Quantifying Ecologic Benefits of Floodplain Projects

American Rivers
-and-
Katie Jagt, PE
Consulting Engineer to American Rivers
Yolo Bypass Fishery Enhancement Planning Team
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EAH: A New Tool for Quantifying Floodplain Habitat Benefits and Impacts

- Evaluate different scenarios for modifying bypass or weir
- Quantifying frequently inundated floodplain habitat for fish and wildlife species
- Quantify frequency of inundation events harmful to waterfowl or their foraging habitat
- Quantify frequency of inundation events harmful to agriculture or production
- Quantify frequency of inundation events harmful to recreational activities or other management objectives
Goals for the metric

• Useful both as a screening and design tool.

• Adapted to measure habitat/benefit for a variety of species/objectives.

• Easily applied by any agency or consultant that uses standard tools and available data.

• Transparent and replicable i.e. not subject to distortion by hidden assumptions, qualitative indices, or weighting factors.
Ecosystem Variables

Physical
• Area
  ✓ depth
  ✓ velocity
  ✓ cover
  ✓ vegetation
  ✓ connectivity

Hydrologic
• Duration
• Frequency
• Timing
## Ecosystem Relationships

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Borrowing Engineering Standards

Intensity-Duration-Frequency Curves in Hydrology  →  Area-Duration-Frequency Curves for Habitat?

Estimated Annual Damage in Flood Risk Analysis  →  Estimated Annual Habitat

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Method Flow

HEC-EFM

Flow Database
Q = f (f, d, T)

Flow Frequency Relationships
Log Pearson III, etc...

ADF Curves
A = f (f, d, T)

AEH Values
For each timing and duration

HEC-RAS

Water Surface Elevations

GIS
Screening for connectivity, depth, velocity, temperature

Flow vs. Area Curves

Hydrologic Data

Physical Footprint
HEC-EFM: Hydrologic Statistics
HEC-EFM: Hydrologic Statistics

- **Timing**: Dec-May
- **Durations**:
  - 1-Day
  - 3-Day
  - 7-Day
  - 14-Day
  - 21-Day
  - 28-Day
  - 60-Day
### HEC-EFM: Hydrologic Statistics

#### Durations

1-Day

<table>
<thead>
<tr>
<th>RANK</th>
<th>PEAK_FLOW_VALUE Q(cfs)</th>
<th>LOGQ</th>
<th>(log Q – avg(logQ))^2</th>
<th>(log Q – avg(logQ))^3</th>
<th>Return Period (n+1)/m</th>
<th>Exceedence Probability (1/Tr)</th>
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3-Day

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<tr>
<th>RANK</th>
<th>PEAK_FLOW_VALUE Q(cfs)</th>
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7-Day

14-Day

21-Day

28-Day

60-Day

#### Log Pearson III Distribution Frequency Prediction

![Flow vs Recurrence Interval Plot](image-url)
HEC-EFM: Hydrologic Statistics

**Durations**

1-Day
3-Day
7-Day
14-Day
21-Day
28-Day
60-Day

Flow (cfs) vs. Recurrence Interval (yr)

- Log Pearson III Distribution Frequency Prediction
- Series 1
HEC-RAS and other hydraulic models
HEC-RAS and other hydraulic models
ADF Curves: Definition

Intensity-Duration-Frequency Curves in Hydrology

Defines the variable we are interested in for design (intensity) as a function of duration and frequency.

Area-Duration-Frequency Curves

Defines the variable we are interested in for design (quantity of functional habitat) as a function of duration and frequency.
Develop ADF Curves

Q vs Area Curves

Recurrence Interval Curves for each duration—in total there are 28 of these curves.
Develop ADF Curves

For Example:
500 acres are inundated for 21 days in 50% of years between December and May.
Develop ADF Curves

For example: 500 acres are inundated for 21 days in 50% of years between December and May.

Photo: Rene Reyes  http://www.biologicaldiversity.org/species/fish/Sacramento_splittail/
EAH Value: Definition

Estimated Annual Damage in Flood Risk Analysis

Defines the total (negative) risk in an area as an annual monetary loss.

Estimated Annual Habitat

Defines the total (positive) risk in an area as an annual habitat gain.
Develop EAH

\[ EAH = \int_{0}^{1} \text{Habitat Area}(P) dP \]

A **SINGLE** value for each flood duration.
Analysis Variables

Physical
- Area
  - depth
  - velocity
  - cover
  - vegetation
  - connectivity

Hydrologic
- Duration
- Frequency
- Timing

Spatial Variables

Temporal Variables
Powerful Scenario Analysis

Physical
- Area
  - depth
  - velocity
  - cover
  - vegetation
  - connectivity

Physical Alterations
- Levee setbacks
- New bypasses
- Floodplain grading
- Weir and grade control structures
- Dredging
- Side channel reconnection

Hydrologic
- Duration
- Frequency
- Timing

Hydrologic Alterations
- Weir Notching/lowering
- Reservoir Operations
- Climate Change
San Joaquin--four scenarios

1. Existing floodway and levee configuration combined with existing hydrology.
2. Existing floodway configuration with altered hydrology designed to increase the frequency of floodplain inundation.
3. Expanded floodway configuration with existing hydrology.
4. Expanded floodway configuration and altered hydrology.
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ADF Curves: Results

December-May, 21 Day Inundation

- Existing hydrology and Corridor
- Corridor Expansion with Existing Hydrology
- Existing Corridor with Reservoir Re-op
- Expanded Corridor with Reservoir Re-Op

Inundated Acres vs Ex. Probability graph showing the trends for different scenarios.
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ADF Curves: Results

December-May, 1 Day Inundation

Inundated Acres vs. Ex. Probability

- Existing Corridor and Hydrology
- Expanded Corridor with Existing Hydrology
- Existing Corridor with Reservoir Re-Op
- Expanded Corridor with Reservoir Re-Op

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EAH Results

Annual Expected Habitat

- Expanded Corridor--Recommended Flow
- Existing--Recommended Flow
- Expanded Corridor--Existing Hydrology
- Existing--Existing Hydrology

Average Expected Habitat (acres) vs. Duration of Inundation (days)

- Chinook
- Splittail

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Benefits as Risk

Risk = Probability x Consequence
### Powerful for Scenario Comparisons

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<tr>
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<th>Chinook Benefit</th>
<th>Splittail Benefit</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Existing</td>
<td>W $</td>
<td>543 acres</td>
<td>215 acres</td>
<td>$ aa</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>X $</td>
<td>720 acres</td>
<td>326 acres</td>
<td>$ bb</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>Y $</td>
<td>398 acres</td>
<td>180 acres</td>
<td>$ cc</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>Z $</td>
<td>578 acres</td>
<td>361 acres</td>
<td>$ dd</td>
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Stakeholder and Scientific Input

Inundation requirements or tolerances for different management activities:

- Salmon Runs
- Splittail
- Rice and other crops
- Foodweb productivity
- Recreational activities
- Waterfowl and shorebirds
Stakeholder Input

Develop 3-5 scenarios for modifying bypass or weir to create inundated floodplain habitat

Operational Parameters
• Timing of notch opening
• Opening duration
• Frequency of opening
• Other

Physical Alterations
• Notch configuration
• Central berm
• Floodplain grading
• Other
Final Product

Technical Report quantifying expected annual benefits and impacts for different management objectives:

- Salmon Runs
- Splittail
- Rice and other crops
- Foodweb productivity
- Recreational activities
- Waterfowl and shorebirds