Evolution of Riparian and Floodplain Restoration Design on Several Western Montana Rivers

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Introduction

Topics covered:

- Definition of riparian and floodplain restoration
- Floodplain attributes as a basis for developing criteria for restoration designs
- Evolution of floodplain restoration design approach
- Floodplain restoration planning for the Upper Clark Fork River—example of design criteria
Definitions

Riparian and floodplain restoration – Creating conditions that will sustain *natural processes* and support *floodplain functions*
Floodplain Attributes

The following floodplains attributes reflect how we think about natural processes and floodplain functions to support designing floodplain restoration projects.
Floodplain Attributes

- Disturbance regime
- Hydrologic connectivity
- Nutrient transport and storage
- Substrate
- Topographic diversity
- Biological interactions
- Light regime
Disturbance Regime

- Frequent, low-intensity disturbances such as livestock grazing, haying, and weed control prevent plant communities from progressing to later successional stages.
Initially, we were designing restoration treatments to address the existing static condition based on a modified disturbance regime.

Our response was to address the local symptoms of this modified disturbance regime:

- restore organic matter,
- limit weed competition and
- facilitate establishing native woody riparian vegetation in the floodplain
- no modification of topography or substrate
Addressing symptoms of modified disturbance regime—Jocko River

Experimental treatments addressed soil moisture, temperature, and competition from other plants
Species responses to treatments

Total Survival by Species for Each Treatment (N=794)

BP = Black plastic, woven polyethylene fabric
CM = Cardboard with wood mulch
CO = Control, 3 feet square brush blanket
MO = Wood mulch only
**Species responses to treatments**

Total Growth Metric by Species for Each Treatment (N=794)

BP = Black plastic, woven polyethylene fabric
CM = Cardboard with wood mulch
CO = Control, 3 feet square brush blanket
MO = Wood mulch only
Evolution of Design—Disturbance Related

- Cease the unnatural disturbance regime
- Restore a more natural disturbance regime and simulate the conditions that would naturally result until the disturbance processes have time to create a full range of ecological niches
Disturbance Regime

- Natural disturbance creates a set of conditions that can be evaluated and copied as part of restoration designs.
- Riparian structure and function rely on natural disturbance regimes – i.e. scour and deposition during floods creates surfaces where cottonwood and willow seedlings can establish.
Hydrologic Connectivity

- Floodplain surface connected at frequent flood return intervals—incorporate full range of hydrogeomorphic features (e.g. oxbows, etc.)
- Topographic heterogeneity (uneven surface) to create diverse hydrology
- Timing of hydrology linked to life histories
Hydrologic Connectivity—Jocko River

- Constructed connected floodplain surface in the former channel location
- Used ‘berms’ to maintain stability
- Revised later designs to allow more free flowing connectivity in the floodplain without ‘berms’
Hydrologic Connectivity

- Pre-construction (left) – confined, disconnected channel
- Post-construction (right) – connected channel and floodplain with floodplain side channels
Key Components of the Cottonwood Recruitment Box (Stewart Rood):

- Timing of the receding limb of the hydrograph after peak flow corresponds with the release of cottonwood seed (June to end of July)
- Flood flow recession exposes streambanks that are between 60 and 150 cm above base flow elevation at the time of cottonwood seed release (generally within 50 meters of the stream edge)
- Maximum stage decline of approximately 1 inch (2.5 cm) per day
- Capillary fringe of approximately 30 to 60 cm
Hydrograph of the Clark Fork River showing the cottonwood recruitment box described by Rood
Influenced by:

- Hydrologic connectivity – floods
- Topography – depressions create sinks where organic materials are trapped and decay over time releasing nutrients into the soils
- Denitrification – Anaerobic conditions, bacteria convert nitrate (NO₃) to atmospheric nitrogen (N₂)
Nutrient Transport and Storage

Floodplain wetlands act as sinks to hold nutrients and organic inputs.

Overbank flows deposit organic material.

Nutrient transport with sediment deposition.
Substrate

Influenced by:

- Sediment transport (scour and deposition)
- Beaver dams—trap fine textured sediments
- Wetlands—accumulate organic matter and support peat development
- Geomorphic position, hydraulic force, and surface roughness are correlated with substrate size and distribution throughout the floodplain
Substrate

Typical floodplain substrate distribution
Substrate

Variable substrate throughout floodplain

Fine textured soil in protected floodplain swales

Coarse alluvium (cobble/gravel) on depositional features
Substrate
Revegetation Plan – substrate depth and texture

CFR3 Soil Staging Estimates

January 2009 Grading Plan Revision
Topographic Heterogeneity

Low

Flat constructed floodplain surface planted with a large number of small size container stock

High

Constructed floodplain swales provide microsites and moisture retention for larger sized planted container stock
Topographic Heterogeneity

Constructed floodplain swales increase topographic diversity
Topographic Heterogeneity

- Micro-topography promotes natural recruitment by trapping seed and protecting seedlings
- Placed large woody debris augments organic content and creates protected microsites
Topographic Heterogeneity

Milltown Revegetation Plan: Comparison of Existing Ground to Design Bankfull Elevation
Bonner, Montana
Topography + Substrate + Hydrology

CFR3 Conceptual Cover Types with Relative Elevation

January 2009 Grading Plan Revision
Biological Interactions

Influenced by:

- Herbivory
- Competition from weeds and invasive plants
- Plant communities’ ability to moderate their environment
- Presence and quality of seed bank
Biological Interactions

Beaver herbivory

Wildlife browse (herbivory) and competition from noxious weed species
Influenced by:

- Shade – woody vegetation canopy cover
- Patches – openings in the woody vegetation canopy structure (trees and shrubs)
Light Regime

Shrubs growing in shade near mature forest

Weedy species common in open floodplain further from mature forest
Attributes of Floodplains

- Disturbance regime
- Hydrologic connectivity
- Nutrient transport and storage
- Substrate
- Topographic diversity
- Biological interactions
- Light regime
Revegetation Treatments

Hydrologically connected floodplain

Microtopography and woody debris placement

Mature shrub salvage and transplant

Browse protection
Purpose—Reconnect floodplain to support self-sustaining, dynamic mosaic of native riparian plant communities.

Design components include:

- Remove tailings that have raised and disconnected the floodplain from Clark Fork River hydrology
- Reconstruct the floodplain including diverse geomorphic features with varied elevations, wetlands, plant communities, side channels, oxbows, and micro-topography
Design Revegetation Cover Types

- Exposed depositional
- Colonizing depositional
- Riparian wetland
- Floodplain riparian shrub
- Outer bank riparian shrub
- Emergent wetland
Revegetation Design

Design plan view of revegetation cover type layout in the floodplain
Revegetation Design Criteria

For each Cover Type identify the following criteria:

- **Geomorphic feature**: location of the cover type within the floodplain
- **Flood dynamic**: anticipated return interval for overbank flooding
- **Distance to groundwater**
- **Elevation**: relative to the two-year flood return interval
- **Soil texture**: range of textures that can support desired plant communities
- **Soil depth**: over alluvium
- **Target ecological types**: reference plant communities
<table>
<thead>
<tr>
<th>Colonizing Depositional Cover Type</th>
<th></th>
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<tbody>
<tr>
<td><strong>Geomorphic feature</strong></td>
<td>bankfull channel</td>
</tr>
<tr>
<td><strong>Flood dynamic</strong></td>
<td>1 to 2 year return flow</td>
</tr>
<tr>
<td><strong>Distance to groundwater</strong></td>
<td>0 to 3 ft</td>
</tr>
<tr>
<td><strong>Elevation</strong></td>
<td>At or 1 ft below 2 yr flow stage</td>
</tr>
<tr>
<td><strong>Soil texture</strong></td>
<td>Sandy loam to coarse gravel/cobble</td>
</tr>
<tr>
<td><strong>Soil depth</strong></td>
<td>0 inches over alluvium</td>
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<tr>
<td><strong>Target ecological type</strong></td>
<td>Sandbar willow community type</td>
</tr>
<tr>
<td>Riparian Wetland Cover Type</td>
<td></td>
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<tr>
<td>----------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Geomorphic feature</td>
<td>bankfull floodplain, connected wetlands, oxbows, side channels</td>
</tr>
<tr>
<td>Flood dynamic</td>
<td>1 to 3 year return flow</td>
</tr>
<tr>
<td>Distance to groundwater</td>
<td>0 to 3 ft</td>
</tr>
<tr>
<td>Elevation</td>
<td>At or 2.5 ft below 2 yr flow stage</td>
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<tr>
<td>Soil texture</td>
<td>Silt to sandy loam overlaying alluvium</td>
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<tr>
<td>Soil depth</td>
<td>12 inches over alluvium</td>
</tr>
<tr>
<td>Target ecological type</td>
<td>Willow/herbaceous habitat types</td>
</tr>
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Floodplain Design

Design cross-section of revegetation cover type layout in the floodplain