Ecological Restoration of Fluvial Ecosystems
Why are We Here?

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Overview

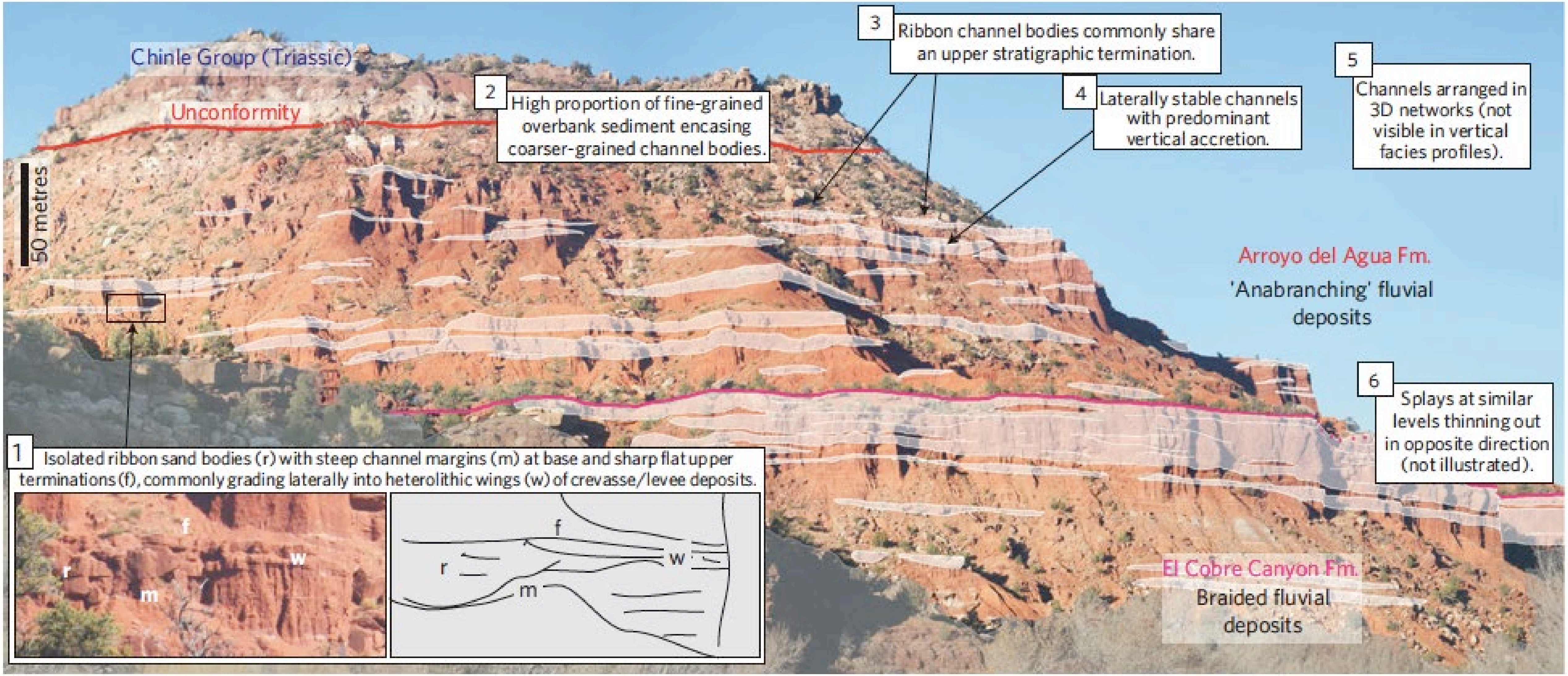
- Course Goals
- A brief history of streams and stream restoration*
- What are the Principles of Ecological Restoration?
- Contrast with Conventional Restoration practices

*More properly "Fluvial Ecosystem Restoration", to include wet meadows, floodplains, channels, etc., systems that are shaped by fluvial processes

Course Goals

- Develop the vocabulary and concepts to introduce Ecological Restoration Principles into stream restoration design, permitting and funding discussions
- Be able to differentiate between restoration projects and infrastructure protection projects
- Be able to differentiate between ecologically-based and form-based restoration projects
- Develop a sense of costs and benefits of various types of restoration
- Provide examples of Ecological Restoration through lectures, classroom exercises, field site visits and hands-on restoration activities

The Evolution of Streams-A 500 Ma history



A Brief History of Rivers and Life

- Before terrestrial colonization by plants (>440 Ma)
  - Sheet-braided planform,
  - coarse-grained alluvium from mechanical weathering,
  - no floodplains or stable banks
- Terrestrial colonization by plants (440 Ma)
  - Mud formation through chemical weathering,
  - fine-grained vertical accretion and induration,
  - some stable banks,
  - floodplains in deltas
- Development of deep roots (400 Ma)
  - Increase in stable banks, lateral accretion (migration),
  - floodplains further inland,
  - increased fine-grained deposition
- Development of arborescence (320 Ma)
  - Large wood and log jams, anastomosing patterns
- Development of beaver dams, canals, lodges, etc. (3-5 Ma)
- Development of human dams, canals, levees, etc. (0.01-0.001 Ma)

< 440 Ma- Sheet Braided Planform

- coarse-grained alluvium from mechanical weathering,
- No floodplains
- No stable banks

Clockwise: Waiho R. NZ,
Klehini R. AK,
Tasman R, NZ,
Slims R. Yukon, CA



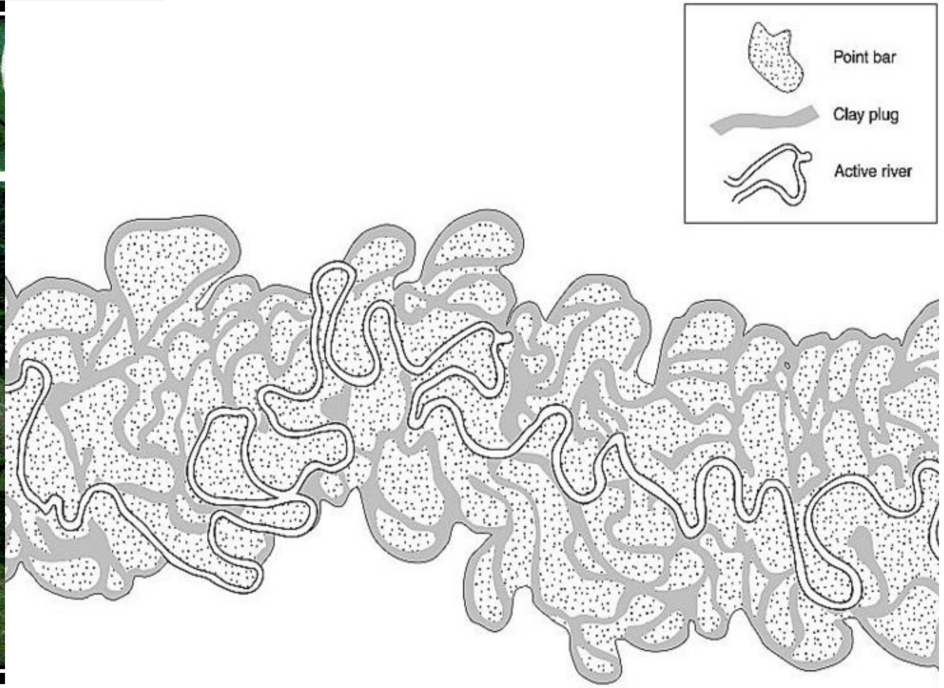

Lateral accretion (meandering planform)

Terrestrial colonization by plants (440 Ma)

- Mud formation through chemical weathering,
- fine-grained vertical accretion and induration,
- some stable banks,
- floodplains in deltas

Development of deep roots (400 Ma)

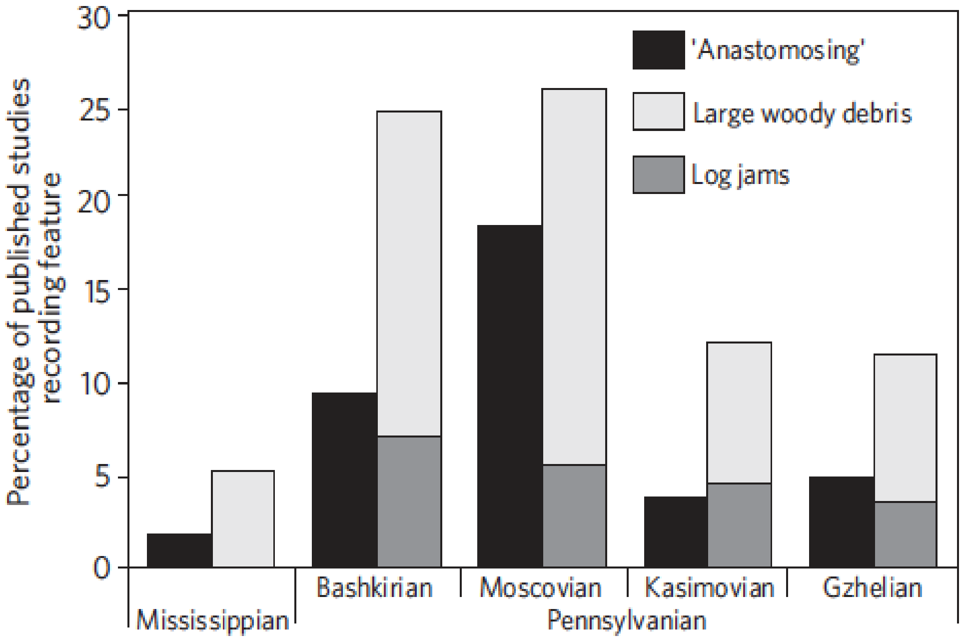
- Increase in stable banks, lateral accretion (migration),
- floodplains further inland,
- increased fine-grained deposition



Anastomosing Planform

Development of arborescence (320 Ma)

- Large wood and log jams
- channel abandonment and filling



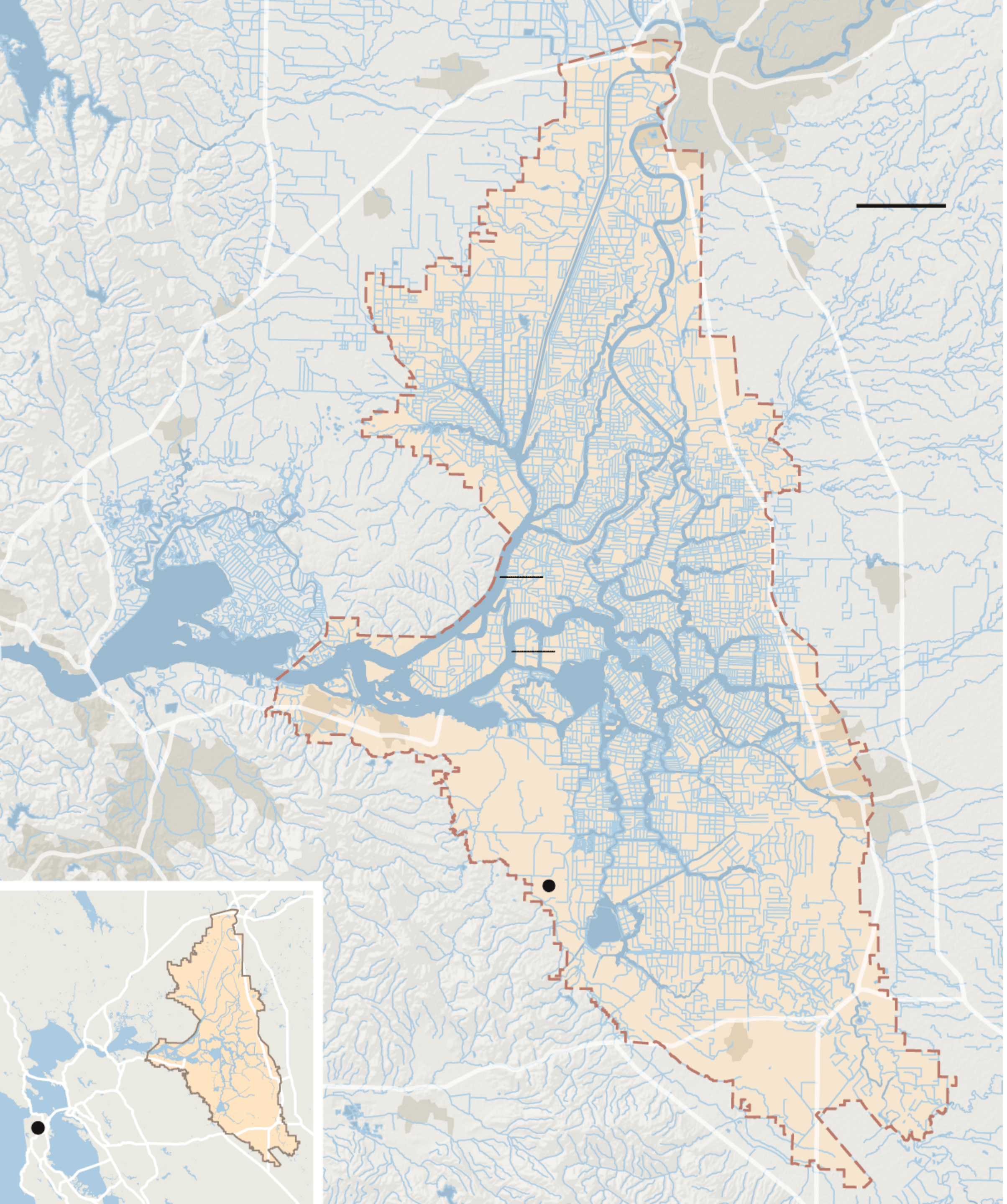
-Beaver appear in the Miocene (about 30 Ma);
-Beaver dams appear in the Pliocene (3-5 Ma)

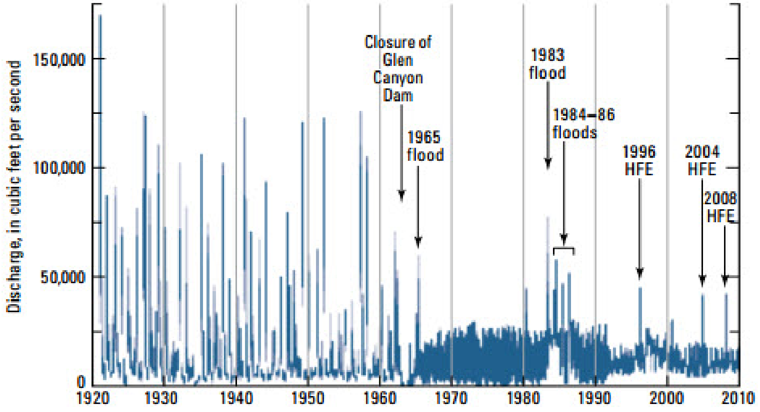
“hydraulic civilizations” appear 0.01 Ma, start taking over planet about 0.0001 Ma

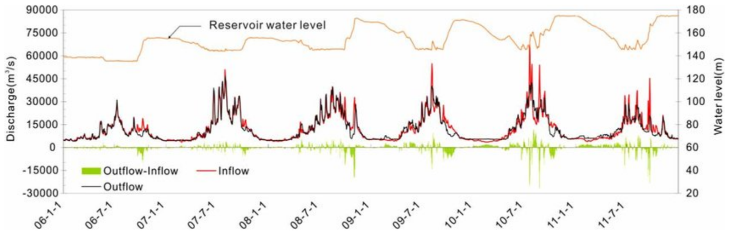
-Dams, drainage and irrigation canals, levees, hardened banks, channel straightening, incision

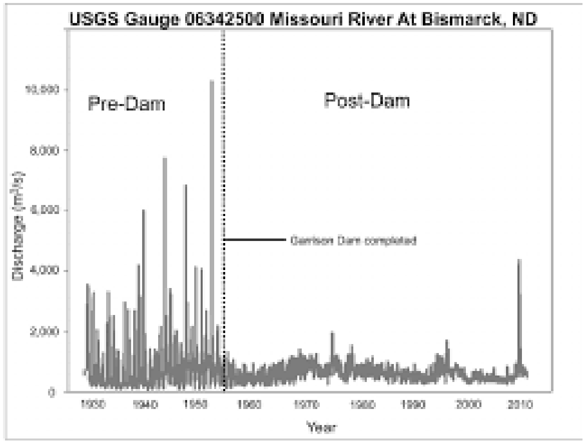
Bank / Bed Hardening

Altered hydrographs and integrated effects









Form-based Restoration (stable channel design)

Principles of form-based restoration (stable channel design)

The concept of channel form equilibrium:

- that a river channel's form is self-adjusting to the prevailing watershed conditions that control the amount of sediment and water delivered to the channel and
- that the dominant or effective discharge controls the size and shape of the channel and that
- this discharge corresponds to bankfull discharge (the point at which flow leaves a channel and spreads out over the floodplain) and that such discharge occurs about 2 out of every 3 years.
- That the channel is stable (sediment inputs = sediment outputs)

Concerns with form-based restoration

- Not the conditions under which species have evolved
- Dominated by hydrological and sediment transport concerns
- Consideration of the interaction of organisms with fluvial processes is minimized
- Based on the (somewhat quaint) notion of equilibrium (e.g. sediment in = sediment out)`and relatively static conditions
- Based on form (usually single-thread)
- Deterministic outcomes
- Low ecological value
- Expensive
- Often at too small a scale to be relevant to ecosystem recovery

Principles of Ecological Restoration

- Incorporates process-based restoration principles
- Incorporates ecological principles to create conditions similar to those in which species have evolved
- Recognizes restoration itself as an ongoing process

Incorporates Process-based Restoration Principles

- Address root causes of habitat and ecosystem change
- Tailor restoration actions to local potential
- Restoration scaled to biological and physical processes
    - larger spatial requirements
    - longer time frames
- Expected outcomes are explicitly stated, including recovery times

See Beechie et al. 2010 for details and examples

Incorporates ecological principles to create conditions similar to those in which species have evolved

- Dynamism is essential for biological diversity (disturbance, environmental variation, shifting mosaic, habitat complexity)
- Stochastic outcomes (probability-based, not deterministic)
- Natural selective pressures-
  - Most individuals die before reproducing
  - Natural variation occurs-those adapted to the existing conditions survive and reproduce
  - Species evolve (Life history strategies and behaviors change over time)
- Focus on net long-term benefit to species and habitat, less concerned with short-term impacts or benefits (i.e. effects on individuals within a population)
- Explicitly recognizes the interactions between biological and physical processes in the restoration process

Recognizes Restoration as a Process

- Minimally invasive procedures first
- Minimize the use of extrinsic energy sources, while maximizing the use of intrinsic energy (e.g. potential and kinetic energy of water, solar energy)
- Explicitly incorporates adaptive management
  - Implementation
  - Monitoring
  - Evaluation
  - Modification of actions based on evaluation
  - Repeat
- Long-term relationship with the land (watershed stewardship)

Summary

- During this week, you will be exposed to the principles of ecological restoration through a variety of mechanisms:
  - Classroom lectures
  - Classroom exercises
  - Field tours
  - Field lectures
  - Hands on experience doing restoration
  - One-on-one or group conversations with instructors
- Overall goals of the course are to:
  - Develop the vocabulary and concepts to introduce Ecological Restoration Principles into stream restoration design, permitting and funding discussions
  - Be able to differentiate between restoration projects and infrastructure protection projects
  - Be able to differentiate between ecologically-based and form-based restoration projects
  - Develop a sense of benefits and costs of various types of restoration projects