

Section 1. Introduction

1.1 Background

The U.S. Army Corps of Engineers (Corps) now pursues “National Ecosystem Restoration” as a priority Civil Works purpose on par with traditional “National Economic Development” purposes such as commercial navigation and flood damage reduction. Further, the Corps’ new Environmental Operating Principles say that Civil Works planning should strive to achieve “environmental sustainability” and “seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.”¹

In traditional Civil Works planning, the stated Federal objective is to contribute to National Economic Development (NED) consistent with environmental protection. Following that overarching goal, desired economic outputs (e.g., commercial navigation) are evaluated in monetary terms, alternative plans are compared using benefit-cost analysis, and plan selection is based on a national economic efficiency standard (positive net benefits criterion). A somewhat different framework has been established for ecosystem restoration planning, however.

According to Corps planning regulations, the Federal objective in ecosystem restoration is to contribute to National Ecosystem Restoration (NER), where contributions are defined as “increases in the net quantity and/or quality of desired resources ecosystem resources”, and “measurement of NER is based on changes in ecological resource quality as a function of improvement in habitat quality and/or quantity expressed quantitatively in physical units or indexes (but not monetary units).” [ER 1105-2-100; Section 2.2 b]. Since restoration outputs are to be characterized and evaluated in non-monetary terms, traditional benefit-cost analysis and plan selection based on a net benefits criterion are not applicable to ecosystem restoration planning. Instead, Corps planning guidance says that ecosystem restoration plans are to be compared using cost-effectiveness analysis to ensure that the least-cost plan is identified for any achievable level of non-monetary restoration output. A cost-effective plan can then be recommended based on a subjective determination that non-monetary outputs are worth the costs of producing them, in consideration of the “significance” of project outputs as indicated by institutional, public or technical recognition of importance. Corps planning guidance emphasizes the importance of the significance concept for helping planners to, firstly, determine the Federal interest in restoration planning for some area, and secondly, judge whether the improvement in resource output associated with some project plan warrants its cost.

The recent emphasis on assuring returns from Federal investments, along with the reality of budgetary constraints, have resulted in a renewed interest in the methods used to evaluate the outputs of environmental projects and programs. Importantly for the Corps, the adequacy of the methods currently being used within the Civil Works program for

¹ *U.S. Army Corps of Engineers Environmental Operating Principles and Implementation Guidance*. March 26, 2002.

characterizing and evaluating the environmental outputs of ecosystem restoration projects has been questioned in a number of forums. For example, the National Research Council (NRC) report *New Directions in Water Resources Planning for the US Army Corps of Engineers* suggests that the Corps needs to move beyond its current reliance on habitat assessment methods, such as the “Habitat Evaluation Procedure” (HEP), for evaluating the restoration projects. On this point the NRC report says, “The difficulty with HEP and similar methods is that they capture only part of the national interest” in ecosystem restoration (NRC, 1999a; p. 77).

1.2 Purpose

This report was motivated by a recognized need to improve the characterization and evaluation of the environmental outcomes of Corps projects. Toward that desired end, the report identifies and examines a diverse set of policy and technical issues related to improving environmental benefits analysis for Civil Works planning. As used here, the term “environmental benefits analysis” refers to the development of an evaluation philosophy, framework and complementary analytical tools to aid Corps project evaluation and selection, but is not intended to imply a planning framework for ecosystem restoration that involves assigning dollar values to restoration outputs (though the prerequisites for economic valuation are discussed). Rather, this report focuses on the analysis and science related to assessing the anticipated results of ecosystem restoration as expressed in non-monetary metrics. The development of this report was informed by several workshops conducted to engage various experts from within and outside the Corps in the search for practical approaches to environmental benefits analysis consistent with traditional water resources planning and evaluation principles. Development of the strategy was informed by field responses to a survey conducted in January 2003.

Environmental benefits analysis is applicable to ecosystem restoration projects, the broader ensemble of environmental enhancement and mitigation features, as well as water resources projects with mixed economic and environmental outputs. As such, the ideas and methods offered are consistent with economic-ecologic linkages and multiple objective tradeoffs that are inherent in the guiding principles and philosophy of the “Principles and Guidelines” (P&G) [Water Resources Council, 1983], the earlier “Principles and Standards” (P&S) [Water Resources Council, 1973], and the Corps’ own planning guidance (ER1105-2-100) which is a further procedural embellishment of the P&G, with updated policies and procedures.

The primary focus of this report relates to the identification and assessment of alternative metrics and analytical procedures for characterizing and evaluating environmental outputs in non-monetary terms. A secondary focus relates to the identification and assessment of alternative plan comparison frameworks for projects plans formulated at least in part to serve ecosystem restoration. With regards to these issues, the report addresses the following questions:

- What non-monetary metrics of environmental quality change may have wide applicability for characterizing and evaluating ecosystem restoration outputs?

- What plan comparison frameworks and procedures are available for plans formulated to serve ecosystem restoration as well as mixed economic and environmental objectives, and what are their strengths and weaknesses for illuminating the economic efficiency implications and tradeoffs among plans?

The report concludes with a proposed strategy for improving environmental benefits analysis that includes several specific options that reflect the current practices, limits and constraints on conventional analysis and rely on ideas, practices and technologies that are currently available, but not yet widely implemented. The presented options are intended to crystallize a few possibilities for improving environmental benefits analysis without suggesting that other possibilities are infeasible. Ideas are presented that may contribute to shaping the next generation of evaluation principles and analytical tools for environmental benefits analysis, both within the Corps and, hopefully, among other Federal agencies confronted with comparable responsibilities

1.3 Organization of Report

The report is organized as follows. The remainder of Section 1 overviews the broad need for improved environmental benefits analysis within and across Corps programs and those of other Federal agencies. Section 2 reviews the planning framework for ecosystem restoration as defined by Corps planning regulations and supporting policy information, introduces the concept of ecosystem services, and discusses the relevance of the service concept for ecosystem restoration planning. Section 3 presents a critical review of ecosystem concepts that might be useful for characterizing and evaluating ecosystem restoration outputs, including concepts of resource “naturalness” and “significance”. It also reviews contemporary ecological theory since an understanding of a number of ecosystem principles is critical for establishing meaningful restoration objectives and formulating and evaluating restoration alternatives. Section 4 provides an overview of the types and attributes of ecological models and methods used by the Corps and other agencies in an attempt to assess the current state of applications and innovation in contemporary project planning and evaluation. Section 5 provides an overview of the planning framework used by the Corps for traditional NED purposes, and how it has been adapted for the ecosystem restoration purpose. It also reviews alternative plan comparison frameworks for project plans formulated to serve both environmental and economic objectives, and comments on their strengths and limits for illuminating the economic efficiency implications and tradeoffs among plans. Section 6 explores important technical and conceptual issues relating to the possibility for using a monetary plan evaluation and selection standard for ecosystem restoration projects. Finally, Section 7 suggests a broad strategy for developing improved benefits analysis models and approaches that includes multiple options.

1.4 Why is Improving Environmental Benefits Analysis Important?

The past 15 years has seen the introduction of many new ideas on, and programs for ecosystem management, restoration, remediation and mitigation, which, when added to many other overarching concepts of sustainable development, cumulative impacts, biodiversity, endangered species protection and “global change”, have created a conceptual and philosophical morass of confusing and ill-defined aims. Understandably, the Corps and most other Federal resource management agencies (e.g., USFS, NRCS, BOR, NMFS, EPA, FWS, BLM) have found it difficult to develop evaluation procedures and complementary analytical tools that translate the principles of ecosystem management into accepted conventional practice. The problems are exacerbated as each agency develops its own version of procedures that reflect their respective missions and traditions of analysis. Problems typically come to the fore in situations where multiple agencies are involved in sharing resource management responsibilities in a given area.

Inherent in improving environmental benefits analysis is not only the notion of improving evaluation of ecosystem responses and associated outputs related to management measures, but also the need to improve analysis of tradeoffs among environmental, economic and social objectives and effects. Changes in National water resources priorities, public demands and the Corps’ missions have fostered a need for improved environmental analysis. However, these factors are not the only catalysts for pursuing improvements in environmental benefits assessment. The recommendations of the recent National Research Council Report (1999a) on the Corps planning procedures, call on the Corps to:

- Thoroughly review the P&G, and modify to incorporate contemporary techniques and public values,
- Improve analytical techniques for environmental benefits and detriments assessment, and;
- Develop a standardized set of tools for quantifying environmental benefits and costs.

Addressing these contemporary demands on analytical capabilities and evaluation frameworks can foster the principles of sustainability and draw upon a wealth of literature and theory. Three decades ago, passage of the National Environmental Policy Act (NEPA) of 1969 and issuance of the P&S for water resources planning, by the U.S. Water Resources Council (1973), demonstrated the need for evaluation frameworks that consider environmental and economic objectives and tradeoffs with national welfare improvement in mind. Both documents were extraordinarily prescient in anticipating contemporary desires to fulfill the potential of sustainable development.² Although the

² The preamble to NEPA (Section 101(a), NEPA 1969) lays out the vision of sustainable development as the "... conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations..." The P&S, with its four Federal planning objectives, representing National Economic Development (NED), Environmental Quality (EQ), Social Well Being (SWB) and Regional Economic Development (RED) principles anticipated, by 23 years, the principal goals of sustainable development as presented by The President's Council on Sustainable Development (1996).

principles and procedures of the P&S are well grounded in decades of water resources planning – representing the most practical elements of decision theory, social choice theory, economic theory and benefit-cost theory—it is only in the past decade that the routine implementation and integration of these principles at the project level was possible (although not routinely practiced). The P&S framework was modified in 1983, resulting in the P&G that the Corps currently uses in its water resources planning studies.

In addition to needing information to assure the formulation and evaluation of effective projects, the reality of finite investment resources make it necessary to prioritize among projects. Prioritizing numerous similar investments, or the “portfolio problem”, requires choosing several worthy projects from among many in which to invest, depending on the goals and objectives for investment. The portfolio dilemma is especially relevant to ecosystem management. Given Federal, state and local budget limitations and considerations of national (Federal) interests and ecosystem management goals and significance of resources, decisions must be made regarding which projects to fund in a given area and in a specified time period. There are numerous “good things to do”; however, we cannot afford to do them all. Choices must be made, and selection should focus on those initiatives that address significant resources and will result in significant outputs in relation to these resources. How to accomplish this evaluation process in a fairly routine and uniformly applied and transparent manner is the focus of this inquiry.

1.5 Fostering Consistent Theory Across Different Management Decisions

Improvements in environmental benefits analysis for ecosystem restoration planning should also improve analysis conducted as part of regulatory permits, mitigation planning, and environmental impact analysis. There are numerous perspectives and evaluation philosophies that have been promoted by academicians and that have been adopted by the various agencies to reflect the intent of legislative mandates for their respective programs. For example, within the Corps of Engineers, there are three distinct evaluation philosophies covering virtually the same resource base (e.g., the Nation’s waters, including wetlands) within the planning program, the operations programs and the regulatory program. The evaluation principles and procedures are different, as are the decision criteria and rules. Hence, the outcomes of management decisions may vary as each of the evaluation frameworks are applied separately. Fortunately, there are initiatives within the Corps to bring to bear many of the general principles of planning and evaluation; for example, a comparable approach to that advocated in this report has been advocated for use in valuing wetland “services” for the Corps’ Regulatory program (King, et al., 2000). There are many resource management agencies throughout the Federal establishment, each with different legislative mandates, creating a vast proliferation of procedures, methods and models all presumably reflecting sound resource management principles and evaluation criteria. The difficulty in harmonizing these different evaluation perspectives has been a substantial obstacle to integrated water resources management, which is perhaps more important than the absence of a truly representative ecological analysis framework.

Progress in environmental benefits analysis will not only improve ecosystem restoration project formulation, evaluation, and justification, it will also improve other environmental analyses and decision making. Ecological theory is the same for all activities that affect ecological resources. However, the extent to which it is applied varies among agency missions, programs, and philosophies both within the Corps and across agencies. Still these various programs (e.g. natural resources management, environmental regulation, and ecosystem restoration) can benefit from, and contribute to improved approaches that infuse contemporary ecosystem science into program objectives and decision-making.

It is essential that efforts to improve environmental benefits analysis proceed via collaborative partnerships with other agencies. While each agency has experience and expertise, none claim the practical, workable construct of ecosystem models and evaluation procedures needed for complex management and investment choices. However, nearly all of the agencies advocate "better science" as important for improved ecosystem management. Some have developed methods or have ongoing work that may be applicable or adaptable to our decision frameworks and analytical needs.

It is prudent and necessary to work with the other agencies: "prudent", to tap their knowledge and expertise, and to leverage research and development resources; "necessary", because we want their "buy in" on the methods we propose to use. An underlying goal of this effort is to determine whether it is possible to achieve a common understanding and acceptance of a shared set of methods for ecological analysis among the Federal agencies responsible for natural resources management and/or environmental regulation. Many agencies currently use ecological evaluation methods that are comparable to those used by the Corps, and many have been developed jointly. However, the use of similar ecological analysis tools applied within disparate, non-economic evaluation frameworks would still represent a major obstacle to integrated watershed management or ecosystem management. Coordination of management actions, projects and regulatory decisions would be hampered by the lack of agreement about the relative cost-effectiveness of complementary measures that would be advocated by each of the respective agencies to achieve a set of ecosystem management goals. The NEPA procedural guidelines encourage the use of bio-economic analysis as part of environmental impact assessments, as does virtually every recent National Research Council report on aquatic restoration actions and watershed planning processes. The Corps, along with several other resource management agencies has developed different approaches to bio-economic analysis. These methods form the basis for additional options for improvements in analytical approaches that might be developed. Box 1.1 summarizes a number of agency and other organizational efforts that may be useful to consider in the development of near-term and longer range approaches for improving environmental benefits analysis. Some of these efforts, along with others we hope to identify as the study proceeds, may be useful in shaping opportunities for

collaboration in the development of new methods or refinement of existing methods for improved application in ecosystem restoration planning and other aspects of ecosystem management.

Box 1.1 Efforts by Others with Potential Applicability to Improving Environmental Benefits Analysis

- 1. USGS - Biological Resources Division** (*FWS (Ft. Collins group)*) Adapting HEP to community scale; current target is bird communities and vegetative structure. Some work on oak-based wildlife community.
- 2. Forest Service** (Rocky Mt. Experimental Station) Moving away from HEP, greater emphasis on larger scale models that incorporate material cycling and spatially explicit models (e.g. FRAGSTATS). Also, “choosing by advantages” approach, which incorporates: Public Health and Welfare; Environmental Impacts; Project Continuity/Viability ; Legal Issues; Cooperators/Partnerships; Other (e.g. acceptability).
- 3. Department of Energy** - Some work emphasizing energy flow and carbon cycling, climate change - models are still in formative stages.
- 4. NOAA - NMFS** -Work is underway on a Success Criteria Report which discusses incorporation of structure & function in monitoring criteria; recently published *Habitat Restoration Monitoring Toward Success, A Selective Annotated Bibliography*. NOAA- NOS - *Habitat Equivalency Analysis* - developed as part of their Damage Assessment and Restoration Program to assess impacts of spills and other perturbations and to develop compensatory mitigation requirements.
- 5. Environmental Protection Agency** - The Office of Research and Development, Corvallis Lab - Synoptic Approach; Wetland Landscape Profiles; Wetland Condition Assessment; Alternative Futures; PATCH, a method which links population models for terrestrial species within a region. Wetland Bioassessment Methodology. Work is underway to develop a bioassessment method for evaluating wetland health for use by wetland a water quality managers. The method builds of the Index of Biotic Integrity (IBI) developed for streams. Some watershed models.
- 6. Natural Resources Conservation Service** - information incomplete; method for indicators of wetland functions.
- 7. Bureau of Reclamation** - work on “multipurpose” analysis (e.g. recreation and environmental needs); restoration guided by compliance emphasis.
- 8. National Science Foundation** - some ongoing work related to biodiversity, food webs, including basin ecosystem productivity algorithms linked with food web processes; most work has a terrestrial focus. Some community model work is underway. May not be emphasizing predictive tools.
- 9. The Ecological Society of America** - Report on Ecosystem Services. (Daily, et al); other papers and reports, workshops proposed - academic plus some “communication plans”.