The importance of habitat complexity & connectivity to river ecosystems

Photo courtesy of Lauren Rogers

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Today’s talk

• What is habitat complexity & connectivity?

• How does habitat complexity & connectivity help create & maintain river ecosystems?
  – Floodplains
  – Watershed-scale

• What happens to river ecosystems when habitats are simplified or disconnected?

Photo courtesy of Katy Doctor

Photo courtesy of John McMillan
What is habitat complexity?

• Physical, biological, & chemical attributes that determine stream productivity
  – Physical habitat structure
  – Species diversity
  – Nutrients
What is habitat connectivity?

- The capacity of river systems to allow longitudinal & lateral dispersal of:
  - biological organisms,
  - chemical components,
  - and physical structures.

Brenkman & Corbett 2005
How does **floodplain** habitat complexity & connectivity create & maintain river ecosystems?

- Define floodplain & identify important habitat features.

- Discuss the importance of high flows as a mechanism for habitat complexity & connectivity.

- Identify river ecosystem functions that result from floodplain habitat complexity & connectivity.
What is a floodplain?

- **Geomorphology**
  - Flat, depositional feature of river valley
  - Adjoins river channel
  - Formed under current climate regime

- **Hydrology**
  - Land subject to 100 year flood event

Photo and schematic courtesy of Tim Abbe
What is a floodplain?

- Ecology
  - Areas periodically flooded by lateral overflow of river or lakes.
  - Biota respond to change in environment
    - Individual
    - Community

Schematic courtesy of Petersen and Reid 1984
Habitats associated with floodplains

- Main channels
- Logjams
- Meander bends & scrolls
- Floodplain channels
- Beaver ponds
- Mid-channel islands
High flows create & maintain floodplains

- Flows which inundate features that typically do not convey water on a regular basis.

- Flows that form channel conditions are not present throughout the majority of a flow year.
High flows create & maintain floodplains

- Floodplain formation

- Wood, sediment, & nutrient recruitment

- Stream ecosystems & their biota have adapted & evolved to the natural hydrologic regime

Photo by John McMillan
Floodplain habitat complexity & connectivity increases ability of inputs to become habitat.

Photo courtesy of Dave Montgomery

Photo courtesy of Lauren Rogers
Floodplain habitat complexity & connectivity
Shorter travel distance for inputs

Displacement distance of tagged logs, 9/1/98-9/1/99

- tagged logs deposited on ELJs
- tagged logs deposited downstream of C-Post

Abbe et al. 2003
Floodplain habitat complexity & connectivity
Increased residence time of inputs

Dashed line – discharge, light grey – river, solid black - floodplain

Jeffres et al. 2008.
Floodplain habitat complexity & connectivity
Greater accumulation of inputs

Pess et al. 2008

Hunts road channel
Mainstem Elwha

500 m

N

[Graph showing comparison of single pieces/km and logjams/km between Hunts road channel and Mainstem Elwha]
Floodplain habitat complexity & connectivity
Greater chance for inputs to create & maintain favorable habitats

Abbe et al. 2003
Floodplain habitat complexity & connectivity
Greater density of periphyton

Coe et al. 2006, 2009
Floodplain habitat complexity & connectivity
Greater density of aquatic invertebrates

Coe et al. 2009
Floodplain habitat complexity & connectivity

Greater density of salmonids

Pess et al. 2008
Floodplain habitat complexity & connectivity

Greater condition factor for salmonids

Jeffres et al. 2008
Enclosed experiment, same age Chinook
Watershed habitat complexity & connectivity
Allows for increased species diversity
Watershed habitat complexity & connectivity
Allows for increased species diversity

Pess et al. 2003
Watershed habitat complexity & connectivity
Increased life history diversity
Watershed habitat complexity & connectivity
Increased life history diversity

Ocean-type Chinook salmon

http://www.skagitcoop.org/index.php/welcome/
What happens to river ecosystems when habitats are simplified or disconnected?

- Increase or decrease the amount & frequency of inputs
  - Water, sediment, nutrients, wood, & energy
- Simplify existing habitats
- Habitat removal
- Decrease salmonid survival at a particular life stage.
- Decrease salmonid survival at a particular life stage.

- Alters species distribution, increases competition, and can decrease overall salmonid survival at a particular life stage.
What happens to river ecosystems when habitats are simplified or disconnected?

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Increase in the frequency & magnitude of water

- 50% of Skagit identified as hydrologically or sediment impaired
- Stillaguamish in similar situation
- Why?
  - Increased precipitation
  - Reduced hydrologic maturity
  - Increased road density
  - Disconnected floodplain habitats
- Potentially reduces salmonid egg to fry survival
Increase in the frequency & magnitude of water

North Fork Stillaguamish (NFS) annual flood events

Waples et al. 2008
Increase in the frequency & magnitude of water
North Fork Stillaguamish (NFS) annual flood events

Waples et al. 2008
Increase in the frequency & magnitude of water

High flows and estimated Skagit River egg to fry survival

\[ y = 0.13e^{-0.05(flood\ recurrence\ interval)} \]
\[ R^2 = 0.9731 \]

Seiler et al. 2002
Increase in the frequency & magnitude of water

Estimated decreased Stillaguamish egg to fry survival

Waples et al. 2008
Habitat removal & isolation

Collins et al. 2003
Habitat removal & isolation
Decreased life history diversity

Ocean-type Chinook salmon

Collins et al. 2003

Beamer, unpublished data.
Outmigrating chinook smolts from lower Skagit River

Beamer, unpublished data.
What is habitat complexity & connectivity?

- Physical, biological, & chemical attributes that determine stream productivity

- The capacity of river systems to allow longitudinal & lateral dispersal of biological organisms, chemical components, and physical structures.

Photo courtesy of Lauren Rogers
How does habitat complexity & connectivity help create & maintain river ecosystems?

- Habitat complexity & connectivity increase the ability of inputs (i.e., water, wood, sediment, & nutrients) to become habitat for a long enough time period to accumulate, be incorporated, and benefit aquatic organisms such as salmonids.

- Habitat complexity and connectivity can increase both species & life history diversity of aquatic organisms.

Photo courtesy of John McMillan
What happens to river ecosystems when habitats are simplified or disconnected?

• A change in the magnitude & frequency of input rates such as flow can lead to decreased survivorship at particular salmonid life stages.

• Reduced habitat quality & quantity can alter species distribution, lead to increased competition, and create specific life stages that limit population size.

Photo courtesy of John McMillan
Questions?

Photo courtesy of John McMillan