Analysis of Riparian Cottonwood Recruitment Potential under Alternative Flow Scenarios in a Restored Reach of the Provo River, Utah

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Central Utah Water Conservancy District
Introduction
Provo River Flow Study

Purpose and Need

• address previous Bonneville Unit Environmental Commitments (CUPCA)
• Utah Lake System (ULS) NEPA analysis

Objective

• provide tools to analyze effects of alternative flow regimes on ecological components of the Provo River system
  – aquatic habitat
  – channel processes
  – sediment transport
  – riparian vegetation
  – water quality
  – recreational usability
Introduction
Riparian Recruitment Model

Objectives

• assess alternative flow regimes
• evaluate effects of restoration designs
• develop flow recommendations to maximize riparian recruitment in restored reaches

Introduction
Importance of Riparian Vegetation to Aquatic Habitat

• instream cover
  – woody debris
  – roots/overhanging banks
• habitat complexity
  – velocity refuges
  – scour holes at log jams
• size of bed material
Introduction

Importance of Riparian Vegetation to Aquatic Habitat

- water quality
  - temperature
  - DO
  - nutrients
- channel morphology
  - bar deposits
  - bank strength

Schematic illustration of major interactions among riverine resources and processes.
Introduction

Why Model Cottonwood Recruitment?

- dominant native riparian tree in intermountain/semi-arid west
  - shade
  - large woody debris
- recruitment success dependent upon fluvial surfaces, flows
  - good “indicator” for ecosystem health
  - good “indicator” for restoration success

- abundance & age diversity reduced on altered systems
  - channel straightening/levees
  - dams/diversions
- body of research exists outlining recruitment criteria
Introduction

General Requirements for Seed-based Reproduction *(Scott et al., 1993)*

- presence of moist, bare surface with fresh sediment at time of seed dispersal
- transport and deposition of seeds onto the surface
- post-germination decline in water levels at a rate slow enough that seedlings do not desiccate
- absence of post-germination floods that would scour seedlings
Channel Straightening & Levee Construction
- loss of floodplain area
- steep banks
  - rapid stage decline

Dam-Altered Hydrology
- lower magnitude of peak
- shorter duration of high flows
- steeper rate of decline

Provo River Hydrographs
Water Year 2000

Study Area
Study Area

- approx. 3 miles below Jordanelle Dam
- 3000-foot long reach
- restoration of channel and floodplain completed in fall 2001

Before

After
Methods

Digital Terrain Model (DTM)
• detailed topographic surveying (total station)
• 3D orthophoto interpretation (May 2003 photography)
• result is topographic “mesh” with 250,000 nodes (1 sq. m each)

Methods

Hydrodynamics Model
• substrate and riparian mapping for roughness parameters
• field-surveys of water surface profiles at different discharges to calibrate roughness
• 2-D hydrodynamics & ground water model (River2D)
  – water depth (positive value = inundated; negative value = below ground surface)
  – velocity
• outputs for each node in mesh for given flow
Methods
Recruitment Model Criteria

• node must be wetted and then exposed within seed dispersal window
  – May 30 to July 19

• within 10 days of being wetted, soil surface at node remains moist and viable for germination
  – groundwater level has not dropped below capillary fringe (20 cm)

Methods
Recruitment Model Criteria

• recession rate not greater than 2.5 cm (1 inch) per day (5-day moving avg)
• final groundwater elevation at end of run (July 31) not more than 1 meter below ground surface
• node is not re-wetted after seed dispersal window
Methods

Model Input/Output

• input is May 1- July 31 hydrograph (92 daily flows)
• for each node, model tracks recruitment success
  – node becomes “live” if meets initial criteria
  – node “dies” if all criteria are not met (recession rate, etc.)
  – node “resets” if re-inundated during seeding window
• final output is total number of “live” nodes at end of model run
• also can output video (*.avi file)

Methods

Model Verification

• field-mapped inundated areas during June, 2003 flood (1,400 cfs)
• field visit in August 2003 to identify areas with live seedlings
• adjusted model parameters (capillary fringe, recession rate, etc.) to match observations
Disclaimers

- model only relevant for seed-based reproduction
  - cottonwoods also reproduce vegetatively
- model only runs for one growing season
  - nodes that are “live” could be scoured by next year’s flood
- model does not account for all criteria
  - antecedent moisture conditions
  - alternative water sources (rainfall, groundwater seeps)
  - variability in soil types
  - variability in seed supply
  - existing plant cover
- model is a tool only
13 Historic Springtime Hydrographs

Discharge (cfs)

1-May 16-May 31-May 15-Jun 30-Jun 15-Jul 30-Jul

Historic Springtime Hydrographs

1950 2000

Discharge (cfs)

0 200 400 600 800 1000 1200 1400 1600 1800

1-May 16-May 31-May 15-Jun 30-Jun 15-Jul 30-Jul
- peak flow = 1570 cfs
- slow receding limb rate
- total AF = 171,632
- 49% more recruitment with 7% more flow

- peak flow = 1280 cfs
- faster receding limb rate
- total AF = 159,675

Historic Springtime Hydrographs

Discharge (cfs)
1-May 16-May 31-May 15-Jun 30-Jun 15-Jul 30-Jul

1993 1999
1993

- peak flow = 2,210 cfs (1,930 cfs)
- peaks before seeding window
- August re-wetting (red death)
- total AF = 237,818

1999

- peak flow = 2,110 cfs
- faster receding limb rate
- higher baseflow
- total AF = 248,747
- 25% more recruitment with 4% more water
Recommended Rates of Decline for Successful Riparian Recruitment

- 125 cfs/day between 2300 and 1800
- 45-80 cfs/day between 1800 and 1600
- 25-40 cfs/day between 1600 and 1400
- 15-40 cfs/day between 1400 and 1200
- 15-60 cfs/day between 1200 and 1000
- 40-60 cfs/day between 1000 and 800
- 60 cfs/day between 800 and 400
- 15 cfs/day between 400 and 300
- 50 cfs/day between 300 and 125
Cottonwood Recruitment Flow Recommendations
1999 Hydrographs

<table>
<thead>
<tr>
<th>1999 Hydrograph</th>
<th>Charleston Historic</th>
<th>“Improved Flows”</th>
<th>“Maximized Flows”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual ac-ft</td>
<td>248,747</td>
<td>242,336 (-3%)</td>
<td>299,837 (+21%)</td>
</tr>
<tr>
<td>May 1 - July 31 ac-ft</td>
<td>125,780</td>
<td>119,369</td>
<td>176,870</td>
</tr>
<tr>
<td>Recruitment Success</td>
<td>21,518 m²</td>
<td>26,495 m² (+23%)</td>
<td>26,628 m² (+24%)</td>
</tr>
</tbody>
</table>
**How Often is Recruitment Possible?**

- Recruitment requires about 220,000 to 235,000 AF annually.

- Over the modeled 50-year POR, 220,000 AF is delivered to Deer Creek from Jordanelle in 12 years (about 1 in 4 years); 235,000 AF occurred 7 years (about 1 in 7 years).

- Recruitment occurred naturally about 1 in 7 years on Provo River.

**Final Thoughts**

**Restoration on regulated rivers**

- don’t forget streamflow
  - projects often emphasize structure but don’t address process
Final Thoughts

**Restoration on regulated rivers**

• flow recommendations need to be more than a single number
  – single “target peak” does not account for variables important for recruitment (i.e. timing, duration, recession rate)

• increased cottonwood recruitment success does not necessarily mean more water