Lessons Learned and Best Practices: Recent Experiences with Cost Effectiveness and Incremental Cost Analyses (CE/ICA) for Ecosystem Restoration Projects

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Recent reviews of Civil Works ecosystem restoration feasibility studies by planning and policy reviewers at HQUSACE have uncovered several recurring policy and technical issues. This paper highlights lessons learned from these reviews and suggested best practices to help address them.

Fundamentally, successful ecosystem restoration studies can build an effective understanding of relationships among elements of the system under study. Each phase of the study itself can improve the quality of planning products and the outcomes they support. Effective ecosystem restoration studies integrate each activity associated with each study step, from identification of problems and opportunities, all the way to plan selection and beyond, benefiting monitoring and adaptive management in the post-construction phase.

In this paper, the following lessons learned and best practices are outlined:

1. Use Conceptual Ecosystem Models
2. Show Management Measures versus Objectives
3. Selection of Ecosystem Output Model
4. Develop Ecosystem Restoration Formulation Strategies
5. Display IWR Planning Suite Software Output Graphs
6. Step through Best Buy Plans

To run specific ideas off other experienced restoration planners, consult your local Planning Community of Practice (PCoP) representative or Greg Miller at the National Ecosystem Restoration Planning Center of Expertise (ECO PCX) to help connect you with technical support.

1. Use Conceptual Ecosystem Models

Take the time to develop a conceptual model of critical processes and components of systems being studied to help teams with problems and opportunities, objectives, evaluation metrics, data needs, management measures, and alternatives. Conceptual models show "cause and effect" relationships and help the project delivery team (PDT) demonstrate the linkages between problems, solutions, and desired outcomes. A good model shows the stressors or drivers causing the problems, the effects of those problems on valued ecosystem resources or attributes, how we might measure those degraded resources (i.e., the metrics for ecosystem outputs or benefits), and what management measures might be effective in addressing those problems, restoring those valued resources, and yielding those outputs or benefits and associated trade-offs. A planning charrette is a good opportunity to develop a conceptual model collectively and at the same time increase understanding among participants of how various systems within the study area operate.

Figure 1 is a very simple example of a conceptual model for a river that is experiencing severe erosion and stream incision. In this example, aquatic and riparian habitat are degrading as a result of excessive erosion, which impacts water quality, and damages, by siltation, the structure of the benthic or bottom habitats. There is a loss of lateral connectivity between the stream and its floodplain (i.e., as the stream incises and deepens, it literally leaves its floodplain behind, or "strands" it, leading to loss of native riparian vegetation potentially impacting both riparian and other aquatic species). Our problem statement for this conceptual model might read: "Urbanization and other watershed alterations are changing the hydrology and hydraulics of Dry Creek, causing downstream channel incision, streambank erosion and bluff failure, which in turn are causing: loss of natural riparian and floodplain vegetation; increased erosion and sedimentation of downstream habitats, leading to poor quality habitat for resident and migratory fish; increased risk of damages to nearby residential structures and critical

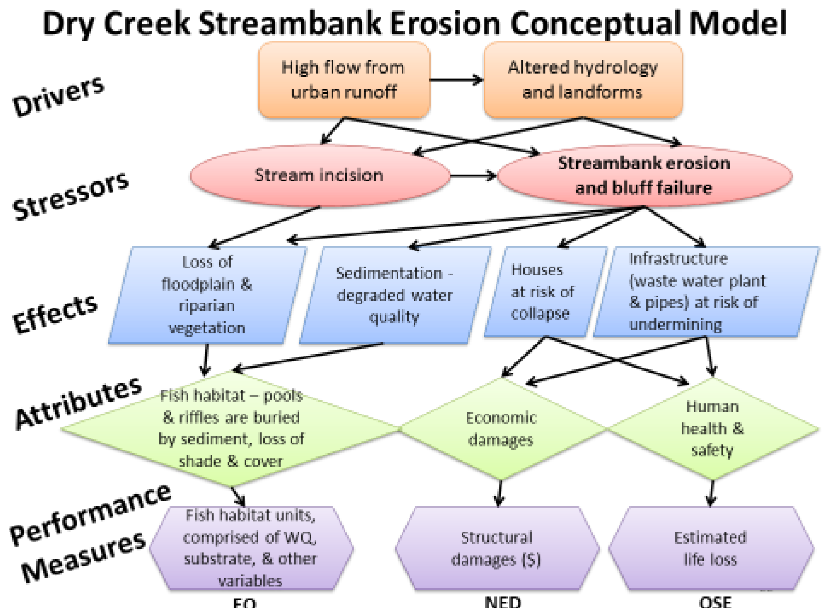

Figure 1 A simple example of a conceptual model for a river experiencing severe erosion and stream incision.

infrastructure; and increased risk to public health and safety from collapse of structures and loss of functionality of a water treatment plant." This example also shows that conceptual models have utility in portraying cause and effect relationships for planning studies beyond just ecosystem restoration.

Going beyond the problem statement, our ecosystem-related planning objectives for this hypothetical study (we could also have flood risk management-related objectives) might focus on restoring both 1) the quality and quantity of degraded aquatic and riparian habitat; and 2) riverine-floodplain connectivity in the Dry Creek watershed over the period of analysis. Our management measures would be formulated to meet these objectives, and we might measure the effectiveness of our management measures or combinations of measures (i.e., alternatives) through their predicted delivery of aquatic and riparian habitat units (indicator species could be selected for each habitat type) using a certified or approved ecological model. Conceptual models can help illustrate "why" we are recommending an action, "how" we intend to cause the desired outcomes, and "what" sorts of trade-offs might be involved. NOTE: Conceptual Ecological Models are not required to undergo review for certification or approval, but should be evaluated during the Agency Technical Review of a draft report.

2. Show Management Measures versus Objectives

We often brainstorm management measures (to solve problems and achieve planning objectives) at a planning charrette or at some point early in the planning process. Our initial goal is creativity, to make sure we leave "no stone unturned" – what solutions could possibly solve the problems at hand? To make sense of the many management measures we might develop, however, we need to screen them to a manageable and realistic subset. One obvious screening criterion is effectiveness – will the management measure under consideration help achieve, and to what extent, a given planning objective? Early in the planning process, this evaluation of effectiveness may be qualitative – will a management measure a) highly, b) moderately, c) slightly, or d) not at all contribute to the achievement of a planning objective (and with what degree of confidence)? Later in the planning process, when we are evaluating alternatives, we are still very much concerned about effectiveness (along with costs, other impacts, resilience, etc.), but we will measure effectiveness quantitatively through, for example, such metrics as habitat units and biotic integrity. Whether qualitative or quantitative, our report documentation should include a table that shows, for each restoration management measure, which objective is likely to be addressed and how completely the measure is likely to address the objective. Figure 2 shows a simple example table using our "Dry Creek" conceptual model.

Management Measures	Ability to Achieve Planning Objectives			
	Objective: Increase/Restore Aquatic Habitat	**Objective: Increase/Restore Riparian Habitat**	**Objective: Increase River/ Floodplain Connectivity**	**Objective: Reduce Damages to Water Treatment Plant**
Instream grade control structures	High	High	High	High/Moderate
High flow detention ponds	Moderate	Moderate	Moderate	Moderate
Terrace banks	Moderate	High	High	Low
Place cobble/ gravel instream	Moderate	None	None	None
Place armor/ rip rap on banks	Low	Low	None	High
Plant native vegetation on banks	High	High	Moderate	Moderate

Figure 2 A report table comparing restoration management measures' ability to address planning objectives and the degree to which the objective will be achieved.

3. Selection of Ecosystem Output Model

Carefully consider the selection of an appropriate ecosystem restoration output model. Very likely, that model will be central to characterizing existing, future without-project, and future with-project conditions. The difference in those with- and without-project conditions represents the ecological "lift" or benefits of your alternatives. Problems can arise when the model selected is not clearly linked to planning objectives, or cannot "simulate" the effects of a management measure to clearly demonstrate how it achieves a planning objective. For each study objective, describe how the metrics and benefits assessment models provide evidence that the objective is being accomplished. To use our "Dry Creek" example again, we would want to select ecological models that can measure changes in the quantity and quality of 1) aquatic habitat; 2) riparian habitat; and 3) riverine/floodplain connectivity. Examples of these might include Habitat Suitability Index models for native aquatic species (e.g., fish) and riparian species (e.g., birds), plus a "one-time use" customized model for stream/floodplain connectivity.

4. Develop Ecosystem Restoration Formulation Strategies

After identification and agreement on the "POOC's" (Problems, Opportunities, Objectives, and Constraints), PDT's often brainstorm management measures to address their planning objectives, as described under #2 above. But what happens between brainstorming management measures and formulating fully-formed alternatives? This is where the development of one or more plan formulation strategies is important. We develop formulation strategies to assemble management measures into a reasonable and logical array of alternative plans. For more information: See the Planning Community Toolbox's Webinar Resources page for two 2016 webinars on plan formulation strategies.

Strategies help us to describe the logic underlying the formulation and screening of alternatives. Again using our hypothetical "Dry Creek" example, one formulation strategy might be to focus on the source of flows driving the increased runoff and higher volumes and velocities of water entering Dry Creek and causing downstream erosion. We might try to delay, capture or divert some portion of the upstream flows before entering the creek with Best Management Practices (BMP's) in the developed/urbanized areas, bypass channels, or detention basins. Another strategy could focus on reducing the erosion and stream incision caused by the higher flows and velocities with instream grade control structures and streamside erosion reduction measures, whether "hard" or "bioengineered" with vegetation. Another strategy could focus on better connecting the stream to the floodplain with terracing, side channels, and overbank wetlands. A "grand" strategy could combine all these measures to maximize achievement of planning objectives, while a "low hanging fruit" strategy could seek to formulate the low-cost, "no regrets" measures, which often do not fully meet the planning objectives. In all cases, the formulation strategies are driven by our planning objectives; they just represent different ways of achieving the objectives to varying degrees.

One cautionary note is not to **solely** rely on the Institute for Water Resources (IWR) Planning Suite to generate all possible combinations of management measures and permutations of alternatives. The software tool can certainly help to identify cost effective and the most efficient set of alternatives (i.e., the "best buy" plans, discussed in section 5). IWR Planning Suite also aids in optimizing alternatives through scaling and siting of various management measures. However, dumping all management measures into the software to evaluate the potentially thousands of combinations is discouraged for several reasons. First, the sheer number of alternatives generated can be difficult to meaningfully evaluate and compare. Accounting for synergistic and antagonistic effects associated with combinations of management measures (through sensitivity analyses, for example) can be agonizing for more than a few dozen cost-effective or best buy alternatives. Second, without a clear notion of which formulation strategies and alternatives best meet or fulfill planning objectives, it can be difficult to discriminate or justify trade-offs among alternatives because there can be dozens of best buy plans. Last, it is important for teams to apply their project area knowledge and the input of experts and others to strategically formulate plans to meet objectives. While using software to generate all possible combinations of measures may appear comprehensive, it can actually create an information burden that hinders logical and reasoned analysis by teams.

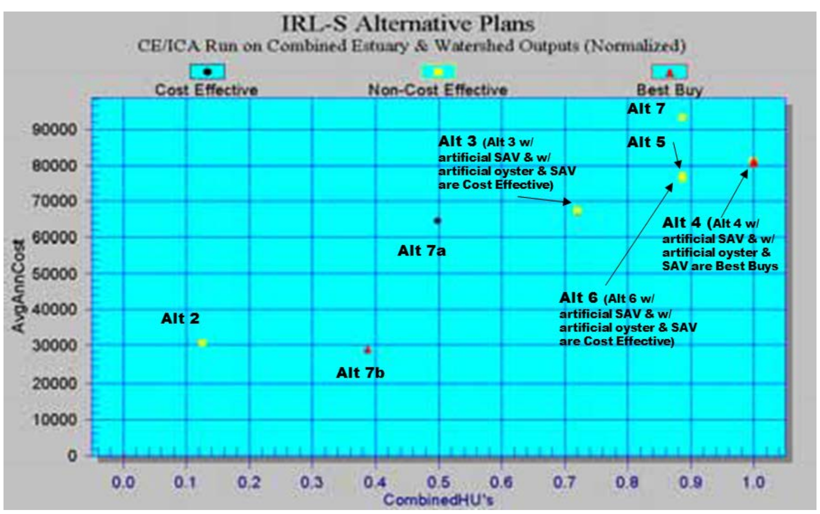

Figure 3 The graph output of the IWR Planning Suite showing CE/ICA results showing the results for "All Plans."

5. Display IWR Planning Suite Software Output Graphs

As most Corps planners are aware, IWR Planning Suite offers several automatically-generated graphs and tables showing the results of CE/ICA. Policy guidance and HQUSACE reviewers strongly recommend including and displaying at least the "All Plans" graph and the incremental cost/benefit box graph showing "Best Buy Plans", both standard graphical displays produced by the software. Figures 3-5 show

Figure 4 The graph output of the IWR Planning Suite showing CE/ICA results showing the results for "Cost Effective" plans.

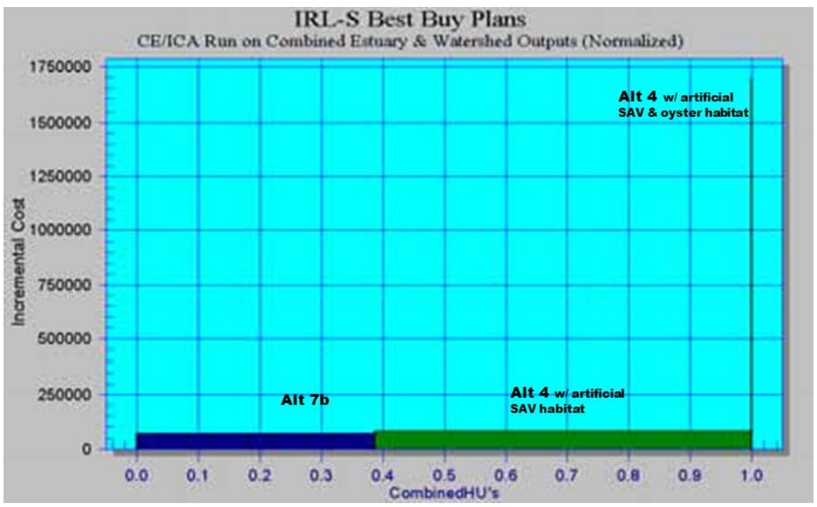

Figure 5 A graph generated by IWR Planning Suite showing the results of a CE/ICA for "Best Buy" plans.

examples of graphs for "All Plans", "Cost Effective Plans", and "Best Buy Plans" (showing incremental cost and output information) used in the Everglades' "Indian River Lagoon – South" Feasibility Study.

Tables showing the associated data should also be provided. This data would include for each best buy alternative plan with plans arranged in order of increasing output/benefit: name, output/benefit, cost, incremental output/benefit, incremental cost, and incremental cost per unit of output/benefit. Users are welcome to customize their graphs with additional information or labels, and may want to display additional information in additional graphs, but the "All Plans" and "Best Buy Plans" are fundamental visual displays required for decision-making and assessment of the "Is it Worth it?" question (see topic #6 below).

6. Step through Best Buy Plans

CE/ICA results **inform** decision-making regarding plan selection and/or National Ecosystem Restoration (NER) plan identification; they do not, in isolation, constitute a **decision.** We cannot just show it is a best buy plan on the incremental cost graph and declare it is the NER plan. What other criteria, besides the results of CE/ICA, are instrumental in NER plan selection? ER 1105-2-100, E-36-41 instructs us to include achievement of planning objectives (i.e., effectiveness), efficiency, completeness, acceptability, significance of the ecosystem outputs/benefits delivered, risk and uncertainty considerations, and the overall partnership context of the plan's benefits in contributing to larger watershed, regional, or national collaborative goals or programs.

A final recommendation of this paper is to use the results of CE/ICA to step through each best buy plan (or less-costly cost effective plan that meets planning objectives) from that which produced the lowest output to successively larger (i.e., more output) plans. During this deliberate "step through" process, the PDT should consider if the alternative under consideration is effective in meeting planning objectives, and to what extent. The PDT should also consider how efficient the alternative is in terms of incremental costs and incremental benefits. Questions to consider include: Is there a sharp break point in incremental costs per unit of output? Is the alternative plan complete? Is it acceptable? How significant are its outputs and why? How does the alternative compare to others in terms of risk or uncertainty regarding project performance or cost escalation? How does the alternative compare to others in the accomplishment of larger watershed or national goals? In considering each "best-buy" plan, answer these questions to make the case that each added increment of cost is "worth it". Systematically describing the results is part of telling the story and building the rationale for plan selection.

To discuss these topics or ask questions, please contact Leigh Skaggs, Plan Formulation Specialist at OWPR, or contributors, Greg Miller of the ECO PCX, Shawn Komlos at IWR, or Jodi Creswell of the Headquarters PCoP. Please send questions related to the Planning Suite at IWR to DLL-CEIWR_IWR-PLAN@usace.army.mil. Visit the Planning Community Tool Box to view additional resources, including past webinars, on Ecosystem Restoration Projects