Section 7. Conclusions and Strategy for Improving Environmental Benefits Analysis

7.1 Conclusions.

During this study numerous issues associated with improving environmental benefits analysis for application in Civil Works studies were identified and examined. Among the conclusions that can be drawn from this report is that there is no "universal unit" for expressing ecosystem restoration benefits that is widely applicable across the full range of effects of restoration plans.

The study revealed numerous interrelated issues of ecology, economics, and evaluation that challenge the selection and development of environmental models, as well as improvements in environmental benefits analysis more generally. The s*cience relating system response to restoration measures* is better developed in principle than in specific applications. The *incorporation of ecological concepts into Corps policy, guidance and practice* is still evolving, and is becoming more complex as the Corps moves toward formulation of projects with combined economic and ecological outputs. For various reasons, Corps *planners have generally relied on a subset of available environmental assessment models* – mostly species-habitat index models – apparently because of inadequate scientific understanding and databases, past computing limitations, and limited familiarity with alternative models. Numerous advances over the past two decades have substantially reduced the inadequacies of science, data, and computing capability.

Among the policy issues debated, several were related to the concept of NER, including the fundamental definitions of the *Federal interest* in ecosystem restoration. There was considerable debate as to whether two categories of *motivation* for ecosystem restoration have emerged, and if so, the implications for specifying *Federal interest* in ecosystem restoration, *characterizing resources of significance, formulating objectives, selecting plan formulation and evaluation models*, and *justifying* proposed investments. These categories include 1) restoring the Nation's ecosystems to a *"more natural condition"--independent of the significance of any specified resources and service flows*; and, 2) *restoring significant ecosystem resources* to a less degraded condition *as determined by services that flow from the resources*.

The notion of "significance", which plays an important role in ecosystem restoration planning was substantially discussed. The study concludes that the notion of "biodiversity associated with scarce species" (as defined by uniqueness and vulnerability), could be pursued to develop a "standard-measure" of "resource significance" that would help discriminate among NER investment choices. This notion can be distinguished from the fundamental notion of biodiversity in that it focuses on those species, communities, guilds and ecosystems designated to be of *ecological significance* by science-based reports, and the work of the WWF, TNC, and others. Pursuing this measure would be compatible with the habitat-based emphasis of the current Corps policy, and with the policy emphasis on resource scarcity as an indicator of

significance. The standard units (see discussion in Section 3) would be based on characteristics of vulnerability and uniqueness, using methods developed by conservation biologists, and taking into account global rather than only localized significance. For example, while some significance may be inferred by plans supporting the North American Waterfowl Management Plan, greater significance would be attributed to plans that support a species such as black ducks – which are rare, relative to mallards – a specie included in the plan but not rare or vulnerable.

Such "scarce biodiversity" may not be the only measure of resource significance that contributes to NER, but placing emphasis and priority on such outputs is supportable because the recovery and protection of scarce resources determines the limits of future management options, including restoration options. If this approach proves applicable, recommendations for future restoration proposals that do note emphasize significant improvement in the status and sustainability of nationally scarce biodiversity, could be questioned as to their value as ecosystem restoration investments.

The study also concludes that a variety of existing ecological models are useful in formulating and justifying ecosystem restoration investments, contributing information to both forecasting ecosystem conditions, and specific outcomes related to resources of significance. The models can be usefully applied alone or in combination, depending upon the circumstances.

In the near term, a combination of community-habitat index models that forecast naturalness (including those such as IBI), and species-habitat index models that forecast suitability of the more natural state for the resources of significance can provide a basis for evaluating plan effects. In those instances where the more natural condition in itself is identified as the resource of social significance, ecosystem-level biodiversity models that are habitat based (e.g. IBI, WCHE, HGM) may serve satisfactorily once calibrated.

This conclusion does not, however, address the limitation that *habitat-based indicators of NER benefit are unlikely to capture all of the Federal interest* affected by restoration plans (as noted by the NRC). Other models, such as *functional capacity indices and process simulation models* are applicable for the multi-output analysis of benefits that appears to be required for multipurpose planning. Ecosystem process models have the advantage of generating more theoretically defensible and explicit results unsurpassed for communication and adaptive management, but are more costly. All existing models have shortcomings requiring substantial development effort, but especially so for the process simulation models. In addition, relatively few species-habitat models have been specifically developed for rare resources.

Additionally, *species-habitat index models usually have limitations, when used alone,* which make them less useful than alternative approaches. Ecosystem restoration planning models often need to account for at least two ecological indicators of importance, one that indicates the more natural support condition, and one or more that indicate condition of the dependent significant resources. A more natural, self-regulating condition is stipulated in Corps policy because the long-term maintenance of all resources

of significance is most often assured by restoring the integrity of the support ecosystem. The single-species models provide a single index of relative environmental benefit based on the optimality of habitat for individual species, but are unreliable indicators of the more natural condition.

More recently developed *community-habitat indexes* set the optimum condition in the most natural ecosystem state and thereby provide a better alternative for indicating naturalness. However, when the resources of significance are identified independently of a more natural condition, it is more appropriate to use models that generate more than one output or a compatible combination of single-output models. Even then, all of the Federal interests may not be captured without additional indicators. Models such as the HGM functional capacity indexes and process simulation models are most suitable at that level of comprehensiveness. The explicitness of process simulation models outputs have advantages over the less explicit outputs of index models and can be particularly useful in NER and NED tradeoff analyses in search of an optimum combination. However, these models are among the least widely developed for restoration needs.

The study also concludes that significant technical obstacles preclude economic valuation of all possible restoration outcomes that could be evaluated in monetary terms. Furthermore, whether or not the utilitarian concept of economic value is the appropriate standard of "value" for evaluating restoration outcomes is open to question. Economic value may not indicate everything that stakeholders need to know about the desirability of restoration projects. This suggests that the current policy guidance that recognizes non-monetary NER outcomes as a category of effects separate from monetary effects is appropriate for evaluating restoration projects. However, a greater level of policy clarity is probably needed to help planners determine the appropriate restoration objectives and valuation standards for restoration planning.

The use of evaluation criteria that includes both non-monetary and monetary effects does not reduce the need for efficiency analysis in the NER planning context, and this need is recognized by Corps guidance. The cost-effectiveness analytical framework for single-purpose NER planning is very useful for evaluating the opportunity costs and marginal tradeoffs among alternative plans. That framework, which is essentially equivalent to the old P&S efficiency framework that plotted net NED effects against some measure of environmental quality change, is also applicable to multipurpose NED/NER planning, and can be readily extended to a multiple criteria efficiency analysis when NER outputs are best expressed in multiple, non-commensurate metrics.

The cost effectiveness framework is less discriminating as the number of choice criteria increases, making identification of more inclusive metrics an important pursuit. A focus for improving ecosystem restoration benefits analysis in the near term is to identify the monetary and non-monetary indicators of output needed to capture all significant effects, and ultimately to reduce them down to the minimum achievable.

7.2 Strategies.

The state of restoration planning capabilities, methods and models summarized above, resulted in a multi-component, three-stage strategy for improving environment benefits analysis, offered here for further consideration. The strategy addresses better use, refinement and further development of ecological assessment models, and improvement of staff understanding and application of assessment and evaluation tools. It also addresses the need for Corps policy and planning guidance to more carefully integrate ecological concepts, along with recent practical experiences in ecosystem restoration planning. The proposed strategy involves overlapping (I) *near, (II) intermediate*, and *(III) long-term* components, which can all start about the same time but differ with respect to the time of anticipated results. While the ideas below focus primarily on Corps specific actions, the need for collaboration with work going on in other agencies is emphasized.

The lack of appreciation for the *linkages among planning objectives, desired restoration outcomes, and model selection and use* appears to be at the root of some environmental benefits challenges. Establishing these linkages is fundamental to environmental benefits analysis, and potentially at the root of not only issues in model selection, but also some of the problems associated with alternative formulation, and project justification.

To the extent possible, the Corps should pursue the environmental benefits analysis improvement strategy in conjunction with other Federal and state agencies that can contribute to and benefit from these efforts. Shared development of methods for environmental benefits analysis might be expected to facilitate more compatible planning standards and practices across agencies.

I. The *near-term* or **Incremental** stage, from immediately to about 2 years, addresses the requirements of the current Corps planning regulations, seeks modest advances in improving environmental models, and emphasizes improving staff model selection and application capabilities relative to existing ecological models. Broadening this base of understanding and proficiency in selecting and applying existing models will provide the essential foundation for being able to apply new models as they are developed, in addition to improving environmental benefits analysis now.

Ia. Models and Methods. Modest model improvements could be made by moving from reliance on single-species index models, to greater use of community-based index models, either alone or in combination with single-species index models. Application improvements would emphasize linking project planning and ecosystem management goals in plan formulation.

A broad suite of existing and emerging models are available for use depending upon the type of project, system and scale of analysis. Few types of ecological models were

developed specifically for restoration purposes and none are ideal, but some are more useful for forecasting ecosystem outputs. The examination of existing models concluded:

- Species-habitat models are sensitive to significant effects at the species level, but are not inclusive enough to formulate for restored natural ecosystem integrity.
- Community-habitat models are inclusive enough to formulate for more natural ecosystem integrity, but may be insensitive to significant effects at the species level
- Index models (e.g., HEP/HSI, IBI, HGM) are most widely available, but tend to exclude important systems context, require greater planner and stakeholder interpretation, and may require both community and species level index models for analysis.
- Process simulation models (e.g., ATLSS, CASM) are less available, but more output and process explicit, can incorporate complete systems contexts, can provide simultaneous output for conditions of naturalness and significant resources, and are superior for organizing lessons learned into improved model structure.
- As ecosystem planning conditions grow more complicated and the science improves, the advantages of process simulation models outweigh the expediency and lower-cost advantages of index models.

Future efforts should investigate the development of a metric based on the biodiversity of scarce species, and its usefulness in determining the significance of forecasted NER plan contributions to significant resources.

Models with the longest history of Corps use are the single-species habitat suitability indices (HSI models), originally developed for mitigation analysis before there was a Corps ecosystem restoration purpose and NER objective. In addition to the previously mentioned NRC and other comments about the shortcomings of using these models, the views of Corps staff vary regarding the adequacy of HSI/HEP models. For example:

- *They work, nothing else needed;*
- *Improvement is needed*;
- *HSIs are useful, but often there is not much underlying rationale or justification for the species and values selected – criteria are not clearly established. Differences in "with" and "without project" values are hard to justify and support;*
- *They are just a means to an end; used because they are easy and you have to do something for project justification*
- *HSIs are not a direct measure of output—suggest a weighted usable area as a more meaningful output measure to be derived from the HSI for the selected species and life history function.*

Some staff recommendations supported future work on developing process models and improved ways for conveying model results and associated information to non-technical decision-makers and stakeholders. Caution to avoid reinventing models that already exist was emphasized, as well as the need to retain flexibility in choices at the district level. The need to think ahead to consideration of outputs in tradeoff evaluation was also noted.

Ongoing efforts within the EMRRP[1] program, such as the development of templates for community-index models should contribute to model improvements in the near term.

Ib. Capability in Model Application. The immediate improvements can be made to environmental benefits analysis by improving the current understanding and ability to apply existing species- and community-index models separately and in combination. As noted earlier, this *broader base of understanding and proficiency will not only improve the current analysis*, but also *establish an essential foundation* for being able to apply new models as they are developed. Immediate analytical improvements can also be made by emphasizing the need to relate restoration objectives and outputs with model selection. The field identified a need for a "toolbox" of environmental evaluation models, and in some instances, the need for model selection and application instruction. The Planning Model Improvement Program Task Force also recommended a toolbox for planning models. Several efforts are underway that contribute to addressing these needs.

A protocol for selecting models for use in ecosystem restoration planning is being developed as a "Model Selection Reference Document". This information will aid in the identification and selection of appropriate environmental models and methods that are currently available for use in ecosystem restoration planning. The Model Selection Reference Document is intended to be an optional resource or planning aide, rather than a set of "requirements", as the field emphasized the need to retain flexibility in model selection. It summarizes different model types, attributes, and limitations, and infuses consideration of the broader Corps planning process -- emphasizing that model selection cannot be approached in isolation from the planning process as a whole. As such, the reference is structured along the Corps six step planning process. The document will serve to help:

1. Conceptualize the appropriate focus for quantitative assessment of environmental outcomes
2. Examine criteria for selecting model types based on the complexity of objectives and risks associated with proposed projects.
3. Identify, modify and develop appropriate assessment models
4. Use quantitative assessment results in plan evaluation and comparison.

The development of the Model Selection Reference Document by IWR staff includes the careful review and commentary of several Corps Planning Improvement Program and PROSPECT course instructors from ERDC-EL and NAE. This interaction between authors and instructors is essential to help assure consistency in course instruction material refinement and presentation, and broader infusion of the material, as appropriate, into existing and new training opportunities.

ERDC-EL is developing a web-based tool catalog as part of the SMART[2] R&D program. This effort and the Model Selection Reference are likely to be linked within the web-based EMRIS system, assuming sustained funding support for the efforts. Such efforts will provide a foundation for the "toolbox" requested by field staff.

[1] Ecosystem Management and Restoration Research Program (EMRRP)
[2] System Wide Modeling, Assessment, and Restoration Technology (SMART)

More general ecosystem restoration planning capabilities. A number of training and other capability improvement opportunities exist to help bridge the gaps that presently exist many studies such as relating planning objectives, desired restoration outcomes, and model selection.

Discussion of environmental benefit analysis concepts and approaches also needs to be incorporated into a number of courses, workshops and other forums. The courses in the new Planner Core Curriculum, as well as nearly a dozen PROSPECT courses should be targeted to incorporate new analytical concepts and tools relevant to environmental benefits analysis and other aspects of ecosystem restoration planning, at appropriate levels of detail, depending upon the purpose and nature of the course.

Inserting material into the new Environmental Course within the Planner Corps Curriculum with the intent that this course will address model selection and application knowledge needs is not sufficient to address these needs. The treatment of models is only a small portion of the course, which is intended to cover nearly "everything environmental", including NEPA assessment and compliance with various other environmental laws. For some staff, a more in-depth treatment of application of the reference protocol would be helpful. Nearly all planners will need a better understanding of the use of model output information in the context of formulation and evaluation.

Additionally, in the short run, it may be useful to hold specialized workshops on model selection using the reference protocol, and actual district studies. Such workshops would improve district staff capabilities, assist the study, refine the instruction material for use in future courses and workshops, as well as advance the understanding of existing model application potential and future model development needs. Including staff from the stakeholder agencies in these workshops could also be beneficial.

Ic. Policy and Guidance. The need to link model selection with restoration objectives and desired outputs emphasizes that future policy development may need to refine or add explicit consideration of the notions of *significant resources, ecosystem integrity, ecosystem services, naturalness, self-regulation, resilience, stability, sustainability, production, materials cycling*, and other ideas. While some of these concepts have been more thoroughly developed than others, and many questions remain about concept validity and practical application, they can form a theoretical basis for NER evaluation. Additional discussion follows.

Restoration objectives and motives and ecological concepts. Corps policy regarding ecosystem restoration has evolved over the last decade and continues to do so. The currently stated Federal objective in ecosystem restoration is to increase the net quantity and/or quality of desired resources through the restoration of significant ecosystem function, structure and dynamic processes that have been degraded. Two possible motives for pursing restoration may be emerging, based on the accumulating experience with ecosystem restoration projects in the Corps. The first may be to secure a beneficial mix of ecosystem services that are more aligned with natural ecosystem parts

and processes. A second may be to restore the "naturalness" of ecosystem properties *as end in itself*, independent of the resulting mix of services and benefits. .

Current Corps guidance does not specifically identify the desired ends of restoration as naturalness for its own sake. Instead, ecosystem restoration guidance emphasizes the "significance" of resources and restoration effects for guiding and justifying restoration while establishing restoration of more natural ecosystem structure and function as the preferred condition for supporting significant resources and natural services. The significance concept as defined by Corps guidance seems broad enough to encompass both naturalness and associated services as desired restoration ends.

The metrics and associated methods used for evaluating restoration projects outputs should follow from the desired ends of restoration in any particular context. If restoration of hydrology and geomorphology represents one valued end to project stakeholders, then the non-monetary metrics chosen to characterize and evaluate project effects might be derived from the pre-disturbance hydrology and geomorphology, or some other relevant reference condition. On the other hand, if the restoration of natural ecosystem services is of prime concern, then project evaluation requires moving beyond metrics indicating a more natural state to include metrics that indicate the desired direction of change in desired service outcomes.

NER Evaluation framework. Corps rules do not require the monetary valuation of restoration outputs, or the use of a monetary standard to identify and choose among economically efficient plans. CE/ICA is used to help assure cost effectiveness in achieving different levels restoration output and to subjectively determine what level of restoration output is worth the cost to achieve it.

This CE/ICA framework is most useful when restoration outputs can be adequately characterized in terms of a single non-monetary output metric. But in many restoration contexts it may not be reasonable or possible to characterize and evaluate outputs in terms of a single metric. In that case, the two-dimensional CE framework can be readily extended to an efficiency analysis defined over multiple criteria. For example, in a case in which plans are evaluated in terms of cost and two non-commensurable, non-monetary measures of NER output, the efficiency analysis would identify plans for which more of one NER output could not be obtained through choice of another plan without incurring higher costs or obtaining less of the other NER output. Additional guidance or training on evaluation under these circumstances may be helpful.

The Corps recently published interim guidance for the evaluation of multipurpose NED/NER plans (EC 1105-2-404). As restoration policy evolves, giving consideration to the concepts noted above, it will be necessary to assure that the evolution of this guidance is consistent with the evolution of restoration policy, along with insights gained from practical application of the EC.

Policy studies on NER and ecosystem services will contribute insights on the above issues. Two policy studies initiated in FY 03 are examining the concept of NER, and the

concept of ecosystem services for potential application in Civil Works ecosystem restoration planning. In the first, the NER concept is being examined as a federal objective and basis for formulating ecosystem restoration projects. Ecosystem services is being examined for potential usefulness in ecosystem restoration planning, particularly in the context of joint projects with both NED and NER outputs.

II. The *intermediate* or **Next Generation** stage, from immediately to about five years, would pursue a fundamental rethinking of the NER objective and desired outputs. Specifically, it would more intensely pursue the idea that ecosystems provide important mixes of ecological services, and the possible advantages and practicality of defining an NER account that specifies these services (both monetary and non-monetary). Further, it would seek to improve the ability to evaluate specified services though the use of ecosystem process simulation models at proper landscape scales. New analytical frameworks for multipurpose NED/NER planning would be explored, including the opportunity cost framework recommended by the *Principles and Standards* several decades ago for evaluating tradeoffs between plan economic and non-monetary environmental effects.

IIa. Models and Methods. During this stage, the development and refinement of ecosystem process models that estimate actual outputs would be emphasized. Efforts to develop and refine ecological models for environmental benefits analysis should be integrally linked to economic and decision making frameworks. This linkage is essential to help ensure that the models and results adequately fit the evaluation frameworks used in Corps planning, and to inform the further evolution of those frameworks.

Research programs such as the EMRRP, SMART[3] and TOWNS[4], and others, along with the EMRIS[5] system could play a central role in the development of guidance for using existing ecological models, expansion of existing prototypes to new applications, and development of new models. Efforts should begin immediately to strategically refine and merge the need for this effort into ongoing and planned research.

Within the EMRRP, work proposed to begin in FY'04 would develop a framework that links habitat analysis, dynamic process modeling, and spatial statistics for application in aquatic systems. The work description says that products will incorporate contemporary ecological principles and, current techniques, lend to adaptation and enhancement as new tools are developed and new ecosystem principles unfold. "Tools developed under this work unit will allow Districts to assess and quantify the impacts and benefits from a wide range of water resource projects while maintaining flexibility so that the analysis procedure is appropriate to the project needs and constraints."

The areas of focus within SMART that seem to have potential for this include: Environmental Processes and Resource Responses; Environmental Assessment and

[3] System-wide Modeling, Assessment and Restoration Technologies (SMART)
[4] Technologies and Operational Innovations for Urban Watershed Networks (TOWNS)
[5] Ecosystem Management and Restoration Information System (EMRIS)

Prediction Technologies; Decision Support and Application Technologies. Among ongoing or planned efforts is a compilation of ecological tools and approaches for system-wide assessments, including habitat-index models, empirical (e.g., statistical) numerical (e.g., process simulation) models, and geospatial techniques (e.g., GIS). Plans include making them available via a user-friendly, web-based framework with a decision support system to facilitate effective selection of assessment tools. Linkages to economic evaluation frameworks will be essential, and this should occur integrally, rather than sequentially. There are also plans to develop prototype applications of system-wide assessment frameworks by working with districts and their partners to develop conceptual models for implementation in project management plans and feasibility studies.

Within the TOWNS R&D program, work proposed on the value of evacuated floodplains could contribute to improving environmental benefits analysis. The work, if funded, would examine alternative uses for, and valuation approaches and measures for evacuated floodplains.

Potential applications of the Ecosystem Functions Model (EFM) beyond the Sacramento-San Joaquin basin should be explored[6]. The Watershed Analysis Tool (WAT), being developed as part of the Flood and Coastal Systems R&D Initiative is integrating HEC NexGen software for watershed studies. Products will streamline the analytical and reporting processes of the NexGen software, while producing more consistent results for watershed-type studies. WAT will link to data processing and modeling and spatially referenced displays, as well as to other models, including to EFM.

The potential roles for and contributions from the Environmental Modeling and System-wide Assessment Center (EMSAC), recently formed within ERDC, should also be explored. The EMSAC is chartered to enhance coordination and technical focus for modeling (assessment and forecasting) activities in order to advance system-wide applications of predictive environmental modeling, assessment, and management tools. It uses a matrix of ERDC elements to form technical teams of engineers and scientists to solve complex system-wide environmental problems involving complex environmental systems across multiple media and over broad spatial scales. The EMSAC integrates R&D in hydrodynamics, hydrology, ecology, and related disciplines, along with applications of technology, modeling and informatics for alternatives analysis and decision-making.

IIb. Capability in Model Application. Improvements in model use and the application of model output information in investment and management decision making could be facilitated by the formation of *model application assistance teams.* Such assistance, applied in conjunction with multi-agency workshops targeted toward actual projects,

[6] EFM uses statistical indicators to link hydrologic regime to aspects of the ecosystem (plant community and fish community). Indicators are tested under different flow regimes for with and without project conditions, and results help users to identify the direction of change (improve, no change, or decline) for the individual ecological parameters. Results can be expressed as spatial areas which can be used in incremental cost analyses.

could be useful in fostering model use capabilities, innovation, and understanding – both assisting a given study, and advancing the state of the science in model development and application.

IIc. Policy and Guidance. Efforts during this stage would pursue further refinement of the NER concept and outputs, relative to ecosystem goods and services, along with alterative analytical frameworks useful in Corps planning, especially for joint NED/NER projects. Emphasis would be placed on conducting ecological analysis in a hierarchical fashion to better serve overall ecosystem management goals. Appropriate landscape and scale effects and considerations (river basin, watershed, flood plain) would be discussed for all projects, providing an improved context for the significance of restoration outputs.

Concept of NER. The understanding of the concept of NER purpose and the NER plan is thought to be clear to some Corps staff, but often not to others. For example, some stated:

- *A general discomfort with justification policy for NER plans, especially in joint formulation*
- *Confusion regarding whether or not restoration pertained to "degradation" "caused by natural change"*
- *General uncertainty about how to determine when an NER project was not justified.*

A policy study started in FY03 has begun a more critical examination of the NER concept as a federal objective and the basis for formulating ecosystem restoration projects. The NER study will examine the potential usefulness of the concept of ecosystem services for defining NER as a formulation construct and for developing a set of standard methods and metrics for characterizing and evaluating NER outputs.

Ecosystem Services. At any given time, the structural features and ecological processes of an ecosystem[7] yield a mix of functions that in turn provide services valued by society. These include both natural and humanly enhanced services. Natural ecosystem services have been defined as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Dailey, 1997). Corps authorities to pursue ecosystem restoration reflect increased public recognition and appreciation of the contribution to human welfare provided by ecosystem services.

Corps guidance (ER 1105-2-100) directs planners to habitat services, which comprise only a subset of the broader suite of ecosystem services of interest to society. Equating biological *resources* with *ecosystem resources* limits evaluation perspective. This limitation in turn reinforces the use of HEP and similar design tools that address only part of the comprehensive ecosystem restoration emphasized as the proper approach to objective setting in various NRC reports. The NRC concluded: "The difficulty with HEP and similar methods is that they capture only a part of the national interest" (NRC 1999).

[7] --as affected by environmental forces and constraints, management actions, and social and economic activity in the area--

The understanding and perceived potential value of the concept of ecosystem services in water resources planning varies across Corps staff. With regard to pursuing further understanding and application of the concept of ecosystem services, some staff say:

- *Try it – often sponsor interest isn't habitat improvement per se, but improved water quantity or quality as restoration outcome*
- *Recognizing and "legitimatizing" other benefits would improve our analysis*
- *National values are questionable; Would the list of services be national or developed on a case-by-case basis?*
- *General list could be difficult to produce, except maybe in broad categories of functions. Still, it might help to create such a thing as part of the planning process, at least at the project level.*
- *Don't need to do this.*
- *Could be useful for combined NED/NER plans.*
- *Could help in determining "is it worth it?"*

Depending upon whether the current support for integrated formulation persists, reintroduction of the NED-EQ tradeoffs, and return to P&S multi-objective formulation and evaluation procedures may be pursued as a means to further support the elements of the **sustainability** philosophy expressed in the PCSD (1996), and evolving through implementation of the Corps' Environmental Operating Principles.

The broader notion of environmental analysis may integrate the "NEPA process" into the P&G/P&S planning process, thus eliminating differing standards and principles for evaluation for ecosystem restoration planning and environmental impact assessment. Potential changes needed in policy and guidance would be identified.

III. Over the *longer-term*, from immediately to about ten years, efforts would be made to pursue the economic valuation of ecosystem services. The objective of this **Monetization** stage would be to marry ecological process simulation models with economic valuation methods towards more comprehensive evaluation of restoration outcomes in economic terms. If deemed practical and acceptable, this could lead to the development of standard analytical tools for different ecosystem services to mirror the techniques for evaluating NED outputs specified by the P&G.

The field and other staff have expressed mixed feelings about pursuing full monetization. Among the various views are:

- *Let's try it*
- *It's a bad idea*
- *Too expensive, there is no confidence in results*
- *Explore it but don't require it, especially for CAP*
- *See work done by NOAA, Forest Service and universities*
- *There could be potential impacts on Regulatory and would we monetize endangered species habitat?*
- *Different regions have different needs*
- *Perhaps it could be considered in terms of "replacement costs" – (e.g. wetland bio-filtration vs. a treatment plant"*

In general, the economic techniques outlined in the P&G for valuing traditional civil works outputs in monetary terms are also generally applicable to the types of "natural" ecosystem service outputs likely to be associated with ecosystem restoration. However,

there are considerable technical obstacles to comprehensive monetary accounting of restoration benefits. *Non-economic obstacles* relate to the complex biological linkages between restoration actions and service outcomes that are often not well understood and readily predictable. *Economic obstacles* relate to methodological limitations for measuring non-market benefits of service outcomes that affect the quality of human life in ways that have no close connection to the use of marketed goods.

In addition to these technical obstacles, some economists, political scientists and philosophers have questioned the relevance of the economic concept of value with respect to ecosystem services such as the sustenance of endangered species that may often be the focus of restoration. Challenges from these critics could hinder the political acceptability of adopting a monetary standard for evaluating and justifying restoration projects.

Nevertheless, in some cases it should be technically possible and practical to estimate monetary values for restoration effects that could be used to inform decisions in ways that are politically acceptable. An obvious example is when restoration project plans measurably affect traditional NED outputs such as flood regulation. In such cases, these effects should be valued and used within the CE/IC framework for evaluating and comparing plan alternatives.

Several efforts ongoing within the Decision Methodologies Research Program will contribute to this pursuit. These include identification of recent and ongoing district studies that monetized environmental outputs, identification of examples in other agencies, and a literature review. In addition, a test case has been proposed that would apply monetization to a completed ecosystem restoration project, in an effort to examine whether and how this information could have been useful in decision making. Other IWR research is examining the potential use of air quality benefits, from reduced emissions attributed to inland waterway shipping relative to truck or rail modes of transportation.