# Prioritizing Restoration Sites in the Columbia River Estuary

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## Abstract

An increased focus on ecosystem restoration in the Columbia River Estuary has driven the development of a restoration prioritization framework for use by regional planning organizations. The first step in the prioritization framework is assessing current conditions in the study area. This assessment is GIS-based, relies on pre-existing datasets, and uses multiple spatial scales to place sites in a landscape and geomorphic context, increasing the potential for successful restoration. A variety of geospatial datasets feed into a science-based scoring matrix, which determines restoration options based on the relative quality of a suite of baseline ecosystem parameters. Examples of datasets used include historic conditions (e.g., floodplain, shoreline, habitats), current shoreline morphology and modification, aerial photography and other remotely-sensed data, and biological survey information.

## Background

### Study Area

The area of interest for this study consists of the Lower Columbia River Estuary, bordering Oregon and Washington in the Pacific Northwest region of the United States (Figure 1). The estuary study area includes the historic floodplain, and ranges from the mouth of the river to the extent of tidal influence at the Bonneville Dam (river mile 148).

### Objectives

The Lower Columbia River Estuary Partnership (LCREP) has been tasked with coordinating and funding ecosystem restoration projects within the study area. The objective of the current study is to develop a tool that will assist in the selection and prioritization of potential sites for restoration actions. Restoration possibilities may include habitat protection/preservation or restoration actions that return historic physical processes (e.g., dike breaching to restore hydrologic connectivity to a site)

## Approach

The prioritization methodology is based in part on previous work for the City of Bainbridge Island in Kitsap County, Washington (Williams et al. 2004), and includes three primary assumptions that form the basis of the methods:

- Alteration of shallow water tidal and adjacent habitats results in degradation of estuarine ecological functions
- Degradation of ecological functions is caused by alteration of one or more key factors that control the development and maintenance of estuarine habitats
- Restoration of habitats and their associated functions depends on reducing, preventing, or eliminating impacts to these controlling factors.

The approach is GIS-based and follows a conceptual model framework recently developed for the Columbia River Estuary, which follows the assumptions listed above (Thom et al. 2004). The first step involves an assessment of existing ecological impairments at a local site scale that is based on homogenous habitat classes. Existing datasets of potential stressors (e.g., dikes, impervious surfaces, dredge areas) are used to develop a score of “impairment” to controlling factors. At a broader management area scale, sites are grouped into hydrologic units to capture relevant watershed processes. The management area and site level datasets are then evaluated together to determine the restoration options and priority level for each site. Restoration planning organizations can use this initial data analysis as a first, science-based step for identifying potential project sites for further data gathering and analysis by local experts prior to funding.

## Conceptual Model

The conceptual framework states that impacts to the fundamental physical aspects of an ecosystem (the “controlling factors”, such as light, hydrology, temperature, etc.) will ultimately affect the functions provided by the system (Figure 5, Thom et al. 2004). Assessing functional impacts at the controlling factor level allows scientists to focus on the key features of a system that need to be in place for any restoration project, and replaces the costs associated with measuring complex ecosystem functions with simpler measurements of physical factors. Figure 5 illustrates the components and linkages of the conceptual model for the Lower Columbia River, as set forth in Thom et al. (2004).

## Geomorphology

The impact a given stressor has on the controlling factors of a site will depend in part on the local geomorphology (e.g., shoreline armoring has little effect on a rocky shore), so the assessment retains a geomorphic context when calculating site conditions. This geomorphic context is based upon several broad classes of formations found in the estuary, such as river floodplains, islands and shallows.

## Scale

The assessment is performed at multiple spatial scales, in order to relate local site conditions to the landscape. This allows each site to be analyzed within the context of other sites that are subject to similar landscape factors. Restoration success can be optimized by selecting moderately impacted sites within minimally impacted landscapes – taking advantage of existing, undisturbed landscape-level factors such as hydrology. Figure 2 shows a matrix of likely restoration options presented by a given management area and site disturbance scenario (adapted from Williams et al. 2004).

The landscape-level units are considered “management areas”, and are defined by the USGS level 6 HUC boundaries in order to effectively capture watershed processes (Figure 3). The local-level units are considered “sites”, and are defined by lumping relatively homogeneous land cover types, as defined by a classified Landsat TM dataset (Figure 4). The lumping process is done in ERDAS Imagine, using clump and eliminate routines to generalize the data into polygons with a size range of 25 to 100 acres. The resulting units contain features with similar small-scale attributes, from which restoration sites can eventually be defined by planners.

## *Application*

### Datasets

The assessment relies on existing quantitative spatial data whenever possible. Multiple data sources are used to measure the impact of each stressor on site controlling factors. Examples of datasets used in the assessment include:

- Diking and tide gate locations obtained from the U.S. Army Corps of Engineers and updated with local knowledge. Provides information on disrupted hydrology to a site.
- Roads/Railroads from state transportation agencies. Provides information on urbanization and disrupted hydrology (most river-bordering roads/railroads are built atop berms).
- Outfalls and NPDES permit sites, obtained from state environmental agencies. Provides information on disrupted water properties, such as contaminants, temperature, nutrients, and turbidity.
- Land use/land cover derived from 30m Landsat TM imagery. Provides information on existing vegetative cover and urbanization, and forms the basis for site delineation and watershed condition.

### Scoring

Scoring for each site is based on a five point qualitative scale, which is guided by the quantitative input data. Based on the conceptual model, site impacts are calculated by weighting the input datasets for each controlling factor in the model. Scores range from 0 (not an issue) to 5 (highly disrupted). The scoring for each site is then up-scaled (in combination with other sites) to the management area, so comparisons can be made between the local and landscape levels. Example scoring from the completed Bainbridge Island assessment is shown in figure 6, which evaluated shoreline reaches within drift cell-based management areas (from Best et al. 2004).

### Discussion

The process allows experts to utilize a systematic approach to grade the condition of the site and the landscape within which the site resides. Once the level of disturbance and type of disturbances are known on these two scales, the restoration strategy most likely to result in success can be identified. Further, knowing the location and condition of the habitat at a site, coupled with other prioritization criteria (e.g., social and economic factors), the sites can be prioritized for actions. The process is open, science-based, and utilizes an organized understanding of the ecosystem to arrive at the best alternatives for restoration actions.

## *References*


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## *Figures*


**Figure 1: Lower Columbia River Estuary Study Area**

| | | | |
|---|---|---|---|
| High Site Disturbance | Restore Enhance Create | Enhance Create Restore | Enhance Create |
| Moderate Site Disturbance | Enhance Restore Preserve | Conserve Enhance Create Restore | Enhance Create Restore |
| Low Site Disturbance | Conserve Preserve | Conserve Enhance Restore | Enhance |
| | Low Management Area Disturbance | Moderate Management Area Disturbance | High Management Area Disturbance |

**Figure 2: Site and management area disturbance/restoration options matrix**

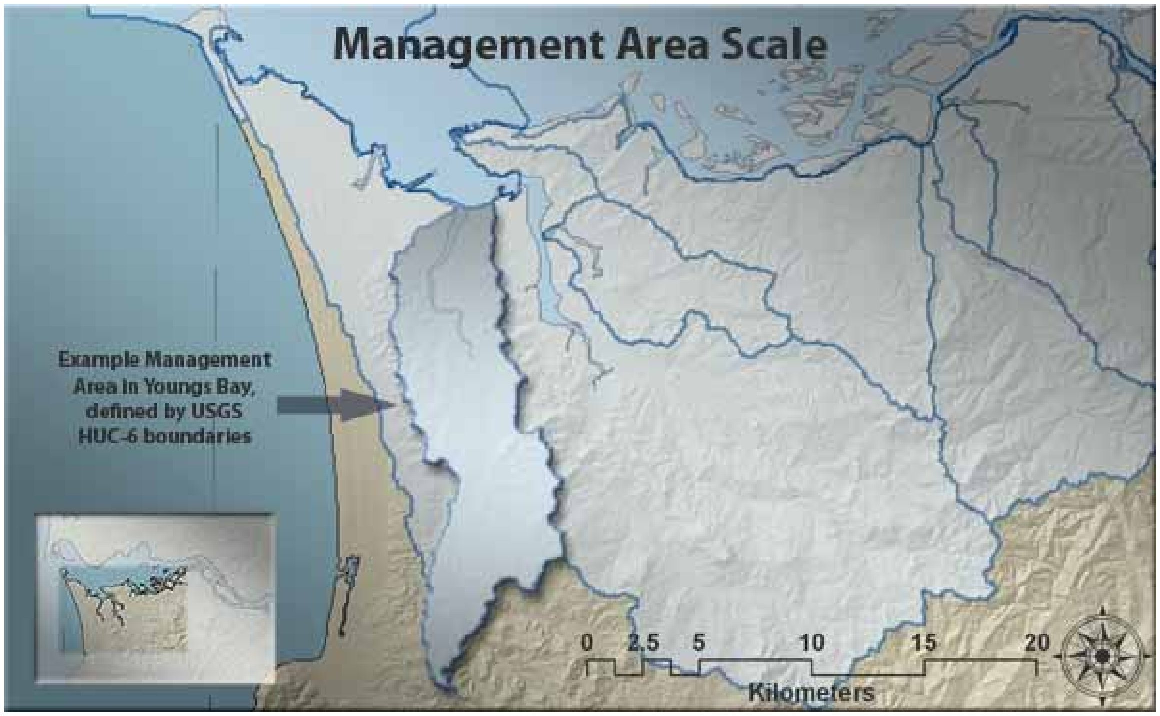


**Figure 3. Landscape-scale management area examples**

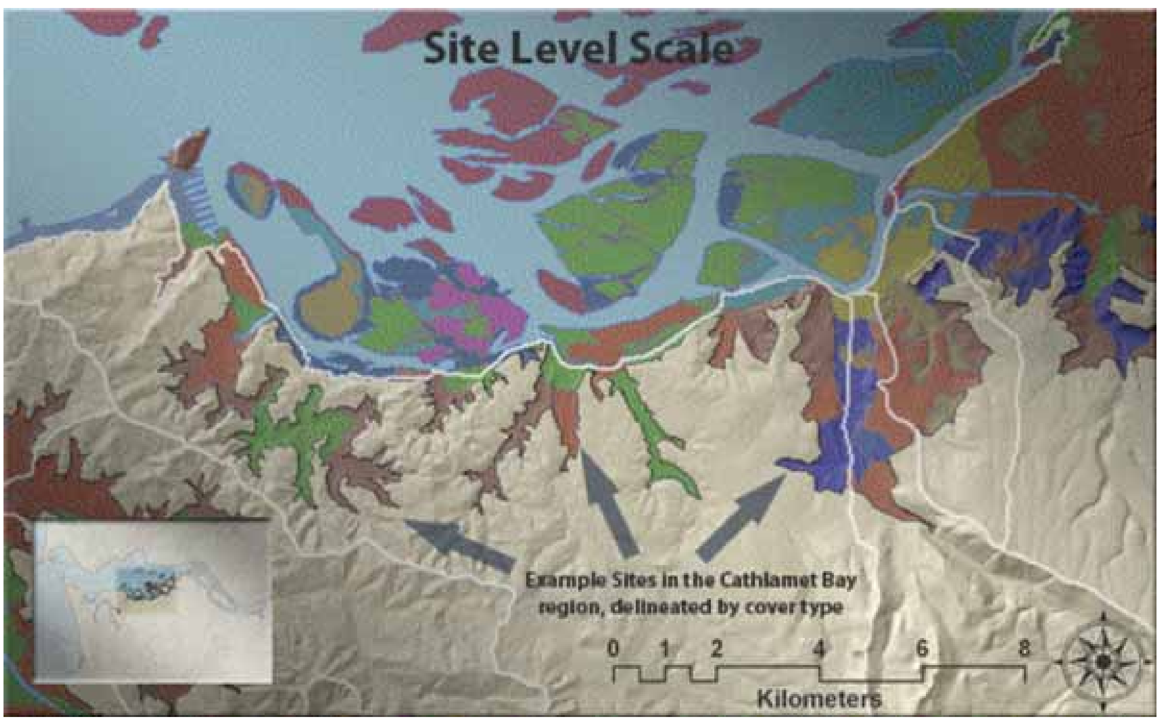


**Figure 4. Local-scale site examples**

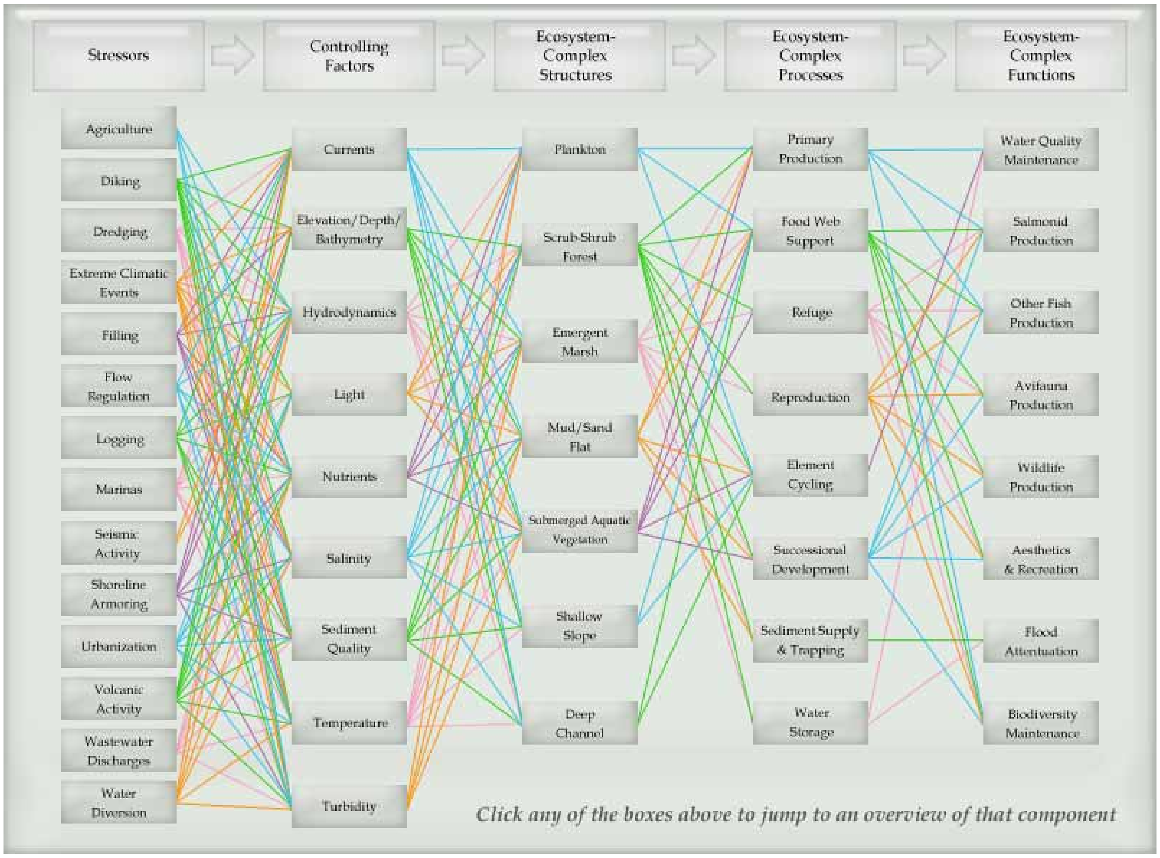


**Figure 5. Conceptual model**

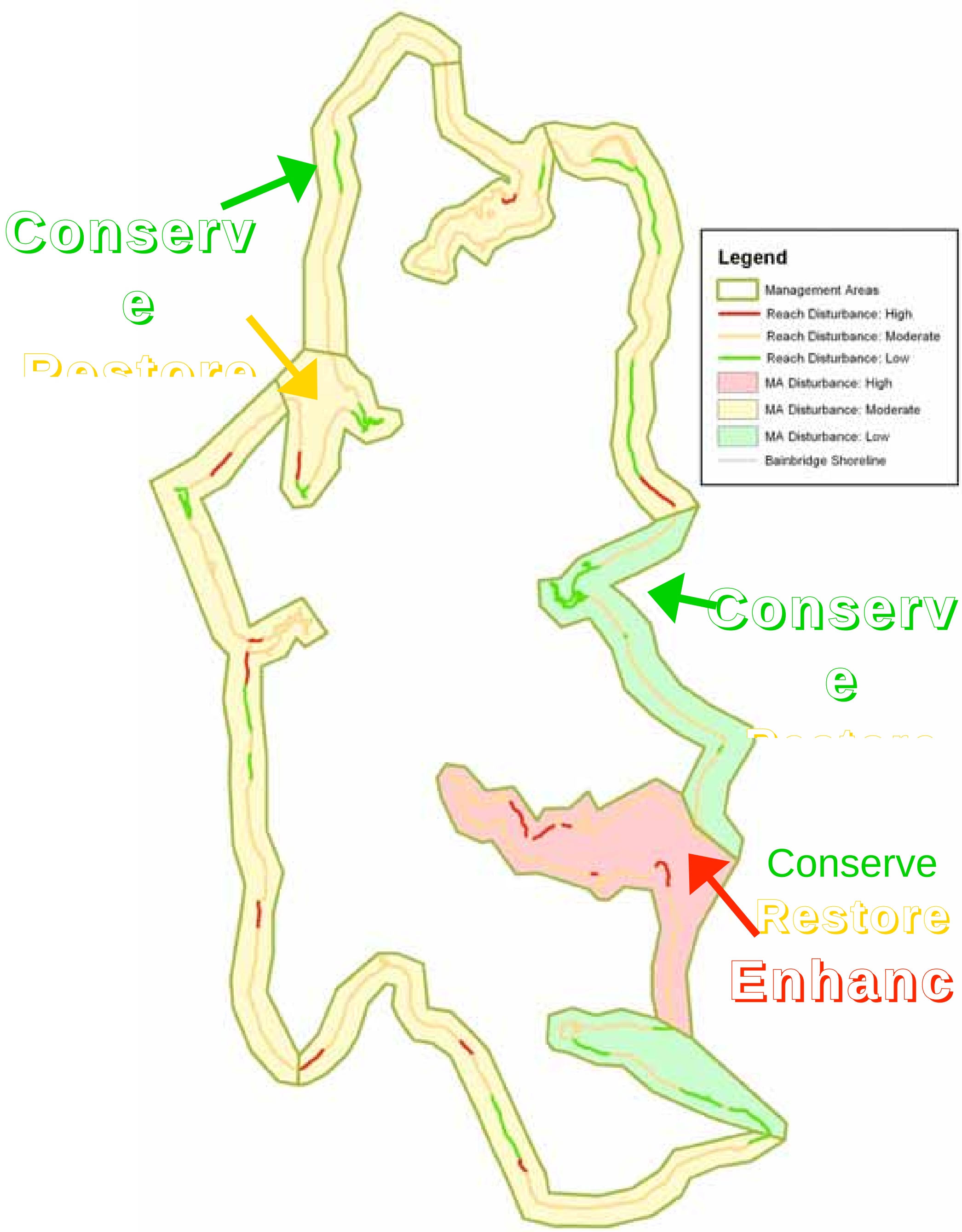


**Figure 6. Example scoring and landscape context from Bainbridge Island**