

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Introduction

On December 8, 1994, the National Science Foundation (NSF) and the Environmental Protection Agency (EPA) signed a Memorandum of Understanding establishing a partnership for the support and merit review of fundamental, extramural environmental research. One of the most successful competitions funded as a result of this partnership is Decision-Making and Valuation for Environmental Policy (DMVEP).

The DMVEP competition encourages research that will contribute to the development of practical, credible approaches for estimating the benefits and costs of environmental programs and improving decision-making about environmental issues. DMVEP started in Fiscal Year (FY) 1995 and has held competitions each FY through 2002, with the exception of FY 2000. In 1997 and 1998, DMVEP held progress review workshops for grantees funded by the 1995 and 1996 competitions to give grantees an opportunity to report their research findings and discuss the future directions of the research area. The proceedings document for the 1998 workshop is available on the EPA National Center for Environmental Research Web Site at http://es.epa.gov/ncer/publications/workshop.

From FY 1997 through FY 1999, NSF and EPA made 45 DMVEP awards, totaling approximately $7.8 million. The DMVEP competition supported a wide variety of topics during this period. Research was solicited in four related areas:

- ***Costs and Benefits of Environmental Programs and Policies:*** This area of research seeks to find and test integrated models and improved methods to estimate and validate the costs and benefits of environmental protection programs and policies.
- ***Ecosystem Valuation:*** Research in this area identifies valuable ecosystem functions and focuses on how comprehensive and critical ecosystem changes can be measured in terms of social welfare.
- ***Human Health Valuation:*** This area of research seeks to improve methods to estimate values for reductions in mortality and morbidity risks resulting from environmental hazards.
- ***Decision-Making for Environmental Policy:*** This area of research examines the behavioral and institutional factors that influence the development, implementation, and evaluation of environmental policies.

The March 21-22, 2002, Workshop on Decision-Making and Valuation for Environmental Policy provides a forum for investigators funded by the FY 1997, 1998, and 1999 competitions to interact with one another and with EPA, NSF, and other researchers interested in valuation and decision-making research. For the proceedings volume, investigators were asked to contribute statements describing the objectives and significance of their work as well as preliminary findings from their research.

Any opinions, findings, conclusions, or recommendations expressed in this report are those of the investigators who participated in the research. For further information about the DMVEP program, please contact the appropriate Program Officers: Susan Carrillo, EPA, (202) 564-4664 or Cheryl Eavey, NSF, (703) 292-7269. Further information on future solicitations and research abstracts may be found on the NSF/EPA Partnership for Environmental Research Web Site at http://www.nsf.gov/home/crssprgm/epa/start/dmvep.htm.

Local Environmental Decision-Making: Non-Mandated Environmental Policies and Public Participation

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In recent years, a wide variety of new policy tools have been designed to facilitate environmental performance in states, firms, and communities. This project focused on the latter and the emergence of civic environmentalism—communities who voluntarily do more to protect the environment than is required. Although the philosophy of many new environmental programs (information disclosure, community-based environmental protection) rests on changing local decisions, not much is known about community variation in capacity to undertake innovative policies.

The project began with a query about the factors contributing to a community's propensity to go beyond environmental compliance? After a comprehensive literature review, the project was focused on the interrelated concepts of social capital and civics as a surrogate independent variable for community cooperation. A search was begun for communities that adopted one of many voluntary environmental policies. The adoption of a greenhouse gas reduction policy was selected as the first dependent measure to sort communities into two comparison groups: environmental policy conformers and performers. The first data collection phase produced a baseline database of more than 160 socioeconomic variables for 3,142 counties. Project investigators developed an empirical model of local voluntary environmental policy effort from this initial dataset. The quantitative analysis employed factor analysis and logistic regression.

Our initial quantitative analysis found that Democratic politics and a civics factor mattered, but not necessarily as expected. The former exhibited the strongest positive relationship to policy adoption propensity; however, the civics measure produced a negative association.

This research advances our understanding by beginning to compare communities across multiple dimensions to learn more about the determinants of local policy innovation, the empirical import of social capital measures, and analytical techniques to differentiate unusual cases from average ones. The research design employed in this project integrates several theoretical models to clarify key conceptual and methodological issues that make it easier for other scholars to study the process and effects of civic environmentalism. This research is significant for the advancement of our knowledge of community environmental policy processes and their effects on environmental outcomes. Pragmatic benefits from this research relate to improving our understanding of nonregulatory policies at the local level. This project will help form policy analysis and policy design in the future, particularly for programs aimed at the community level. If local factors condition community policy capacity as our research suggests, then more attention needs to be given to capacity building at the local level.

Although the quantitative measurement and modeling described above advance the understanding of civic environmentalism on its own, the intention also is to use the analysis to identify community cases worthy of more detailed qualitative work. A few provocative scholars have pointed out the quantitative techniques such as regression focus used by researchers on average cases when more interest lies in unusual ones. Therefore, the models are currently being used to identify a matched-paired sample of two kinds of communities where local representatives will be contacted to respond to structured and semistructured surveys.

Collaborative Research: Cultural Models, Values, and Networks in Environmental Decisions

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This project focuses on the interactions of mental models, cultural values and behaviors, and social networks in processes of environmental decision-making and intergroup conflict. The goal is to promote sustainable environmental practices and further possibilities for adjudication of norms over transcultural boundaries.

The studies integrate four modeling techniques with roots in psychology, sociology, and anthropology: (1) mental models, (2) social network models, (3) the cultural-consensus model, and (4) value assessment and confrontation.

These methodologies are used to assess folk-ecological models, values, and behaviors relative to a rainforest environment among native and immigrant Maya and Ladino groups in Lowland Mesoamerica, and relative to hardwood forest and aquatic environments among Native Americans and majority culture sportsmen in northern Wisconsin (see Figure 1). In both sites, culturally diverse groups live in close proximity, and share a common environment. This approach allows examination of cultural differences in mental models of the same environment and the generality of findings across environments.

The studies show that different cultural groups subject to equal pressures on their common resources respond with strikingly different culturally patterned behaviors and cognitions. Overall, there is a complex interplay between mental models, values, and agro-forestry practices that are distinctive to each group. Moreover, groups may have distorted perceptions of each other's mental models and behavior. Finally, the studies also suggest a nonobvious role for religion in helping human societies to resolve "The Tragedy of the Commons" and other ecologically pertinent forms of "The Prisoner's Dilemma." Supernatural agents may act to allow humans to engage nonhuman resources in relations of "indirect reciprocity" so as to better monitor and accommodate nature's requirements for continuing human support. Initial results were published in "Folkecology and Commons Management in the Maya Lowlands" (*Proceedings of the National Academy of Sciences* 1999; 96(13):7598-7603). A comprehensive overview of Mesoamerican findings will appear as a target article for international commentary in *Current Anthropology* 43(3). Preliminary findings for North America have been submitted for publication.

On a theoretical level, these studies are important to establish a framework for exploration of the relationships between environmental cognitions, values, and behaviors, and to provide a means of evaluating the transferability of ecological information within and between cultures. On a practical level, these studies reveal how intergroup conflict is significantly mediated by differences in mental models and associated values, particularly environmental conflicts between Native Americans and the majority culture. Mutual recognition of these differences may render even unavoidable controversy and indeterminacy in ecological behavior less acrimonious and harmful to human and environmental health. The results have direct policy implications for state and federal lawmakers and environmental agencies, international policymakers, and nongovernment organizations.

Recently, the project is looking at younger native Maya who no longer speak the native language as their first language. Although the complexity of their ecological models of plant-animal relationships is fairly rich, they show evident biases that older natives do not show such as overgeneralizing the role of palms in animal life. It was found that Ladinos also overgeneralize the value to animals of economically important species such as tropical cedar and mahogany. The cognitive ramifications of these use biases are still being explored. Also, probes are being run for goals, attitudes, and values among Menominee and majority culture hunters. Although each group's model encourages conservation, differences in models lead to misunderstanding and mistrust, particularly in regard to majority-culture attitudes towards Menominee (as potential negotiating partners).

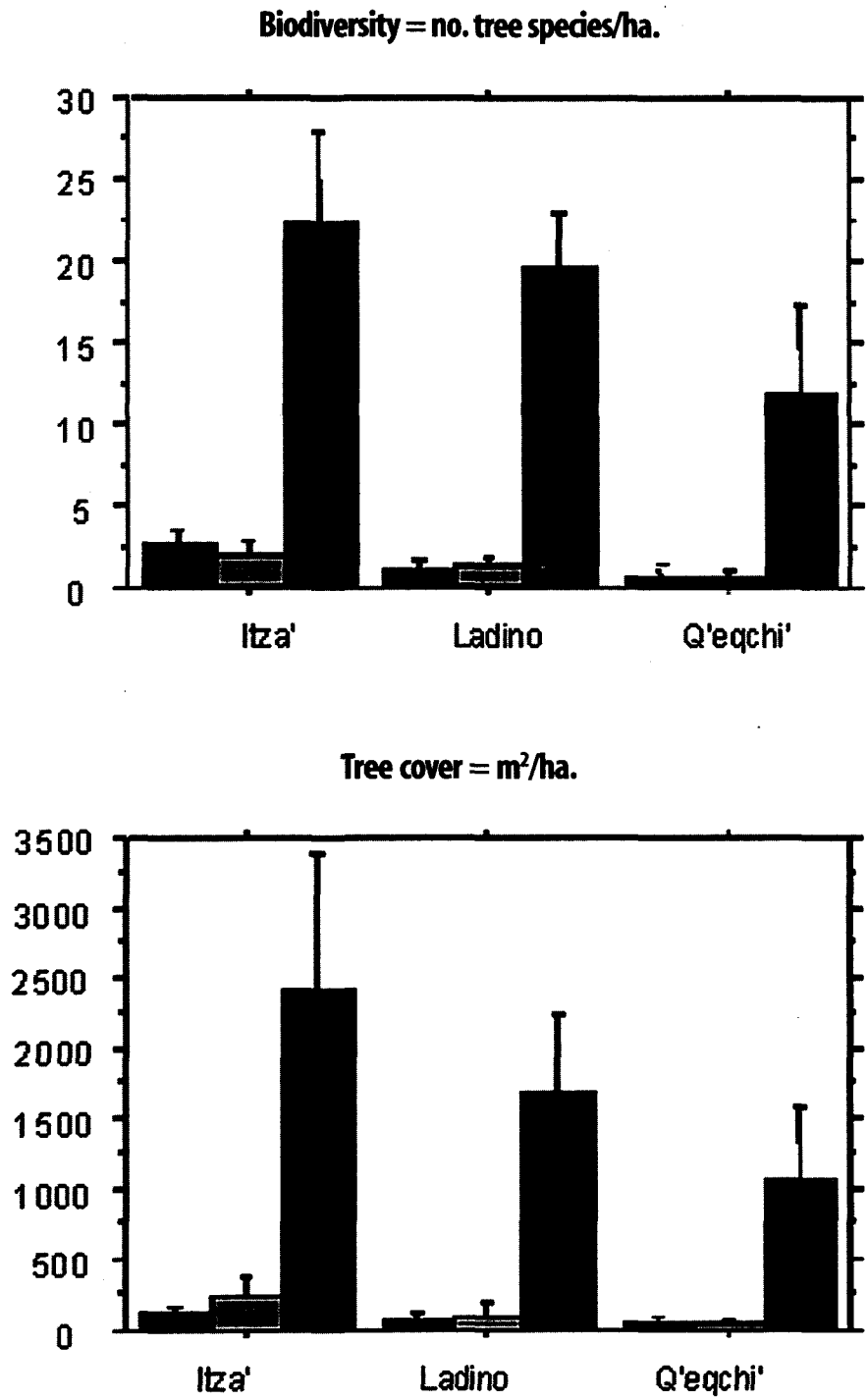

Figure 1. Biodiversity (number of tree species) and tree cover (square meters per hectare) as a function of ethnic group (Itza' = Native Lowland Maya, Ladino = Spanish-speaking immigrants, Q'eqchi' = Highland Maya immigrants) and type of land use (milpa = agricultural plot, guamil = fallow, reserve = forest).

Indicators of Ecosystem Value: Deriving Units of Exchange for Habitat Trades, Banking, and Preservation Priorities

James Boyd[1] and Lisa Wainger[2]
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Ecosystem compensation and exchange programs require benefit analysis to guarantee that compensation or trades preserve the social benefits lost when ecosystems are destroyed or degraded. Current regulatory procedures tend to underanalyze the social value of ecosystems being traded or ecosystem losses requiring compensating mitigation. For example, a common practice in wetland mitigation decisions is simply to require an "acre for an acre" of biophysically similar wetland when another is destroyed. This kind of compensation rule fails to account for many of the things that determine the social value of a particular ecosystem such as a site's location in the greater landscape, the importance of local substitutes for and complements to the site, and future risks to the site's ability to provide services.

On the other hand, state-of-the-art economic methods that employ these basic elements of valuation are difficult and costly to apply. The conventional economic solution involves monetization of the value provided by an ecosystem's services using hedonic, travel cost, contingent valuation, and other econometrically sophisticated methods. However, although monetization is desirable in theory, it is often impractical. In practice, it is rare to see agency decision-makers or private conservation organizations making land use decisions based on comprehensive monetization exercises.

One resolution to this conflict is a methodological middle ground: evaluation tools that identify, based on sound economic principles, likely differences in ecosystems' social benefits, but that also are easily implemented by noneconomists using existing data sources. This study derives, applies, and critiques a set of ecosystem benefit indicators. Organized around the concepts of ecosystem services and valuation principles, this project shows how Geographic Information System (GIS) mappings of the physical and social landscape can improve understanding of the ecosystem benefits arising in specific locations. The core of the project is the development of a pilot ecosystem service indicator system and the application of that system to real-world land use decisions. The indicator system focuses on landscape factors that limit or enhance an ecosystem's ability to provide services and limit or enhance the expected value of those services. This kind of analysis yields an organized, descriptive, and numerical depiction of sites involved in specific mitigation projects.

The GIS landscape analysis is a clear improvement over assessment methods that ignore landscape context when assessing trades and compensating mitigation. First, landscape analysis allows for qualitative analysis of benefit tradeoffs. Second, in some cases, the indicators allow for relatively unambiguous improvements in decision-making (e.g., when tradeoffs are minimal and one ecosystem can be seen to clearly dominate another). Third, the data and tools foster a spatial, holistic approach to benefit assessment. Fourth, there is high confidence that this kind of tool can lead to more transparent and consistent evaluations than crude standardized trading ratios or reliance on "best professional judgment."

The project concludes with an evaluation of the limitations associated with indicator-based assessment tools. Indicators, by their very nature, sacrifice precision and raise methodological issues that are more explicitly and better handled by conventional monetization (econometric) tools. An understanding of limitations is therefore an important component of the pilot project.

Establishing Correlations Between Upland Forest Management Practices and the Economic Consequences of Stream Turbidity in Municipal Supply Watersheds

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This research project evaluated the causes and consequences of increased sedimentation and persistent turbidity during a major flood in western Oregon in 1996. Turbidity was related to land and reservoir management activities. The response and costs incurred by the City of Salem, Oregon, and its water users to the storm and its aftermath were analyzed, and a framework was developed for understanding the evolving relationships among land, reservoir, and water supply management and managers in response to changing social demands and natural events in the Santiam watershed.

Several complementary approaches were employed to examine the linkages among forest land use, reservoirs, and municipal water supply during the 1996 flood and afterwards. Through interviews, a detailed analysis was conducted of costs incurred by the City of Salem, including both acknowledged and hidden costs. Using clay mineralogy, the sources of turbid water were fingerprinted, and these sources were related to land management practices and reservoir management within the upstream watershed. Geographic Information System analysis was used to look at the spatial relationships between land management activities and sources of persistent turbidity in the watershed.

The high turbidity triggered diverse economic consequences. Damage from clogging of the filters, plus other short-run costs to the city's water utility totaled $1.1 million. Some industrial water customers incurred costs of $2 to 3 million, primarily in lost revenues, because they responded to the city's request to curtail operations during the crisis. The city, at a cost of $1.6 million, subsequently increased its ability to cope with future pulses of high turbidity by expanding an early-warning monitoring system, increasing its treatment capacity, securing backup supplies from other sources, and increasing storage of treated water. This rare occurrence of high turbidity clarified the value of having a watershed that usually delivers extraordinarily pure water: on average, it allows the city to avoid $2 to 4 million in annual treatment costs.

A detailed look at the relationships among landforms, turbidity, and clay mineralogy revealed that earthflows are overwhelmingly the dominant source of the extremely fine clays producing persistent turbidity in the Santiam Basin (see Figure 1). These clays comprise between 70 and 90 percent of the clay fraction from earthflows but are rare in other landforms. Along with being highly concentrated spatially, delivery of clays to the stream network are also concentrated in time. Almost all major turbidity episodes occur during large winter storms, but the time between major storms is a key factor determining turbidity levels.

The flood revealed the complex and often contradictory web of management objectives among the agencies and parties responsible for water management in the Santiam. It highlighted how management for one narrow set of objectives might exacerbate problems in another sector. For example, decades of logging in the North Santiam Basin targeted the most unstable piece of ground, thereby potentially exacerbating sediment production during storms. The operation of dams for flood control prolongs the release of persistent turbidity downstream, causing problems for municipal water users. Relying on the normal behavior of a watershed to produce clean water under all circumstances exposes societal vulnerability to inherent geological hazards.

The next steps will be to communicate these findings to a diverse audience, including city planners, watershed councils, resource management agencies, and the larger scientific community.

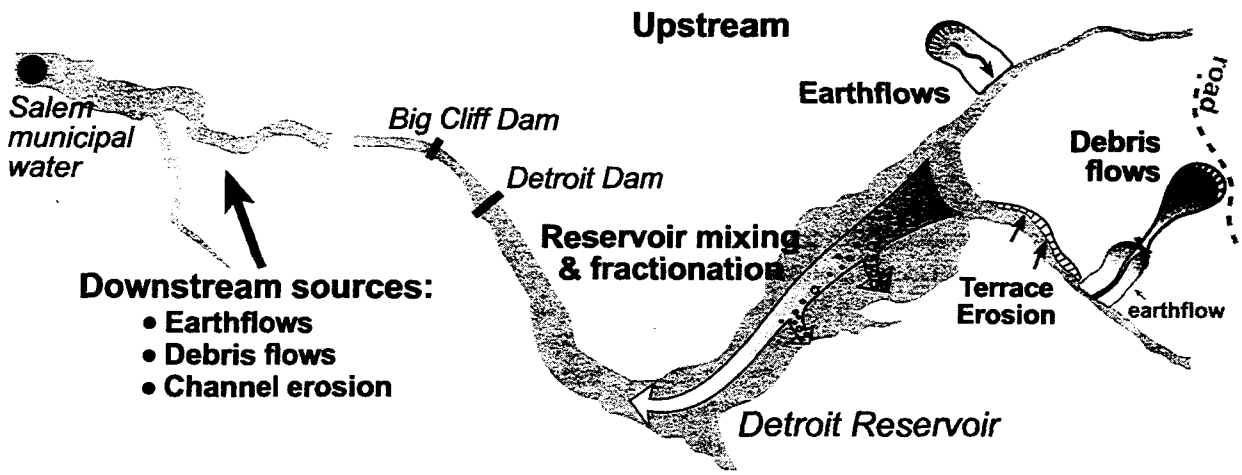

Figure 1. Persistent turbidity pathways in the North Santiam River.

Land Management With Ecological and Economic Objectives: Developing a Production Possibility Set of Wildlife Species Persistence and Timber Harvest Value

Claire Montgomery[1], Jeffrey Arthur[1], Darek Nalle[1], Stephen Polasky[2], and Nathan Schumaker[3]
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The primary objective of this study was to integrate biological and economic models in an optimizing framework to address economic issues related to efficiency. The resulting model was used to estimate the productive capacity for three outputs (timber, great horned owls, and common porcupines) on a forested landscape over time, ignoring landowner types and objectives, and to compare that to likely management on the study landscape by simulating the current landowner pattern and objectives. The wildlife species were selected to represent competing conservation objectives; their habitat needs are different.

The study area was a 1.7-million hectare forested landscape in the Oregon Cascade Range. A spatially explicit dynamic simulation model, PATCH,[1] was used to model the impact on wildlife of timber harvest-induced habitat alteration. A proxy for PATCH, that quickly predicted populations as a function of habitat attributes, was used in the optimization. The optimization model was solved repeatedly for the maximum net present value of timber harvest subject to varying levels of constraints for wildlife population sizes using a heuristic algorithm. The solutions are an estimate of the set of maximum potential combinations of the modeled outputs. To simulate likely management, net present value of timber was maximized on private land (about 45% of the area), and timber harvest was disallowed on federal land.

Results are illustrated in Figure 1. Three graphs show maximum potential combinations for each pair of outputs. The current landowner simulation is shown by a marker on each graph. Maps show the configuration of owl habitat for three outcomes: maximum timber value, the current landowner simulation, and the maximum potential combination that achieved the same owl population as the current landowner simulation.

The study illustrates how analysis based on estimation of productive capacity for a site can be used to search for opportunities to improve current management. We found that it might be possible to increase owl populations by 30 percent over likely current management levels without reducing timber values or porcupine populations or conversely, to increase the timber by 13 percent and porcupines by 30 percent without reducing owl populations. Current management, in which private land is managed for timber in response to market incentives and federal land is managed almost exclusively for other forest uses, appears to be inefficient. Models like this one may prove useful for identifying situations where the payoff for making the difficult policy changes to markets and/or to federal land management to encourage landscape-level management of forests is likely to be great.

Incorporation of more realism in the wildlife models (e.g., predator/prey relations, more refined habitat preferences), the timber model (e.g., roading, site quality), and the vegetation model (e.g., disturbance regimes, more refined vegetation classes) will improve the practical usefulness of this approach. The model can be used to improve understanding of the tradeoffs between alternative conservation objectives by carefully selecting wildlife to model that represent different conservation goals (e.g., old-forest-dependent endangered species versus large numbers of species with more general habitat needs). Finally, there are many forest uses, aside from wildlife and timber, that might be modeled using this framework (e.g., fire risk, recreation).

[1] Schumaker NH. A users guide to the PATCH model. EPA/600/R-98/135. Environmental Research Laboratory, U.S. Environmental Protection Agency, Corvallis, OR, 1998.

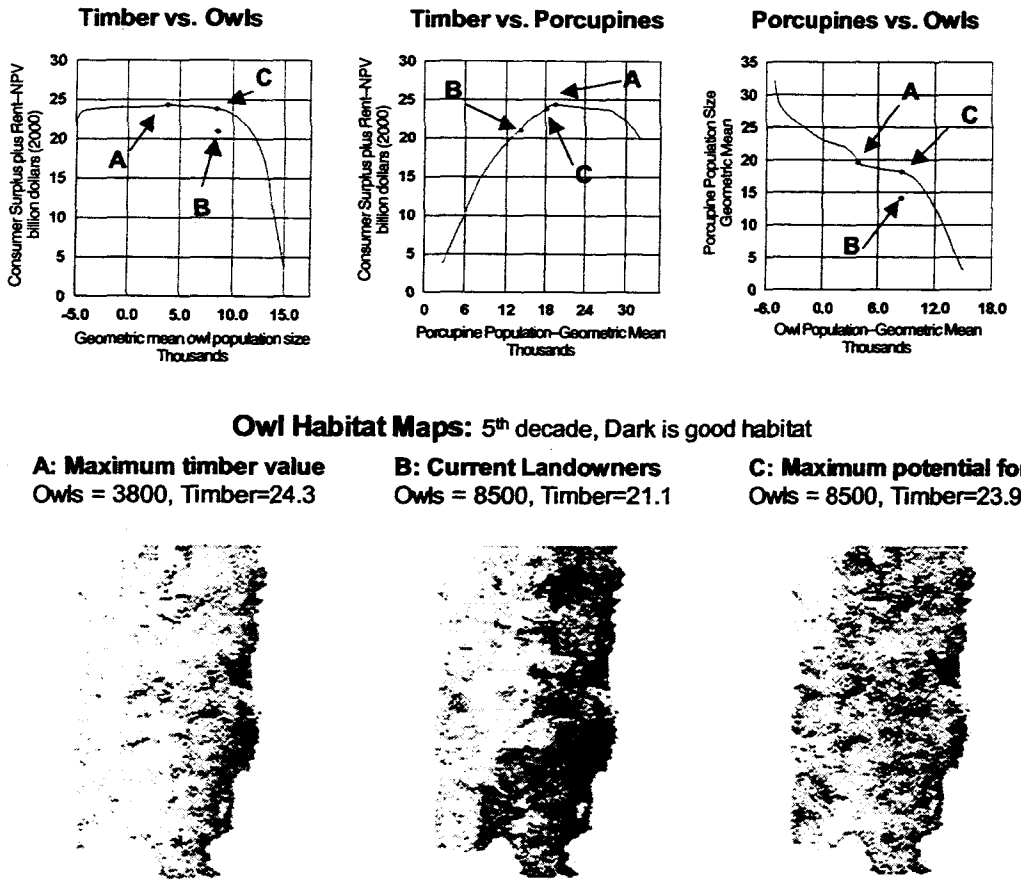

Figure 1. Results of simulated likely management.

An Integrated Framework for Analyzing Wetlands Policies: Ecosystem Services, Spatial Targeting, and Cost Effectiveness

Stephen C. Newbold
Department of Environmental Science and Policy, University of California, Davis, CA

This research project focuses on developing a framework for analyzing the potential environmental and economic impacts of alternative wetland management strategies. The broad objectives of this research are to: (1) estimate functions describing relationships between the extent and configuration of wetlands and other land use types to the provision of three classes of ecosystem services that wetlands can provide: water quality enhancement, provision of habitat for wildlife, and flood control benefits; (2) estimate wetlands restoration costs and exogenous land use conversion probabilities; and (3) incorporate these into a spatial optimization model that can determine the optimal configuration of restoration activities for a range of environmental objectives subject to a budget constraint.

Thus far, models for two ecosystem services from wetlands have been developed for the Central Valley of California: the provision of habitat for mallards, and the attenuation of nutrients from nonpoint source runoff. Habitat benefits were estimated by a count regression model that relates breeding mallard abundances to the configuration of land use types in the study area. Water quality benefits were estimated by a spatially distributed model of nonpoint source runoff as well as nitrogen and phosphorus attenuation in wetlands. County assessor data were used to estimate average land values for each land use type in each county in the study area. Wetlands construction costs were estimated using expected costs for proposed Wetlands Reserve Program projects in California for the year 2000. The habitat and water quality models, along with the estimates of restoration costs, were integrated into a numerical optimization framework, and two decision scenarios in the Central Valley of California were analyzed. The first scenario was a case of optimal spatial targeting in a small watershed, and in the second scenario, sites were selected from those offered for enrollment in an easement program throughout the study area. The results indicate the potential for gains in effectiveness from spatial targeting and substantial tradeoffs between environmental benefits. Maximizing habitat quality in the watershed yielded a 38 percent increase in mallard abundance and a 3 percent decrease in nitrogen loads to the river. In contrast, maximizing water quality resulted in a 25 percent decrease in nitrogen loads and a 2 percent increase in mallard abundance. Qualitatively, similar results were obtained when sites were chosen from a set of offered sites throughout the valley, but the tradeoffs were not as severe. The results also suggest that at traditional funding levels, the Wetlands Reserve Program in California could reduce nitrogen loads to rivers by approximately 29,000 kg and increase total mallard abundance in the breeding season by approximately 440 individuals throughout the Central Valley in a given year.

Support of mallard populations and the attenuation of nutrients from nonpoint source runoff are not the only environmental benefits that wetlands can provide, but they were used here to illustrate methods for modeling ecosystem services, targeting restoration activities using spatial optimization models, and measuring the tradeoffs between different environmental goals. Future work will focus on developing a model of flood control benefits from wetlands, and estimating exogenous land use conversion probabilities.

Environmental Protection and Endogenous Technical Change: A Theoretical and Empirical Analysis

James J. Opaluch, Shunsuke Manage, Di Jin, and Thomas A. Grigalunas
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Technological change is central to maintaining standards of living in modern economies with finite resources and increasingly stringent environmental goals. Successful environmental policies can contribute to efficiency by inducing, rather than inhibiting, technological innovation. Yet, little research to date has focused on the design and implementation of environmental regulations that encourage technological progress, or in measuring productivity change in the face of depletion of natural resources and increasing stringency of environmental regulations.

This research project models and measures productivity change, with an application to offshore oil and gas production in the Gulf of Mexico using Data Envelopment Analysis. This is an important application because energy resources are central to sustaining our economy, and because petroleum products are currently among the most significant energy resources. The traditional issue of measuring productivity change was recast by recognizing that production activities implicitly embody joint production of market and environmental outputs. Thus, measures of productivity change consider both market and nonmarket outputs.

The net effects of technological progress and depletion on productivity or offshore oil production in the Gulf of Mexico were measured using a unique field-level set of data of production from all wells in the Gulf of Mexico for the time period from 1946–1998 (see Figure 1). Past technology indexes based on simple counts of technological innovations were updated and extended to account for the importance of each innovation using the results of an industry survey. Results are consistent with the hypothesis that technological progress has mitigated depletion effects over the study period, but the pattern differs from the conventional wisdom for nonrenewable resource industries. Contrary to the usual assumptions of monotonic changes in productivity or an inverted "U" shaped pattern, productivity declined for the first 30 years of the study period. More recently, however, the rapid pace of technological change has outpaced depletion and productivity has increased rapidly, particularly in the most recent 5 years of the study period.

Next, the Porter Hypothesis was recast, and a revised version was tested. The Porter Hypothesis states that stricter environmental regulations can contribute to productive efficiency. The Porter Hypothesis was recast to include market and nonmarket outputs. The results show a long-run upward trend of productivity, accounting for environmental and market outputs. Granger causality tests were used to examine the direction of causality between innovation and environmental regulation. Although firm conclusions of the causal relationship between environmental stringency and technological innovation (new inventions) could not be made, we found a clear causal direction from environmental stringency to less structural aspects of innovation such as so-called "learning by doing."

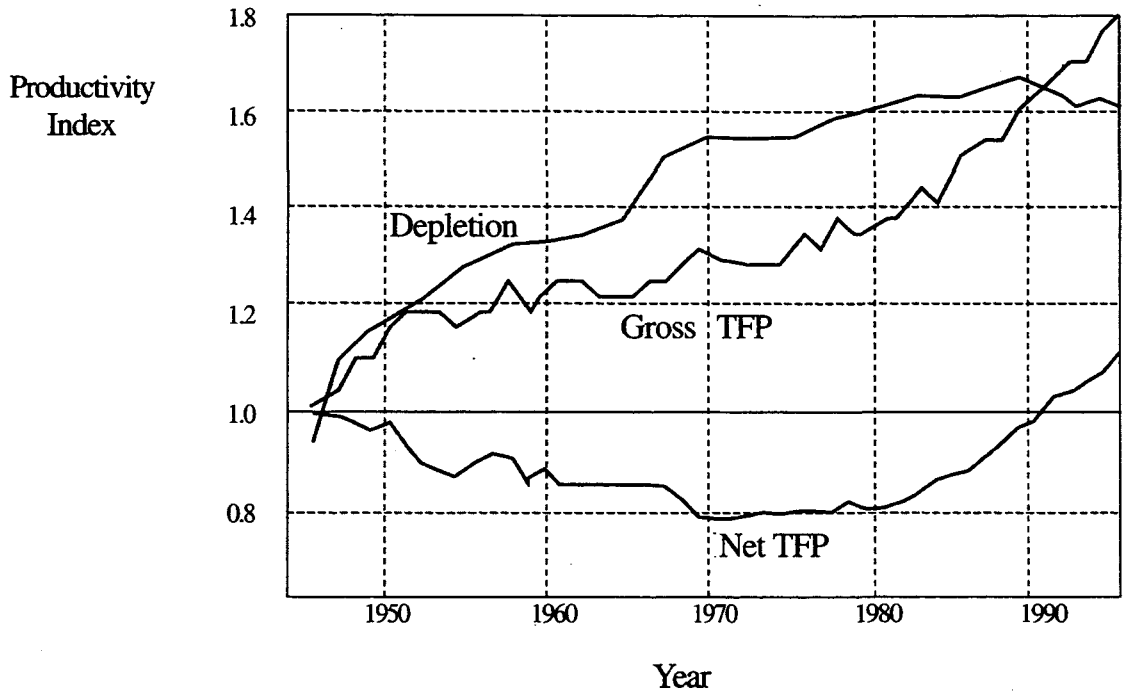

Figure 1. Estimates of Total Factor Productivity (TFP) and depletion in Gulf of Mexico OCS production, 1946-1998.

Applying Consensus and Cultural Models To Improve Environmental Decision-Making

Michael Paolisso and Erve Chambers
University of Maryland, Baltimore, MD

This research project seeks to strengthen the capacity of national and state agencies and local communities to better incorporate stakeholder interests, beliefs, and values into environmental decision-making. Specifically, the research combines theoretical and methodological developments from environmental and cognitive anthropology to identify and model environmental stakeholders' priorities, beliefs, and values related to ecology and pollution. The resulting cultural models are formal representations of shared explicit and implicit knowledge, interests, beliefs, and values that members draw on to process, understand, and give value to the contemporary environmental challenges facing their communities, industries, and ecosystems.

The project includes undertaking field-based research with three Chesapeake Bay stakeholder groups: environmental professionals, which includes scientists; conservationists and resource managers; and farmers and commercial fishermen, known locally as watermen. For each of these groups, qualitative and quantitative studies are being completed of the cultural schemas and models that organize implicit, assumed environmental knowledge, particularly as it applies to local and state decision-making related to pollution control and natural resource management. The results of the qualitative research suggest that the three stakeholder groups share a continuum of underlying values about preserving the environment, and all strongly support efforts to protect the environment and sustainably use natural resources. Key values that are implicitly shared among the groups are a sense of moral responsibility to protect the environment, a willingness to sacrifice short-term benefits for longer term environmental good, and a feeling of dependence on the environment for their livelihood and lifestyle. Despite an underlying agreement on core environmental values, farmers and watermen perceive strong differences between their environmentalism and environmental knowledge, compared to environmental professionals, and vice versa. This can be most clearly seen in the comparison of watermen and environmental professionals in the context of recent decisions to increase regulation of the blue crab fishery.

Using the cultural model approach, a watermen model of blue crab management was identified (see Figure 1). Watermen conceptualize the blue crab fishery as jointly managed by divine providence and secular management. God, personified in nature, provides crabs for human consumption, and it is beyond the capacity of science and management to fully understand and regulate nature. For watermen, nature is too random and variable for science to understand. What science can and should understand is how man's pollution affects blue crabs. In other words, science can only understand what man has created, not what God has created. Moreover, science must provide information for environmental decisions on pollution, with the end result as a decrease in the pollution that threatens crab reproduction and the sustainability of the blue crab fishery. Finally, despite public rhetoric, watermen believe in a role for natural resource management agencies. This role should focus on assisting watermen to control the greed of some individuals whose overharvesting makes it difficult for a larger group of watermen to continue to be economically viable. Thus, although nature provides crabs, humans need to help manage the crabs by addressing pollution problems and developing policies that promote sustainability of the blue crab fishery. In the end, the research has found that despite public discourse on blue crab management in which watermen and environmental professionals are strongly opposed to each other's positions on regulations, watermen have an underlying cultural model of blue crab management that has components of the ecological model used by scientists and resource managers to guide their decision-making. The fact that this similarity has not been recognized lends credence to the viewpoint that there is a need to promote dialogue among stakeholders at the cultural model or schema level.

The project will continue to explore whether similar cultural models of environment and pollution exist with the other stakeholder groups, the farmers, and environmental professionals. Final project activities will emphasize integrating this underlying environmental knowledge, beliefs, and values into ongoing decision-making for pressing environmental concerns on the Bay.

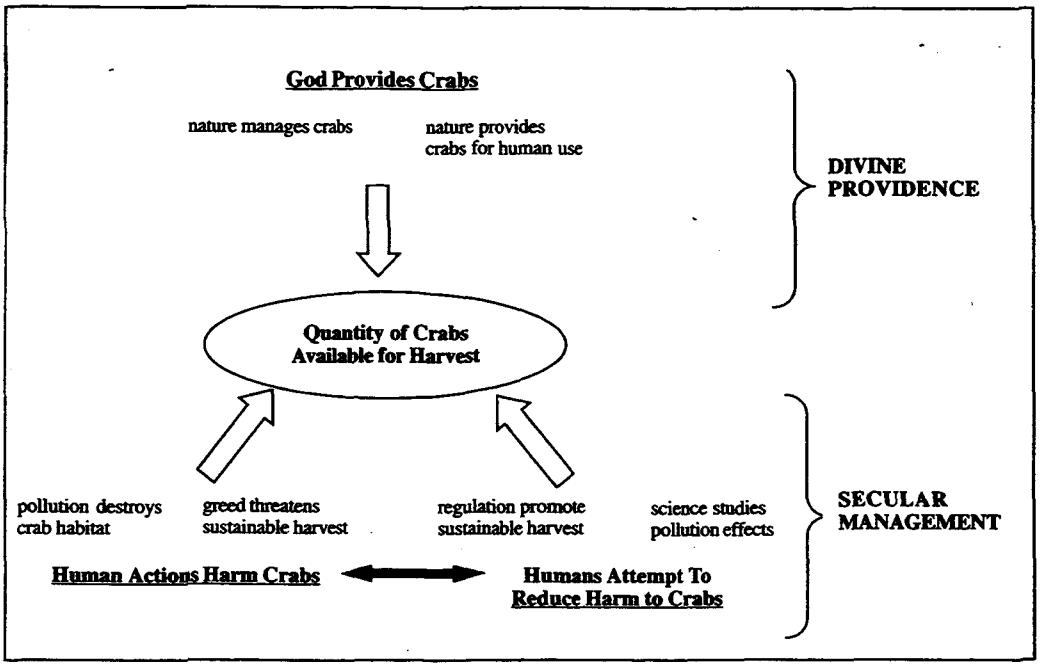

Figure 1. Cultural model of watermen's reasoning about blue crab management.

Delineating Optimal Habitat Locations for Inclusion in Migratory Flyways

Charles ReVelle, John Boland, Justin Williams, Scott Malcolm, and Daniel Bain
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Land development, especially of wetlands, has resulted in the degradation and elimination of important stopover habitat for migratory birds within the Atlantic flyway, and the process of elimination is likely to continue to occur. To assist in securing the survival of species that use the flyway, a decision support methodology was developed to identify alternative configurations of newly protected habitat locales. Such locales would be utilized to augment and enhance the currently protected areas in the U.S. portion of the Atlantic flyway network.

The methodology selects new areas for protection, achieving a connected, braided network of habitat stepping stones extending from Maine to Florida (see Figure 1). The methodology consists of a zero-one optimization model to suggest new areas for protection. The model uses:

- *Geographic Units.* Seven hundred fifteen counties from the 17 Atlantic flyway states between Maine and Florida were used as the basic geographic units.
- *Managed Areas.* Certain types of federally managed lands (e.g., national parks, wildlife refuges) comprised the existing baseline system of protected stopover habitat.
- *Bird Species.* Two species with well-known wetland habitat needs, the black duck and the sora rail, guided the formulation of the Flyway Model.
- *Flight Distance Standards.* Three alternative distance standards were used to define allowable distances between successive stopovers in the network: 97, 121, and 145 km (60, 75, and 90 miles), although any desired standard can be used.
- *"Quality" Index.* Aside from location considerations, the desirability of counties as stopover locales was measured by a single quality index based on both the prevalence of wetlands (representing habitat suitability) and land costs.

Two objectives were explored. The first objective was to maximize the total geographic "coverage" of the flyway region, where a county is defined as being "covered" if it has a (new or existing) stopover within the specified distance standard. The second objective was to maximize the average "quality" of new stopover locales, defined in terms of the quality index. Solutions were developed on the tradeoff curve between the objectives of coverage and quality. The solutions should be thought of as approximate plans or policy options. The results will be useful in the development and evaluation of wetland policies, programs, and plans administered by natural resource agencies and conservation organizations.

The flyway model was a first step in a multiyear research effort on nature reserve selection and design. The presence of the EPA-funded flyway project at Johns Hopkins indicated prior and important focus to the David and Lucille Packard Foundation, which awarded funds for this project through a competitive process, a research grant entitled "The Multi-Objective Design of Nature Reserves." This project is a collaboration between Johns Hopkins University (Dr. Charles ReVelle, Co-P.I.) and Princeton University (Dr. Simon Levin, Co-P.I). Techniques and models are under development to select the reserves that assure the representation of multiple species and address important spatial considerations such as the shape of reserves and the existence of wildlife corridors.

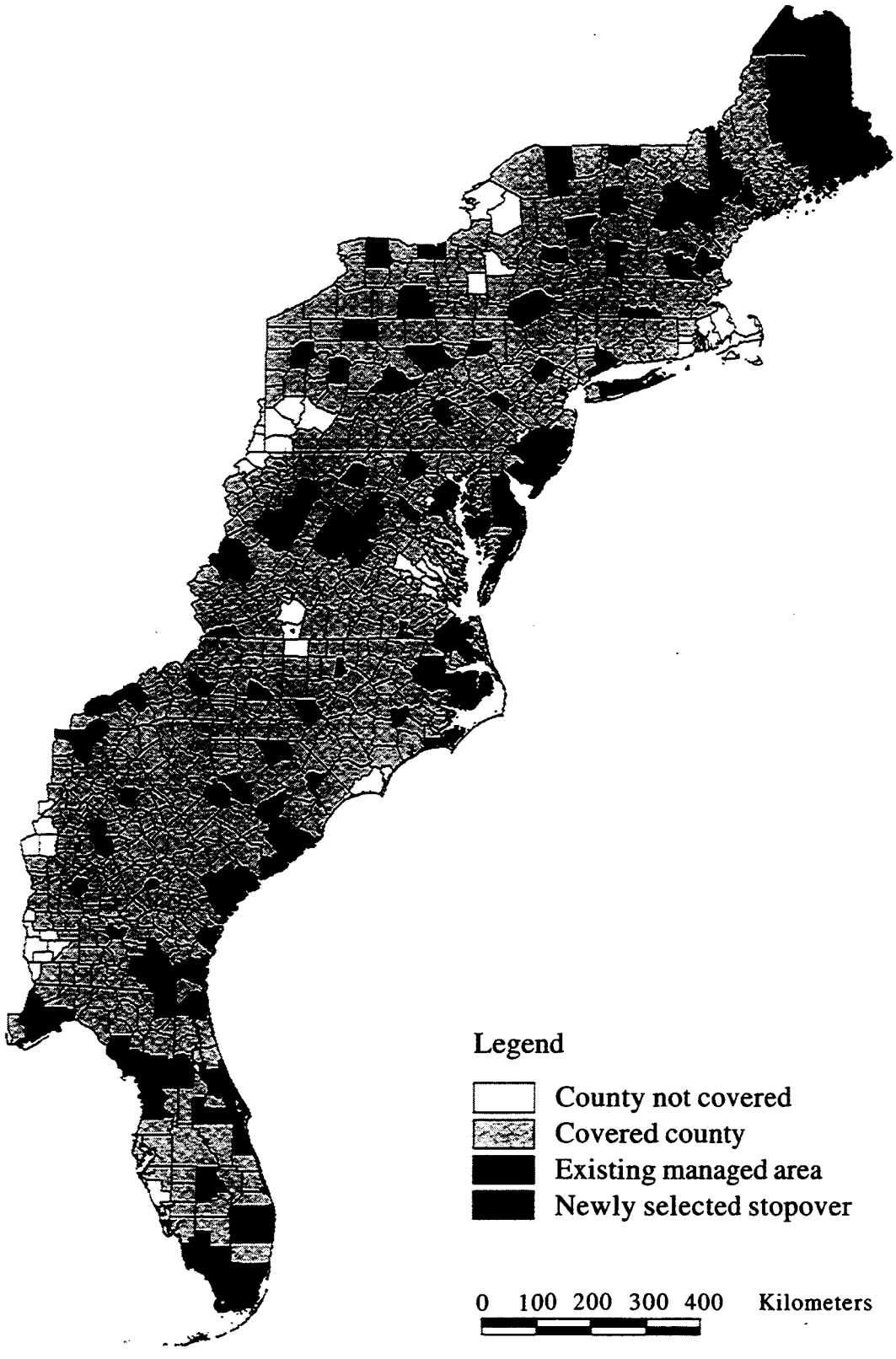

Figure 1. Sample solution for augmenting the Atlantic Flyway. Thirty-eight (38) new stopovers are selected to augment the existing managed areas. Approximately 95 percent of the flyway region is covered under the distance standards (121, 97 km). The quality achievement rating is 0.36, slightly below the average quality rating of 0.40.

Negotiating for Sustainable Development: An Evaluation of the CBEP Decision Process

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The goal of this research project is to understand the factors that facilitate cooperation between stakeholders involved in watershed partnerships and other community-based environmental protection initiatives, with a particular focus on the U.S. Environmental Protection Agency's National Estuary Program (NEP). The NEP is one of the most prominent and well-developed examples of community-based environmental protection, and thus provides an excellent laboratory for the study of cooperation.

The theoretical perspective for this study relies on political economic theories of collective action, which attempt to identify the social, political, and environmental factors that raise or lower the benefits and costs of cooperation. To understand the effect of collaborative policies like the NEP on various indicators of cooperation, a comparative approach has been adopted that utilizes surveys of stakeholders from 20 estuaries included in the NEP and 10 non-NEP estuaries. The main hypothesis is that the NEP can change attitudes and restructure social relationships in ways that increase the likelihood of cooperation.

Preliminary findings suggest that the NEP has several interesting effects on the possibility of cooperation. Social networks within the NEP are larger, more likely to bridge multiple levels of the federal system, span conflicting interest groups, and integrate scientific researchers (see Figure 1). NEP stakeholders are more likely to believe that estuary policies are effective, although this effect is confined to stakeholders with social values that are congruent with the consensual approach of watershed partnerships. The NEP also appears to reduce "cognitive conflict," which is the tendency of stakeholders with competing values to have very divergent perceptions of the severity of environmental problems and the fairness of estuary policies.

Several positive effects of the NEP on stakeholder attitudes and social connections are demonstrated, which suggest that collaborative policies deserve continued attention from the environmental policy community. Furthermore, several key beliefs were identified about watershed policies that influence perceptions of effectiveness; these beliefs provide good targets for policymakers. However, the findings also highlight some of the difficulties of multistakeholder negotiations and suggest that collaborative policies are not appropriate for all types of environmental problems and stakeholders.

The next step is to focus a sharper empirical lens on key questions about watershed and community-based policies that have not been answered. Do watershed partnerships actually lead to more cooperative behaviors and improve environmental outcomes like water quality? Do successful watershed partnerships have positive spillover effects for other policies, (e.g., by improving the effectiveness of water permit enforcement)? Do the factors that encourage cooperation among stakeholders vary across types of stakeholders, (e.g., farmers versus local government officials versus environmental interest groups)? Answering these more detailed questions will provide an even fuller picture of the evolution of cooperation in watersheds.

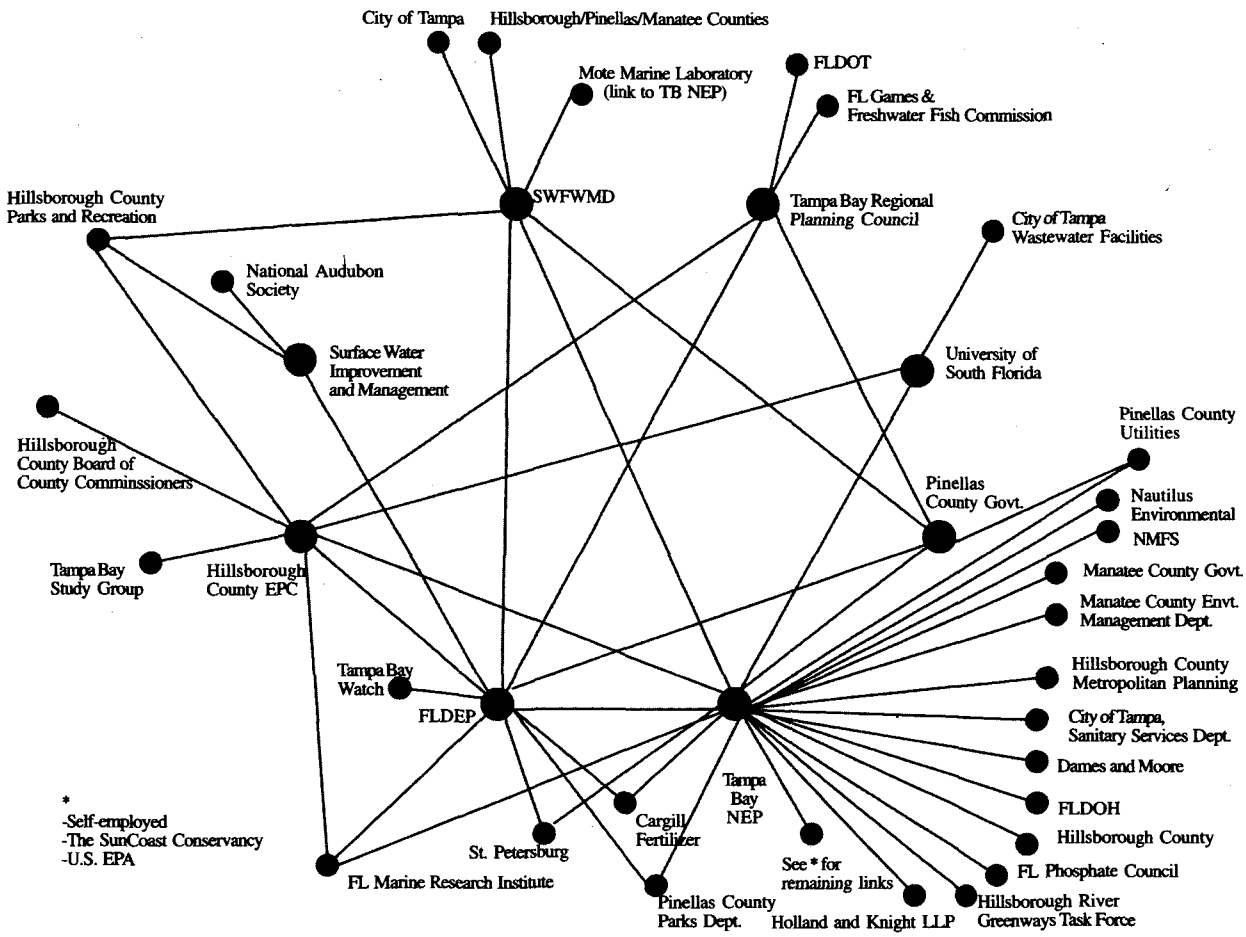

Figure 1. The Tampa Bay NEP Network.

The Contribution of Economic Analysts to Environmental Decision-Making: Lessons From the FERC Experience

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This research project evaluates whether and how different forms of economic information (benefit estimates, cost estimates, economic impact, etc.) influence environmental policy decisions. Case studies are being completed in several areas: hydropower dam relicensing, natural resource damage awards, and federal water project investments. This project considers the frequently made claim that environmental valuation—environmental benefits measurement—is necessary for, and often is central to, environmental decision-making.

Benefit measurement, albeit not for environmental services, has long been practiced by the Corps of Engineers, the Federal Power Commission (now FERC), and others responsible for water resources development. More recently, legislation has called for expanded use of benefit cost analysis in environmental decision-making, and recent administrations have issued guidelines and requirements for conducting benefit cost analysis. Court and administrative processes levy fines for oil spills and other disturbances to the environment, presumably based on money estimates of the environmental damage.

The economics profession has responded to this apparent demand for benefit measurement with refined theoretical foundations as well as new data collection and analysis methods to support an extensive environmental valuation research program. The environmental economics literature now includes thousands of articles describing, applying, and comparing measurement techniques. Among these articles are many arguing that environmental valuation is both desired by decision-makers and makes an essential contribution to democratic decision-making.

The heterodox economists' (American Institutionalism and neo-Austrian) critique of the profession's environmental valuation research program argues that such measurement is inconsistent with the decentralized preference discovery and revealing processes of both markets and democratic decision-making. As a result, they argue environmental valuation will be of little interest when making environmental decisions, and an alternative policy-economics research program is needed to support environmental decision-making.

Based on a review of FERC decisions, it is concluded that environmental valuation estimates, for the reasons argued by the critics, are rarely done and if done, have been used to legitimize decisions made on other grounds. Instead, the FERC decision-making process is structured to assess tradeoffs of money measures of opportunity cost (forgone power benefits and other benefits) against measures of physical changes in the environment. However, the understanding and measurement of opportunity costs often are limited. Economics research into improved opportunity cost measurement would make a more significant contribution to FERC decision-making than further work on environmental valuation.

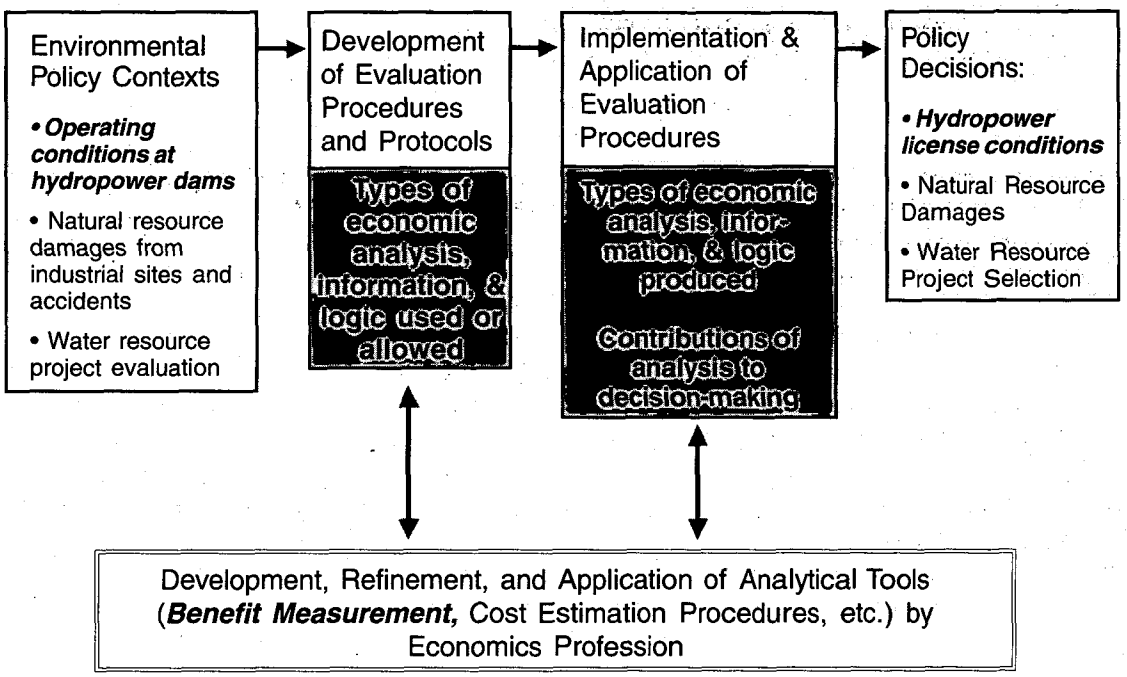

Figure 1. The contribution of economic information to environmental policy.

Estimating the Cost of Carbon Sequestration in Global Forests

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This research project explores the cost of large-scale, global carbon sequestration programs in forests. The specific objectives of the project are to develop: (1) a model of the marginal cost of carbon sequestration in forests; (2) a global carbon storage database for forested biomes; and (3) alternative strategies for carbon sequestration in forests and estimate costs.

This research explores the theoretical link between the marginal damages from carbon emissions and the annual marginal benefits of carbon sequestration. A carbon sequestration valuation function is then developed and incorporated into a model of global timber markets. The resulting carbon sequestration-forestry model is integrated with an integrated assessment model to complete the links between sequestration, the carbon cycle, and energy markets. Simulations with different climate damage functions are prepared to show the optimal time path for carbon sequestration and the potential costs of sequestration programs.

The results suggest that over the next 100 years, forests could sequester 38.6 to 102 billion metric tons at carbon prices ranging from $61 to $187 per ton. Carbon sequestration in forests could be large enough to have an effect on carbon abatement prices and the energy market, although the effect is not dramatic. Nearly 70 percent of sequestration is predicted to occur with reduced deforestation and additional plantations in tropical and subtropical regions of South America, Africa, and Asia-Pacific. The remaining 30 percent of sequestration is predicted to occur in the temperate zone. Much of the carbon results from land use change, although changing rotations and management intensity are relatively more important in the temperate zones (see Table 1).

To date, there have been no global estimates of the costs of carbon sequestation, and other studies have not considered the importance of dynamic factors such as forest growth and rising climate damages. Failing to account for system-wide and dynamic effects could bias other estimates of carbon sequestration costs downward. These estimates account for timber market activity, and thus account for potential leakage in markets. Most of the additional storage (70%) is predicted to occur in tropical regions through reductions in deforestation. Surprisingly, storage in markets does not account for much additional carbon sequestration at the prices considered.

A number of additional steps should be taken with this research. First, the integrated results could be linked to estimates of climate and carbon impacts on forest growth and distribution to assess whether climate impacts affect the cost of carbon sequestration. Second, although land supply functions are included for all regions of the world, the model does not fully integrate global forestry and agricultural markets. Additional research should be undertaken to develop a global economic model of forestry and agriculture. Third, given the potential importance of trading and property rights, the single global demand function for forest products and carbon rent should be expanded to include regional demand functions for forest products to capture potential trade effects and the effects of different distributions of initial property rights to carbon in forests.

Table 1. Proportion of carbon sequestration arising from different activities in different regions. These estimates assume that carbon damages rise from approximately $23 per ton of emissions in 2000 to $188 per ton by 2100.

	Land Use Change	Increasing Age	Manage. Intensity	Market Storage	Land Use Change	Increasing Age	Manage. Intensity	Market Storage
	2010 (Carbon Price = $33.01)				2100 (Carbon Price = $187.54)			
Temperate Regions								
N. America	79	21	1	(2)	51	39	7	3
Europe	30	85	0	(15)	63	25	8	4
FSU	97	4	0	(1)	74	18	6	2
China	100	0	0	0	82	13	2	3
Oceania	100	0	0	0	83	5	3	9
Temperate	*85*	*18*	*0*	*(3)*	*63*	*28*	*6*	*3*
Tropical Regions								
S. America	77	25	0	(3)	90	9	1	0
India	98	0	2	0	90	(1)	3	8
Asia-Pacific	98	3	0	(1)	80	17	4	(1)
Africa	98	3	0	(1)	96	4	1	(1)
Tropical	*88*	*14*	*0*	*(2)*	*89*	*9*	*2*	*(0)*
GLOBAL	87	16	0	(2)	81	15	3	1

Teaching Proper Use of a Household Hazardous Waste Facility

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"Why do people use toxic household products?" "Can we teach them to be more careful in their use and disposal of these products?" The purpose of this research project was to teach residents about the County's new Household Hazardous Waste (HHW) disposal facility, but to do so in a way that discouraged unnecessary use and waste and encouraged long-term behavior change. Five behaviors were targeted: (1) switch to nontoxic alternative products; (2) store chemicals at proper temperatures to extend shelf life; (3) use up leftovers instead of disposing of them; (4) share unwanted leftovers with friends; and (5) take spoiled products to the HHW facility.

Over a 2.5-year period, a holistic program was developed, using psychological principles of how people process messages, what increases acceptability of the message, what increases memory for the information, and what can be done to help people maintain new behaviors. A variety of strategies for getting groups interested in the program were used. One strategy that did not work was to send materials to church groups and ask them to develop programs in conjunction with our "liaison." Only a handful of churches provided us with the name of a person interested in organizing their group, and only one group reported a successful leftover exchange. This approach was abandoned, and speaking at senior centers took place as a way to find out what might interest people about HHW. It was learned that people are concerned about toxics and eager to learn about effective nontoxic alternatives. A new program was developed around these interests. A key feature is that the individual's attitude and behavior change are embedded in a significant reference group so they can learn from each other. To date, more than 80 groups have participated in our group discussions. Two people from each group completed a questionnaire as a rough index of program impact.

Reported Behavior Change. Since our presentation, 33 percent of the respondents had taken something to the HHW disposal facility. If this percentage of "proper disposers" generalized to everyone who saw our presentation, the behaviors of more than 400 households (33% of the estimated 1,275 households not already using the facility) were potentially changed.

Attitudes. Participants' attitudes and behavioral intentions differed significantly from matched control group members who had missed the meeting, supporting the idea that participants had been influenced by their friends' comments and behaviors during the meeting. How does this level of change (33%) compare to previous promotion campaigns? Five other respondents—or 10%—reported they had already been using the facility in the 5 years since it had opened. Costs for this impact are fairly modest (approximately $25 per group for the presentation; average group size of 31).

The current program aims to extend this work in several broad areas; (1) training observers to document meeting content so that those processes can be related to attitude and behavior change; (2) evaluating the handouts; (3) developing additional mechanisms for institutionalizing long-term change; and (4) packaging the program so that county personnel in other states would use our program in designing their own education and outreach program.

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