Assessing Ecosystem Restoration Benefits

Briefing for Planning Associates

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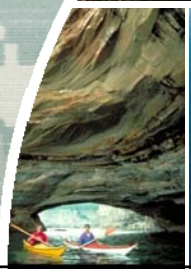
2 February, 2012



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Objective

Address the Office of ASA(CW) directive regarding deficiencies in Corps ER feasibility reports and studies, and to demonstrate programmatic success to OMB and the public through:

- Establishment of the **state-of-the-science** and improvements in practice by those engaged in EBA
- Development of **scientifically valid metrics and methods** for assessing benefits from environmental restoration
- **Clear communication and accounting** of the benefits of proposed and in-place restoration projects, as well as the Corps' ER Program

Problem/Approach

- Poor fundamental understanding of ecosystem process and condition,
- No consensus for scientifically-recognized and peer reviewed methods and metrics,
- Failure to identify and quantify uncertainty,
- Incomplete accounting of benefits,
- Poor documentation,
- Model certification.

- Primary audience are District planners; broader benefits to HQUSACE and ASA(CW),
- Focus on providing key capabilities that improve EBA practice,
- Limited investments in model development and service-based research

Capabilities

- **Conceptual models** to link ecological state, uncertainties, restoration actions, metrics, and predicted trajectories,
- **Objectives and Metrics** for scientifically-valid assessment of project benefits,
- **Ecological Modeling** for forecasting ecosystem response to hydro-geomorphic manipulation and associated algorithms for quantifying benefits,
- **Characterizing Uncertainty** for risk-informed planning and improved decisions,
- **Reference Systems** to serve as a guiding image and a basis for scaling benefits.
- **Adaptive Management** to manage risks and maximize benefits
- ***Programmatic Assessment*** tools, guidance and information applicable at regional and national levels
- ***Ecosystem Services*** to account for social and economic benefits

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EBA Process
(With Research Focus Areas Noted)

Define the Problem and Objectives

(Conceptual Models; Reference Conditions; Framework)

Forecast Outcomes and Quantify Outputs

(Metrics; Modeling and Forecasting; Reference Conditions; Uncertainty; Adaptive Management)

Select the Preferred Plan

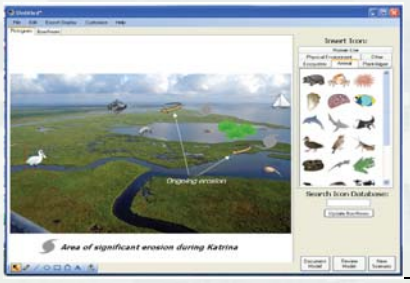
(Reference Conditions; Risk & Uncertainty; Decision Analytics)

Implement and Evaluate

(Reference Conditions; Monitoring and Adaptive Management)

Conceptual Modeling

- **Problem**
  - Poor understanding of ecosystem response
  - Poor objective statements
  - Metrics not associated with ecological realities
  - Lack of a consensus view



How addressed:

- Defined principles and good practice
- Developed support tool CEMCAT
- Several case study applications
- Library of examples

Model Documentation:

- Allows ***on-the-fly*** notes/comments
- Keeps narrative description w/ visual display

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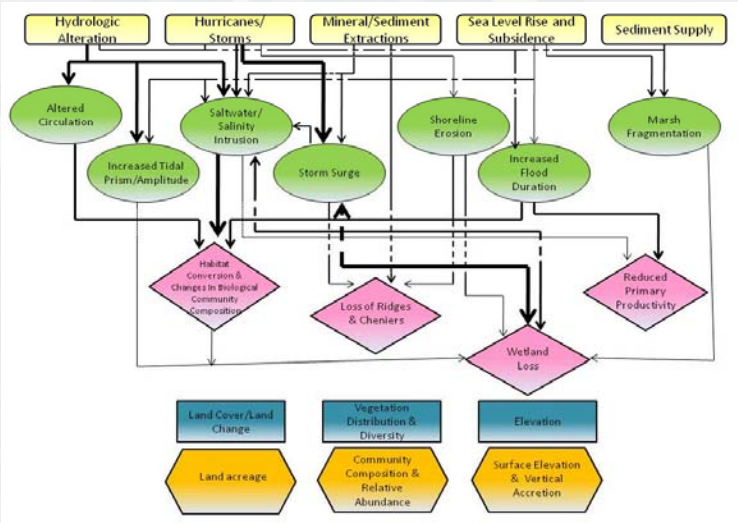
SW Coastal LA CEM



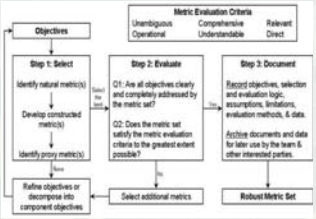
Metric Development for EBA

Challenges:

- **Critical considerations in development of metric sets often overlooked**
- **Diversity of projects w/ diverse objectives**
  - ► ***a challenge to compare dissimilar metrics within & between projects***
- **How to ensure metrics are scientifically valid**

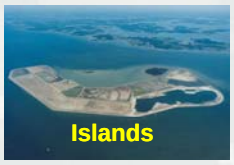
How addressed:

- **Protocols for Metrics Development**
- **How to Ensure Scientific Validity**
- **Comparing Project with Dissimilar Metrics**
- **Common Practices: Nonmonetary Metrics**
- **New Metrics: e.g. A Biotic Security Index, RCI – based multi-function metric**



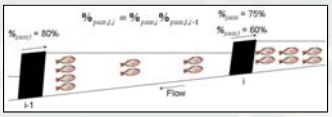
$$\text{BSI} = \sum_{s=1\ldots n} (h(wR)(wD)(wG)(A_1 - A_0))_s$$

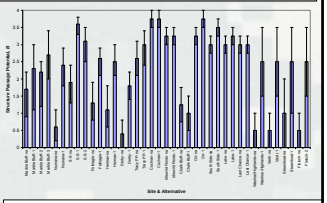
Challenge

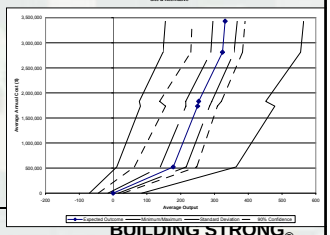


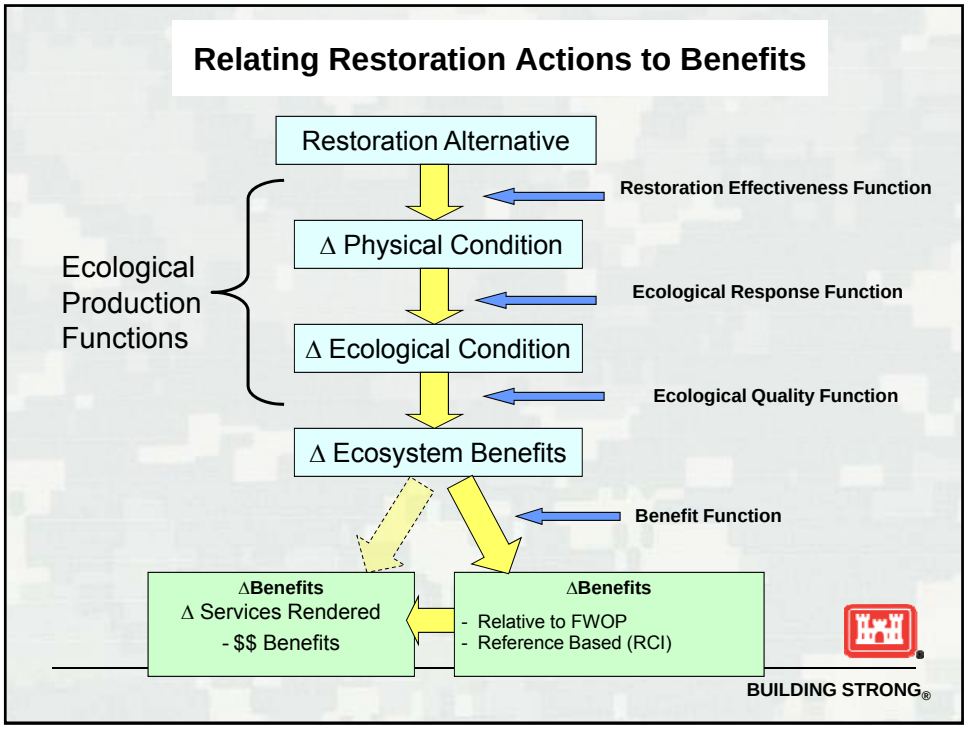
Forecasting and Modeling

- Challenges:
  - Lack of familiarity with modeling and model development
  - Depth and breadth of need
  - Model certification
- How addressed:
  - Establishing principles and outlining standards of practice
  - Providing case studies
  - Fostering comfort with model development and use
  - Model Database








Relating Restoration Actions to Benefits
Restoration Alternative
Restoration Effectiveness Function
Δ Physical Condition
Ecological Production Functions
Ecological Response Function
Δ Ecological Condition
Ecological Quality Function
Δ Ecosystem Benefits
Benefit Function
ΔBenefits
Δ Services Rendered
- $$ Benefits
ΔBenefits
- Relative to FWOP
- Reference Based (RCI)
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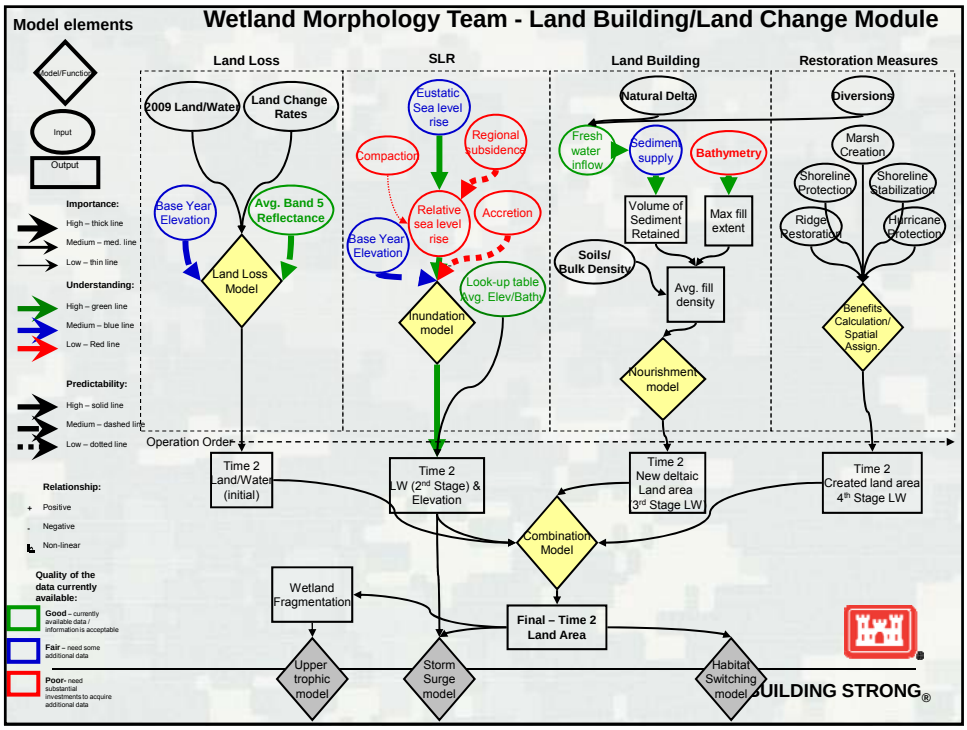
Model elements
Wetland Morphology Team - Land Building/Land Change Module
Model/Function
Input
Output
Importance:
High – thick line
Medium – med. line
Low – thin line
Understanding:
High – green line
Medium – blue line
Low – Red line
Predictability:
High – solid line
Medium – dashed line
Low – dotted line
Relationship:
Positive
Negative
Non-linear
Quality of the data currently available:
Good – currently available data / information is acceptable
Fair – need some additional data
Poor- need substantial investments to acquire additional data
Land Loss
SLR
Land Building
Restoration Measures
2009 Land/Water
Land Change Rates
Base Year Elevation
Avg. Band 5 Reflectance
Land Loss Model
Eustatic Sea level rise
Regional subsidence
Compaction
Relative sea level rise
Accretion
Base Year Elevation
Look-up table Avg. Elev/Bathy
Inundation model
Natural Delta
Fresh water inflow
Sediment supply
Bathymetry
Volume of Sediment Retained
Max fill extent
Soils/ Bulk Density
Avg. fill density
Nourishment model
Diversions
Marsh Creation
Shoreline Protection
Shoreline Stabilization
Ridge Restoration
Hurricane Protection
Benefits Calculation/ Spatial Assign.
Operation Order
Time 2 Land/Water (initial)
Time 2 LW (2nd Stage) & Elevation
Time 2 New deltaic Land area 3rd Stage LW
Time 2 Created land area 4th Stage LW
Combination Model
Wetland Fragmentation
Final – Time 2 Land Area
Upper trophic model
Storm Surge model
Habitat Switching model
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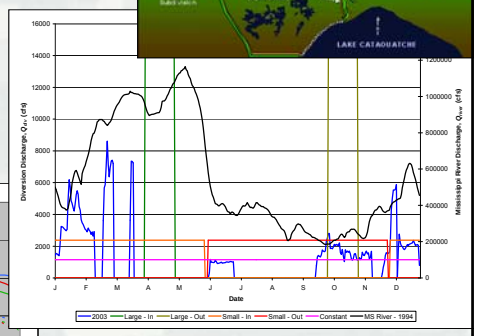
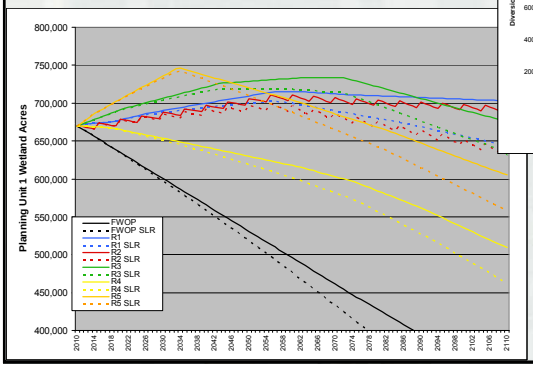
SAND Model: Diversion Benefits

- Predicts future wetland acreage
- Sediment and nutrient inputs offset losses due to consolidation, subsidence, SLR, erosion, etc





Uncertainty Treatment

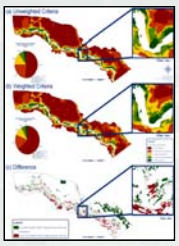
- Examines predictive confidence
- Monte Carlo simulation for parametric uncertainty
- SLR through scenario analyses

Uncertainty & Risk-Informed Decision Making

Challenge:

- **Addressing disparate, conflicting physical, environmental, economic, & societal considerations**
- **Perceived as overly complex**
- **MCDA not well documented for restoration projects**

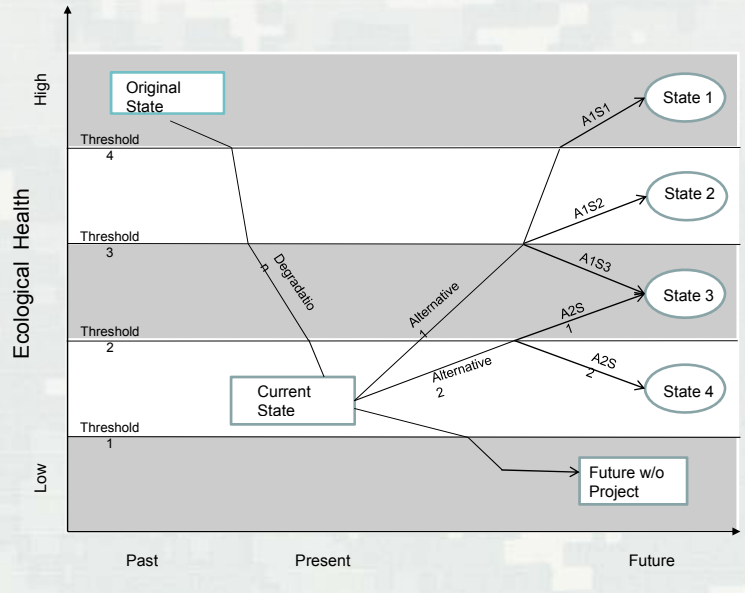
LCA & Sea Level Rise



How addressed:

- **Method for identifying and quantifying uncertainty**
- **Protocols for using MCDA to support ER planning and risk management**
- **Guidance for incorporating uncertainty into decisions**
- **Several case study summaries**
- **Monitoring and adaptive management guidelines**

Missouri River Cottonwood Restoration



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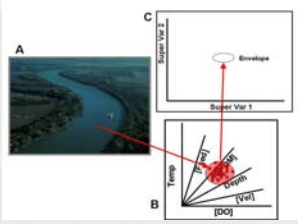
Reference Based Concepts

Challenge: **Is there utility in using reference based concepts as fundamental objective in Corps Ecosystem Restoration Planning?**



Key Considerations:

- **Which reference target to choose?**
- **Which parameters to measure?**
- **How to address projects of differing scale?**
- **How to reconcile reference conditions characterized by different metrics? Multiple metrics?**
- **How to incorporate reference condition comparisons into a national ecosystem restoration program?**

$$C.M. = \frac{1}{n}\sum_{1}^{n}\frac{\left|x_{1_i} - x_{2_i}\right|}{\left(x_{1_i} + x_{2_i}\right)}$$

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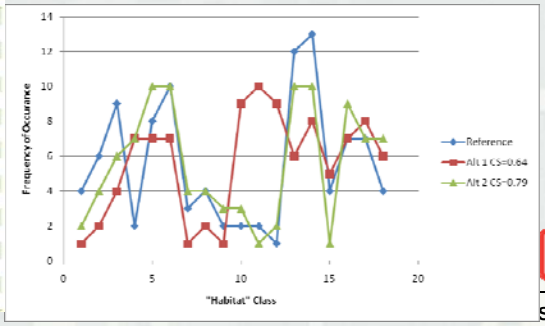
Similarity Models

Fish Index of Similarity based upon Habitat (FIS(H)):

- Uses Canberra Coefficient of dissimilarity to compare frequency distribution of habitat (characterized by multiple variables)
- Investigating applicability of other metrics
- Relies upon the application of a reference or "comparison standard"

$$B.C. = 1 - \frac{2\sum_{i=1}^{s} \min(X_{ij}, X_{ik})}{\sum_{i=1}^{s} X_{ij} + \sum_{i=1}^{s} X_{ik}} \qquad C.M. = \frac{1}{n}\sum_{1}^{n} \frac{\left|x_{1_i} - x_{2_i}\right|}{\left(x_{1_i} + x_{2_i}\right)}$$

Class	Depth	Velocity	Cover
1	0 - 3 ft	0 - 2 fps	Yes
2	0 - 3 ft	2 - 5 fps	Yes
3	0 - 3 ft	>5fps	Yes
4	0 - 3 ft	0 - 2 fps	No
5	0 - 3 ft	2 - 5 fps	No
6	0 - 3 ft	>5fps	No
7	3 - 8 ft	0 - 2 fps	Yes
8	3 - 8 ft	2 - 5 fps	Yes
9	3 - 8 ft	>5fps	Yes
10	3 - 8 ft	0 - 2 fps	No
11	3 - 8 ft	2 - 5 fps	No
12	3 - 8 ft	>5fps	No
13	>8ft	0 - 2 fps	Yes
14	>8ft	2 - 5 fps	Yes
15	>8ft	>5fps	Yes
16	>8ft	0 - 2 fps	No
17	>8ft	2 - 5 fps	No
18	>8ft	>5fps	No



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Monitoring & Adaptive Management

Challenge:

- **WRDA 2007 Monitoring Requirements**
- **Quantification of project success & to facilitate adaptive management**
- **Standards & needs not uniform across project types**
- **Return on Investment?**

Milltown Dam

Truckee River

How Addressed:

- **Guidance documents describing how to develop and implement monitoring and adaptive management plans**
- **Several case studies (Louisiana Coastal Authority, Truckee River, Milltown Dam, Yellowstone R.)**
- **Methods for quantifying the benefits of adaptive management and assessing return on investment.**

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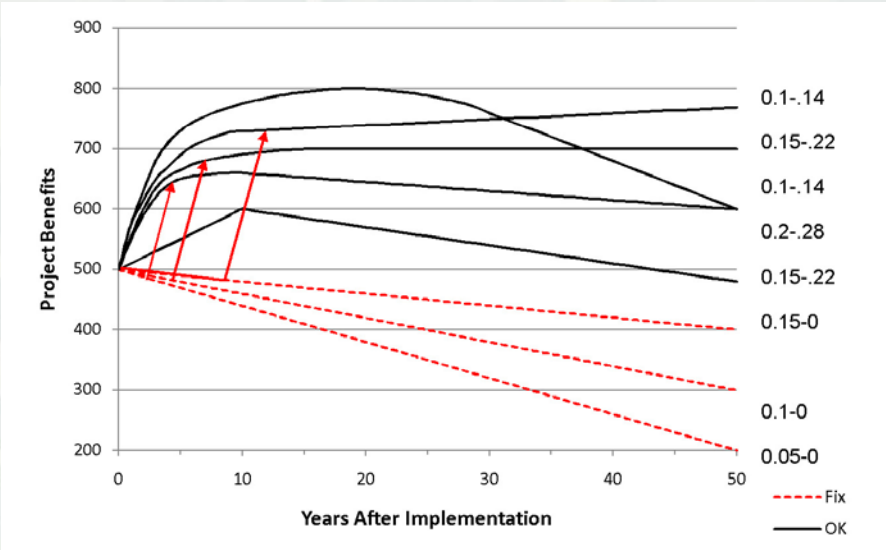
Assessing AM Benefits



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Ecosystem Services & Corps Activities

Ecosystem Service	Evaluation Account
Water Supply and Regulation	NED & EQ
Erosion Regulation/ Sediment Management	EQ & NED
Natural Hazard Regulation	EQ & NED
Water Purification and Waste Treatment	OSE
Biodiversity Maintenance	EQ
Recreational Opportunities	NED
Food	OSE
Fiber, Fuel, and other Raw Materials	NED
Climate Regulation	EQ & OSE
Clean Air	EQ
Science and Education	OSE
Maintain Cultural Diversity	OSE
Spiritual and Inspirational	OSE
Aesthetics	EQ

Results of EBA Workshop on Ecosystem Services, June 2008

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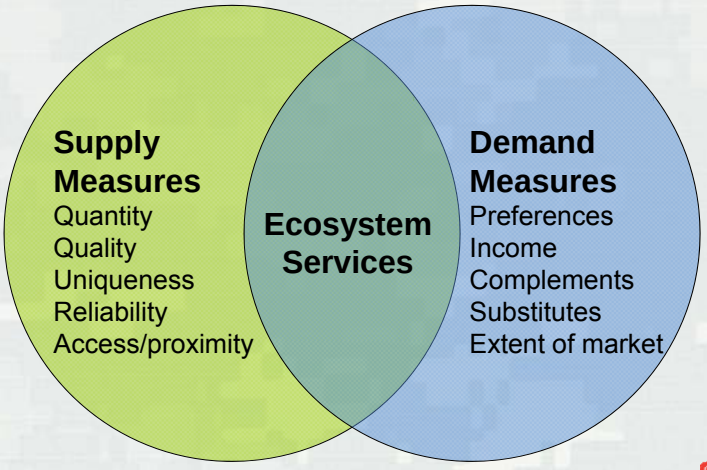
Economic Supply and Demand Framework



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Demonstrations/Case Studies

Purpose: Illustrating the benefits assessment process, methods and tools – e.g., conceptual modeling, metrics development, decision analysis, modeling and forecasting, benefits quantification.

Status: Have several complete and ongoing projects and are prioritizing based upon value and schedule.

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Retrospective Assessment

Authority	Projects Catalogued	Total Projects	Documents Received	Average Cost ($K)	Total Cost ($M)
Section 204	2	12	5	$650	$7.8
Section 206	37	44	157	$2,204	$97.0
Section 1135	65	92	253	$1,644	$150.3
WRDA Stand Alone	6	7	38	$20,100	$140.7
CWPPRA	14	14	142	$5,743	$76.6
UPPER MISS	48	48	228	$3,029	$145.4
ERA-104	1	3	2	$569	$1.7
TOTAL	**173**	**220**	**825**	**$2,816***	**$619.5**

Data as of 06 June 2011 * Average of all 220 projects

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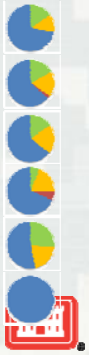
SUCCESS BY ECOSYSTEM TYPE

Ecosystem Type (Can be more than one per project)	% (n = 150)	Was the project successful in achieving goals/success criteria as determined from project documentation?			
		Yes	Partially	No	Not Determinable
Riverine	59%	16%	13%	< 1%	74%
Reservoir/Lake	33%	18%	18%	2%	66%
Nontidal Wetland	30%	16%	20%	0%	64%
Estuarine	11%	6%	19%	6%	69%
Tidal Wetland	10%	27%	20%	0%	53%
Upland	1%	0%	0%	0%	100%



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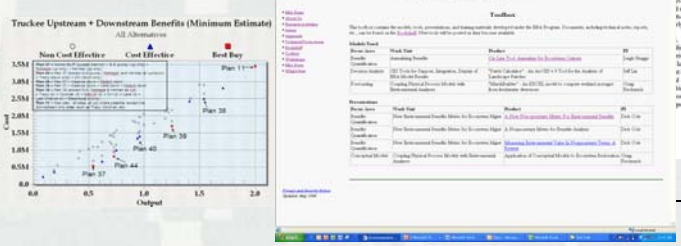
Web Portal

- Technical Notes and Reports (~30)
- Journal Papers (~10)
- Models and Tools (~20)
- Case Studies (~10)
- Webinars (~15)
- Other Resources



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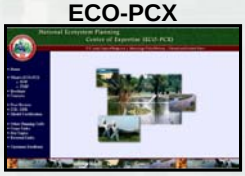
Technology Transfer

Ecosystem Restoration Gateway

www.CorpsEcoRestoration.us

ECO-PCX



EBA & Research

Restoration Fact Sheets

Community of Practice

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Remaining Slides are to Support Discussion, not Part of the Formal Presentation

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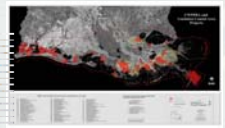
Corps ER Mission

Restore significant **ecosystem** ***function, structure, and dynamic processes*** that have been degraded

- Nationally and regionally significant
- Wetlands, riparian and other floodplain and ***aquatic systems***



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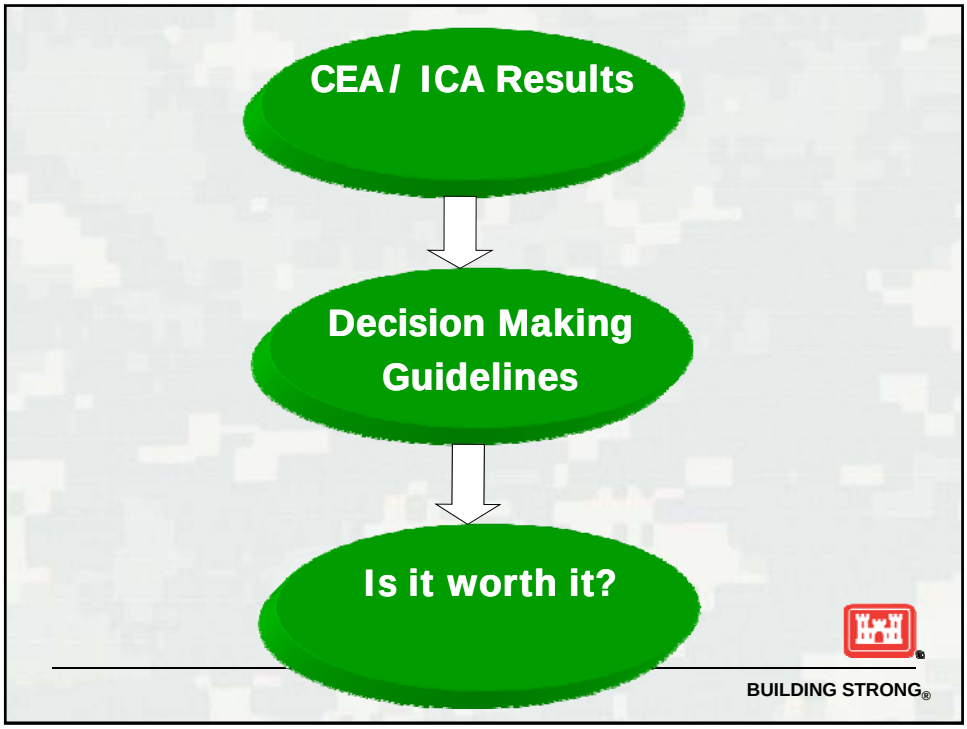
Key Policy Documents

- The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (also referred to as the P&G) establishes the framework for federal water resources planning
- The Planning Guidance Notebook (ER 1105-2-100) establishes the Corps objective in ecosystem restoration planning and defines procedures
- Engineer Regulation 1165-2-501, Civil Works Ecosystem Restoration Policy, provides official civil works policy guidance specific to ecosystem restoration.
- Engineer Pamphlet 1165-2-502, Water Resources Policies and Authorities (Ecosystem Restoration-Supporting Policy Information), provides policy information to guide Corps involvement in ecosystem restoration activities.
- Engineer Pamphlet 1165-2-1, Digest of Water Resources Policies and Authorities, (Chapter 19, Environmental Restoration and Protection), provides a broad digest and background of Corps civil works policies and authorities, but is not a formal guidance document.

Corps Planning Guidance: ER 1105-2-100
(22 April 2000)

- **Recommend the NER Plan**
- **"… justified alternative & scale having the maximum excess of monetary & non-monetary beneficial effects over monetary & non-monetary costs."**
- **"...occurs where the incremental beneficial effects just equal the incremental costs, or alternatively stated, where the extra environmental value is just worth the extra costs." (App. E-28.e(1))**
- **In other words, "Is it worth it?"**



Is it worth it?

Possible decision making guidelines:

- output target
- output thresholds
- cost limit
- breakpoints
- unintended effects
- does it make sense?

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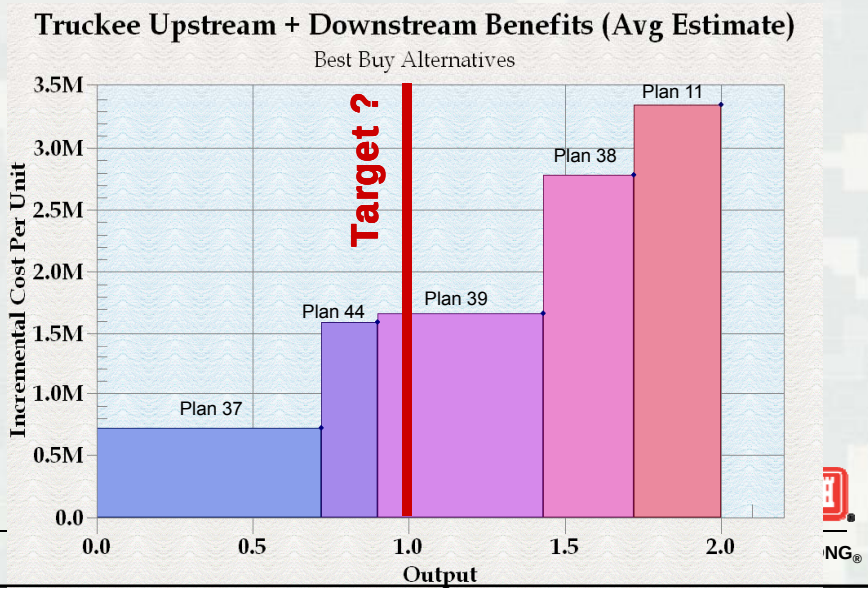
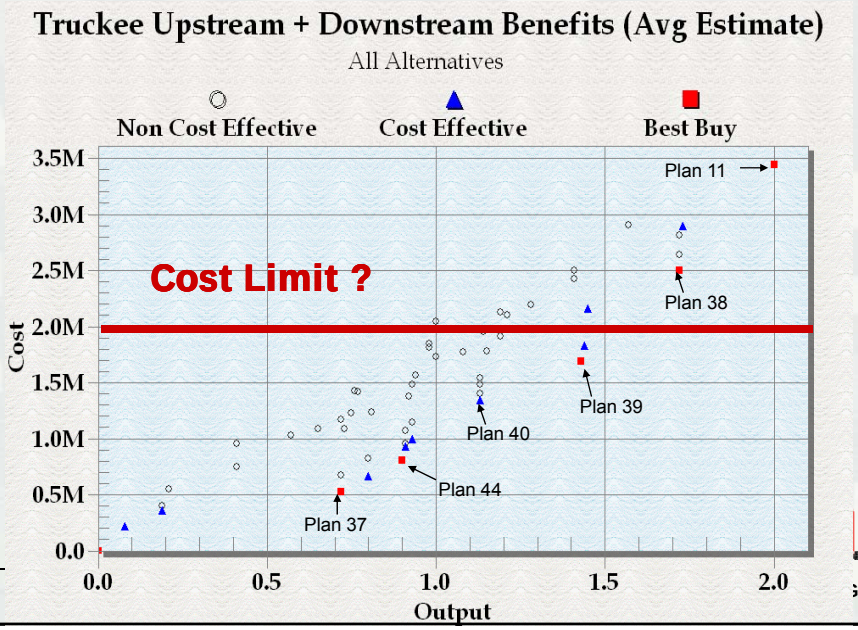
Target?



Cost Limits?



ER 1105-2-100

- "Selecting the NER plan requires careful consideration of the plan that meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness." (Appendix E, E-41)

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ER 1105-2-100

- Additional factors to consider:
  - Partnership context
    - higher priority to those projects planned in cooperation with other Federal resource agencies & regional & national interagency programs
  - Reasonableness of costs
    - decision-maker ascertains that the benefits are really worth the costs
  - Rarely will the NER plan not be among the best buy plans (App. E, E-41)

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Update Budget Criteria?

- Scarcity
- Connectivity
- Special Status Species
  - Provides significant contribution to key life requisite of special status species
- **Hydrologic Character**
  - Restores the natural hydrologic "signature" of a system (timing, magnitude, duration, frequency of flows)
- **Geomorphic Condition**
  - Establishes suitable structure and physical processes (erosion, sediment transport, deposition) for successful restoration
- Plan Recognition
  - Contributes to watershed or basin plans as emphasized in "CW Strategic Plan"
- Self-sustaining
  - Ideal goal is self-sustaining ecosystem consisting of natural processes

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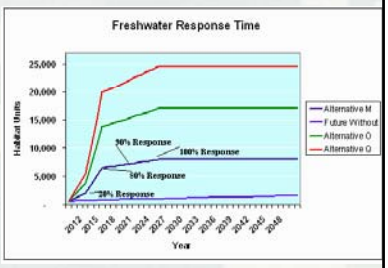
Other Technical Challenges

- Baseline Condition
- Appropriate Metrics
- Timeline/Scale
- Spatial Footprint
- Aggregation/Comparison
- Uncertainty/Risk



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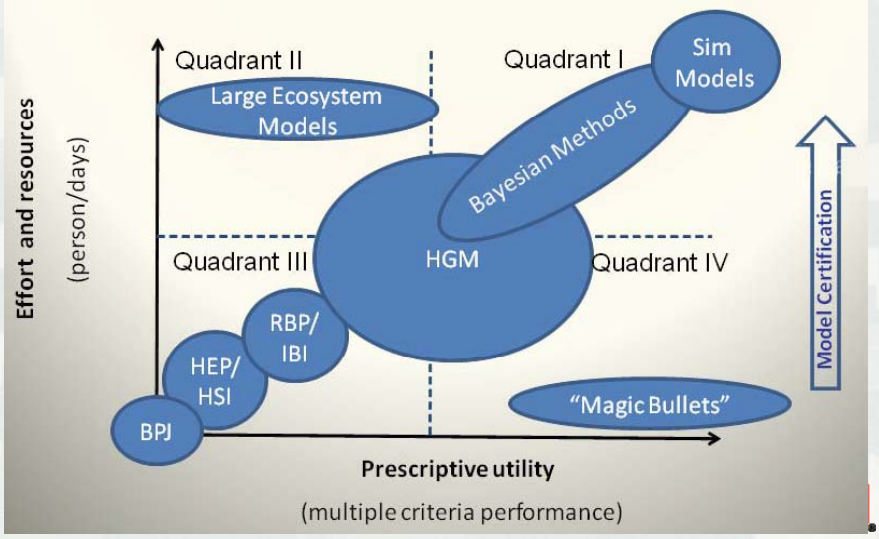
Ecological Modeling



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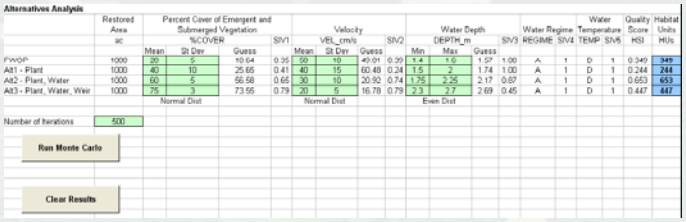
Monte-Carlo Simulations

Product Title: TN – Monte Carlo Simulations in Microsoft EXCEL

How it Addresses the Problem:
•Microsoft EXCEL has a random number generator feature that can be employed to develop rather simple yet powerful statistical analyses for estimating uncertainty. This brief technical tip explains how it is done.

Benefit to Corps Users:
•A means of addressing uncertainty using existing tools and models



Alternatives Analysis

	Restored Area ac	Percent Cover of Emergent and Submerged Vegetation %COVER			SIV1	Velocity VEL_cm/s			SIV2	Water Depth DEPTH_m			SIV3	Water Regime REGIME	SIV4	Water Temperature TEMP	SIV5	Quality Score HSI	Habitat Units HUs
		Mean	St Dev	Guess		Mean	St Dev	Guess		Min	Max	Guess							
FWOP	1000	20	5	10.64	0.35	50	10	49.01	0.39	1.4	1.6	1.57	1.00	A	1	D	1	0.349	349
Alt1 - Plant	1000	40	10	25.65	0.41	40	15	60.48	0.24	1.5	2	1.74	1.00	A	1	D	1	0.244	244
Alt2 - Plant, Water	1000	60	5	56.58	0.65	30	10	20.92	0.74	1.75	2.25	2.17	0.87	A	1	D	1	0.653	653
Alt3 - Plant, Water, Weir	1000	75	3	73.55	0.79	20	5	16.78	0.79	2.3	2.7	2.69	0.45	A	1	D	1	0.447	447
		Normal Dist				Normal Dist				Even Dist									

Number of Iterations: 500

Run Monte Carlo

Clear Results

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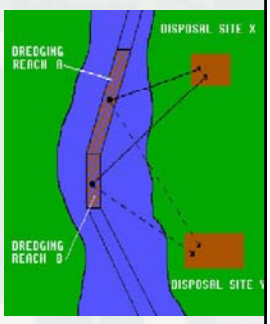
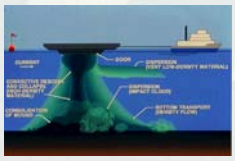
D2M2

•System-wide planning tool to optimize placement of dredged material based on costs and environmental benefits

•System analysis model of long-term material disposal system using linear programming

•Develop network of alternatives linking dredging reaches and placement alternatives with dredging/transportation/processing alternatives





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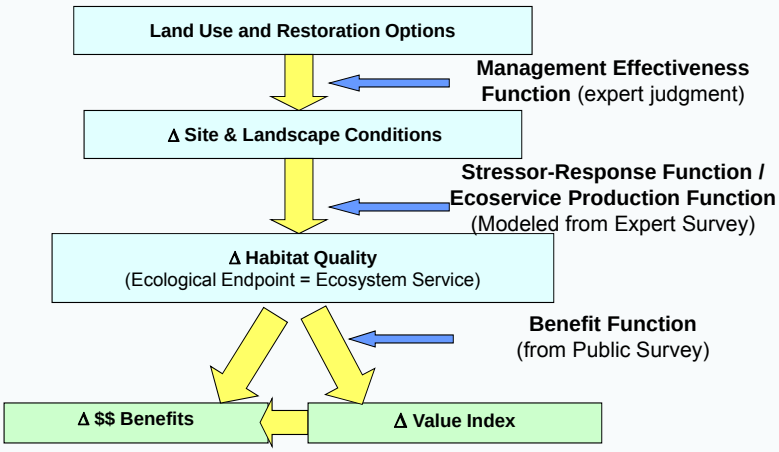
Saltmarsh Restoration & Habitat Services



Steps in Ecological Production Function Development & Use

1. Develop conceptual models that identify key variables and relationships
2. Develop models of functional relationships for physical and ecological response
3. Establish objectives and *performance standards* for each benefit/service
4. Forecast conditions, conduct analyses and document results, then subject to decision factors

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Methods to Support Production Function Development

1. Models – Conceptual, Analytical, Index, Statistical, Simulation, Spatial
2. Literature review and summary / meta-analysis
3. Elicited best professional judgment
4. Combinations of 1-3

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Example Case Studies

▪ Restoration of Delta Streams/MVD	Complete
▪ Truckee River Fish Passage Restoration/SPK	Complete
▪ Ecological Dynamics Simulation (EDYS)/SWF	Complete
▪ Grassy Lake GLO Survey/SWL	Complete
▪ Eco-hydraulic Marsh Accretion Model/MVN	Complete
▪ SW Coastal LA Conceptual Model/MVN	Complete
▪ Barataria Basin Barrier Shoreline WVA /MVN	Review
▪ Piedmont Stream Conceptual Model/ misc.	Review
▪ FIS(h) Model Application/NAP	Draft
▪ Livingston Manor /NAP	Outline
▪ Reno Bottoms/MVP	Annotated Outline

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