Assessing the Cumulative Effects of Multiple Restoration Projects

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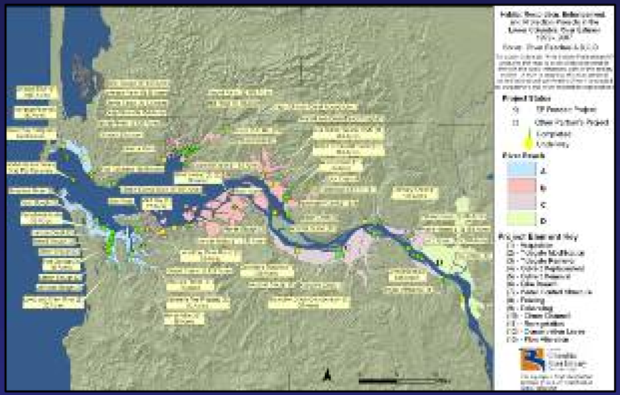
Restoration & Assessment in an Understudied Complex System



- Multiple Agencies and NGOs (Introduction)
- Both Species & Ecosystem Goals (Session 1)
- Various Restoration Methods (Session 1)
- Ecological Gradients (Session 2)
- Uncertain Ecological Relationships (Session 2)
- Interlocked Human Communities (Session 3)

Accountability

- By Action Agencies to NMFS
- By Implementers to Funder-Sponsors
- By Agencies/NGOs to Stakeholders
- By Federal Agencies to Congress
- By State Agencies to State Legislatures
- By Elected Representatives to the Public

Cumulative Ecosystem Response: Presentation Overview

- Study Began in 2004 with Corps Funding
- Purpose, Context, and Study Area
- Approach
  - Riverscape Scale Analytical Methods: Time and Space
  - Site & Catchment Scale Examples

Corps of Engineers Approach

- National Research Council Reports, 2004: Call on U.S. Army Corps of Engineers (USACE) for *integrated large-scale systems planning, adaptive management methods, expanded post-project evaluations, and a collaborative approach*
- USACE Hurricane Protection Decision Chronology study: cites a *"Tyranny of incremental decisions."*

USACE 12 Actions for Change, 2006: Employ systems-based approach – *"shift the focus from isolated, individual projects to interdependent groups of projects…from local solutions for immediate problems to regional solutions for longer term problems"*

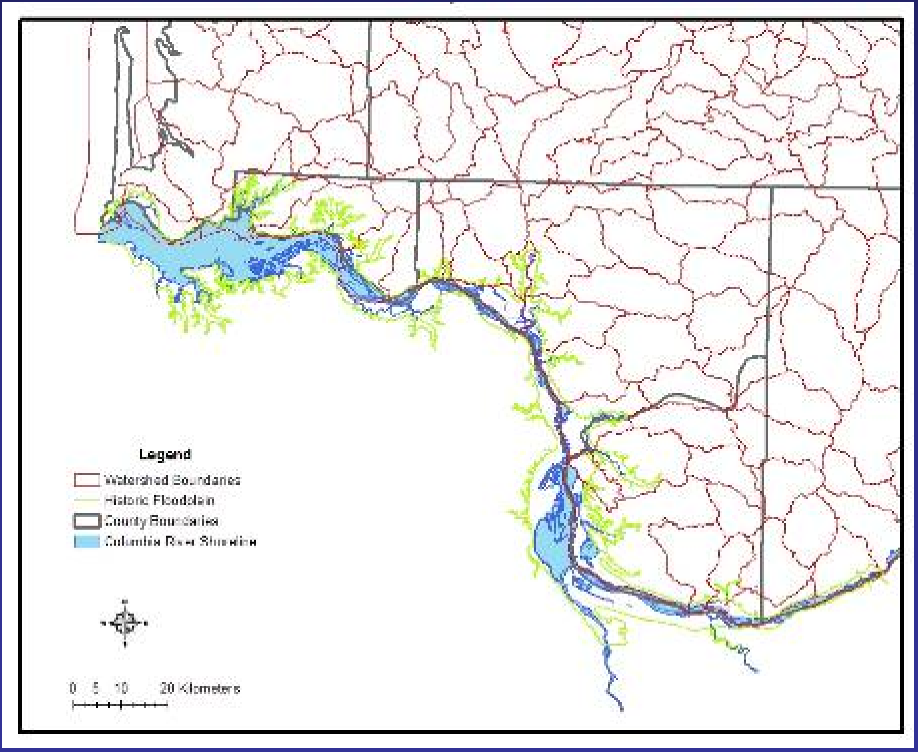
Study Area in Global Context

Columbia River Estuary: Diking & >40% flow reduction during spring freshet → 62% reduction shallow water juvenile salmon habitat in estuary. (Kukulka and Jay 2003)

Global:

- Loss of Freshwater Biodiversity
- *Loss of Lateral Connectivity (Main Stem - Floodplain)*
- Floodplain Dynamics & Inundation Regime
- Environmental Flows/Pulse
- Floodplain Forest Coupling

see Junk et al. 1989;
Poff et al. 1997;
Bunn and Arthington 2002



Historical Tidal Columbia Floodplain with Washington Watersheds

Study Purpose

Standardize methods to evaluate the effectiveness of Columbia River estuary hydrological reconnection ecosystem restoration projects and the secondary and cumulative effects of these projects at larger scales, i.e., on-site, local, and landscape scale effects.

Cumulative Effects Terminology

"The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR § 1508.7).

Fields Reviewed Watersheds, Land-margin ecosystems, Fisheries, Wetlands, Forests, Ecotoxicology

Modes of Accumulation Time crowding, Space crowding, Time lags, Cross-boundary, Landscape pattern, Compounding, Indirect, Triggers and thresholds (CEQ 1997)

Categories of Cumulative Effects

Ways that effects can accumulate:

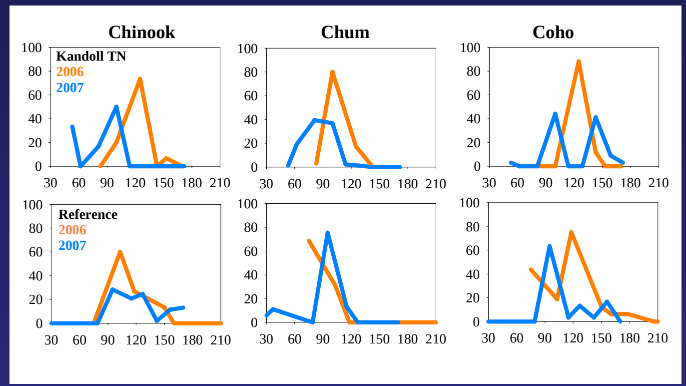
- Frequent and repetitive effects on an environmental system (time crowding)
- Delayed effects (time lags)
- High spatial density of effects on an environmental system (space crowding)
- Effects occur away from the source (cross-boundary)
- Change in landscape pattern (e.g., fragmentation or the reverse)
- Effects arising from multiple sources or pathways (compounding effects)
- Secondary effects (indirect effects)
- Fundamental changes in system behavior or structure (triggers and thresholds)

(Council on Environmental Quality 1997)

Selecting Indicators Relative to Restoration Goals: Ecosystem Approach

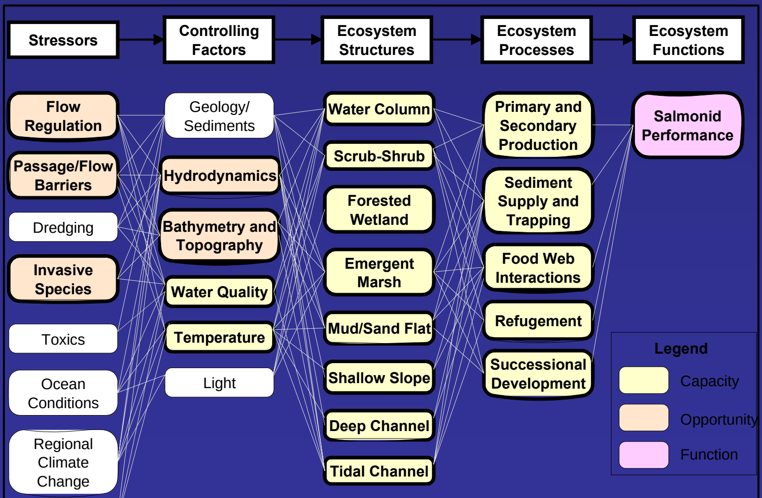
- *Habitat Opportunity*
- *Habitat Capacity*
- *Realized Function*

Simenstad & Cordell (2000)



Organism or Ecosystem?

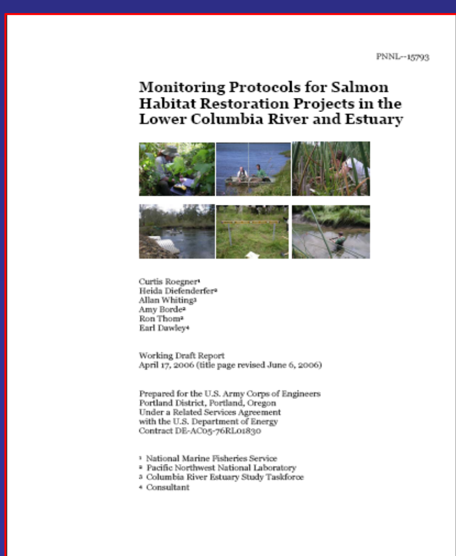
Build it and they will come?



Restoration Measure	Direct Effects	Indirect or Long-Term Effects	Cumulative Effects	Salmon Effect Category
Dike Breach	Tidal Inundation	Land use, Plant comm., Channels	Exchange, Food web, Hab. area	Opportunity & Capacity
Tidegate or Culvert Replacement	Tidal Inundation Fish Passage	Spawning area increase	Habitat area	Opportunity
Channel Excavation	Channel area, morphology	Increased wetted area	Habitat area	Opportunity & Capacity

Predict Effects of Typical Restoration Actions: Conceptual Model

Core Indicators: Monitoring Protocols for Salmon Habitat Restoration Projects



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Monitoring Protocols for Salmon Habitat Restoration Projects in the Lower Columbia River and Estuary

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Available URL: http://www.lcrep.org/lib_other_reports.htm

Key Indicators of Cumulative Effects

Macrodetritis & prey production and export–

Fundamental Shift in Food Web (Sherwood et al. 1990)

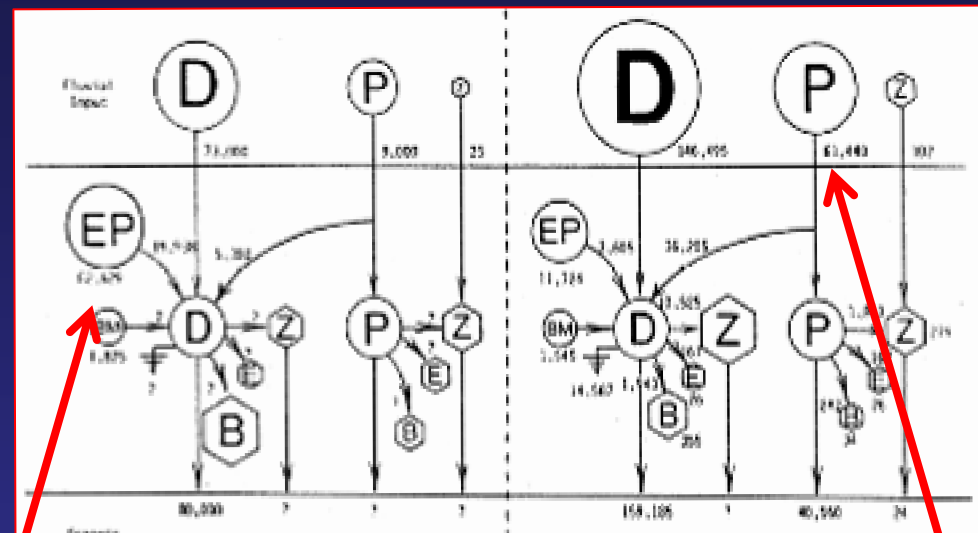
Connected channel edge development

Nexus of terrestrial and aquatic productivity

Wetted Area (Inundation)

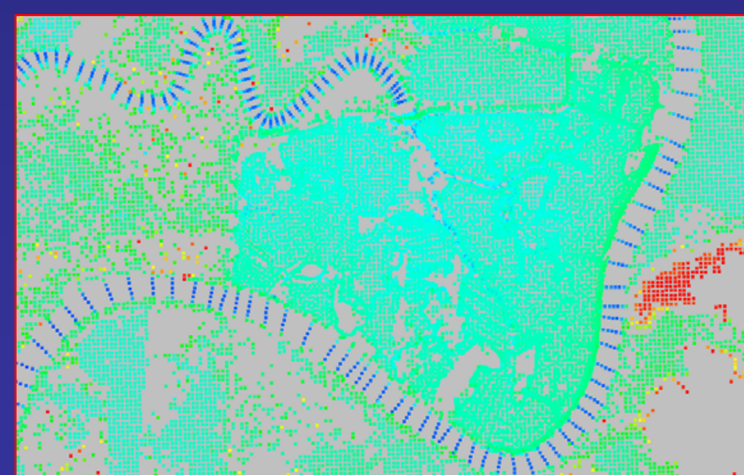
Merged LiDAR, Cross-Sections, Topographic Survey Data – Grays River

Pre-1870 Recent



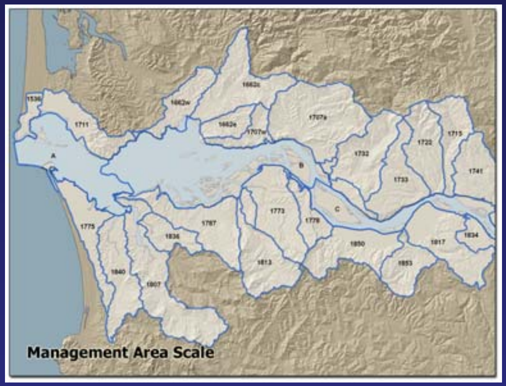
Emergent plant input reduced

Phytoplankton input from reservoirs increased



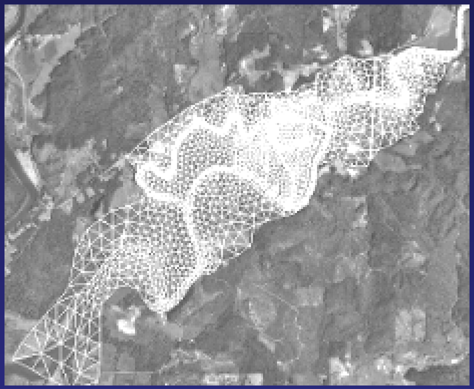
Adaptation of an Impact Assessment Levels of Evidence Approach

Base Model



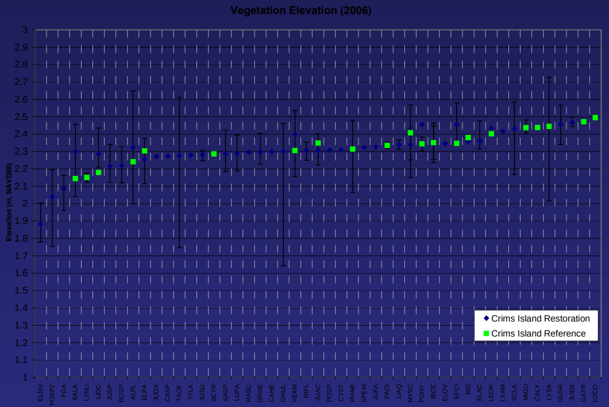
Base GIS Model/Adaptive Management Framework

Synergy



Hydraulic Modeling & Statistical Tests for Cumulative Effects

Predictive



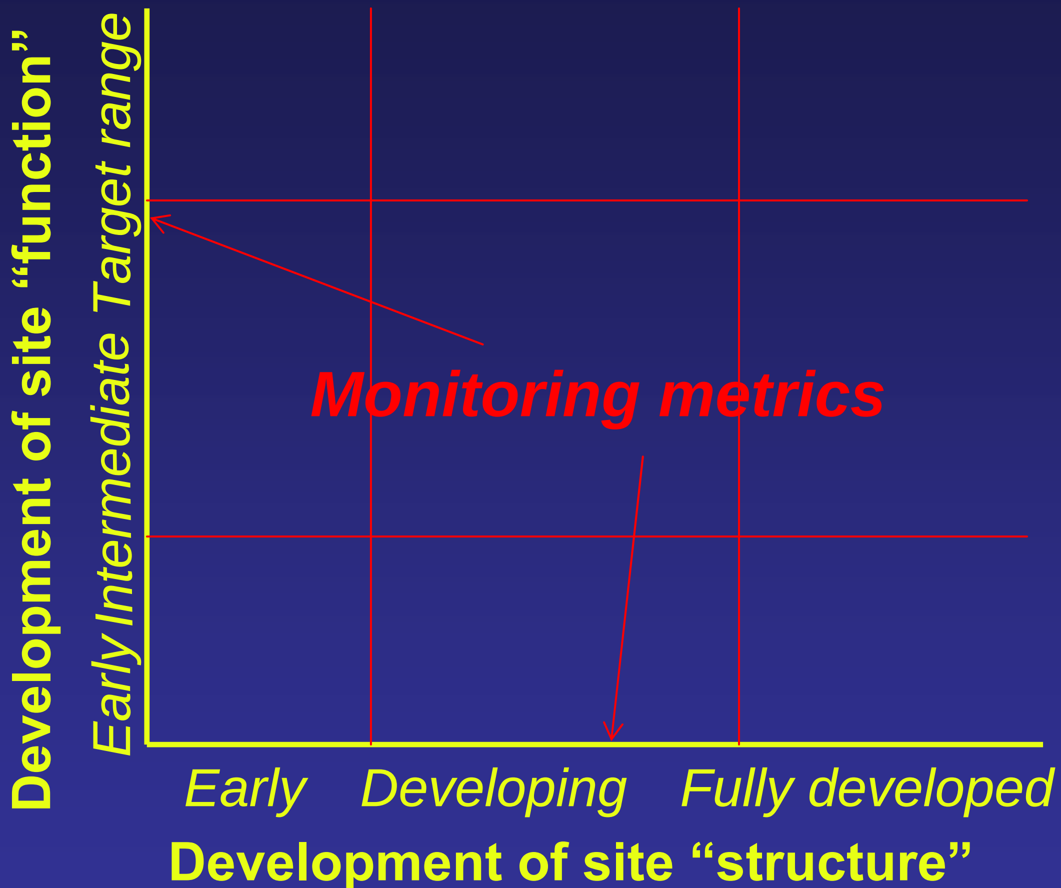
Ecological Structure & Function Relationships

Cumulative Effects Evaluation

Baird and Burton (2001)
Downes et al. (2002)

Causal Criteria

- Strength of Association
- Consistency of Association
- Specificity of Association
- Temporality
- Biological/Ecological Gradient
- Biological/Ecological Plausibility
- Experimental Evidence
- Plausibility

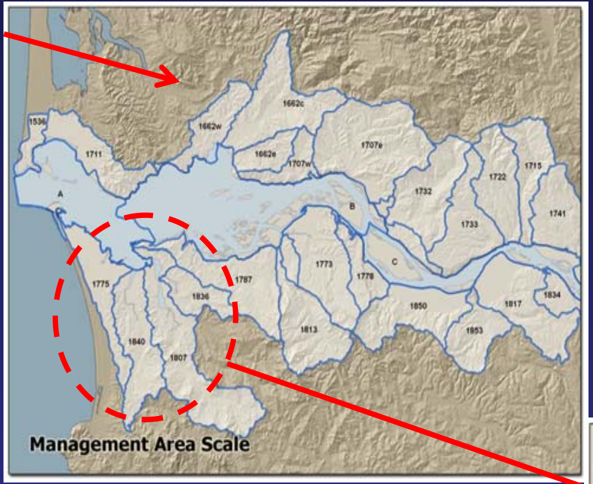


(Adapted from Bradshaw 1987)

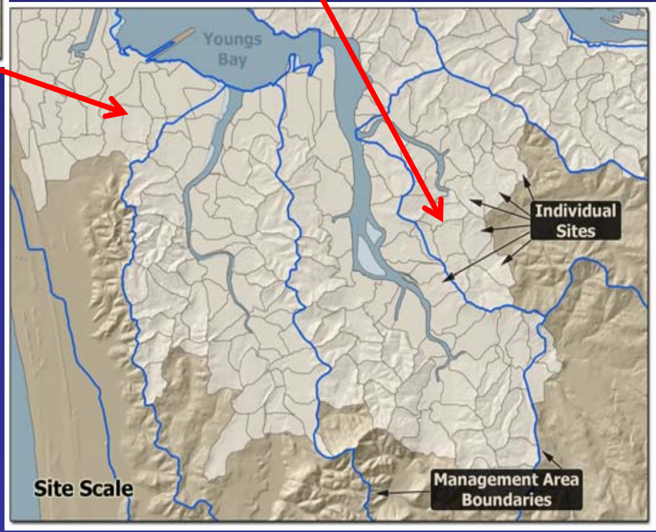
Levels of Evidence: Correlative data used to make the case for causal inference and against alternative hypotheses.

Base Model

<u>Management Units</u> = HUC 6 hydrological units. There are ~60 MUs in the 235-km tidal floodplain.



<u>Site Units</u> = definable hydrologic divisions. There are ~2,300 SUs in the 235-km tidal floodplain.



<u>Data</u>:

•Stressor and Landscape Indicators

•Site Evaluation Cards

Net Restoration Effect:

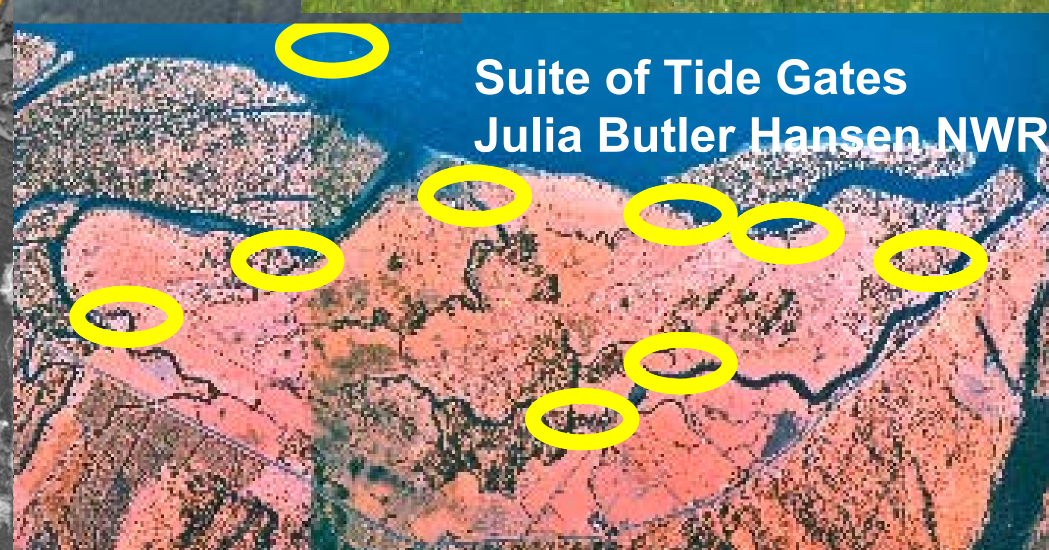
NRE = (Δfunction) (area) (probability)

Cumulative Net Ecological Impact:

CNEI = ∑(Δfunction x area x probability)

-Thom et al. Rest.Ecol. 13(1) 2005

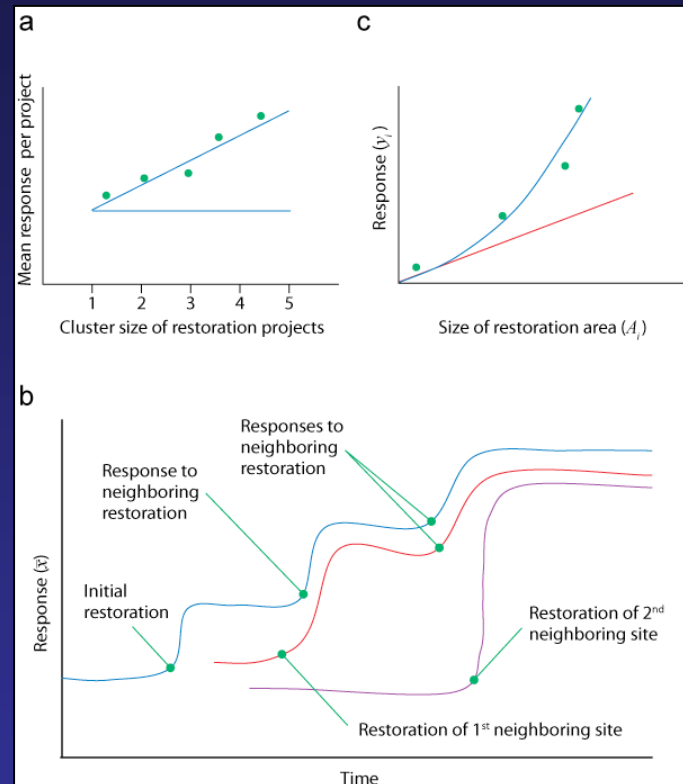
Synergy: Project Spatial and Temporal Sequencing



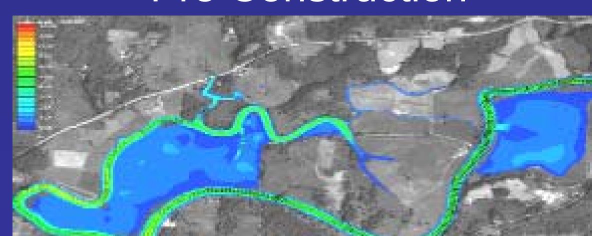
Cumulative Effects Statistical Tests

-Hypothetical responses to space crowding (project cluster size), project size, and restoration of neighboring sites.

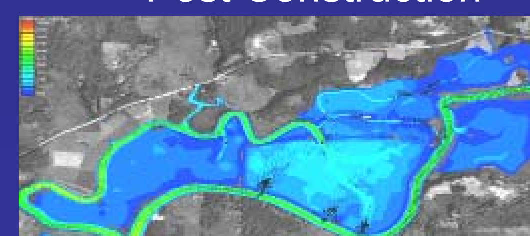
-Data may be from experimental restoration installations … or simulations of wetted area from hydrodynamic model.



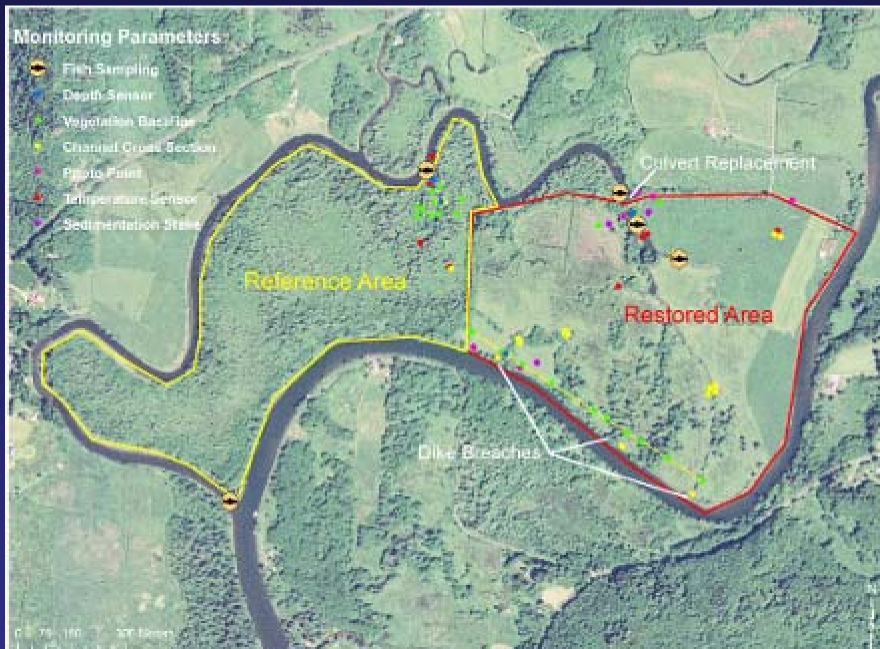
Pre Construction



Post Construction



Developing Predictive Ecological Relationships



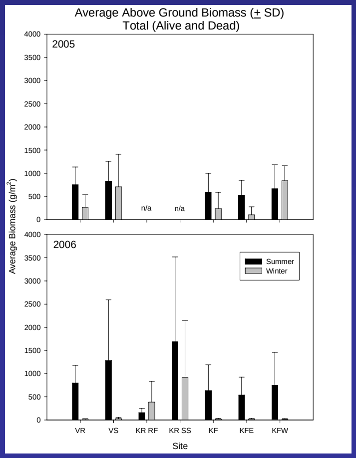
Paired Reference/Restoration

	SSE 2005	SSW 2005	SSE 2006	SSW 2006	KR
SSE 2005		72.6	92.8	-	23.4
SSW 2005			-	94.0	30.6
SSE 2006				86.3	23.4
SSW 2006					53.2
	VS 2005	VR 2005	VS 2006	VR 2006	
VS 2005		24.5	94.1	-	
VR 2005			-	98.2	
VS 2006				13.1	

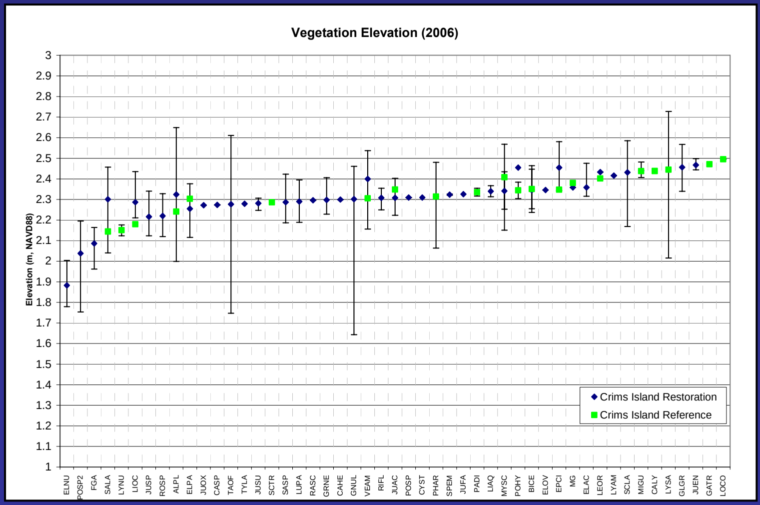
Similarity Index: Plant Cover

Site	Stake Pair	Accretion Rate (cm/y)
Kandoll Farm	1	1.3
	2	3.1
	3	3.5
Johnson Property	1	1.8
	2	2.2
	3	2.3
Grand Mean		2.4

Sediment Accretion Rate



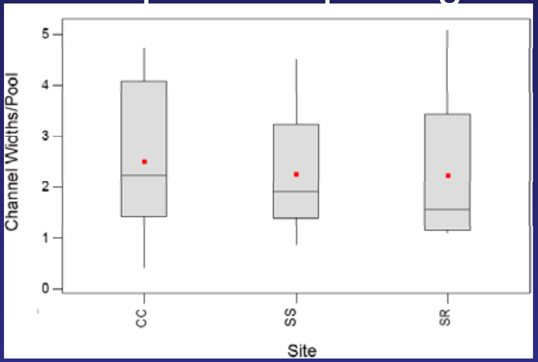
Organic Matter Export



Vegetation-Elevation Relationships

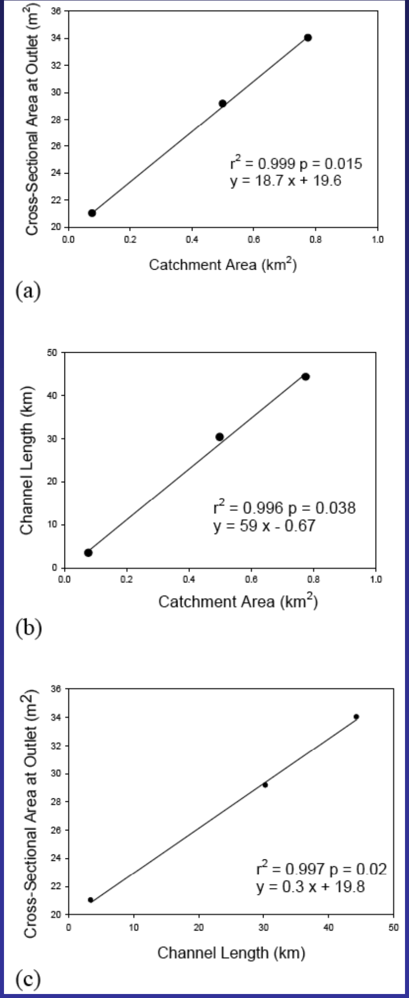
Clarifying Restoration Targets with Reference Site Ecological Data

Reach Scale: Spruce Swamp Pool Spacing

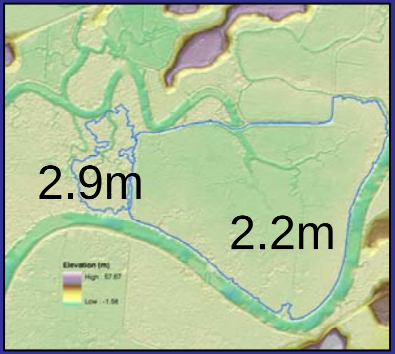


2.3 Channel Widths/Pool[1]

Catchment Scale: Spruce Swamp Hydraulic Geometry[2]



Mean Elevation[2]



[1] Diefenderfer & Montgomery. In Press. *Restoration Ecology.*

[2] Diefenderfer, Coleman, Borde, & Sinks. In Press. *Int'l. J. of Ecohydrology and Hydrobiology*

Evaluation & Application

1) Would the *Preponderance of Evidence* from base, synergy, and predictive lines…convince a reasonable person that the combined restoration projects and programs achieve measurable change toward the restoration goal in the CRE?
2) If so, how does this positive effect compare to continuing land conversion & degradation in the CRE?
3) What steps are necessary to achieve greater effectiveness in restoring habitats? What needs to be implemented to result in cumulative effects of multiple projects in CRE ecosystem?
4) What suite of projects produces most significant return of marsh macrodetritus to the CRE ecosystem, an increase in connectivity, an increase in habitat opportunity for juvenile salmon, and maximum flood attenuation, sediment trapping, nutrient processing, etc?

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Co-authors:

- Gary Johnson, Ron Thom, John Skalski, Amy Borde, Blaine Ebberts, Curtis Roegner, Earl Dawley

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