Disturbance in a highly managed river: How much is enough?

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Disturbance Magnitude

High

Big

low

High

Small

- tectonic processes
- mountain building etc.

- climate
- glaciation, etc.

- volcanic activity

- earthquakes

- landslides, debris flows

- fires

- floods

- storms, droughts

Montgomery and Buffington, 1998
The Cedar River

- Scales and nature of physical disturbance
- Anthropogenic (press) disturbance history
  - Dams
  - Hardened banks
  - LU/ LC change
- Natural (pulse) disturbance history
- Biological response of spawning sockeye salmon (O. nerka)
Anthropogenic Press Disturbances

- Changes in Channel Complexity
  - Decreased channel/floodplain interaction
    - Altered hydrology – Bankfull Days
    - Mapped Active Channel Edge Density
  - Changes in sediment characteristics
    - Gradation Index (Gr) (Julien 2002)
    - Pebble Counts
      » King County 1993
      » Jones & Stokes et al. 2001
• Natural Pulse Disturbances
  – Periodic floods (yearly to decadal)
  – Periodic landslides (decadal)

• Biological Response
  – Shifts in sockeye salmon spawning distributions in space and time (yearly to decadal)
Mean Sediment Gradation (GR) for Index Reaches 1 through 4 in the Lower Cedar River, Washington, 1993 and 2001

\[ Gr = \sqrt{\frac{d_{84}}{d_{50}}} + \frac{d_{50}}{d_{16}} \]
February 28, 2001 -- 6.8 Magnitude Earthquake

50,000 m³ of Sediment Deposited in Cedar River
Revetments

\[ ED = \frac{\sum_{k=1}^{n} e_{ik}}{A} \times (10,000) \]

1990 Channel

2002 Channel

Revetments
Changes in Average Active Channel Edge Density in Four Index Reaches of the Cedar River, WA 1936 - 2000

\[ ED = \frac{\sum_{k=1}^{m} e_{ik}}{A} (10,000) \]

(McGarigal and Marks 1995)
Changes in Average Active Channel Edge Density in Four Reaches of the Cedar River, WA 1936 - 2002

Nisqually Earthquake Landslide

2001
Reach 4 Comparisons of Mean Live Adult Sockeye Counts
1952 - 2003 Cedar River, Washington

Post-Disturbance

Pre-Disturbance

Week of Survey

Mean Live Adult Sockeye Counts

- 20000
- 15000
- 10000
- 5000
- 0

35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56
Pre- and Post-Disturbance Proportion of Total Live Sockeye Spawning in Reach 4 Cedar River, 1952-2003
Lewis et al. 1995
Conclusions

• Flow is **the** organizing process in river systems.
• Hydrology is the integrator of flows and channel-floodplain connectivity and can be expressed in terms of:
  – BF Days
    • indicator of the work that gets done on river channels.
  – Gradation Index
    • hydrologic alterations are mechanistically involved in the simplification of the physical template.
  – Edge Density
    • spatially explicit quantitative measure of channel complexity.
• Spawning fish distributions adjust relative to changing sediment/ channel habitat characteristics.
• Restoration of river ecosystems requires consideration of synergistic impairments to watershed processes and functions.
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