The Importance Of Evaluating Remediation Technologies on the Environment

Jennifer Holder, Ph.D.
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Introduction

- Important to evaluate impacts of proposed remediation technologies on the environment
  - If no immediate danger to public, impacts to the environment from proposed remediation could outweigh potential benefits
  - Results of remedial options evaluation can be used in risk management decision making
- A number of different methods can be used to assess impacts
  - Standard environmental assessment tools: monitoring and statistical analyses of pilot test data
  - Economic analyses using cost-benefit models
  - Habitat function models
- Focus on case study where impact assessment of remediation technology used standard environmental assessment tools
- Other methods also summarized

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Case Study

- Study site—Former oil field in Central California
- Source—Accidental releases through leaks in the distribution system
- Contaminant—Semi-refined petroleum product (diluent) used to facilitate pumping of the viscous crude oil present at the site
- Habitat—Sensitive ecological habitats and special-status species

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Pilot Test Remedial Design

- Remediation pilot test: Steam/hot water injection and biosparging
- ~1 ha area
- Well field layout
  - 4 injection wells
  - 9 extraction wells
  - 4 vapor extraction wells
  - 3 groundwater monitoring wells
- 3 main phases of pilot test
  - Pre-operations: mobilization and construction
  - Operations: hot water, steam, and cold water injection
  - Post-operations: cool-down, decommissioning, and demobilization

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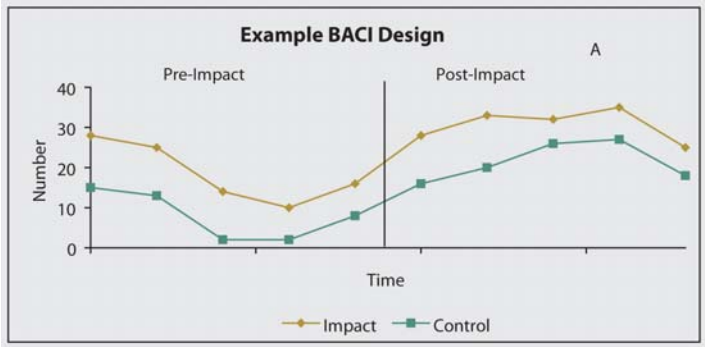
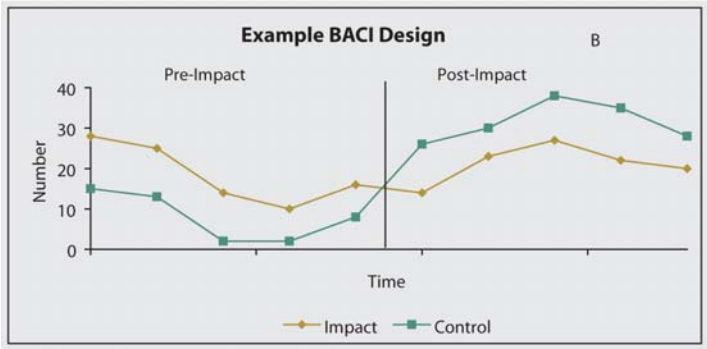
Pilot Test Impact Assessment Methodology

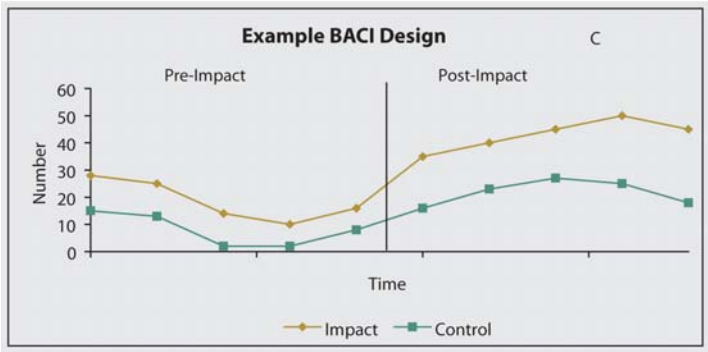
- Primary physical impacts—associated with construction, implementation, and decommissioning of the pilot test.
- Secondary impacts—associated with functioning of the pilot test on environmental resources.
  - Abiotic impacts: thermal impacts
  - Biotic impacts: other indirect types of stressors on biology at the site
- Standard ecological measures—similarity, diversity, richness, and heterogeneity
- Before-After, Control-Impact (BACI) analysis
  - Use of comparison sites (reference) as covariates to reduce extraneous sources of variability (such as seasonal effects on variable of interest)
  - Use of analysis of variance (ANOVA) to compare impact site to control site over time

Conceptual BACI Example

- Example A: Variable is seasonal. Similar variability between sites and within a site. No statistically significant impact.
- Example B: Variable is seasonal. Pattern changes post-impact. Statistically significant effect.
- Example C: Variable is seasonal. Divergence between sites, post-impact. Statistically significant effect.







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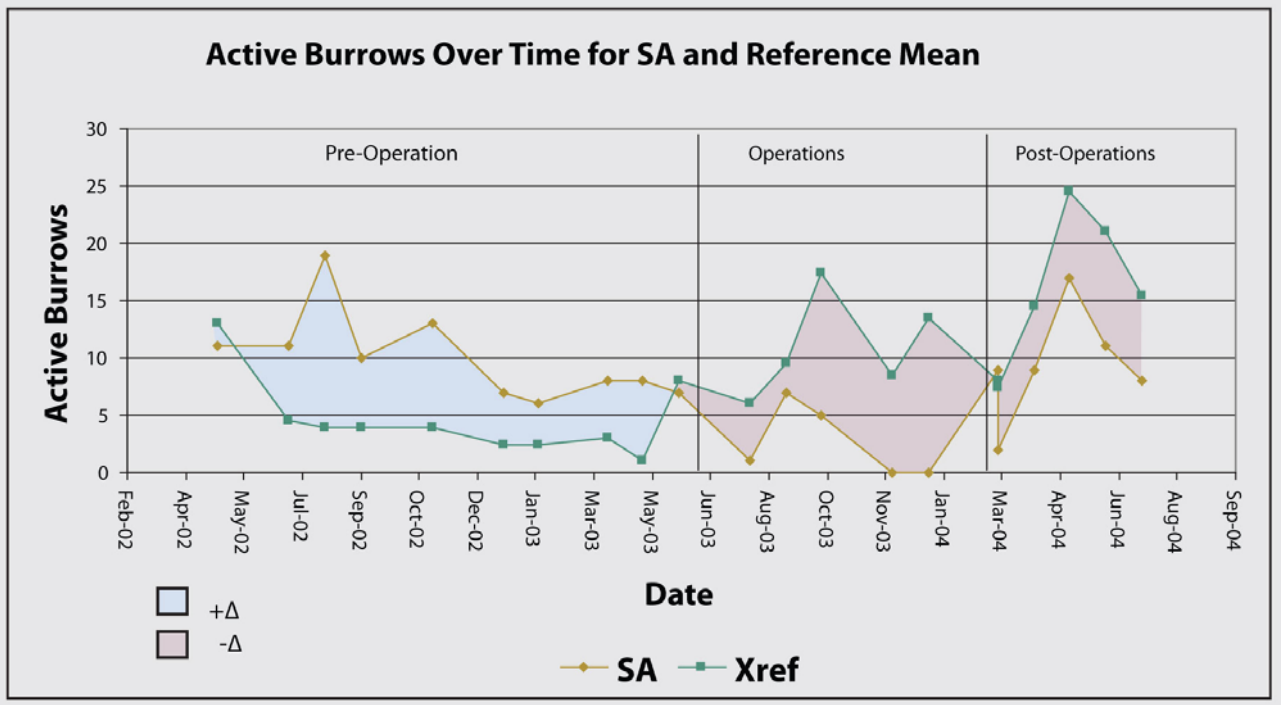
Modified BACI Design

- Case study more complicated than a simple BACI
  - Multiple reference sites and impact sites
  - Three periods: Pre-operations, Operations, Post-operations



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Pilot Test Assessment Results—Primary Impacts

- Impacts to more than half of offroad portions of site
  - Compaction of soil
  - Disturbance by equipment
- Near total loss of perennial plant species in disturbed area
- Other biological resources assumed to have similar impact since they are dependant on vegetation
- Time required to install and implement steam technology is anticipated to be more than simple excavation

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Pilot Test Assessment Results—Secondary Impacts

- Abiotic Parameters
  - Treatment zone heated to appropriate temperature
  - Near surface soil temperatures were more influenced by ambient temps than pilot test, except post-operations when extraction wells were turned off and shallow soil temps rose
  - VOC and fuel emissions were within permit conditions

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Pilot Test Assessment Results—Secondary Impacts (continued)

- Biotic Parameters
  - Vegetation: Strong seasonal component. Once variability was factored out using BACI, only marginally significant results were found. Biological significance is unknown.
  - Arthropods: Seasonal variability was slight. No statistically significant impact of pilot test found.
  - Wildlife: Seasonal variability was slight. Only variable with statistically significant difference was number of active small mammal burrows. Biological significance is unknown.

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Case Study Conclusions

- Primary Impacts: Substantial within construction boundaries
  - Area of disturbance smaller compared to excavation but duration of installation and implementation of steam technology requires more time than excavation
  - Temporal loss of habitat could result in habitat for sensitive species, wildlife and plants being unavailable for a longer period of time
- Secondary Impacts: Impacts to abiotic and biotic parameters appear to be minimal

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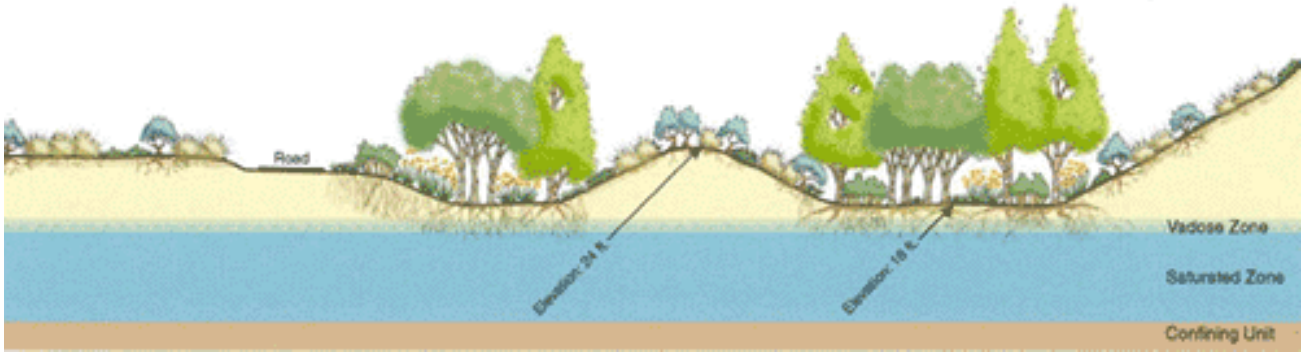
Other Examples of Remedial Option Analysis Tools

- Economic Analysis Assessment Tools: Cost-benefit framework that measures effects using dollars or an ecological metric
- Habitat Function Assessment Tools: Assesses the functions provided by a habitat before and after remediation and/or restoration
- Both tools can compare the impact of different restoration options on an area



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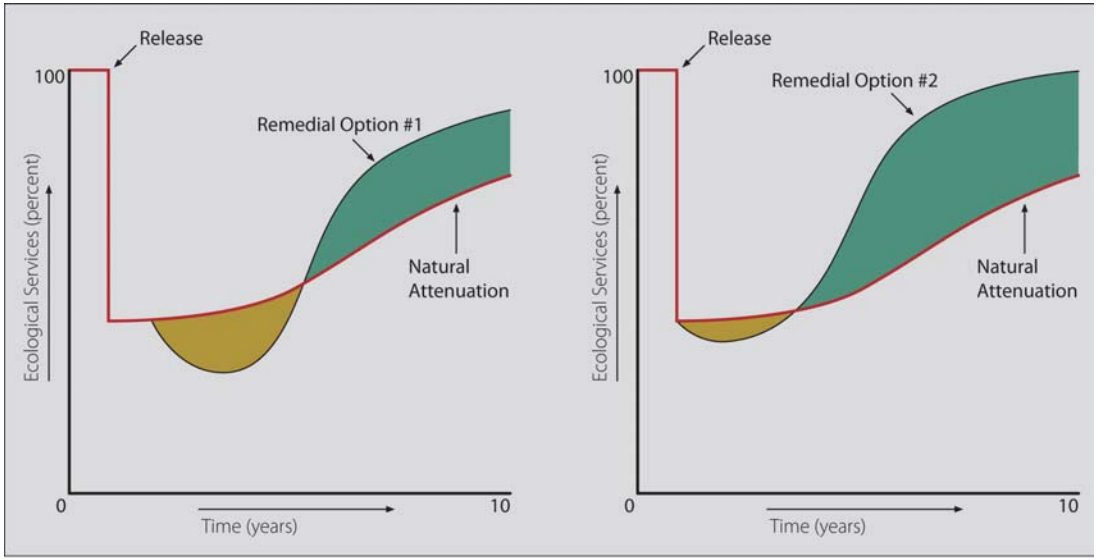
Economic Analysis Assessment Example

- Habitat Equivalency Analysis (HEA)
  - Cost-benefits comparison focuses on suite of ecological services provided by natural resources at site
  - Ecological services are beneficial outcomes of functioning ecosystem and valued people
  - Stressors that impair ecosystem functioning include contaminants and remedial impacts



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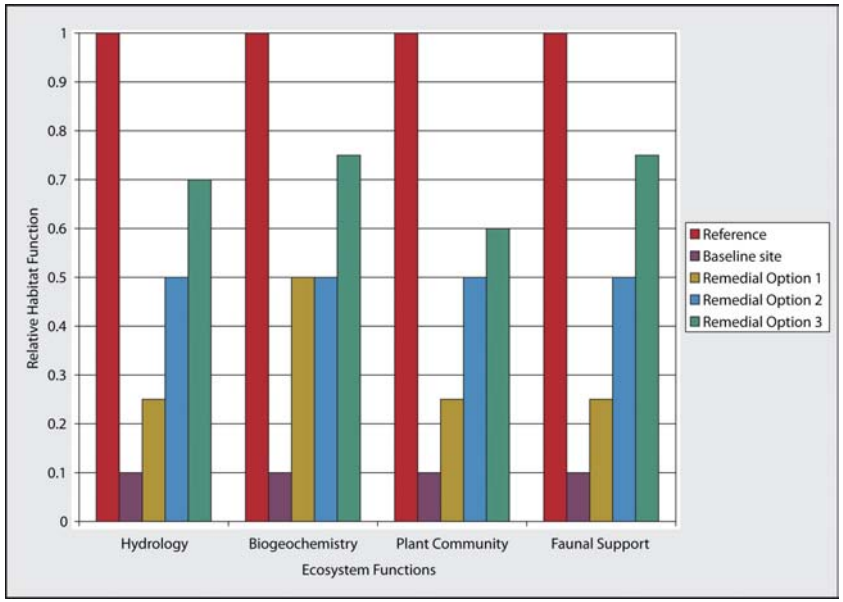
Habitat Function Assessment Example

- Modified Hydrogeomorphic Model
  - Baseline habitat function is measured at contaminated site and at non-contaminated reference location
  - Baseline assessment gauges how contaminants or other stressors impact the ecosystem functions that the site provides
  - Tool also assesses potential increases in ecosystem functions associated with different proposed remediation technologies and restoration activities



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Conclusions

- A number of different assessment tools can be used to evaluate the impacts associated with remedial technologies.
- Results of these assessments can be used by risk managers to:
  - Make decisions regarding the utility of a pilot test technology for site-wide use;
  - Compare among remedial options to identify those with lowest environmental impacts; and
  - Assess the impact of remediation plus restoration on habitat function
- Allows for informed decision making in cases where impacts of an invasive remediation technology may outweigh the benefits achieved by reducing contaminant mass.

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