Opportunities to Improve Ecological Functions of Floodplains and Reduce Flood Risk along Major Rivers in the Puget Sound Basin

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Managing floodplains for multiple benefits

Rationale:
• large-scale projects must incorporate broader objectives;
• more efficient than projects working in opposition to each other;
• functional floodplains are capable with risk reduction
Uses of Puget Sound Floodplains

15% of urban areas
30% of highly developed urban areas
70% of cultivated land

2. Social values of floodplains
Ecological characteristics

- Fine-scale heterogeneity/diversity of habitats
- Flood-mediated disturbance regime
- Full representation of successional stages

Determinants

- Lateral and longitudinal connectivity with river
- Vertical zonation

1. Floodplains as landforms and ecosystems
Overview of assessment

**Goal:** identify areas where ecological function can be improved and flood-related risk can be reduced

**Audience:** 1° regional planners, state and federal policy makers and funders; 2° local floodplain managers with information needs
Geographic scope: valleys of 17 major rivers draining to Puget Sound

**Resolution:** attributes (topography, land cover, etc.) indicating function and risk are represented on 10 m grids

**Output:** primarily categorical (1, 2, 3) that is “transparent” rather than ordinal (1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}) that has implicit valuation
Where are opportunities?

1. Current ecological function can be improved by re-connecting floodplain areas to rivers and/or changing land cover/land use
   
   "Assess current functions"

2. Flood risk can be reduced by enhancing protection, increasing resilience, or reducing exposure

   "Assess current risks"
Ecological functions of floodplains

1. Store and convey floods
2. Supply and retain sediment and wood in river networks
3. Retain and transform nutrients
4. Support forest ecosystems
Floodplain fragmentation

Roads, levees, and railroads fragment floodplains and disconnect some fragments from rivers.
Function 4: support floodplain forests

Stillaguamish River at the confluence with Pilchuck River

Connected floodplain with forest, wetland
Connected floodplain with modified cover
Disconnected floodplain with forest, wetland
Disconnected floodplain with modified cover
Risk: Hazard+ Exposure

**Hazards**
1. Inundation during floods
2. Channel occupation

**Exposure**
1. Key facilities
2. Land uses (agriculture, medium/high development)
3. Transportation corridors (roads)
Key facilities

- 1251 Class A or B water systems
- 47 Municipal wastewater treatment facilities or large septic systems
- 191 Fire stations, hospitals, or emergency medical service facilities

2. Social values of floodplains
“Logic models” to produce categories of function or risk

Function 1. Store and route floods:
3: connected river area, undeveloped, no roads/levees/railroads
2: connected low floodplain, undeveloped, no roads/levees/railroads;
1: connected high floodplain, undeveloped, no roads/levees/railroads;
-1: disconnected floodplain, undeveloped
-2: connected floodplain with medium/high development

Function 3a. De-nitrification:
2: Wetland, shallow groundwater, or hydric soils; no impervious surfaces, soil >30% silt/clay, >2% organic material
2: Wetland, shallow groundwater, or hydric soils; no impervious surfaces, soil >30% silt/clay, <2% organic material

4. Assessment of ecological functions and risks to people
Opportunities to combine flood risk reduction and improved ecological function

Criteria:
• Fragment is connected or 1° of disconnection
• Development or key facilities
• At least 10 ha of undeveloped land
Opportunities to increase flood conveyance and aquatic habitat in floodplain units with relatively narrow active channels.
Fish-related products

Delineation of rivers

Upstream length of Chinook-bear stream:
green > 400 km, red < 100 km
Assessment of ecological functions and flood-related risks to people on floodplains along 17 major rivers in Puget Sound basin will be published by USGS in 2014, geospatial information will be available on-line.

Contributes basic information (delineation of low floodplains, river areas, and fragmentation) and integrates disparate information to facilitate regional planning and management of floodplains.
Additional slides
Puget Sound Partnership 2020 floodplain recovery target includes restoration of 15% of degraded floodplain.
Differentiating types of floodplain based on relative elevation

GIS based method for determining the elevation of the land surface relative to the river (“Height above Water Surface”, Jones 2006)

1. Floodplains as landforms and ecosystems
Delineating high floodplain, low floodplain, and river areas

1. Floodplains as landforms and ecosystems

- Apply threshold
- Elevation of land relative to river

*Stage change for p = 0.1/yr event (10yr)*
*Stage change for p = 0.5/yr event (2yr)*

Floodplain threshold: $dz=2 \cdot \log(area/10)$
Active channel threshold: $dz=0.5 \cdot \log(area/10)$
Channel movement across floodplains links physical process to biological structure

Integrated floodplain management

Levee setbacks
– Puyallup River, WA

Seasonal use
– Yolo Bypass, CA

Raising infrastructure
- farm equipment pads

Konrad et al. 2008, River Research and Applications 24
FLOODPLAIN FUNCTIONS

1. Store and route floods

\[ fn1 = fp \times vb_{undev} - 2 \times (fp > 0) \times (1 - vb_{mhdev}) \times (1-vb_{undev}) \]

3: connected river area, undeveloped, no roads/levees/railroads
2: connected low floodplain, undeveloped, no roads/levees/railroads;
1: connected high floodplain, undeveloped, no roads/levees/railroads;
0: not floodplain or road/levee/railroad
-1: disconnected floodplain, undeveloped
-2: connected floodplain with low development

1a. Store floodwater

\[ fn1a = (dstage_{high} - dz_{ned}) \times (fp > 0) - (fp == -1) \]

> 0: depth of water over floodplain during a nominal flood in meters;
0: valley bottom areas outside of floodplain; road/levee/railroad
-1: disconnected areas of floodplain

1b. Convey floods

\[ fn1b = (fp > 1) \times (vb_{undev}) \times (riv_{grad_{ned}}) \]

hydraulic gradient (m/m)
0: areas outside of LiDAR coverage; disconnected floodplain; high floodplain; valley bottom; or road/levee/railroad

2. Regulate sediment and wood supplies in river networks

4: forest areas adjacent to river composed of unconsolidated material; no impervious, roads, levees, or railroads
3: undeveloped areas adjacent to river composed of unconsolidated material without forest; no impervious, roads, levees, or railroads
2: forested connected floodplain composed of unconsolidated material; no impervious, roads, levees, or railroads
1: undeveloped connected floodplain composed of unconsolidated material without forest; no impervious, roads, levees, or railroads;
0: not erodible material; floodplain with roads, levees, or railroads; valley bottom areas outside of floodplain
-1: developed areas adjacent to river composed of unconsolidated material; no impervious, roads, levees, or railroads
-2: developed, connected floodplain composed of unconsolidated material; no impervious, roads, levees, or railroads
-3: undeveloped disconnected floodplain composed of unconsolidated material
-4: developed disconnected floodplain composed of unconsolidated material; no impervious, roads, railroads, or levees
-5: areas adjacent to river composed of unconsolidated material, with impervious, roads, levees, or railroads

2a. Supply sediment