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Research Prospectus

Willamette Ecosystem Services Project

Western Ecology Division

May 2007

Goal

The Willamette Ecosystem Services Project seeks to quantify ecosystem services and understand the effects of anthropogenic stresses on those services in order to provide a rigorous scientific basis for valuing ecological benefits of existing and proposed policies.

Problem Statement

The EPA has not adequately valued the ecosystems services that provide for human well-being.

While the agency has achieved impressive reductions in point source pollution, further improvements in environmental quality over the past decade have been problematic. This is primarily because of economic constraints to implementing regulations and because of our inability to influence non-point source pollution.

Economic constraints have led to requiring benefit-cost analysis before regulations can be put in place. The EPA uses traditional benefit-cost analysis to evaluate proposed actions that are intended to protect the environment (http://www.epa.gov/regulations/follow.htm; Executive Order 12866, 30 September 1993). Frequently, these analyses are performed for single issue problems with little spatial and temporal understanding of how proposed decisions will affect the ecosystems involved, or of their contribution to human well-being. To that end EPA has been criticized by its Science Advisory Board (SAB) for dramatically undervaluing improvements to ecosystems resulting from proposed regulations (US EPA, 2006). Undervaluing ecosystem services can result in failure to implement necessary environmental regulations.

Non-point source pollution such as agricultural runoff and greenhouse gas emissions, does not lend itself to traditional "end-of-pipe" regulation. Besides arising from dispersed, uncontrolled sources, non-point pollutants become intricately linked with ecological processes. Ecosystems can affect the amount of pollutants entering the soil, air and water. Ecosystems can influence pollutants in different ways depending on the particular source and type. Ecosystems can remove or sequester pollutants thereby providing a cleansing service. However, ecosystems that are disturbed, or are in a state of decline may not provide those services that contribute to human well-being and can actually add to adverse effects.

EPA's inability to value ecosystem services has prevented full recognition of the benefits to human well-being provided by proposed regulations and policies. While today's technology and knowledge can reduce considerably the human impacts on ecosystems, they are unlikely to be deployed fully until ecosystem services cease to be perceived as free and limitless, and their full value is taken into account. We may know the technological cost of providing clean drinking water and clean air, but we do not really know the value of lost or existing ecosystem services, which may perform the same functions more economically. Without this understanding we cannot realistically determine the cost of pollution-control regulations, nor can we calculate the economic benefits of ecosystem services.

Project Objectives

- Provide a model-based approach that predicts responses of ecosystem services to probable future conditions.
- Identify critical knowledge gaps in the ecological processes underlying ecosystem services.
- Quantify ecosystem services, including their distribution, status, and responses to current and projected future conditions.
- Evaluate net benefits of bundled ecosystem services and tradeoffs among management actions that affect these services.

Research Needs

The research proposed in this project addresses some of the most complex, divisive, and important ecological challenges that will be facing the nation through this century. EPA's Regional and Program Offices have a growing need to evaluate complex environmental problems. This is particularly true for non-point source pollution resulting from land use practices and widely dispersed pollutants such as nitrogen deposition and carbon dioxide emissions.

With the success of sulfur trading to control this important source of acid rain, the EPA has demonstrated the ability to achieve designated reductions in point source pollutants using economic forces. Moreover, trading has had limited success in regulating other ecological goods and services such as fisheries and water resources (Colby 2000). Similar approaches for controlling non-point pollutants—ranging from greenhouse gases to water pollutants—by harnessing the power of market economics are being considered. However, effective application of economic-based techniques to non-point pollution requires the ability to apply value to ecosystem services.

The EPA recognizes ecosystem services as the outputs of ecosystem processes that contribute to human well-being (USEPA 2006). To protect and manage ecosystems in support of human well-being, we need to know what services ecosystems provide, the distribution of those services across the landscape, and what ecological processes influence them. Applying the concept of ecosystem services provides a way to value ecological processes and their linkages to any end point of concern.

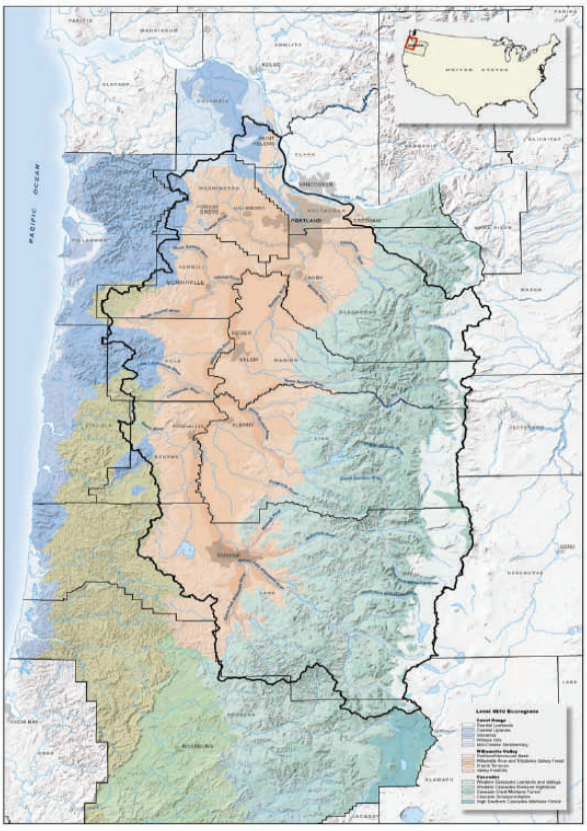
The scientific community is increasing research activities in an effort to articulate and measure the gamut of ecosystem services. Early publications include Holdren and Ehrlich (1974), Costanza et al. (1997) and the Ecological Society of America (1997). These efforts, along with the more recent Millenium Ecosystem Assessment (2005), provide a developing scientific basis and conceptual organizing framework for considering the range of ecosystem services that influence human well-being. This knowledge needs to be applied directly to issues facing the EPA.

In order to quantify ecosystem services we need to understand the complex web of ecosystem processes that create and sustain those services, and how human and environmental stressors affect these processes. Ecosystem processes can mitigate impacts of environmental stressors, but processes can also be negatively impacted, decreasing the amount or quality of ecosystem services they provide.

Most importantly, we need to be able to quantify the collective benefit of many ecosystem services to human well-being. Restoration of riparian systems to provide fish habitat, for example, would also enhance a number of other ecosystem services such as nitrogen control and carbon sequestration. Sequestering carbon biologically not only removes greenhouse gases from the atmosphere, it also improves soil structure, which reduces nutrient losses and improves erosion control. This notion of multiple, linked ecosystem services can be viewed as "bundled services" and is a key component of this project. That is, we will not examine services individually in response to stressors, but will consider bundles of services in relation to ecosystem processes and environmental stressors.

The immediate context for this research is the Ecological Research Multi-Year Plan (ECO MYP) of the Office of Research and Development. The plan's focus on ecosystem services provides overall direction for this research effort. Our most direct Regional Office client will be Region X, in which our study area is located (Figure 1), but we envision national applicability across EPA Regions and Program Offices, and we will seek to interact with Regions and other ORD researchers to help broaden the application of our efforts. In addition, we will seek to understand and represent Program Office needs in liaison with the Ecology National Program Director.

Figure 1. The Willamette Ecosystem Service District.



Approach

We propose to conduct research in an area of western Oregon, roughly defined by the Willamette River Basin, but including counties, ecological regions, and other components of the appropriate spatial context, termed the "Willamette Ecosystem Service District" after Heal et al. (2001) (Figure 1). However, the quantification of some services, such as carbon sequestration may require a larger, regional perspective.

Our approach is based on the concept of human-centric ecology—the study of ecosystem structure and functioning from the perspective of human well-being. It is reflected in using "placed-based societal issues and values" to provide context for the research (Figure 2.). The place-based perspective allows the results to be explicitly relevant to the stakeholders in the geographic area. Societal issues and values provide the framework for the selection of specific ecosystems services and the formulation of future scenarios. Issues include national and regional concerns like global climate change and air pollution, but they also include local concerns like land use, fish and wildlife, agriculture, and timber production.

The project builds upon a strong foundation of research on landscape condition and projected future change from the Baker et al. study (2004). The capabilities of WED scientists in conjunction with collaborators and existing scientific networks will provide for characterization and evaluation of land use/land cover, forest productivity, wildlife, agricultural practices, riparian wetland and aquatic biota.

Within the place-based framework, natural and human stresses to ecosystem structure and functioning form the basis of scenario development for futures analyses and for determining ecosystem service response functions. Population trends, pollutants, land use patterns and climate—past and predicted—provide the forcing functions for changes in ecosystem structure and functioning.

Once the relations between specific ecological processes and ecosystem services are quantified, response functions are generated. In this way, ecological effects of anthropogenic and natural forcing functions are translated into effects on ecosystem services. Moreover, the linkages and trade-offs among bundles of ecosystem services can be established.

Quantified responses of ecosystem services or bundles of services, to changes in ecosystem structure and functioning are the basis for developing futures scenarios. Anticipated changes in ecosystem services resulting from future policy changes or changes in stressors, such as global climate change and land use, will be evaluated for the study area as a whole (Figure 3). In this way, quantifiable future projections of changes in ecosystem services can be calculated for use in economic and policy analyses. These quantified bundles of ecosystem services can also form the basis for trading by establishing the ecological metrics for benefit-cost analyses.

The targeted, integrated ecological research conducted within this project will yield a framework and knowledge-base for evaluating regulatory decisions from the perspective of their impacts on ecosystem services. Products will link validated ecosystem models with user-friendly interfaces. The results will help EPA and others evaluate implications of regulatory actions with regard to ecosystem services over large spatial areas.

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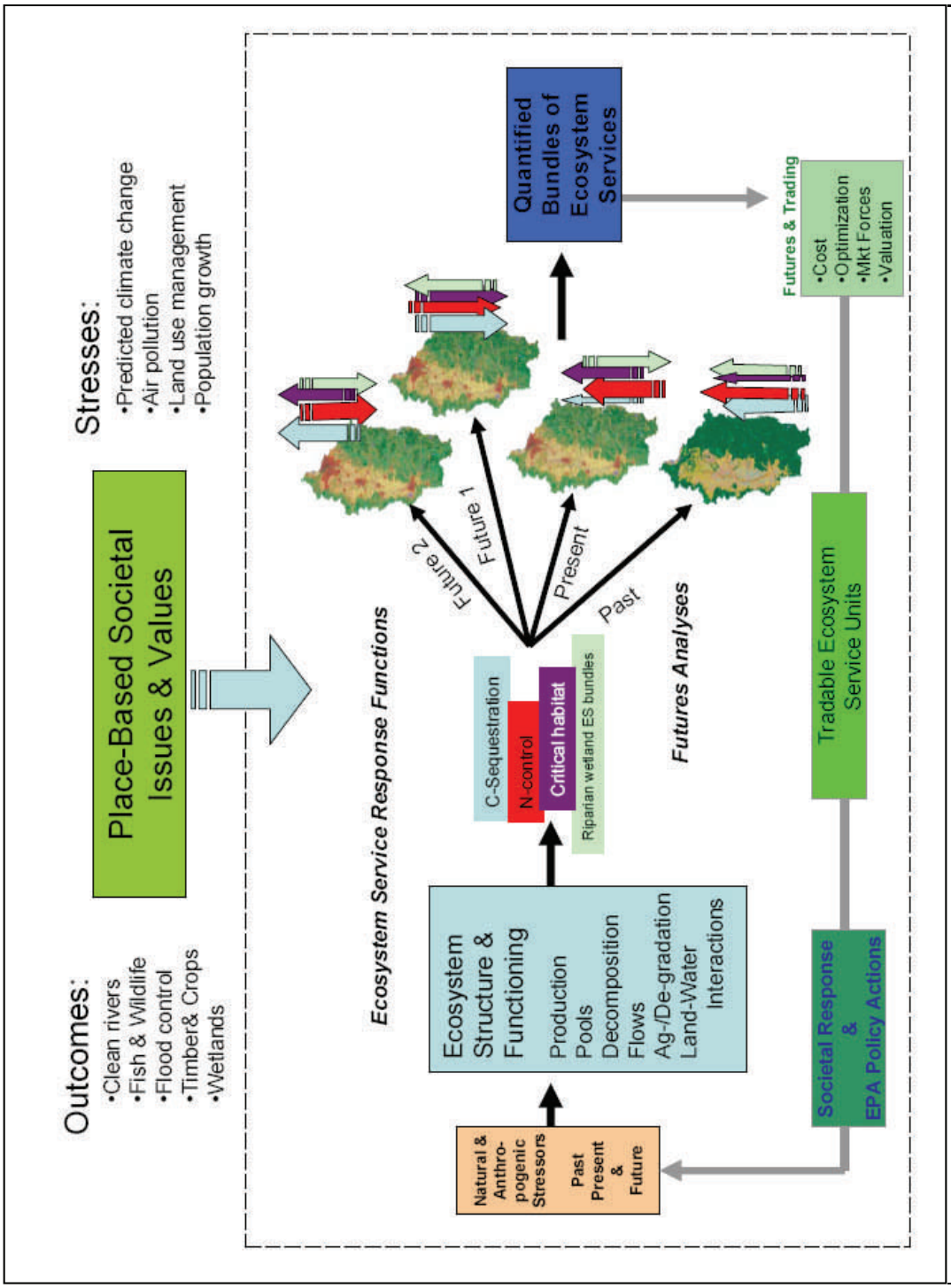

Figure 2.
Flow path illustrating the project goals of quantifying ecosystem services through understanding the connection between natural and anthropogenic activities and stressors, their impact on the web of complex ecosystem processes and pools, and understanding how these ecosystem processes provide services of interest.

Figure 3.

Depiction of the tradeoffs and bundling of ecosystem services within a land-use category. A land-use practice might have a negative impact on a service as well as a positive impact on others. The evaluation of ecosystem services must include the linkage and tradeoffs between services.