Natural Disturbances Affecting Riparian Vegetation in Forested Landscapes

Joe R. McBride, University of California, Berkeley and Richard R. Harris, Northern California Society of American Foresters
Presentation Outline

• Definition of terms
• Characteristics of streams and the riparian environment
• Riparian communities in forested landscapes
• Natural disturbances and vegetation responses to disturbances
• Human effects on natural disturbance regimes
• Implications for active management
Terms

• Riparian = area adjacent to a river or stream
• Riparian zone = area influenced by water moving into or out of the river or stream
• Riparian woodland/forest = woodland/forest growing in the riparian zone
Riparian Zone
Riparian Zones

Dry Creek, Sonoma County

Battle Creek, Tehama County

Riparian Zone in Conifer Forest
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Characteristics of Streams

- Topography
- Channel Cross Section
- Stream Gradient
- Meander Patterns
- Riffle Pool Sequences
Terminology of the Cross Section

- Flood Plain
- Levee
- Escarpment
- Stream
- Gravel bar
Stream Gradient

Steepness of the stream surface

% slope (gradient) = \frac{\text{rise}}{\text{reach}}
Stream Gradient

Strawberry Creek in:
Strawberry Canyon = 9%

Berkeley Campus = 3%
Meander Patterns
Ripple-Pool Sequence

Photo: www.fisheries.org
Riffle-Pool Sequence in Streams
The Roles of Geomorphology and Hydrology in Structuring Riparian Communities
Variation in Channel Cross Section

Headwaters

Lower Reach
Variation in Channel Cross Section

- Riparian Zone
- Headwaters
- Riparian Zone
- Lower Reach
Characteristics of the Riparian Environment*

- Depth to water table
- Inundation
- Scouring
- Nutrient concentration
- Dissolved oxygen

*from a plants point of view
Environmental Gradients

- Water Table
- Inundation
- Scouring
- Nutrients
- Aeration
Water Table = zone of water saturation in the soil

Depth = increases with distance above the water surface in a stream
Influent Stream = water table is fed by upland drainage; higher away from the stream.
Depth to Water Table

Effluent Stream = water table is fed by the stream; (losing) drops away from the stream
Root Growth Potential Study
Duration of Inundation

Inundation

- Period of time a location in the stream channel or adjacent landscape is under water

+ During periods of inundation the oxygen in the soil (and gravel) is expelled
Seasonal Inundation

April

Dry Creek - Sonoma County

September
Willow

Partially Submerged Willow

Aerenchyma
Scouring

Physical abrasion caused by the movement of sand and gravel
Scouring Stream

Photo: travelpanamablog.com
Scouring of Willows ("training")
## Wood Characteristics

<table>
<thead>
<tr>
<th>Tree Species</th>
<th>Specific Gravity*</th>
<th>Modulus of Elasticity**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak</td>
<td>0.68</td>
<td>17</td>
</tr>
<tr>
<td>Willow</td>
<td>0.39</td>
<td>10</td>
</tr>
</tbody>
</table>

(*gm/cm; **psi)
Nutrient Concentration

The concentration of available nutrients increases with distance from the stream.
Variation in particle size

Raymondskill Creek - Pennsylvania
(photo from Ammodramus)
Variation in Phosphorus Concentration

Raymondskill Creek - Pennsylvania

*photo from Ammodramus*
# Transpiration Rates

<table>
<thead>
<tr>
<th>Species</th>
<th>Transpiration (gal/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood</td>
<td>25</td>
</tr>
<tr>
<td>Willow</td>
<td>13</td>
</tr>
<tr>
<td>Valley Oak</td>
<td>4</td>
</tr>
</tbody>
</table>

*Based heat flux measurements in 10” dbh trees*
Aeration

Incorporation of oxygen into stream water.
Stream Aeration
Dissolved Oxygen

Riffle-Pool Sequence in Streams
Pattern of Willows and Alders along Dry Creek, Sonoma County
Factors Controlling Seedling Establishment in the Riparian Zone

- Seed supply
- Seed bed condition
  - Moisture
  - Oxygen
Seasonal pattern of Seed Production
(Stella et al, 2006)

<table>
<thead>
<tr>
<th>Species</th>
<th>Peak Seed Release Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fremont Cottonwood</td>
<td>May 1, June 15, July 15, August 1</td>
</tr>
</tbody>
</table>
Seed Bed Condition

Gravel Bar

Water Table

Capillary Fringe

Stream
Seed Bed Condition

Gravel Bar

Too Dry

Water Table

Capillary Fringe

Stream

Too Wet
Recruitment Box Model
(Mahoney and Rood, 1998)

Stream Hydrograph

Potential Recruitment Band

Seed Release

March       April        May        June        July         August
Questions?
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Riparian Communities in California

• Coastal Riparian Forests
• Intermountain Riparian Forests
• Southern California Riparian Forests
• Sierra Nevada forests
  – East side
  – West side
Coastal Riparian Forests

Common Species
Red alder
Redwood
California bay

Environmental Factors
High annual precipitation
Mild temperatures
Summer fog
Sedimentary rock

Example Stream
Casper Creek (Mendocino County)
Intermountain Riparian Forests

Common Species
- Fremont cottonwood
- Red Osier dogwood
- Sitka willow

Environmental Factors
- High annual precipitation
- Warm summers; cold winters
- Igneous/metamorphic rock

Example Stream
- Salmon River (Siskiyou County)
Sierra Nevada Riparian Forests
West Side

Common Species
Fremont cottonwood
Mountain alder
Pacific dogwood
Incense cedar
Red willow

Environmental Factors
Moderate annual precipitation
Snow melt runoff
Hot summer; cold winters
Granitic rock

Example Stream
Middle Fork Feather River (Plumas County)
Sierra Nevada Riparian Forest
East Side

Common Species
Western black cottonwood
Aspen
Water birch
Yellow willow

Environmental Factors
Moderate annual precipitation
Snow melt runoff
Hot summer; very cold winters
Granitic rock

Example Stream
Middle Fork Feather River (Plumas County)
Southern California Riparian Forest

Common Species
Western black cottonwood
Western sycamore
White alder
Willows

Environmental Factors
Low annual precipitation
Hot summer; mild winters
Sedimentary/ granitic rock

Example Stream
Santa Ana River
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Natural Disturbances

- Flooding
- Land sliding/debris flows
- Wild fire
- Wind throw
Flooding
Impact of Flooding on Environmental Gradients

Water Table

Inundation

Scouring

Nutrients

Aeration
Inundation/Aeration

Mud lines – Navarro River

Silt Deposits - Bull Creek Flat
Scouring

Redwoods fallen into stream
Scouring/Stream Meandering

Bull Creek - Humboldt Redwood State Park
Human Effects on Flooding

<table>
<thead>
<tr>
<th>Flood Reduction</th>
<th>Flood Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam Construction</td>
<td>Logging</td>
</tr>
<tr>
<td>Storm water retention projects</td>
<td>Agriculture</td>
</tr>
<tr>
<td></td>
<td>Urbanization</td>
</tr>
</tbody>
</table>
Landslides/Debris flows
Types of Landslides/Debris Flows

1. Rock Fall
2. Rock Slide
3. Slump
4. Flow
5. Complex
Impact of Landslide/Debris Flows on Environmental Gradients

- Water Table
- Inundation
- Scouring
- Nutrients
- Aeration
Effects of Landslides/Debris Flows on Riparian Vegetation

Cascades Range, Oregon
(photo by Gordon Grant)
Historic Landslides

Jackson Demonstration State Forest
<table>
<thead>
<tr>
<th>Reduce occurrence</th>
<th>Increase occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dewatering slopes</td>
<td>Logging</td>
</tr>
<tr>
<td>Retaining walls</td>
<td>Road building</td>
</tr>
<tr>
<td>Armoring stream banks</td>
<td></td>
</tr>
</tbody>
</table>
Logging

Cascade Range, Oregon
Road Building

Willamette National Forest – Oregon

Lolo National Forest - Montana
Effects of Slope and Channel Instability on Riparian Vegetation

Alder stands on 1964 age debris flow deposits, French Pete Creek, Oregon (photo by Gordon Grant)
Wild Fire
Impacts and Responses of Riparian Vegetation to Wildfires

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant mortality</td>
<td>Seedling establishment</td>
</tr>
<tr>
<td>Loss of canopy</td>
<td>Sprouting</td>
</tr>
<tr>
<td>Shift in species composition</td>
<td>Recruitment of large woody debris</td>
</tr>
</tbody>
</table>
Independence Fire Study
(Kobziar and McBride, 2006)
Variation in Response to Burning
**Independence Fire Study: Response to Burning**

<table>
<thead>
<tr>
<th>Species</th>
<th>Sprouting (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arroyo willow</td>
<td>30</td>
</tr>
<tr>
<td>Bitter Cherry</td>
<td>50</td>
</tr>
<tr>
<td>Douglas spirea</td>
<td>100</td>
</tr>
<tr>
<td>Mountain alder</td>
<td>30</td>
</tr>
<tr>
<td>Pacific dogwood</td>
<td>30</td>
</tr>
<tr>
<td>Red osier dogwood</td>
<td>50</td>
</tr>
<tr>
<td>Thimbleberry</td>
<td>100</td>
</tr>
<tr>
<td>Twinberry</td>
<td>65</td>
</tr>
<tr>
<td>Incense cedar</td>
<td>0</td>
</tr>
<tr>
<td>White fir</td>
<td>0</td>
</tr>
</tbody>
</table>
Fire Scar Dating
Deer Creek Study

(Russell and McBride, 2001)

- Canopy Cover (%)
- Basal area (ft²/ac)
  - Conifers
  - Hardwoods
- Seedlings (#/ac)
- Saplings (#/ac)

Time Since Last Fire
Recovery of herbaceous, aspen and willow in the Angora Creek floodplain one month after the Angora fire.
Natural wind throw, intermittent stream, Oregon Cascades
Factors Effecting Wind Throw in Riparian Forests

- Channel and floodplain width
- Wind funneling by topography
- Soil saturation
- Tree species
Channel and Floodplain Width
Wind Funneling by Topography
Wind Funneling by Topography at The Sea Ranch

Identification of Areas of High Windthrow Potential at the Sea Ranch

Joe R. McBride

Soil Saturation

Dry

Wet
Tree Species

Tree Characteristics Associated with Wind Throw and Breakage

1. Root System Form
   - Douglas-fir: Bad
   - Grand Fir: Good
   - Overall: Good

2. Weak wood
   - Douglas-fir: Good
   - Grand Fir: Bad
   - Overall: Bad

3. Height
   - Both species: Good
   - Overall: Good

4. Live crown ratio
   - Both species: Bad
   - Overall: Bad
Human Effects on Windthrow

Reduce Potential
Road location

Increase Potential
Logging
Road building
Selected References


END