An Ecological Framework for Reviewing Compensatory Mitigation: Biotic Processes in Riverine Wetlands

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1. Introduction
2. Biotic characteristics are closely linked to hydrology and soils
3. Biotic elements provide indicators of wetland health and function
4. Measuring recovery of riverine wetlands using performance standards and reference sites
5. Summary
1. Introduction
Corps’ Mitigation Regulation
33 CFR Part 332

- Use Watershed Approach
  - Involves selection of mitigation sites to help maintain and improve the quality and quantity of aquatic resources

- Consideration of what is best for the aquatic environment

- Mitigation must be directly related to the impacts and appropriate to the degree and scope of the impacts

- Survey Reference wetlands if possible to better understand hydrology, soils and dominant plants
Riverine Wetlands
Critical Biotic Characteristics of Riverine Wetlands

- Landscape Characteristics
  - Restoring Riparian Zone
- Linking Hydrology and Soils
- Site Location and Design
  - Historical conditions
  - Reference site conditions
- Performance Standards that reflect Ecosystem Services
- Flora and Fauna Monitoring Metrics
- Invasive Species Eradication or Control
Watershed Approach for Site Selection

- Restoration Nodes
- Wildlife Corridor
Consider Entire Riparian Zone

- Transitional zone between the terrestrial and aquatic ecosystems
- Hydrology is driven by the flood-pulse concept
- Vegetation is adapted to flooding (pulse) events and dry down

Sources: Gregory et al. 1991, Junk et al. 1989
Riparian Zone Structure

- Aquatic organisms live in all zones from the phreatic zone to the water column.
- Wetted channel contains water year-round.
- Active channel is usually flooded at least once each year.
- Roots of trees growing in the riparian zone often draw water from groundwater.
- Water flows from river channels into groundwater and from groundwater into river channels.
2. Linking Biotic Factors to Hydrology

- Climate varies throughout US
- Hydrology driven by climate
- Elevation and stream gradient vary
  - Mountains
  - Coastal plain
  - Deserts
- Consider plant adaptations to climate, hydrology, elevation, and soil type when designing mitigation
- Site selection and restoration design based on these factors
Variable Discharge due to Climate

- Temperate Climate
  - Little interannual variation in flow

- Semi-arid Climate
  - Large interannual variation in flow—flood/drought cycles

Mountain Stream

Desert Stream
Stream Gradient

High-gradient Mountain stream
Riverine Wetlands along Large Rivers on East Coast

Chattahoochee River, Georgia

Large Arid Rivers

Colorado River
Montane Riverine Wetland

Truckee River
Small Coastal Streams
Riverine Wetlands along Dynamic Mediterranean-type Climate Rivers affected by:
- Floods
- Fires
- Drought
- Invasion
Important Stressors & Adaptations

- Low light availability
  - Shade-tolerance
  - Larger leaves

- Fluctuation in groundwater levels
  - *Phreatophytes =* water loving
  - Develop deep root systems to search for deeper water in hot, dry summer
  - Adapted to flood disturbance – spread propagules
  - Tolerate infrequent inundation
Horizontal Zonation Relates to Hydrology

- Monitor vegetation along cross section

Diagram showing different vegetation zones:
- Mixed Riparian
- Cottonwood
- Valley Oak

Legend:
- Winter water table
- Summer water table
3. Biotic Elements Provide Indicators of Wetland Health and Function
Scientific–Based Approach

- Historic conditions (with uncertainty)
- Indicator condition (e.g., cold-water fish assemblage)
- Un-recoverable damage
- Restoration Potential
- Current conditions

Time: 1800, 1850, 1900, 1950, 2000, 2050, 2100

Socio-economic / policy choices

SFEI 2005
Biotic Monitoring Metrics

- **Flora**
  - Survivorship
  - Percent cover
  - Native vs. Nonnative
  - Species diversity
  - Structure
  - Health

- **Fauna**
  - Presence
  - Species diversity
Riparian Vegetation Structure

- Multiple layers or strata
  - Trees (canopy)
  - Shrubs (understory)
  - Vines (woody and herbaceous)
  - Herbaceous plants (forbs)
  - Grasses
Riparian Zone Structure
Percent Cover of medium and high strata increasing in restoration sites over 5 years
What about other Metrics like Health?

Figure 15. Mean percent of leaves that are colored, fallen, or have evidence of herbivory for Salix laevigata.
Monitoring Riparian Dependent & Special Status Wildlife

Western Pond Turtle
(*Actinemys marmorata*)

Riparian Brush Rabbit
(*Sylvilagus bachmani riparius*)
Fencing Experiment for Deer Browsing

Mean Height

Mean Change in Height (cm)

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<th>Growing Season</th>
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<th>Fenced</th>
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Mean Canopy Diameter

Mean Change in Canopy Diameter (cm)

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Wildlife Camera Trapping

- Remote motion and heat sensor cameras
- Duration: 8 months (May-December 2013)
- Photo documentation of deer browsing on willows
- Highest frequency of deer visits during months of May, July and December
Mean Number of Dear Visits per Day at Redwood Creek
May 2013 - December 2013
USACE 2015 Mitigation and Monitoring Guidelines

Performance Standard Categories
- Physical Structure
- Hydrology
- Flora
- Fauna
- Water Quality

Riparian Wetland Ecosystem Services
- Flood Storage and Protection
- Improving Water Quality
- Biodiversity
- Wildlife Corridor
- Groundwater Recharge
- Recreation
- Cultural and Aesthetic Resources
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<th>WET</th>
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(Mecke 2018)
# Recommendations

**Permittee-Responsible Riparian Restoration Projects in the Central Valley of California:**

<table>
<thead>
<tr>
<th>Performance Standard Category</th>
<th>Assessment Method</th>
<th>Function</th>
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<tbody>
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<td>Physical structure</td>
<td>CRAM</td>
<td>Structural patch richness</td>
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<tr>
<td>Hydrology</td>
<td>HGM</td>
<td>Flood protection and energy dissipation</td>
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<td>Flora</td>
<td>CRAM</td>
<td>Plant community</td>
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<td>Fauna</td>
<td>WET</td>
<td>Wildlife abundance and diversity</td>
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<td>Water quality</td>
<td>WET/HGM</td>
<td>Sediment stabilization/retention of particles</td>
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Developing Performance Standards based on Hydrology & Soil Conditions

Sandy loam soil

Clay loam soil

Figure 1. Mean soil moisture for the three experimental treatments. Measurements were taken on the north and south side of each plant using a TDR 300 field scout with 20cm probes.

Figure 2. Mean plant height for all species in the three experimental treatments. The non-irrigated treatment on the East country property has the highest mean plant height.

Figure 3. Mean percent cover for all species in the three experimental treatments. The non-irrigated treatment at the Taylor property has the highest mean percent cover.
Describes the development pathway of an ecosystem through time.

1. Reclamation
   Partial restoration of specific, not all, functions of the original ecosystem (e.g., constructing a trapezoidal pond for groundwater regeneration; potential natural recruitment of wetland vegetation).

2. Rehabilitation
   Partial restoration of underlying natural processes to produce a cascading beneficial effect of restoring ecosystem function which result in improved ecosystem structure (e.g., constructing a pond for groundwater regeneration planted with wetland vegetation and LWD for multiple species habitat and nutrient cycling).

3. Restoration
   Full restoration of ecosystem function and structure to the original state.
Comparing Restoration to Reference & Control Sites
Choosing Reference Sites

- Use to develop Plant Palette and compare to recovery of restoration site over time
- If possible find at least one or more
- Most similar hydrology, gradient, and geomorphology
- Least impacted by humans
- Data sharing
Using Historical Maps, Photos, and Records as Reference Conditions (SFEI 2011)
Reconstruct Historical Ecology of Rivers & Riverine Wetlands

- Mediterranean-climate
- Dynamic hydrology
- Braided channels
- Intermittent reaches
- Riparian vegetation shaped by episodic flooding disturbance regime

Fairchild 1934 (courtesy of UCLA)
5. Reviewing Compensatory Mitigation & Monitoring Plans

- Linking Revegetation to Hydrology and Soils
- Relate Timing of Planting to Climate
- Consideration of Reference Site Conditions when designing projects (Van den Bosch and Matthews 2017)
- Performance Standards should be
  - Easily measurable
  - Robust – not just plant survivorship and % cover
  - Linked to ecosystem services
  - Use Assessment methods like HGM, WET and California Rapid Assessment Method
- Develop interim standards for monitoring to ensure restoration is on the right trajectory (Matthews and Endress 2008)
Questions?
Active Revegetation

- Types of propagation
  - Pole cuttings of trees and shrubs - easy and cost effective
  - Grow from seeds
  - Divisions of perennial herbs and grasses with rhizomes
  - Direct seeding
How to Select Irrigation?

- Drip system
- Water truck
- Driwater
- Natural
Sometimes You Get Lucky with Passive Restoration

Roots grow up to 5cm a day!