Reconnecting 'Disconnected Rivers'

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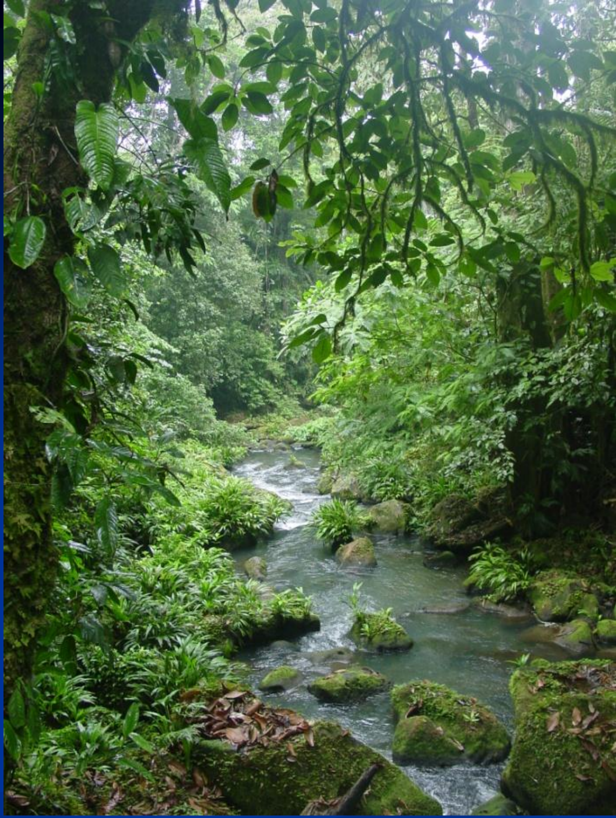
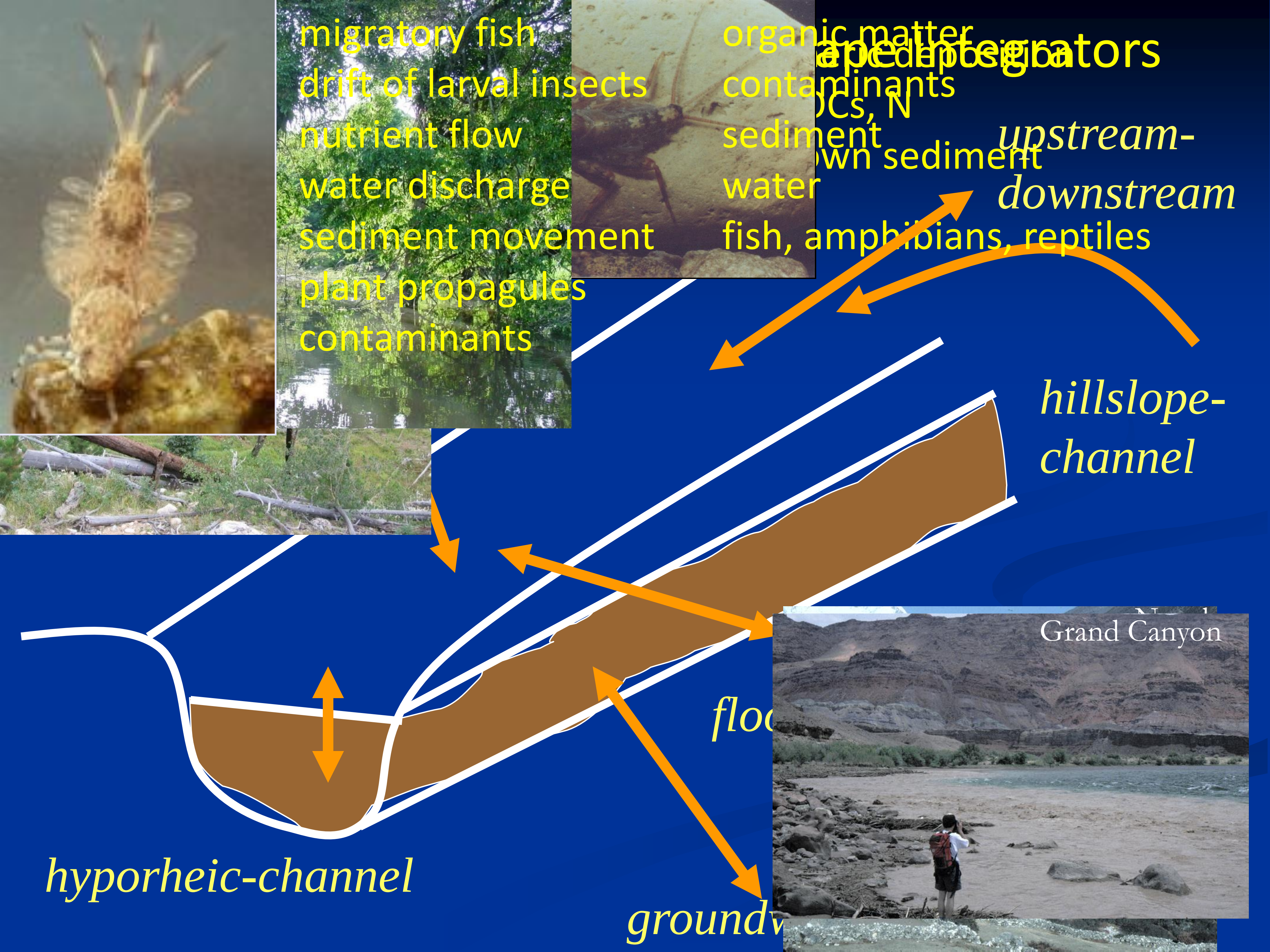
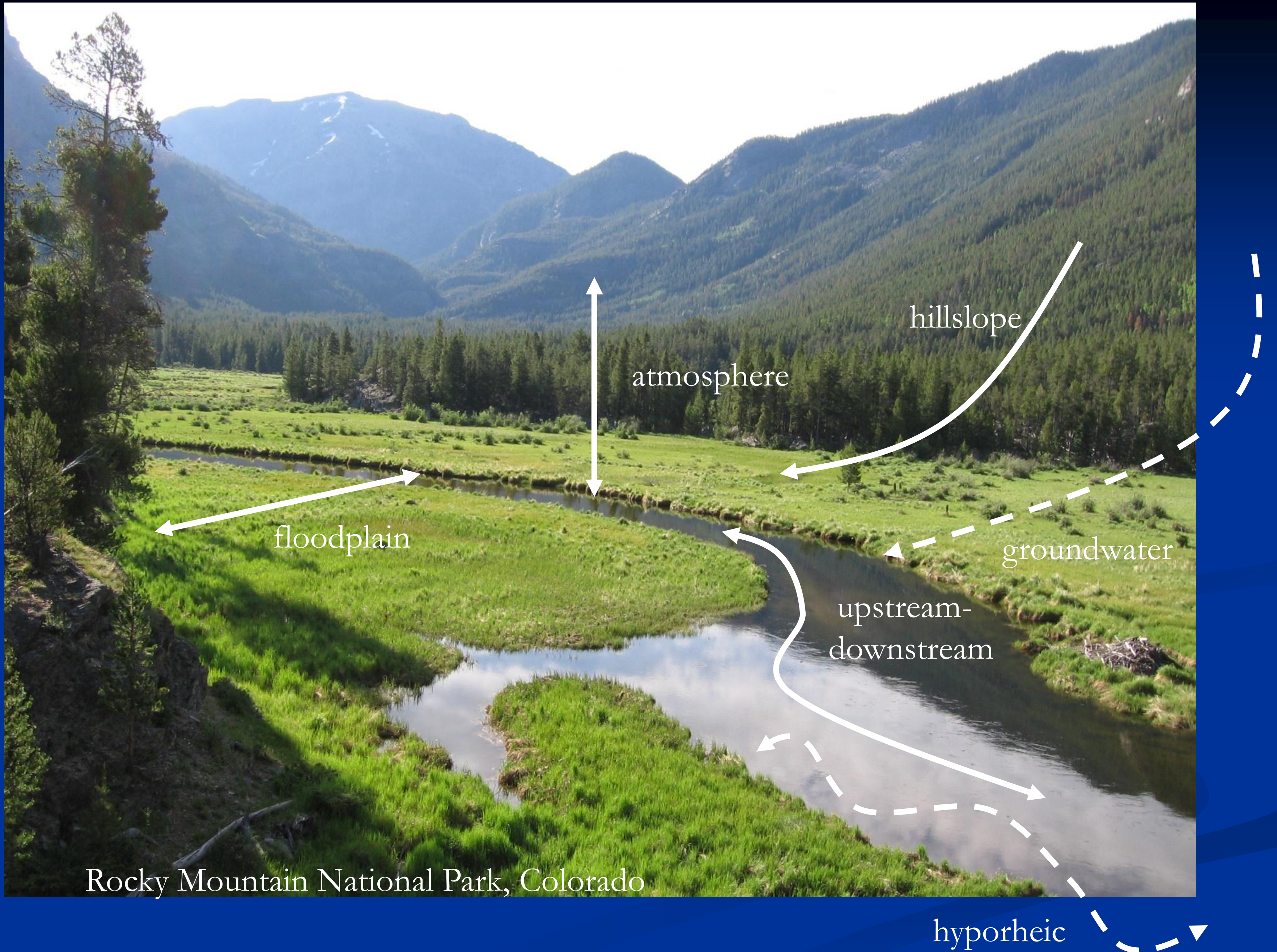
Why care about rivers?

- river as ecosystem
- ecosystem services (clean water, fisheries, recreation, esthetics, flood control, habitat)
- landscape integrator – links physical & biological variables





migratory fish
drift of larval insects
nutrient flow
water discharge
sediment movement
plant propagules
contaminants
organic matter
contaminants
sediment
water
fish, amphibians, reptiles
upstream-
downstream
hillslope-
channel
hyporheic-channel
Grand Canyon


hillslope
atmosphere
floodplain
groundwater
upstream-
downstream
hyporheic
Rocky Mountain National Park, Colorado

River Health

A healthy river exhibits physical diversity of flow and form,

biological diversity of organisms and communities, and

3d connectivity with fluxes of energy, matter, & organisms

Channel
+
Floodplain

Physical Diversity

hydrology sediment
hydraulics
substrate
geometry

temporal & spatial

Biodiversity

biological characteristics
connectivity (x, y, z)

temporal & spatial

Habitat

River health

Humans indirectly & directly alter rivers

Indirect alterations:

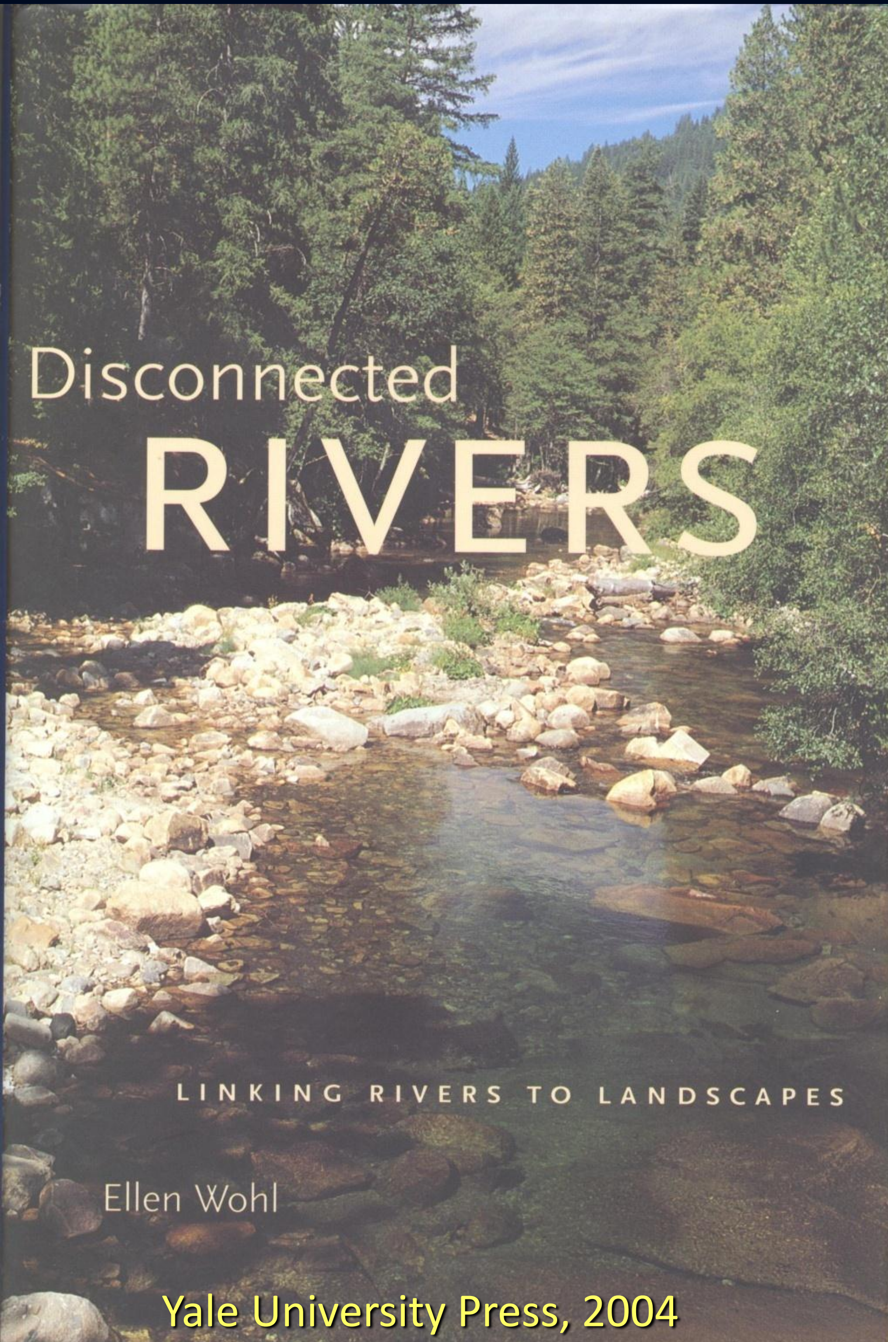
- changes in land cover (deforestation, afforestation, crops, urbanization)
- human-induced changes in climate

Direct alterations:

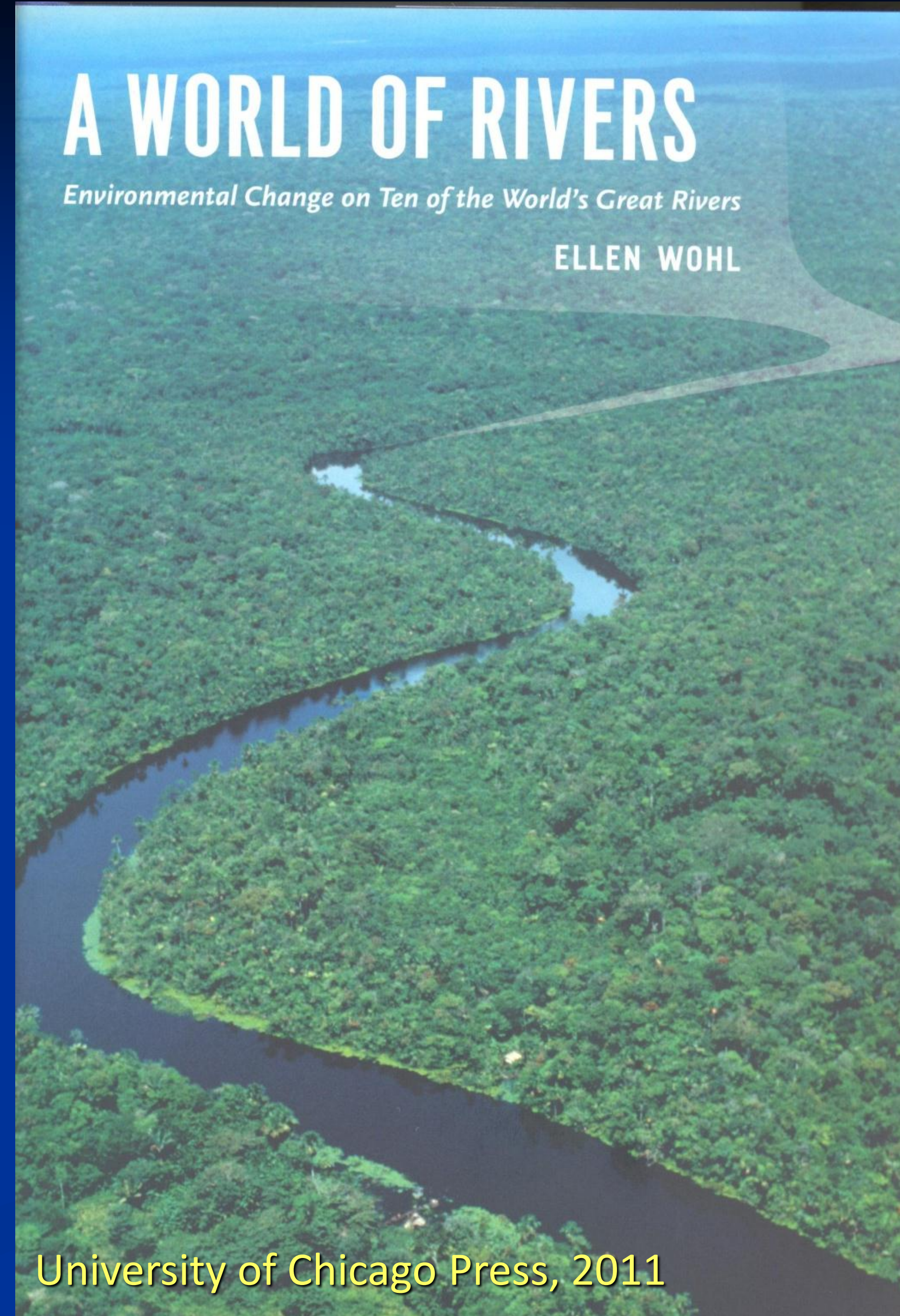
- flow regulation (dams, diversions, augmentation)
- channelization, bank stabilization
- levees
- removal of native species & introduction of exotic species

↓

Reduced river connectivity and physical & biotic diversity



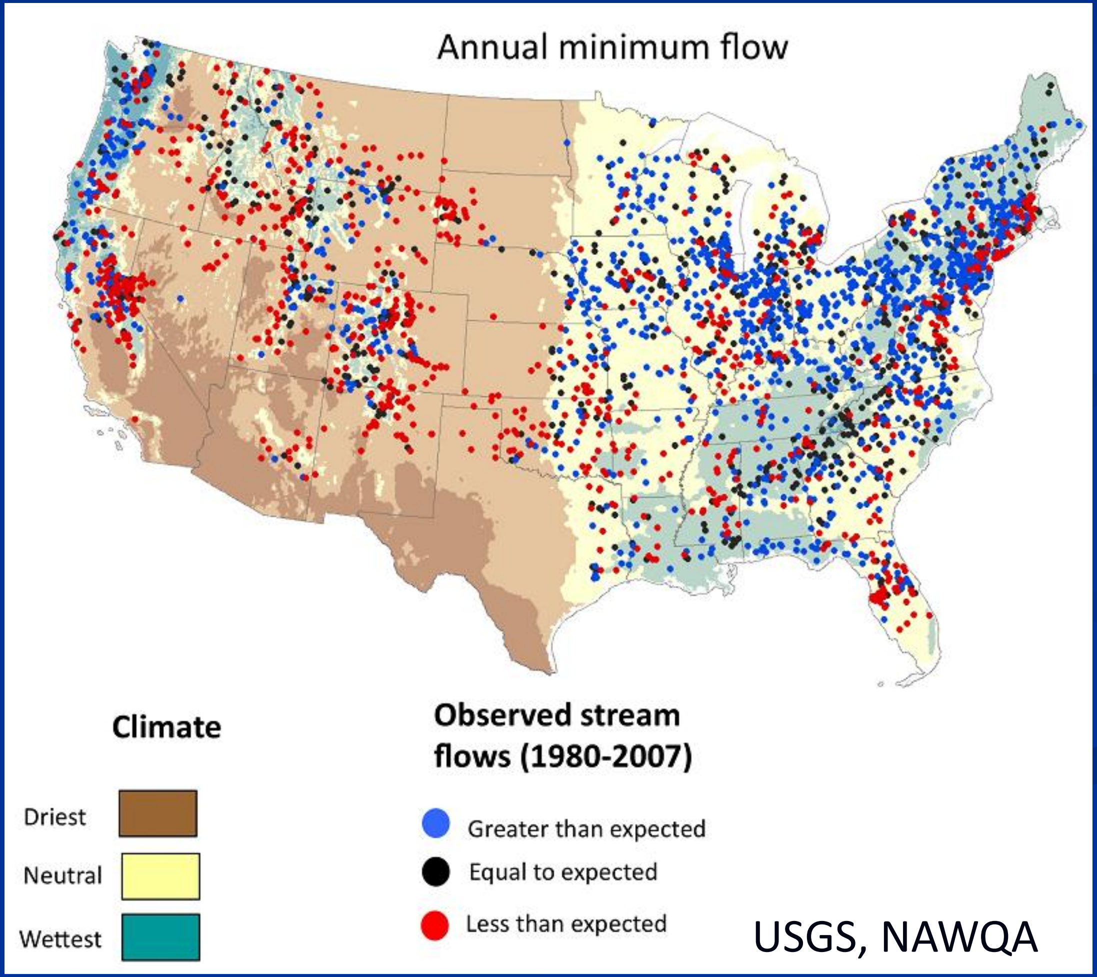
Yale University Press, 2004



University of Chicago Press, 2011

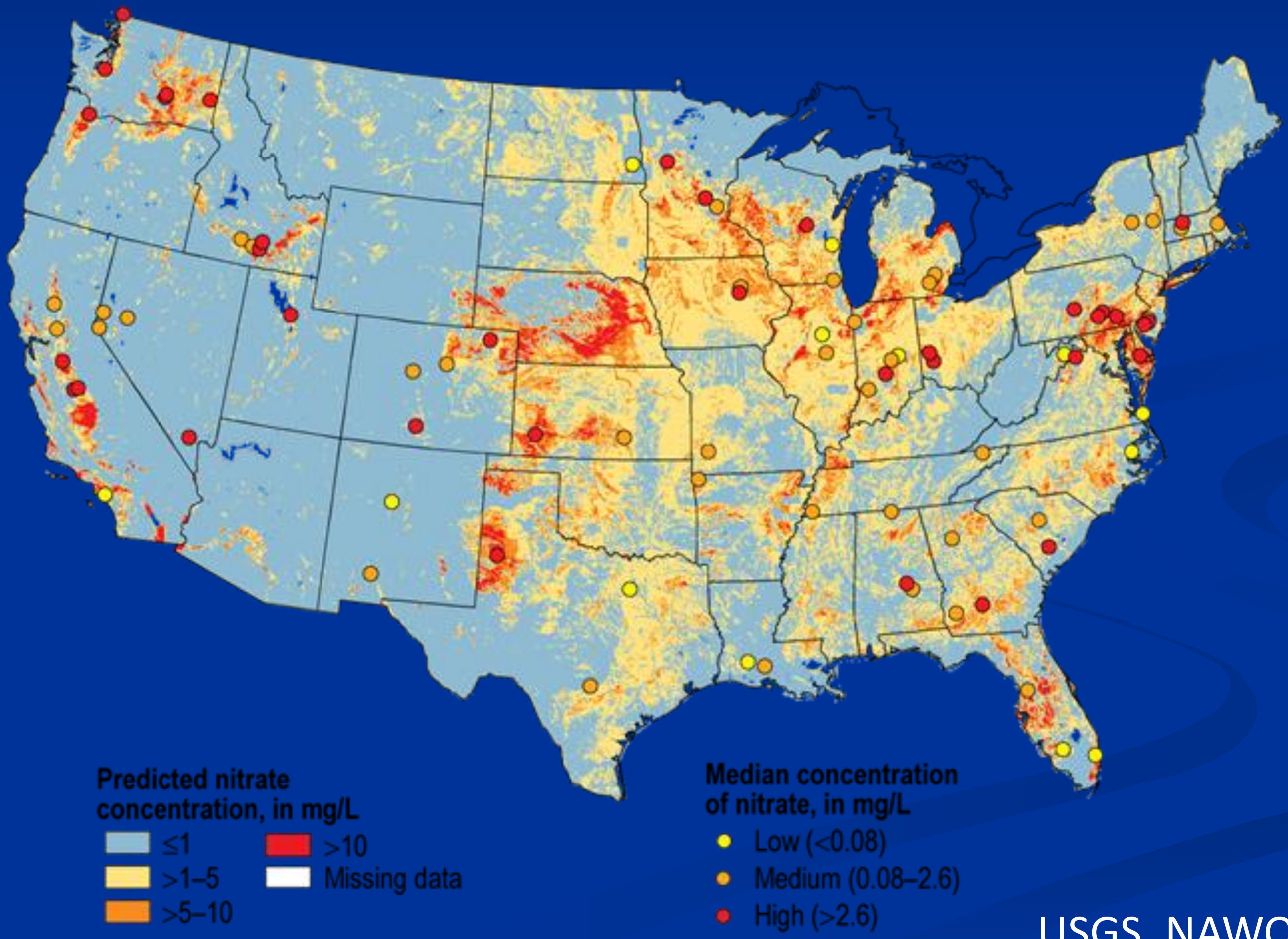
How extensive & intensive are these alterations?

- in the US, 75,187 large dams & > 2.5 million small dams
- all watersheds larger than ~ 2000 km^2 (excluding Alaska) have some dams

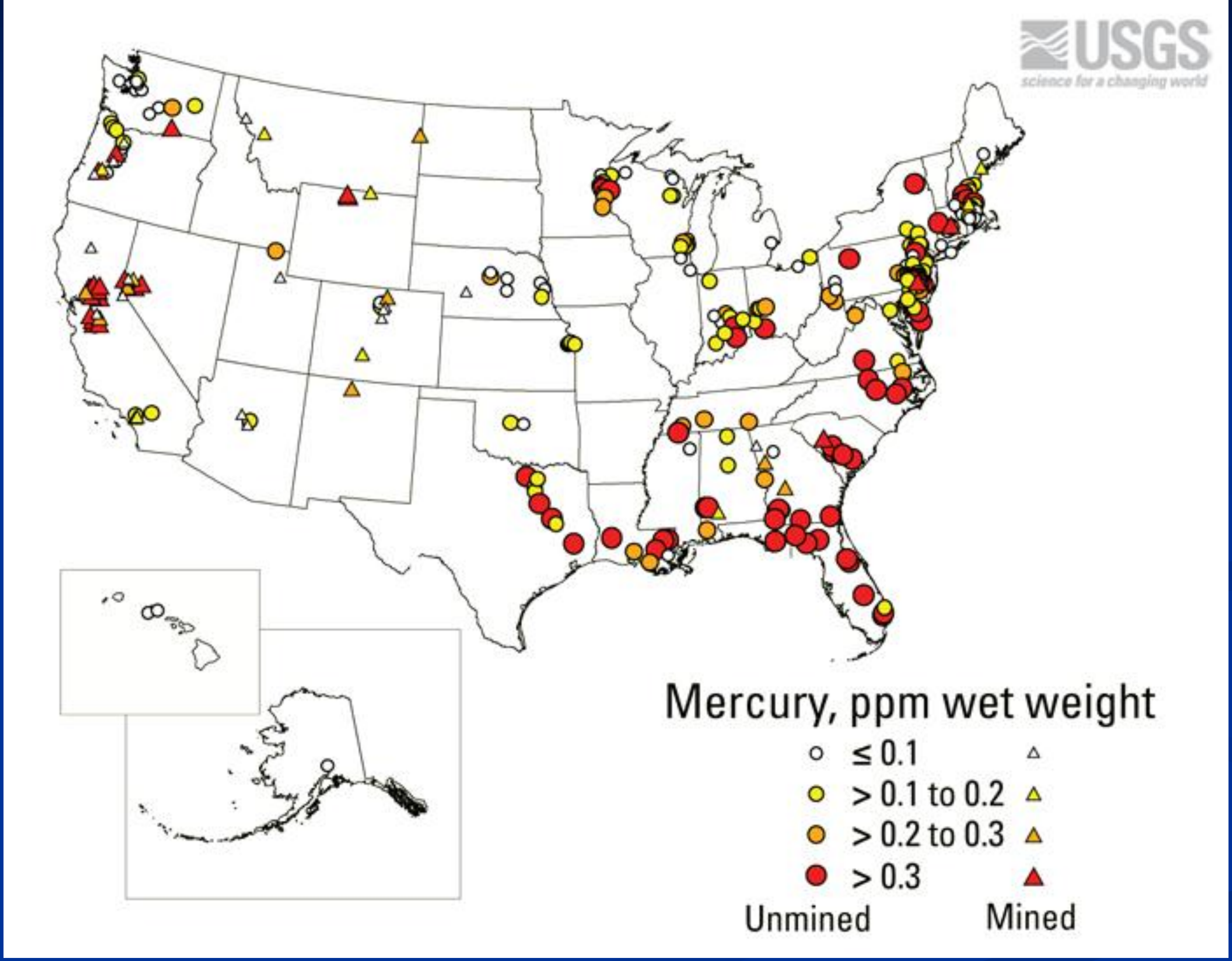


minimum flows inflated or diminished in 74% of streams assessed

- USGS 1991-95 National Water Quality Assessment: streams & ground water in basins with significant agricultural and/or urban development almost always contain complex mixtures of nutrients & pesticides
- > 1/3 of the rivers in the US are listed as impaired or polluted by EPA
- almost half US waters fail to meet biological water-quality standards



USGS, NAWQA


USGS
science for a changing world
Mercury, ppm wet weight
≤ 0.1
> 0.1 to 0.2
> 0.2 to 0.3
> 0.3
Unmined
Mined

• the conservation status of 15 of the 40 major watersheds in the US is rated critical, the highest category for a ranking based on degree of land-cover alteration within the catchment, degradation of water quality, alteration of hydrologic integrity, degree of habitat fragmentation, effects of introduced species, & impacts of direct species exploitation

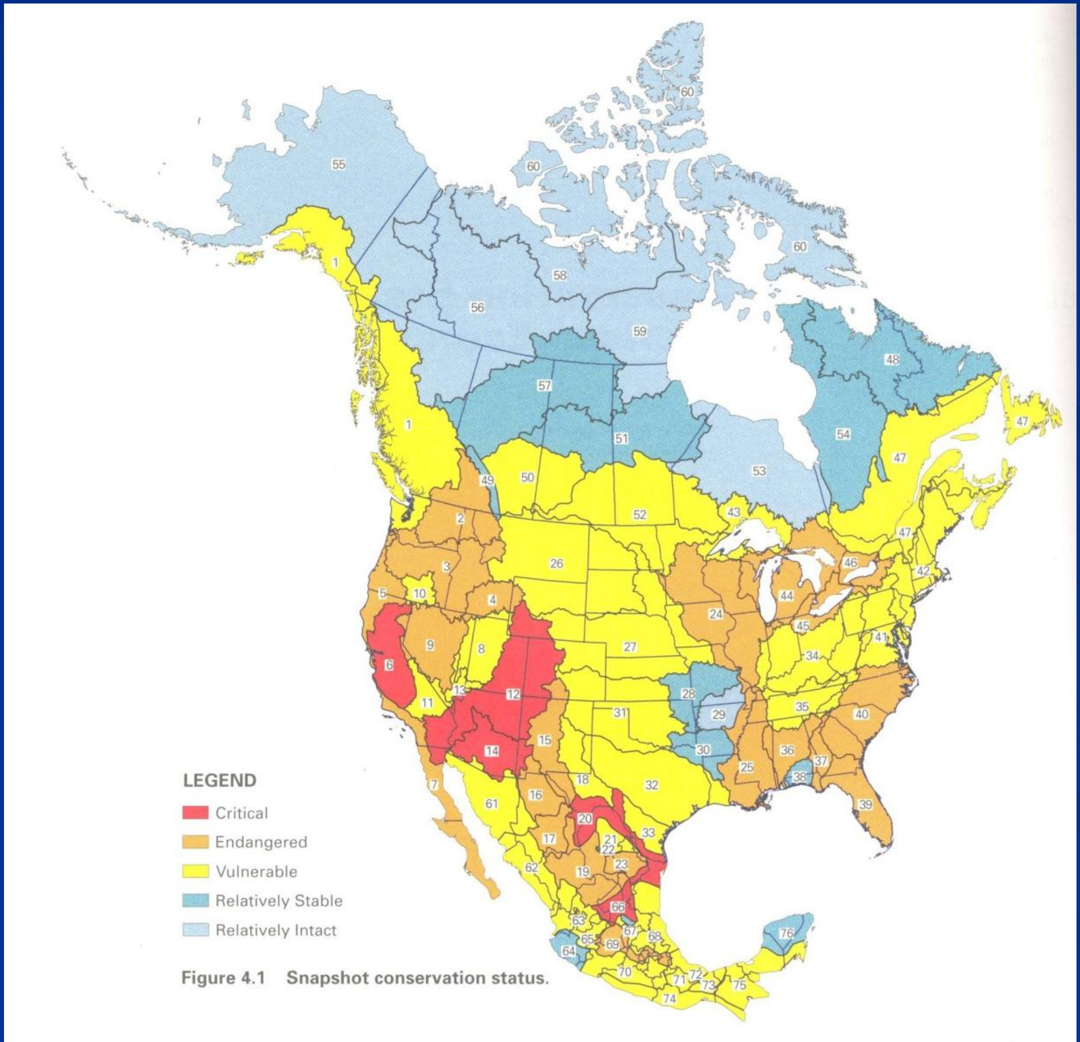


Figure 4.1 Snapshot conservation status.

Abell et al., 2000

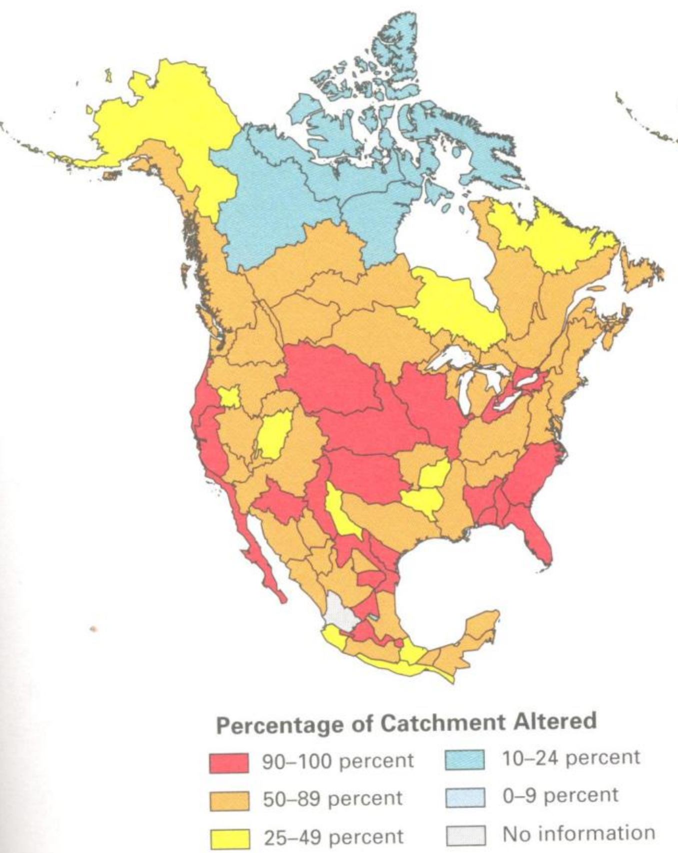


Figure 4.2 Land cover (catchment) alteration (estimated).

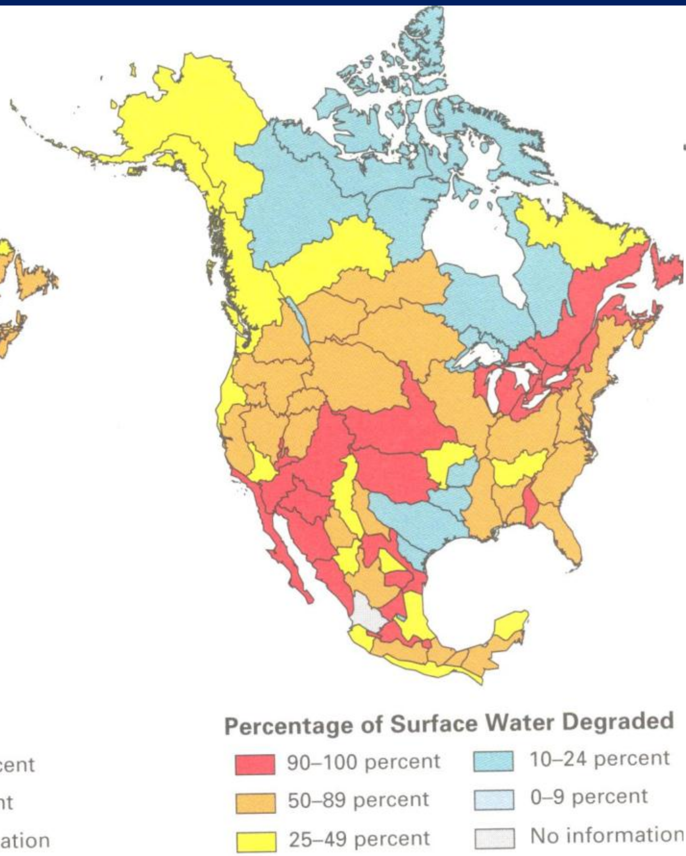


Figure 4.3 Surface water quality degradation (estimated).

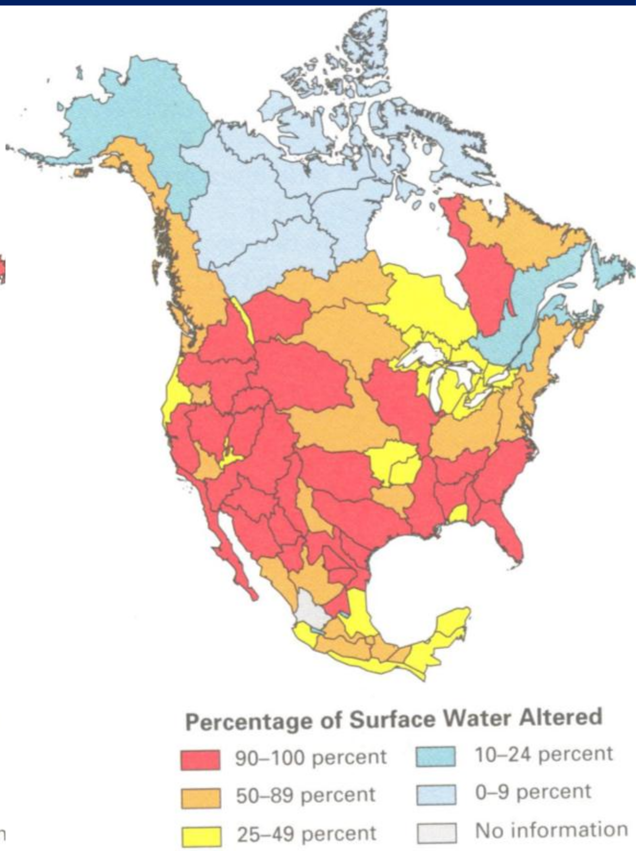


Figure 4.4 Alteration of hydrographic integrity (estimated).

Abell et al., 2000

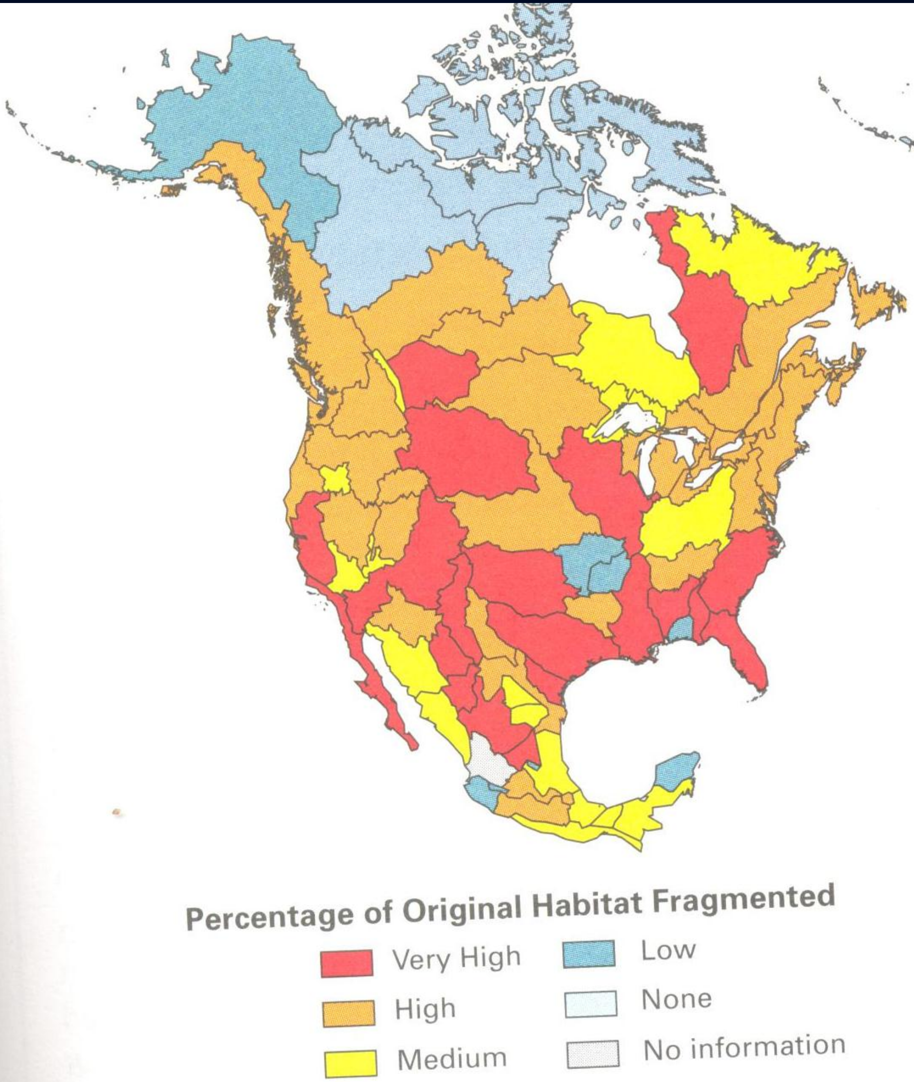


Figure 4.5 Degree of habitat fragmentation.

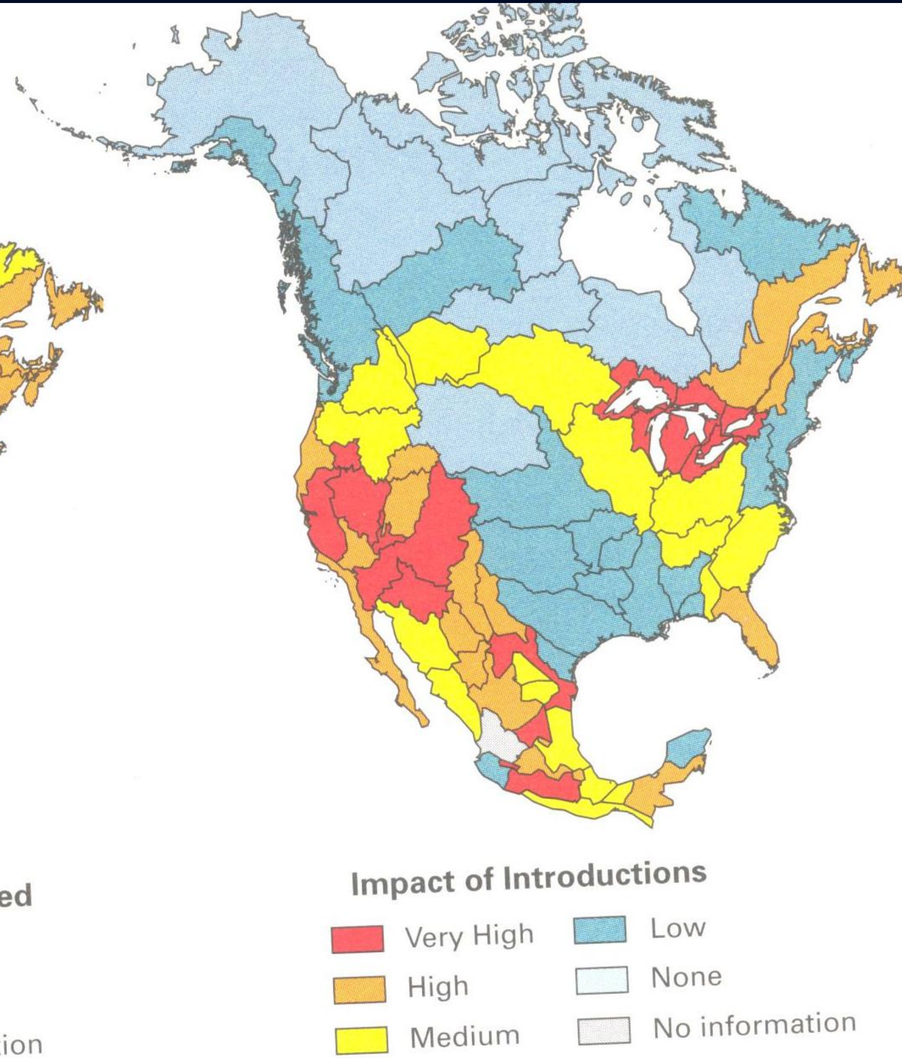


Figure 4.6 Effects of introduced species.

Abell et al., 2000

- estimated 70-90% of riparian forests have been lost nationally
- wetland losses > 50%, and close to 90% in some portions of US

- at l
- 1/3
- ext biota

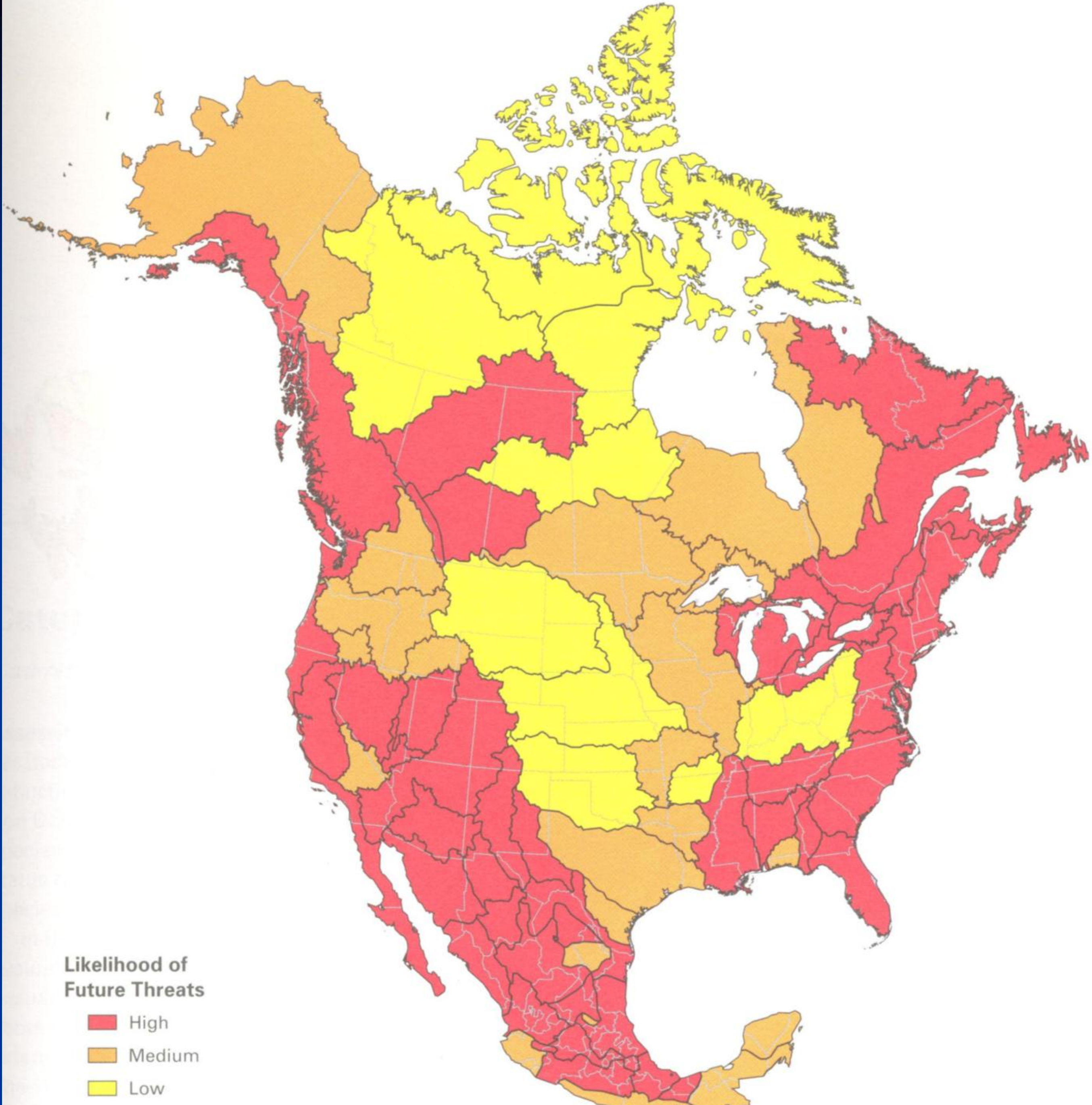
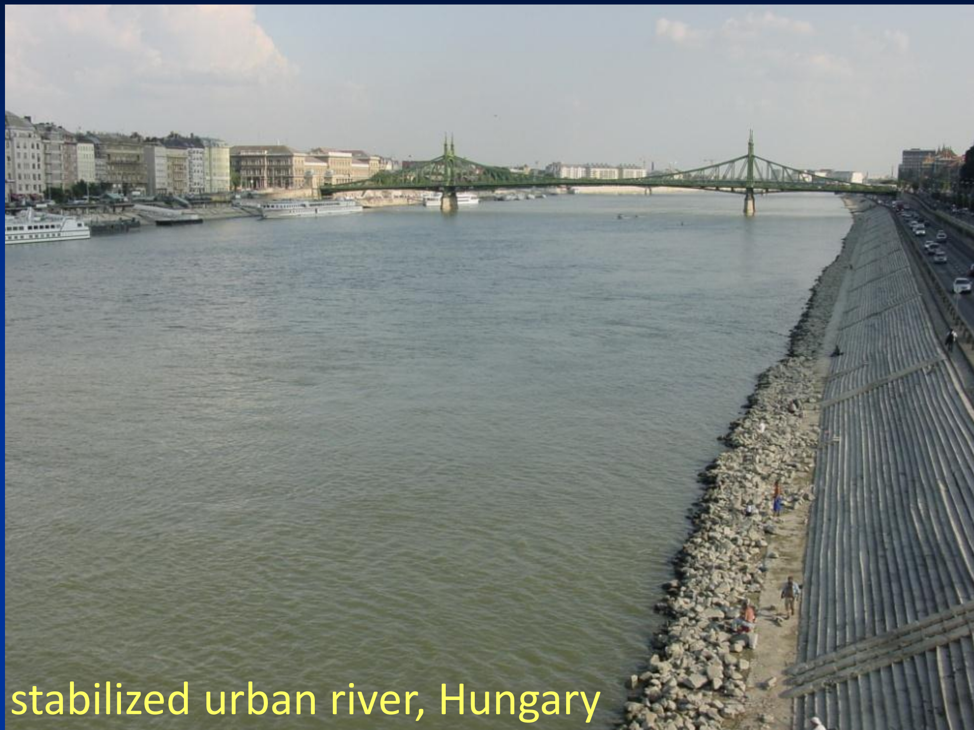


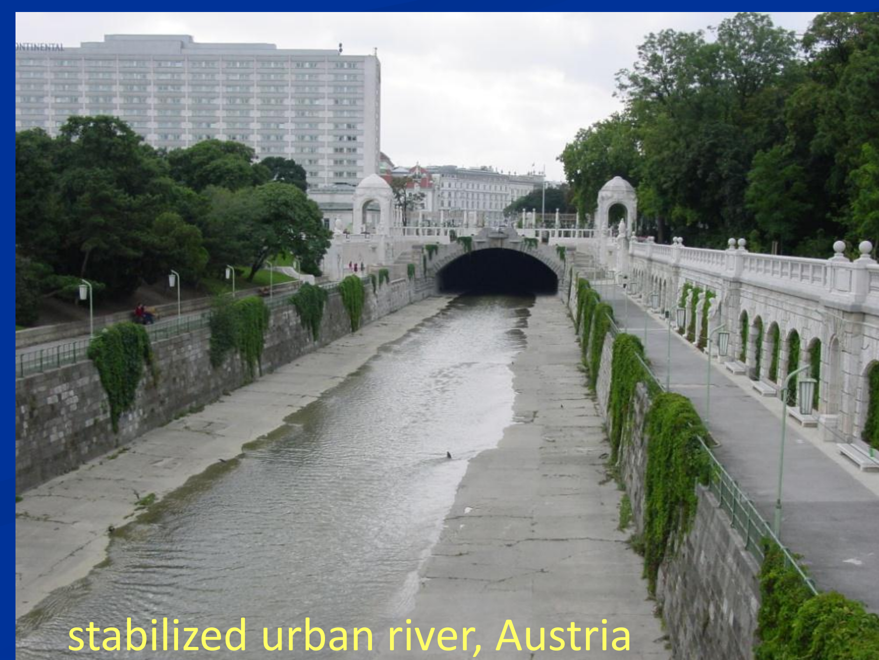
Figure 4.9 Threat assessment.

Abell et al., 2000

Human-induced uniformity impairs river health



stabilized urban river, Hungary



stabilized urban river, Austria

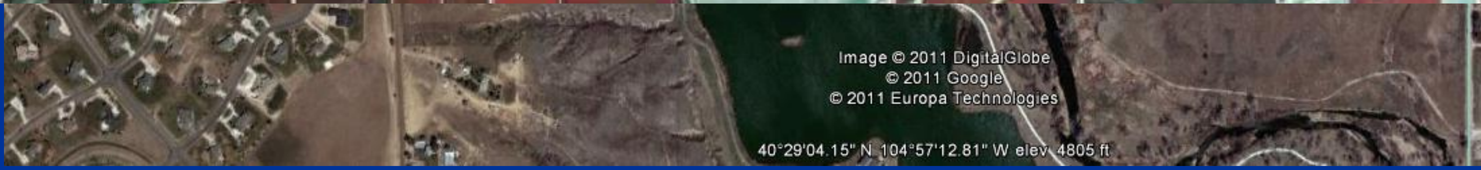


Image © 2011 DigitalGlobe
© 2011 Google
© 2011 Europa Technologies
40°29'04.15" N 104°57'12.81" W elev 4805 ft

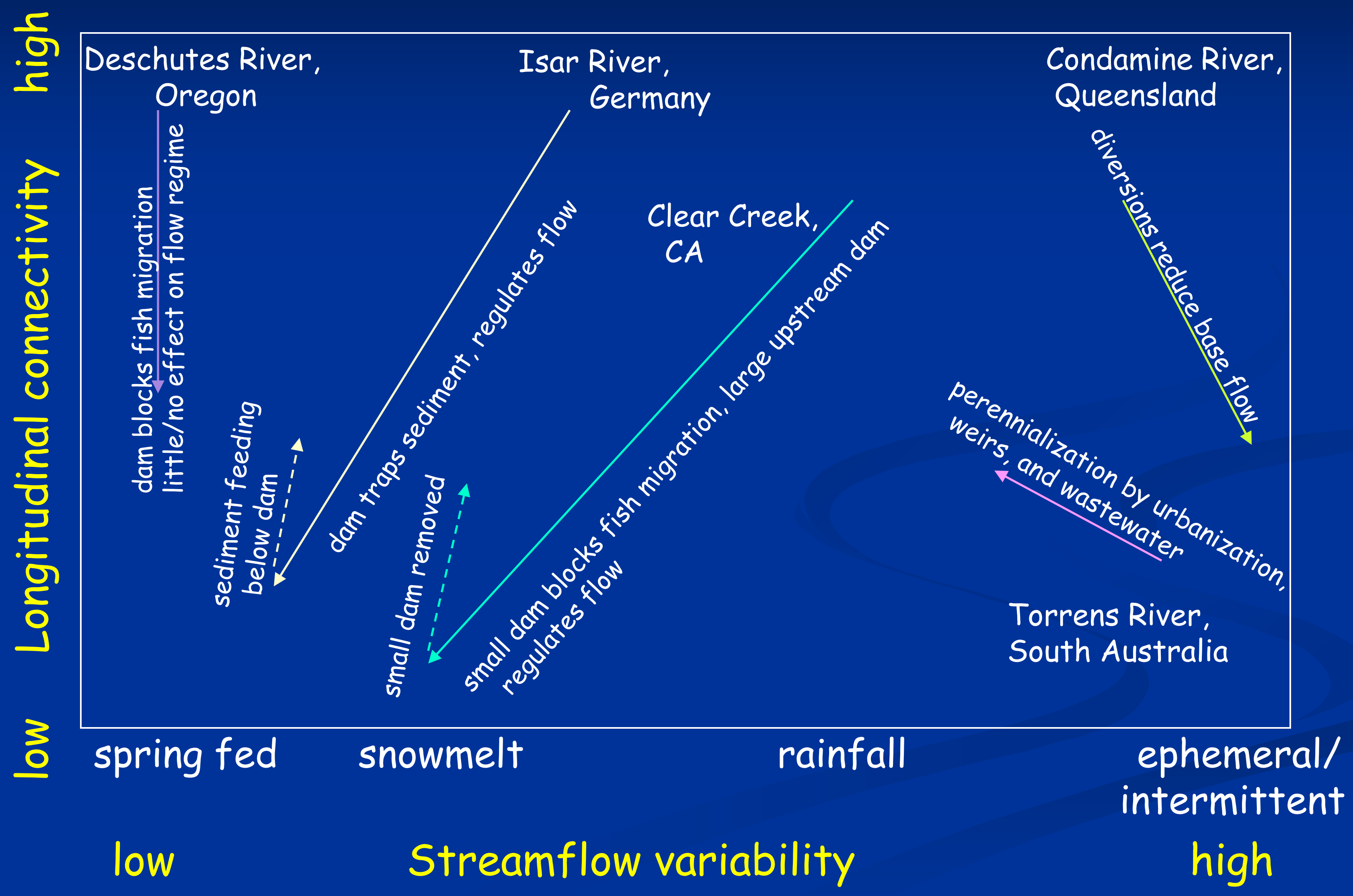
do

Better to conserve physical & biodiversity of rivers

than to attempt to restore following human alterations

Use connectivity diagrams to conceptualize river trajectories

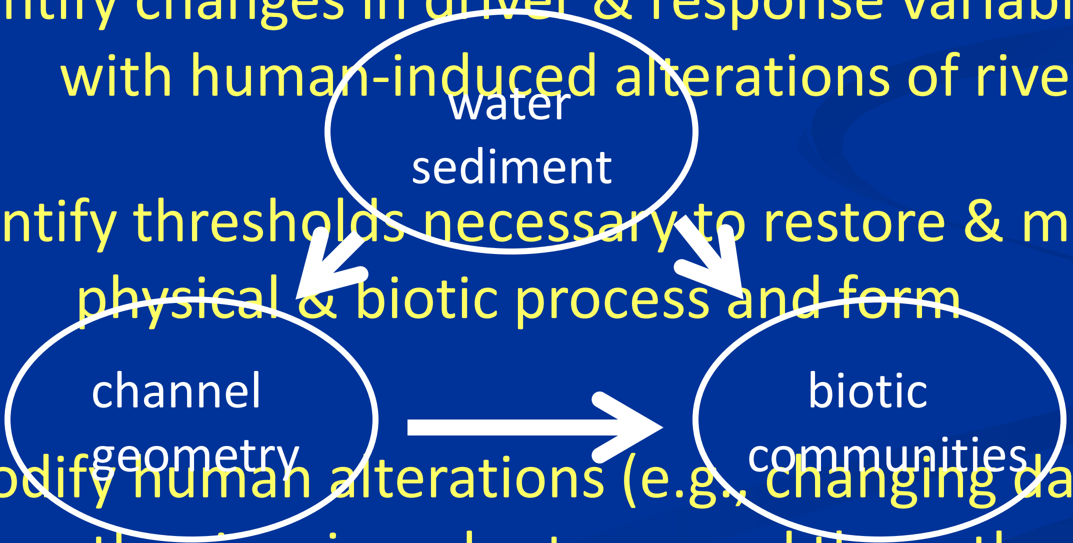
(Kondolf et al., 2006)



But …

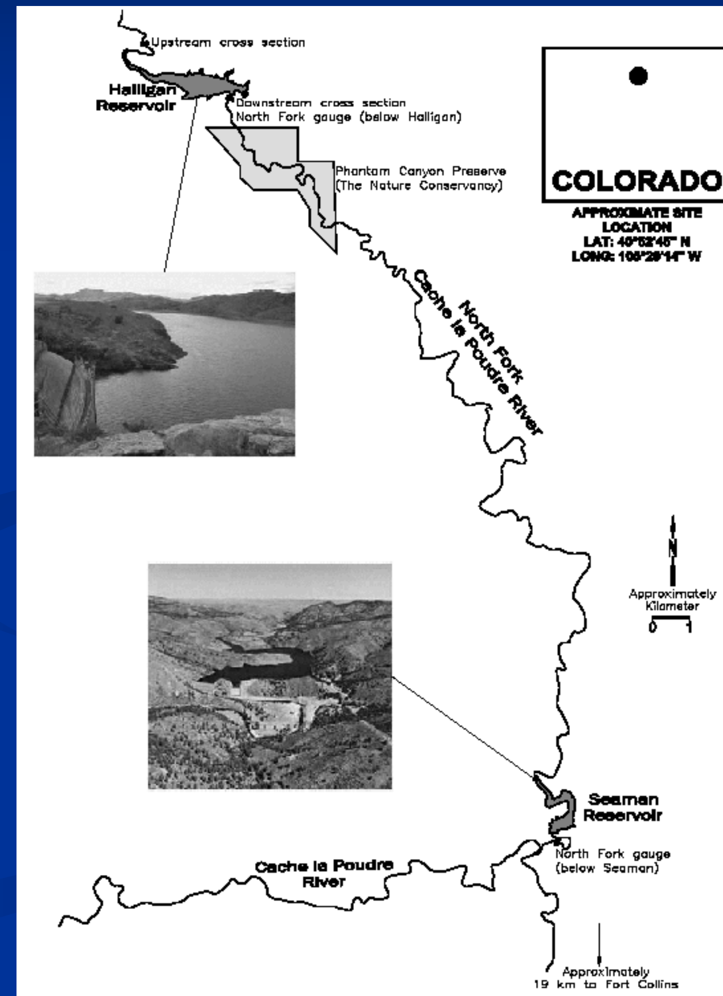
the worst effects of alterations can be reduced by restoring links between process and river form

- identify interactions among physical driver & physical & biotic response variables
- quantify changes in driver & response variables associated with human-induced alterations of rivers
- identify thresholds necessary to restore & maintain desired physical & biotic process and form
- modify human alterations (e.g., changing dam operations) to the river in order to exceed those thresholds



North Fork Poudre River, Colorado

900 km^2 drainage area
bedrock canyon; boulder-bedded, pool-riffle channel
summer snowmelt peak flow
upstream dam built 1910
concern about loss of bed mobility,
    pool infilling,
    lack of riparian vegetation recruitment,
    drying of floodplain



(Rathburn et al. 2009)

Several studies indicate

- reduced base flow & extreme peak flows
- reduced sand & gravel transport – changes in periphyton, aquatic insects, & predators (fish, birds)
- clogging of spawning gravels
- aging & senescence of riparian forest
- encroachment on xeric plants on floodplain

Recommendations for flow thresholds to

mobilize interstitial sediment
mobilize majority of bed material
erode stream banks
inundate overbank areas

interstitial fines flushed
* grain size distribution
* channel geometry
* entrainment equation

→ threshold discharge

↓

majority of bed material mobilized
* grain size distribution
* channel geometry
* entrainment equation

→ threshold discharge

↓

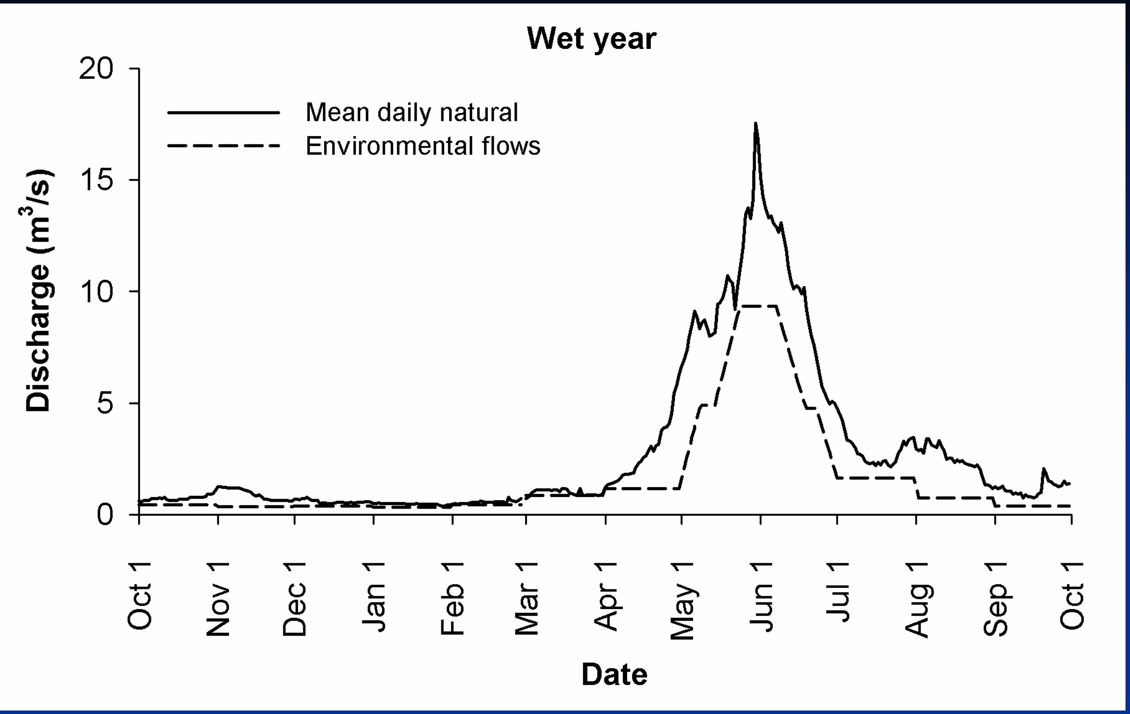
overbank flow occurs
* valley geometry
* channel geometry
* hydraulic model

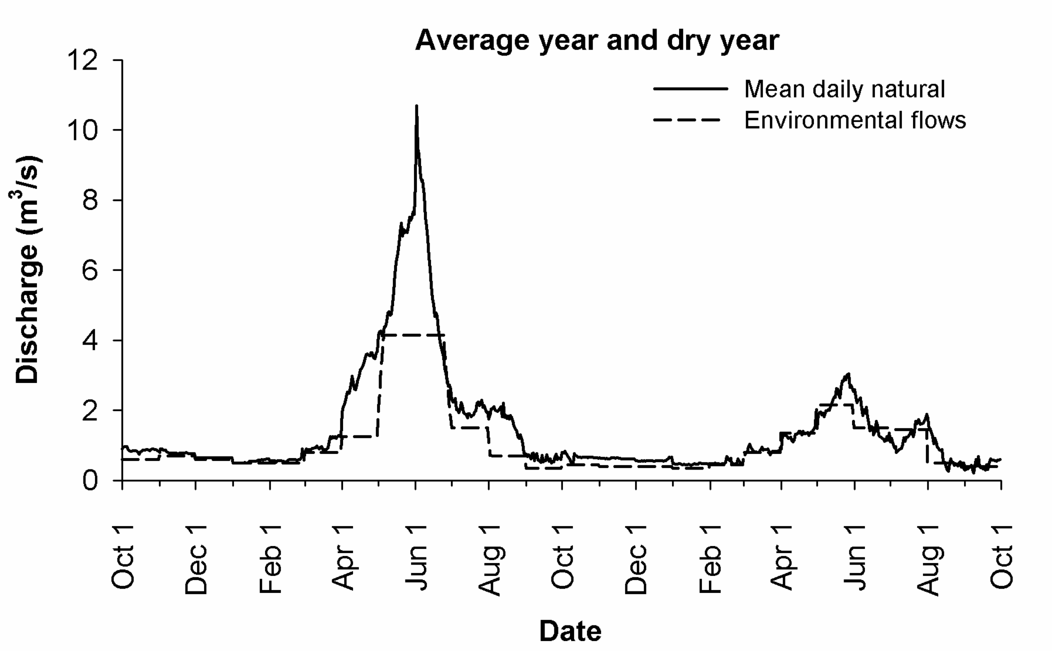
→ threshold discharge

↓

lateral channel mobility
* channel geometry
* bank characteristics (incl. vegetation)
* bank erosion model

→ threshold discharge


Wet year
Discharge (m3/s)
20
15
10
5
0
Mean daily natural
Environmental flows
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Date


Average year and dry year
Discharge (m3/s)
12
10
8
6
4
2
0
Mean daily natural
Environmental flows
Oct 1
Dec 1
Feb 1
Apr 1
Jun 1
Aug 1
Oct 1
Dec 1
Feb 1
Apr 1
Jun 1
Aug 1
Oct 1
Date

Advice from a River

Stay current
Be thoughtful of those downstream
Immerse yourself in nature
Follow the path of least resistance
The beauty is in the journey

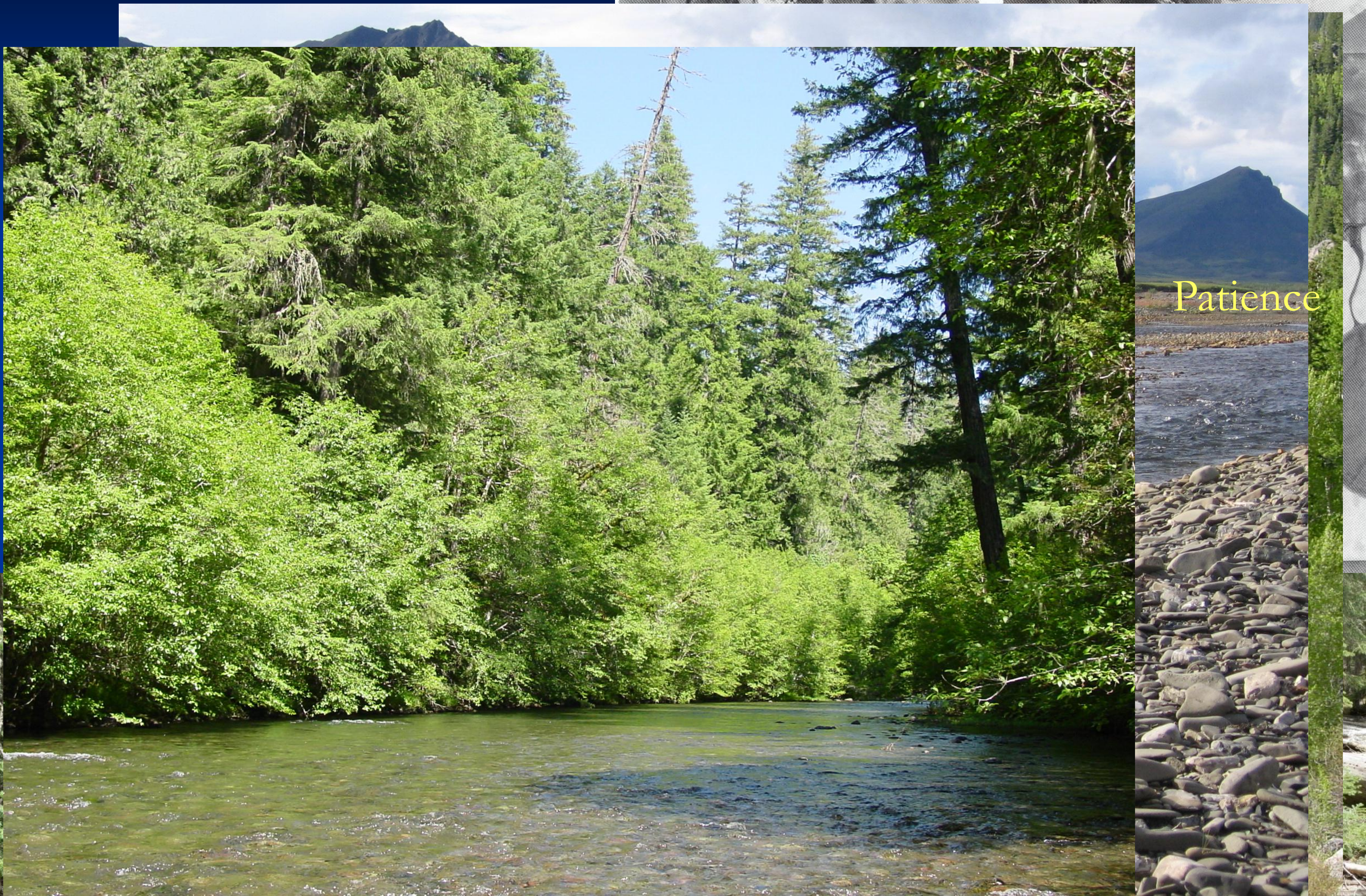
Ilan Shamir

Thinking like a geomorphologist

Connectivity of geomorphic process across drainage basin

Context for management & restoration

Evolution of rivers through time



Patience

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