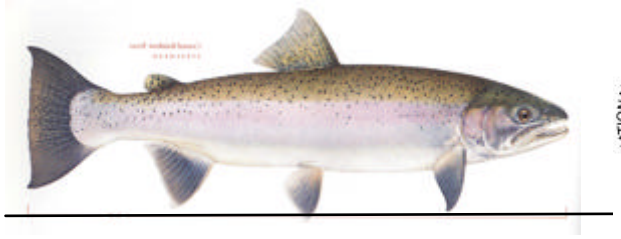
Looking Forward to Steelhead Recovery

David Boughton
NOAA, SW Fisheries Science Center,
Santa Cruz




Copyright 2005 - geology.com

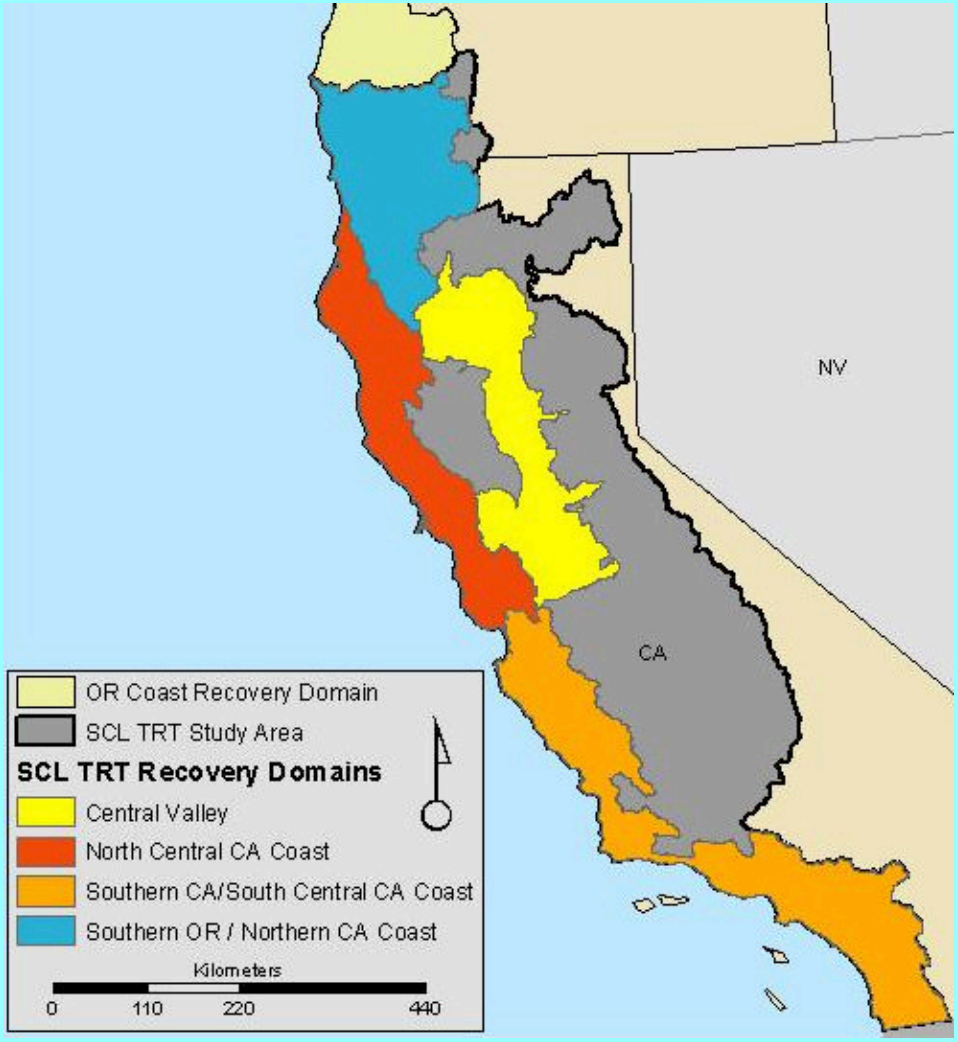
Recovery Domains in California

Oregon-Northern California Coast
- coho salmon

North-Central California Coast
- coho salmon
- Chinook salmon
- steelhead

Southern California Coast
- steelhead

Central Valley
- Winter Run Chinook salmon
- Spring Run Chinook salmon
- steelhead



Principles

General

Fish: Secure evolutionary processes,
Demographic resilience

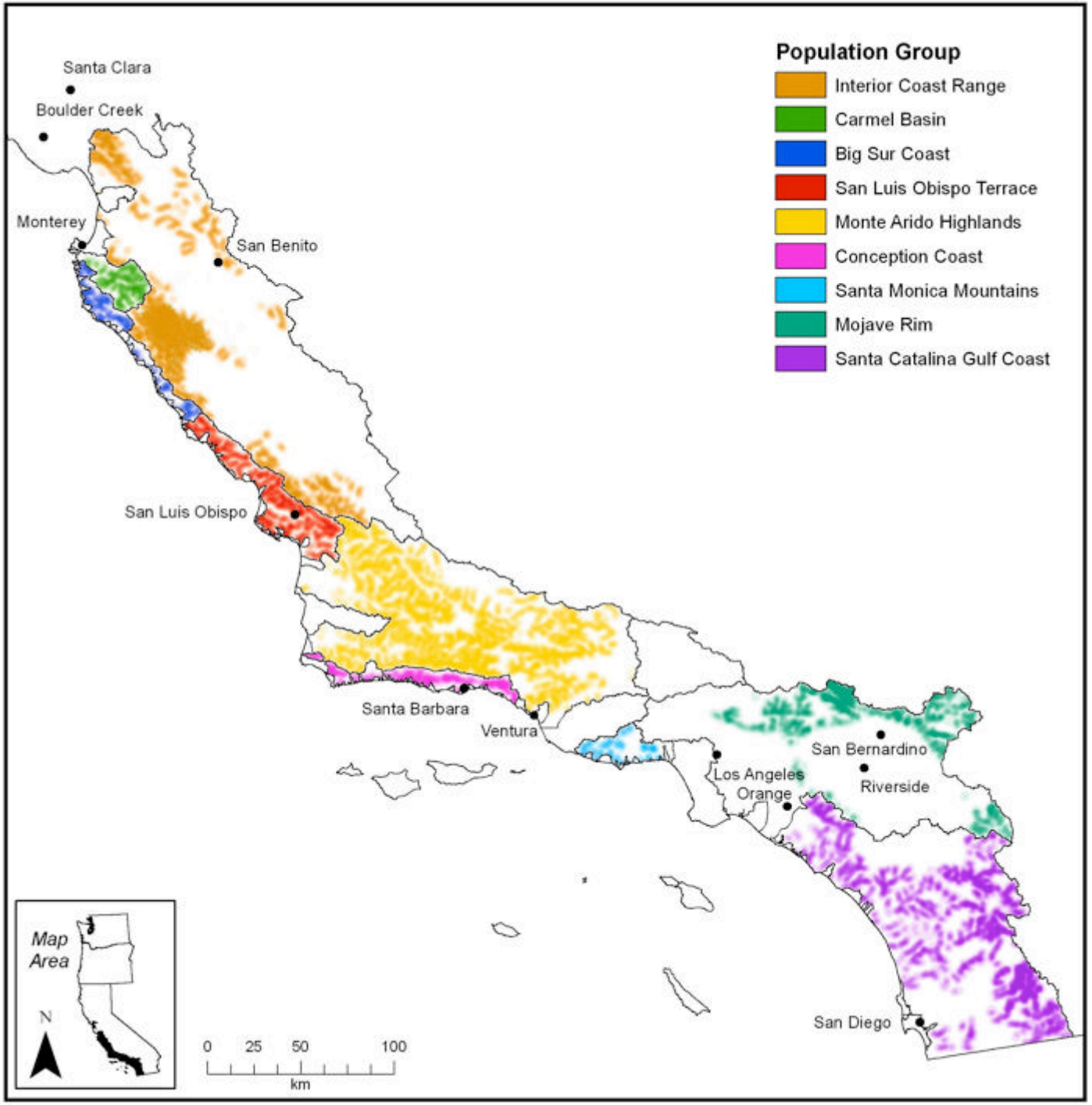
Habitat: Maintained by ecosystem processes,
Our leverage is greatest on freshwater side

Among Populations

Replication and redundancy
System of Core 1, 2 and 3 populations

Within Populations

Abundance, productivity, diversity, spatial structure
Process-based habitat restoration


Population Group
Interior Coast Range
Carmel Basin
Big Sur Coast
San Luis Obispo Terrace
Monte Arido Highlands
Conception Coast
Santa Monica Mountains
Mojave Rim
Santa Catalina Gulf Coast
Santa Clara
Boulder Creek
Monterey
San Benito
San Luis Obispo
Santa Barbara
Ventura
San Bernardino
Riverside
Los Angeles
Orange
San Diego
Map Area
N
0 25 50 100
km

Principles

General

Fish: Secure evolutionary processes,
Demographic resilience

Habitat: Maintained by ecosystem processes,
Our leverage is greatest on freshwater side

Among Populations

Replication and redundancy
System of Core 1, 2 and 3 populations

Within Populations

Abundance, productivity, diversity, spatial structure
Process-based habitat restoration

Principles

General

Fish: Secure evolutionary processes,
Demographic resilience

Habitat: Maintained by ecosystem processes,
Our leverage is greatest on freshwater side

Among Populations

Replication and redundancy
System of Core 1, 2 and 3 populations

Within Populations

Abundance, productivity, diversity, spatial structure
Process-based habitat restoration

Obsolete Concepts:

Stationary Climate
-> Rainfall and Temperature vary year to year,
but mean and variance are stable.

Pristine Habitat
-> Pre-settlement conditions provide an objective
reference for habitat restoration goals.

The Problem of Complexity can be solved
-> Science and engineering
can provide efficiency/capacity gains
with no unintended consequences

New Concepts:

Self-Organization

Hierarchical Structure
(Near-Decomposability)

Adaptive Capacity

Resilience
("Upside Uncertainty")

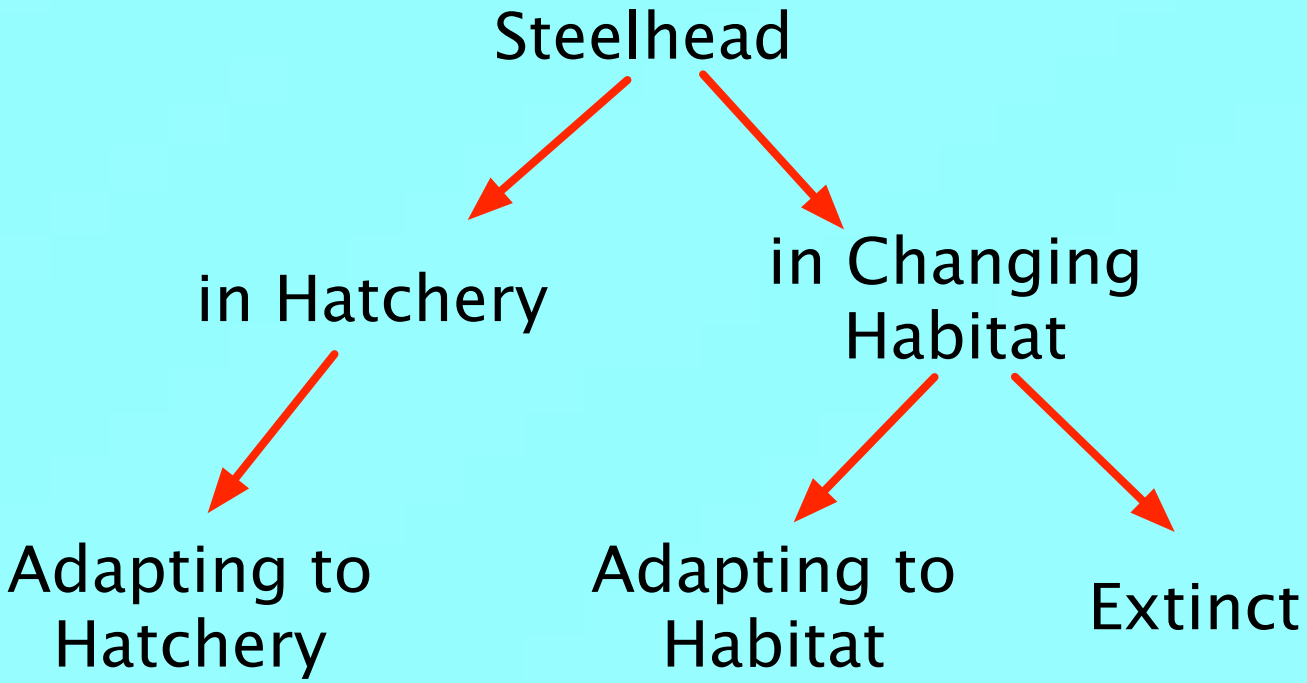
Self-Organization

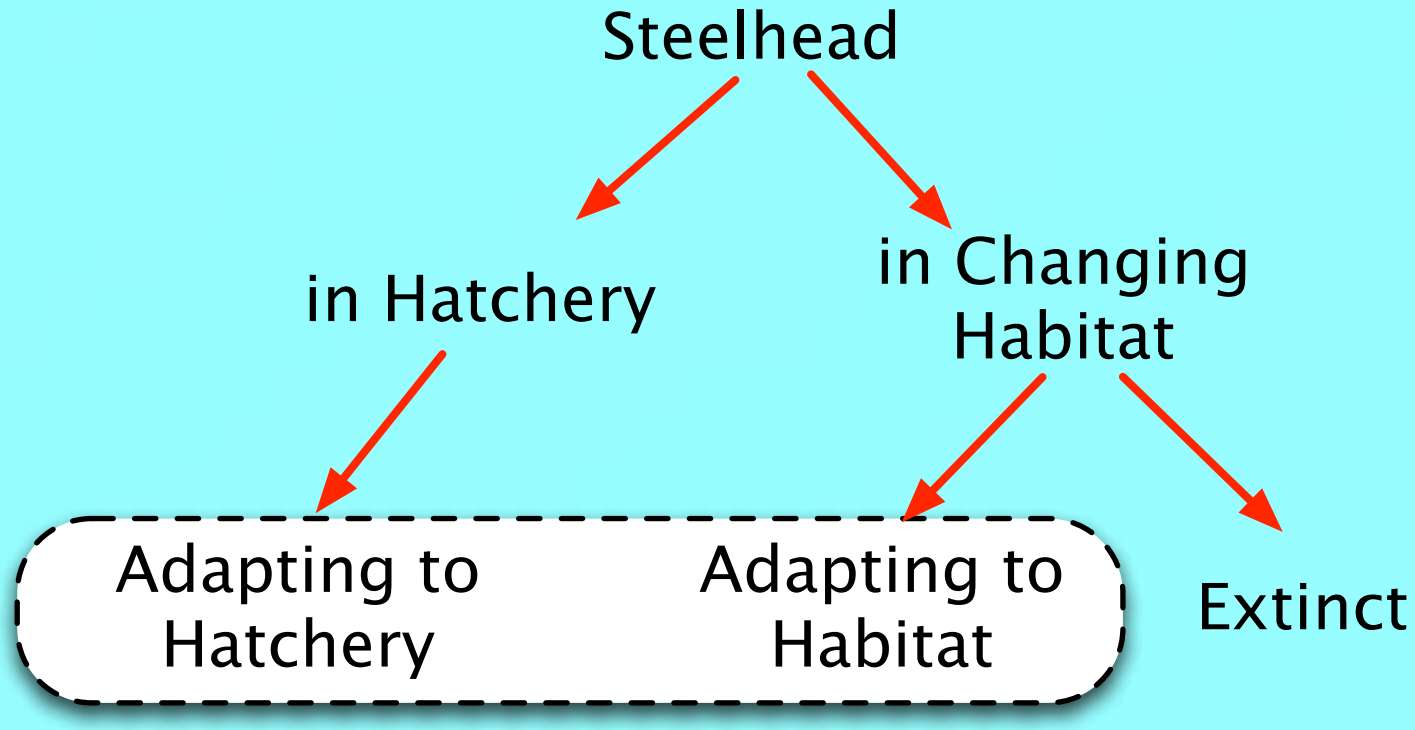
Steelhead Populations
-> Evolution toward maximum fitness

Stream Systems
-> Directional, iterative adjustment
toward minimum geomorphic work

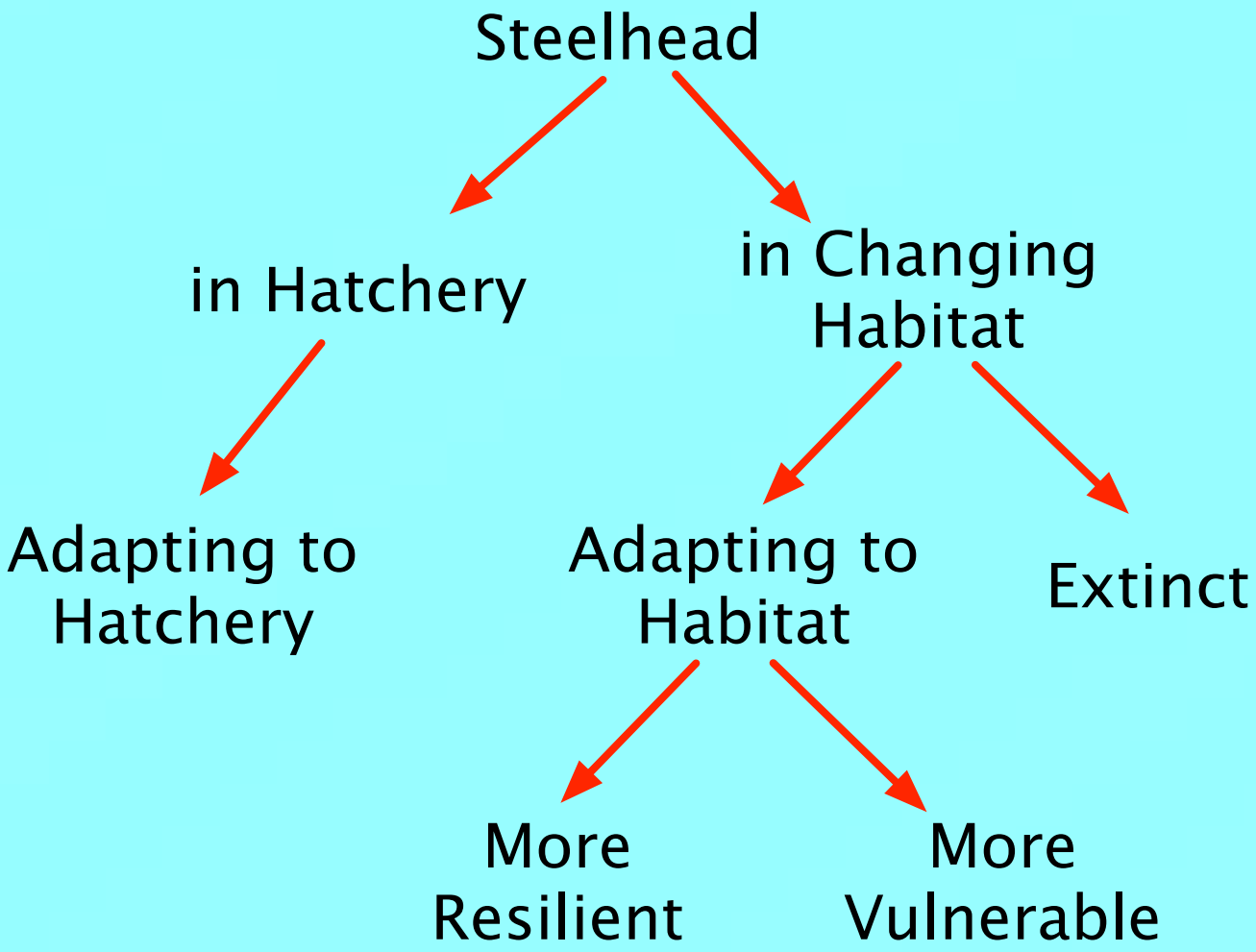
Climate
-> Adjustment of energy stocks and flows
toward global radiative balance

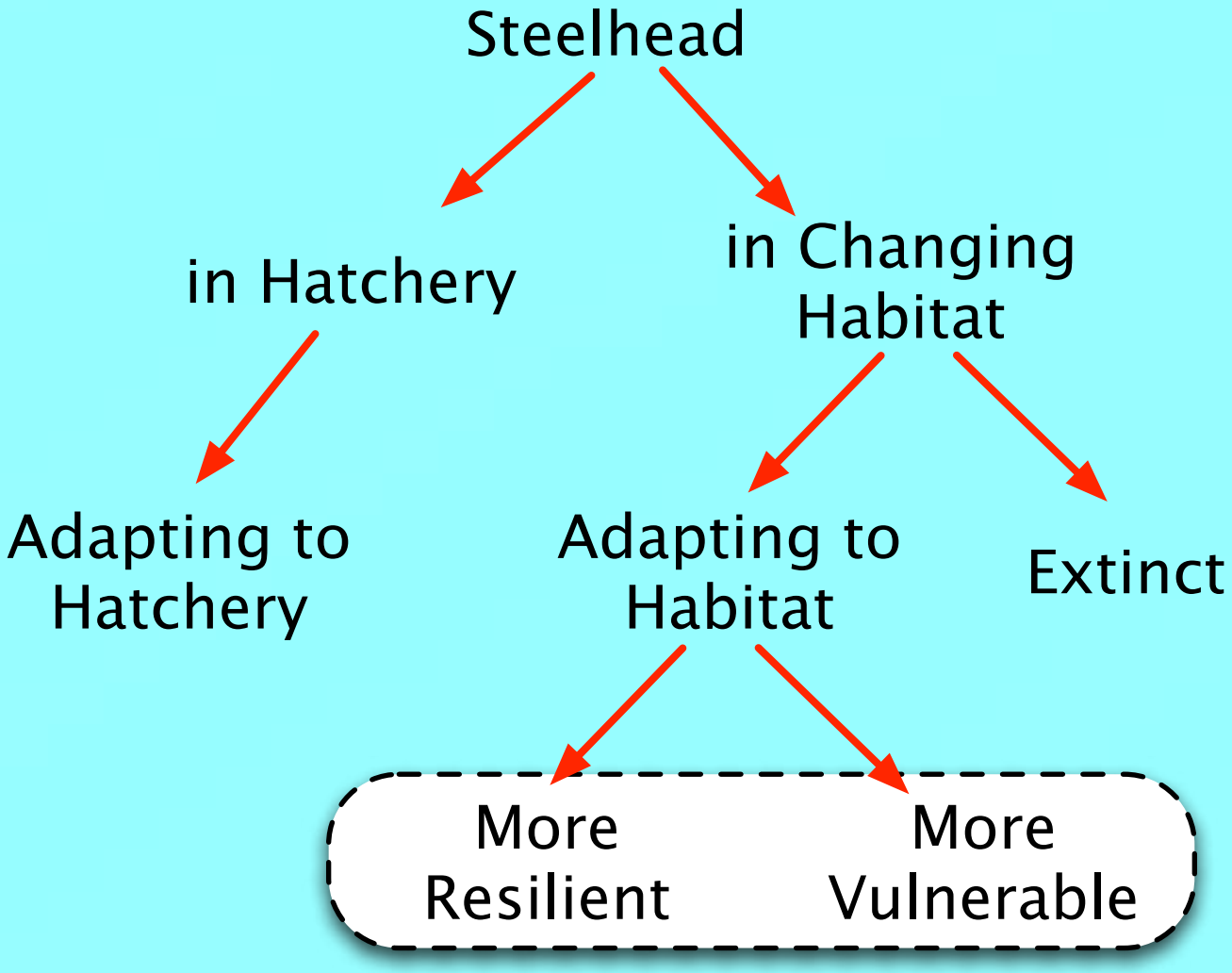
People
-> Maximize utility?


Steelhead
in Hatchery
in Changing Habitat
Adapting to Hatchery
Adapting to Habitat
Extinct



Mostly Empirical, Inductive


Steelhead
in Hatchery
in Changing Habitat
Adapting to Hatchery
Adapting to Habitat
Extinct
More Resilient
More Vulnerable


Steelhead
in Hatchery
in Changing Habitat
Adapting to Hatchery
Adapting to Habitat
Extinct
More Resilient
More Vulnerable

Release the Adaptive Capacity of Steelhead

Stream systems

that generate abundant opportunities for steelhead

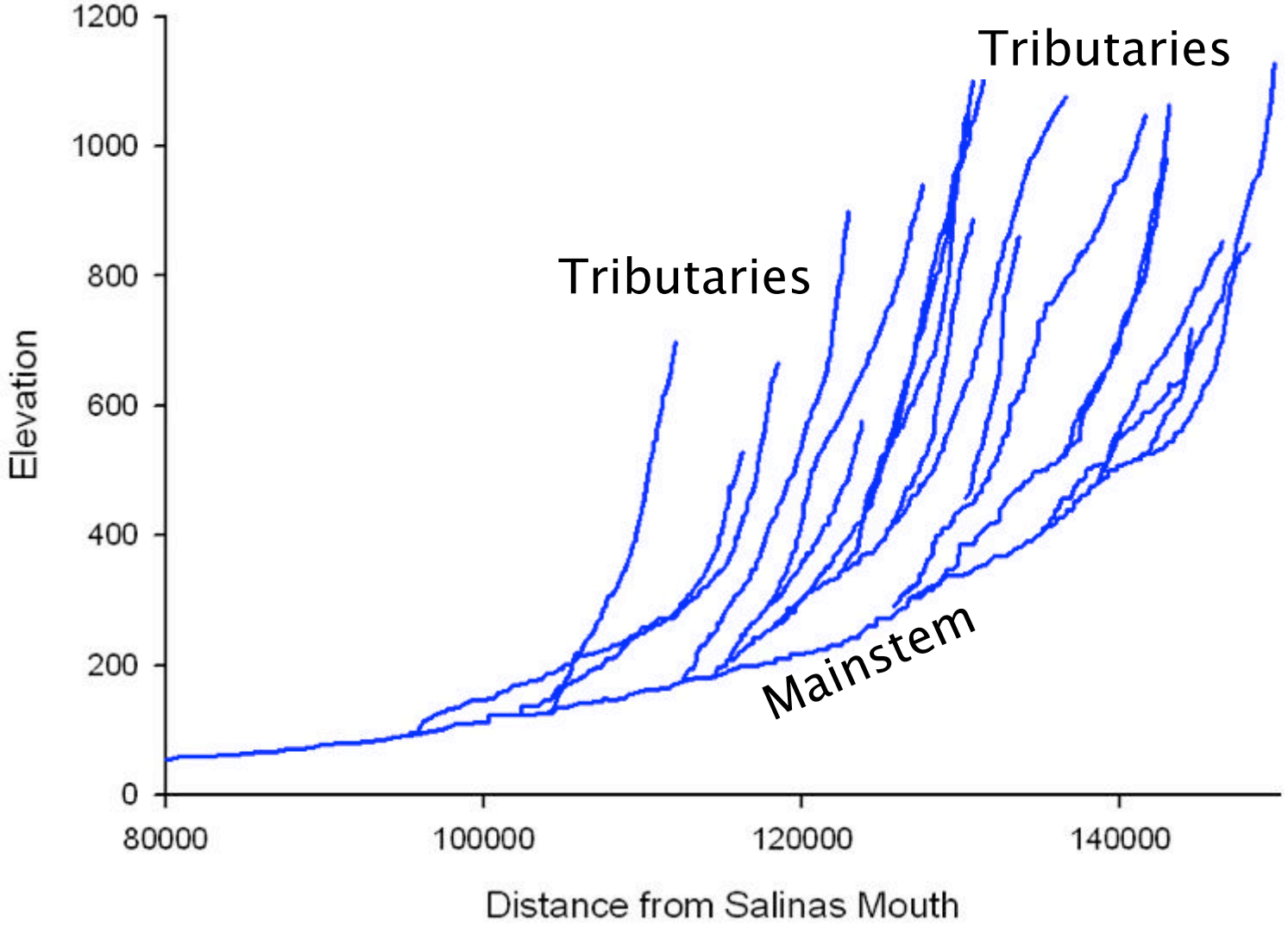
to pursue diverse life-history pathways

within their evolutionary competence

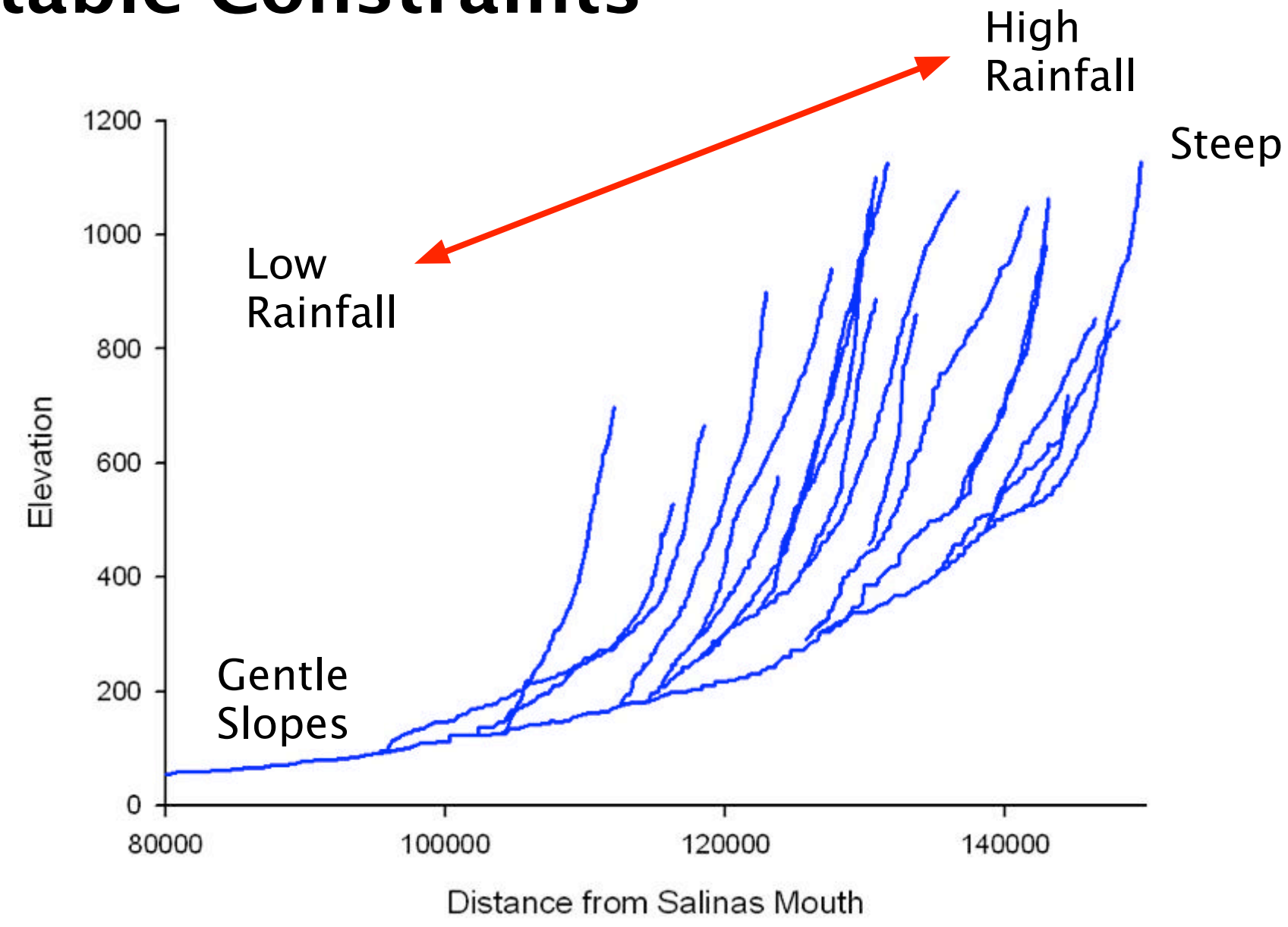
Stream Systems

Water
&
Sediment
&
Riparian Vegetation

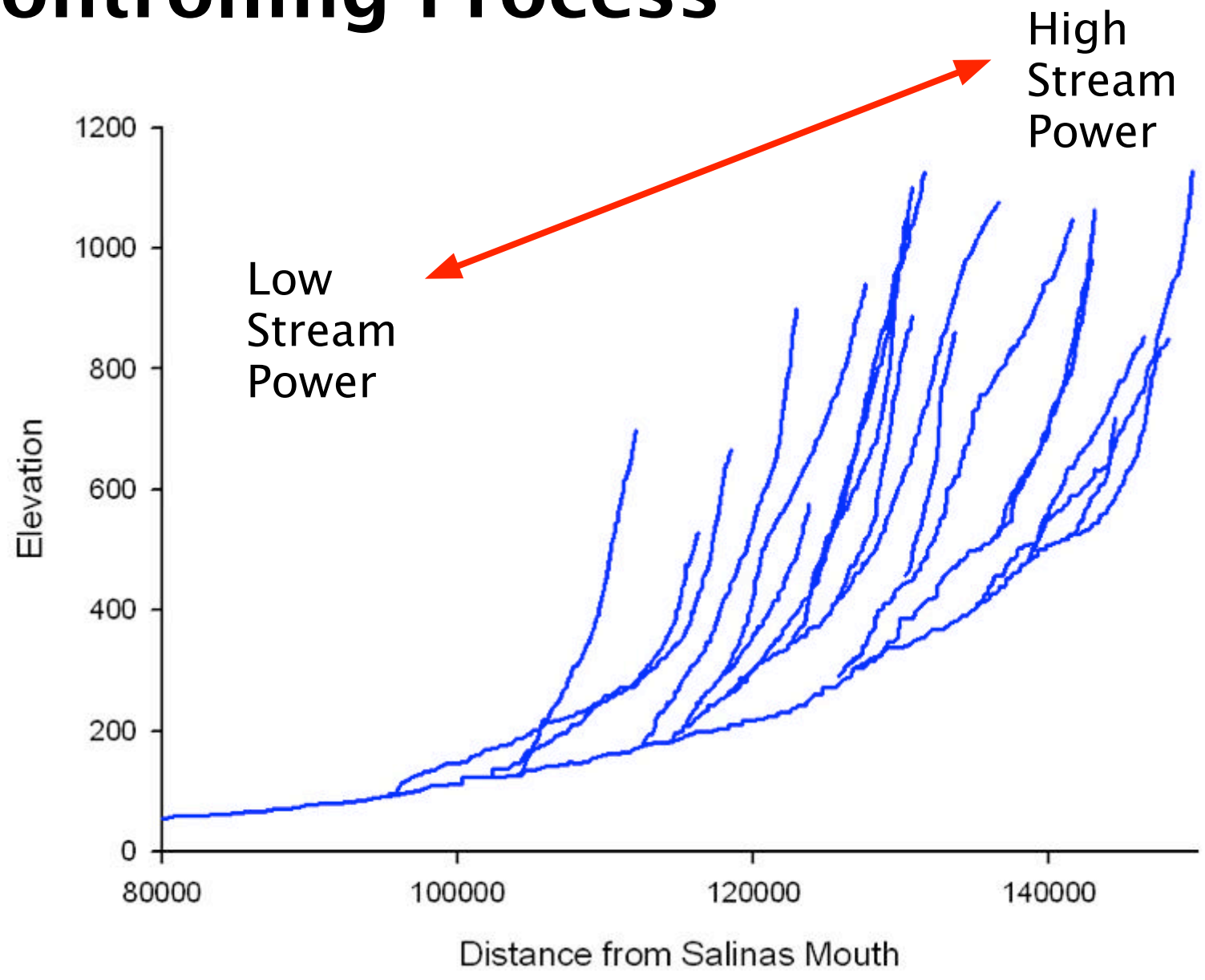
Profile of Arroyo Seco & Tribs



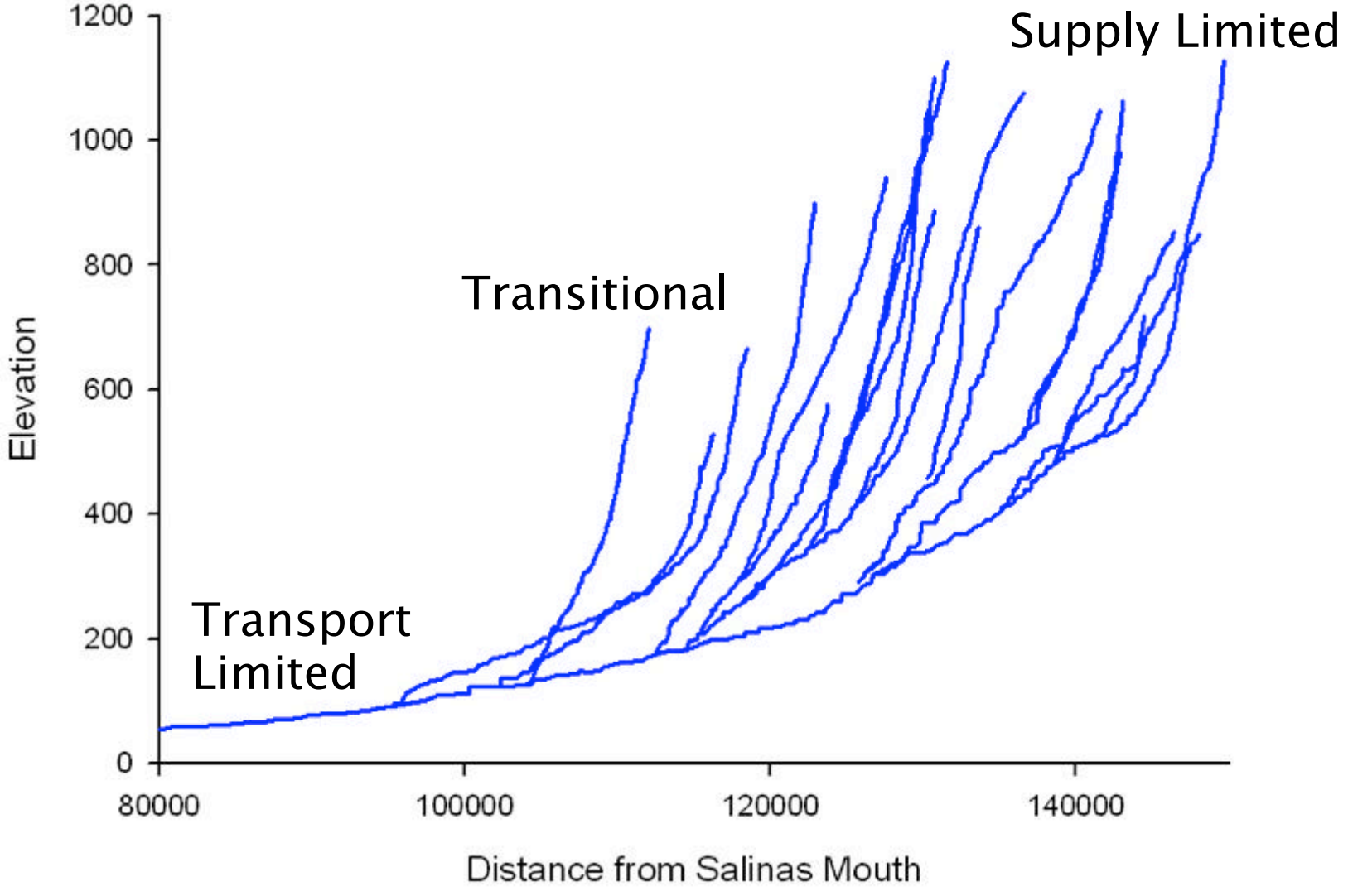
Stable Constraints



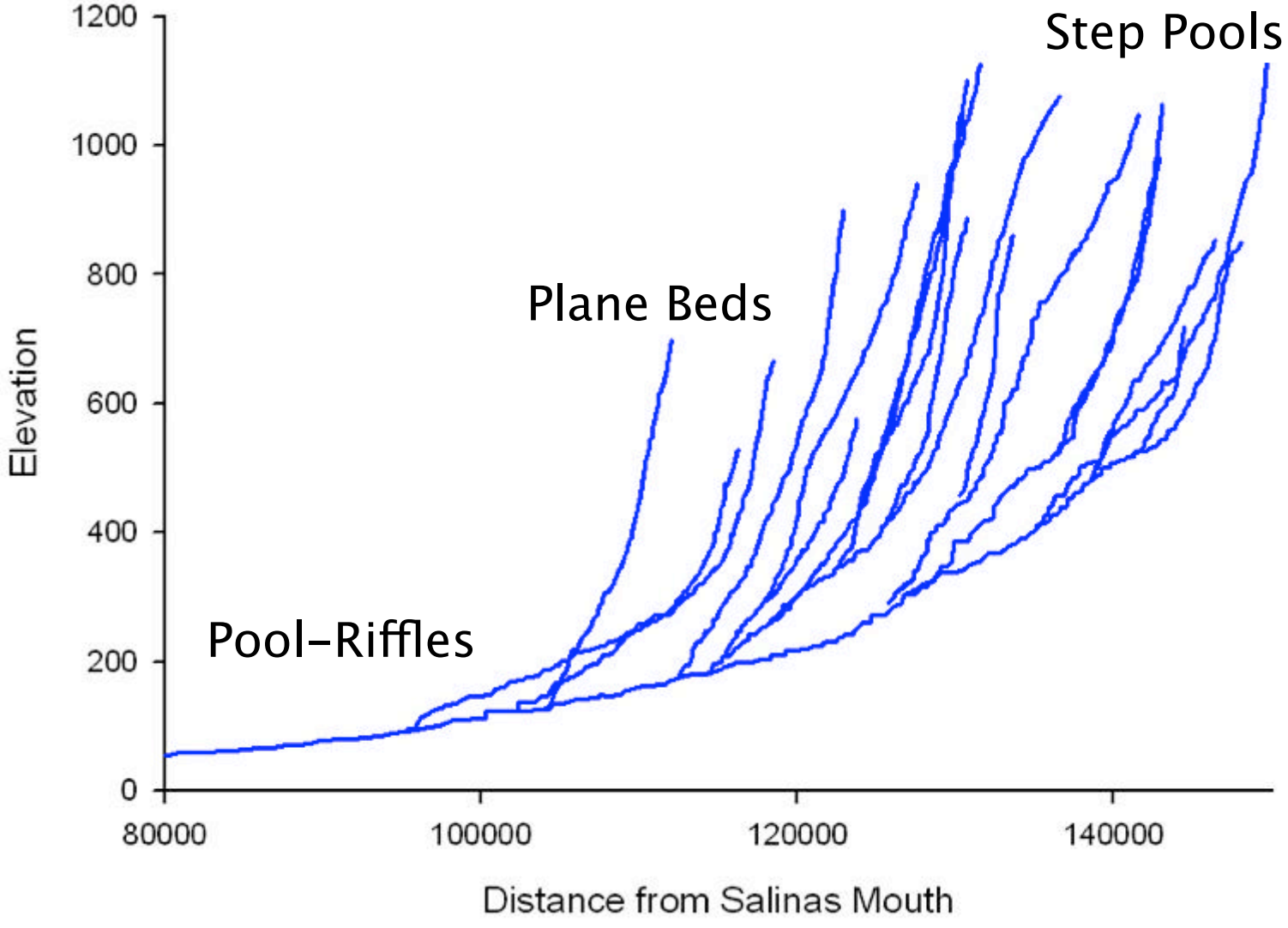
Controlling Process



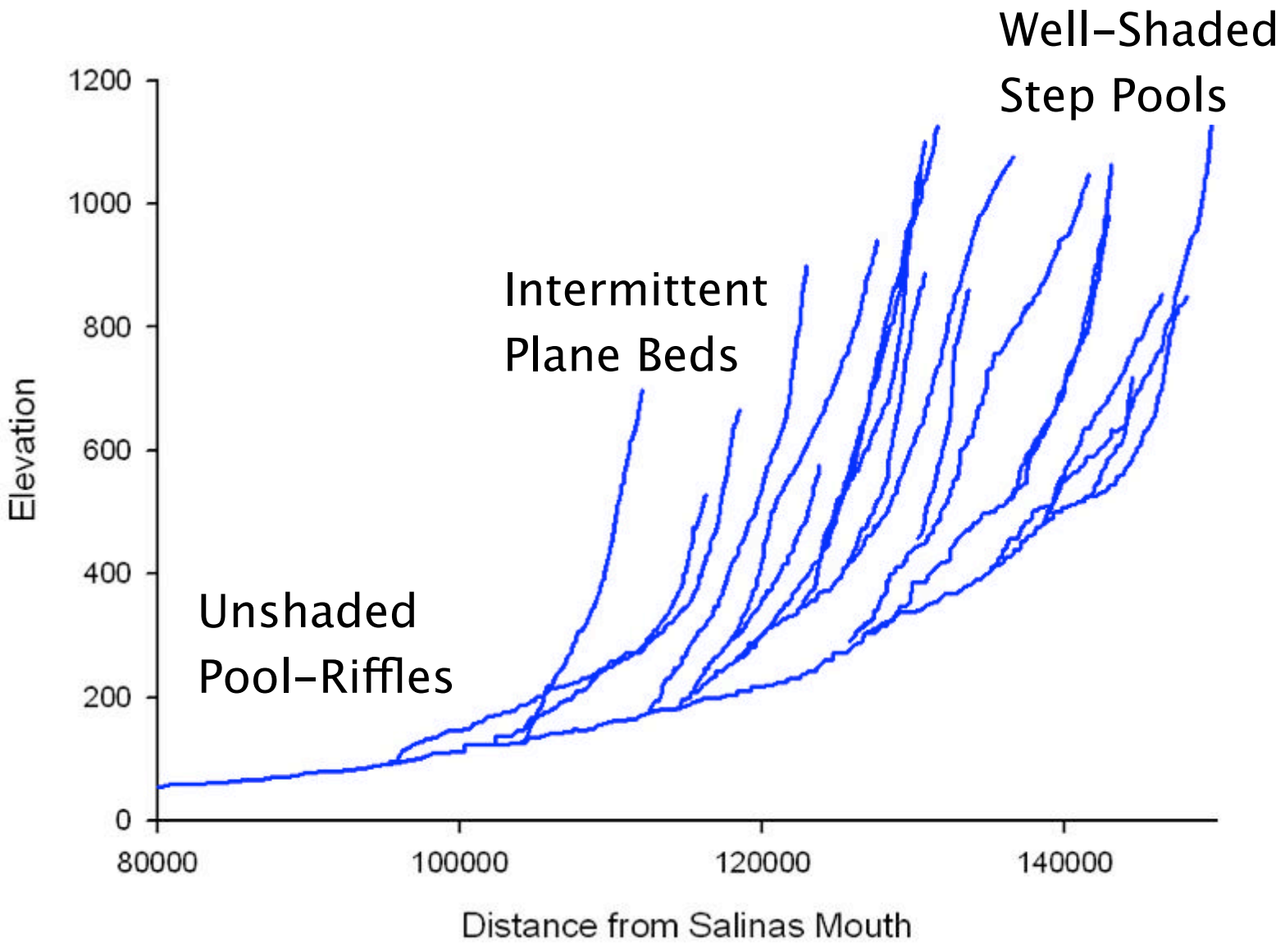
Sediment Movement



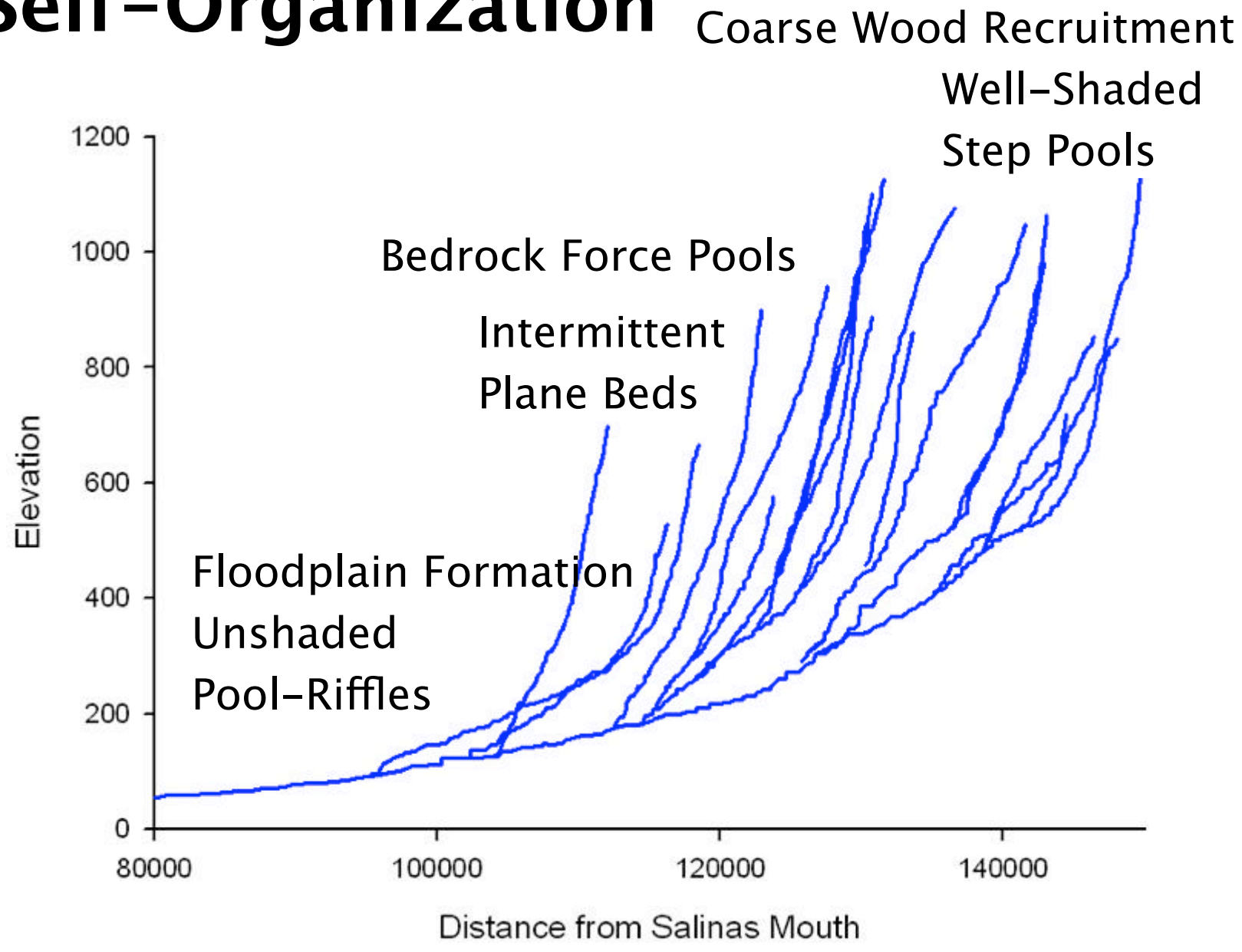
Self-Organization



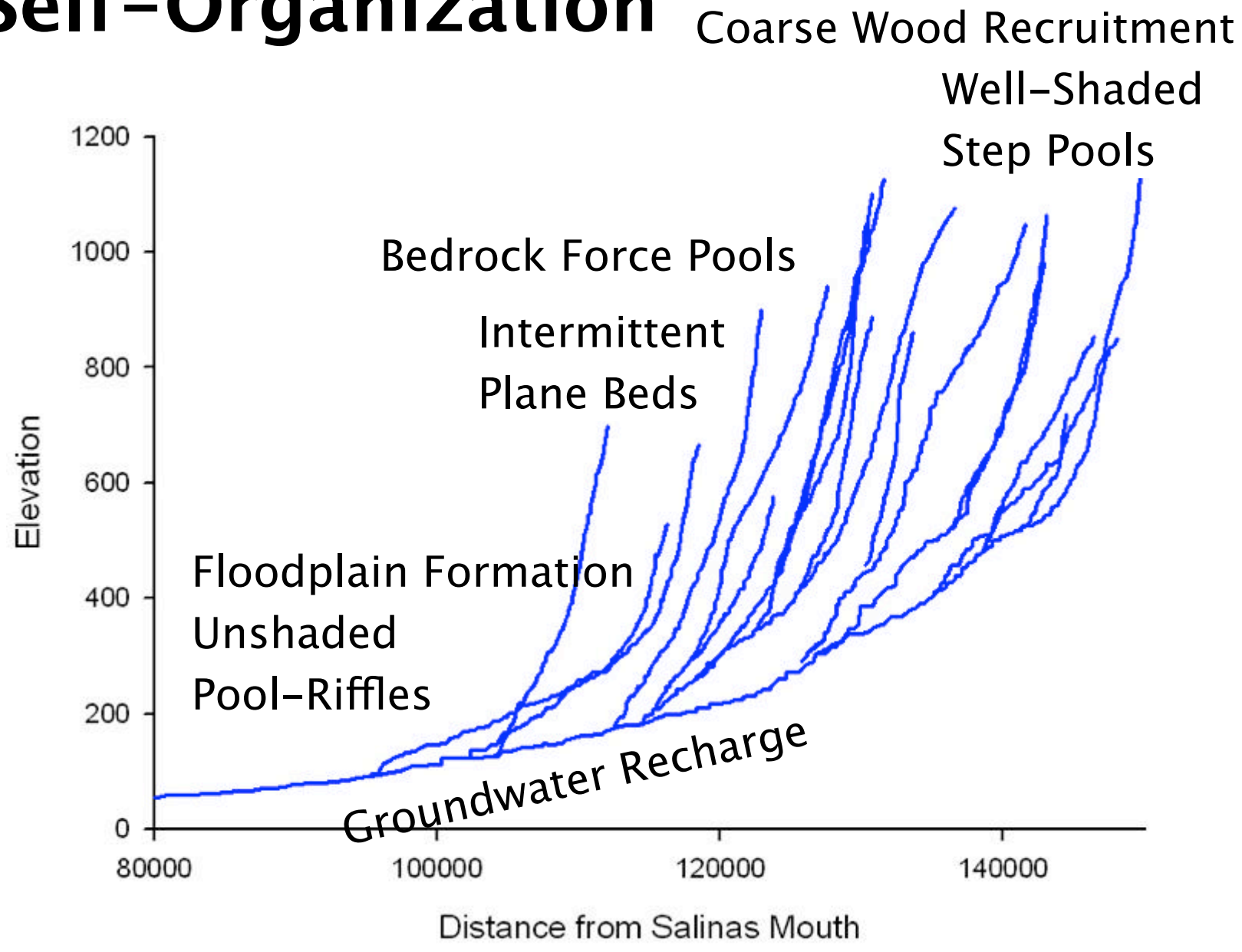
Self-Organization



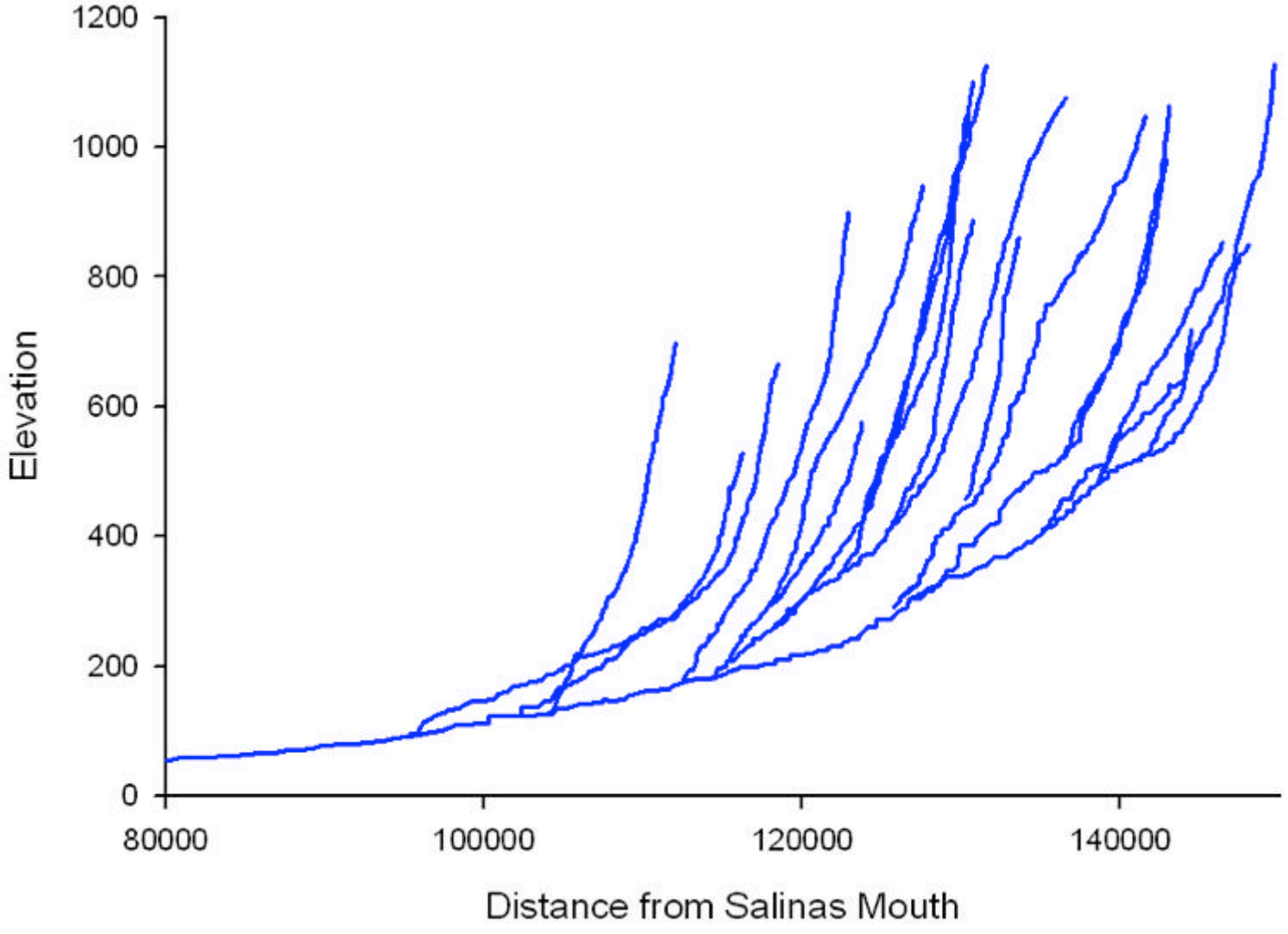
Self-Organization



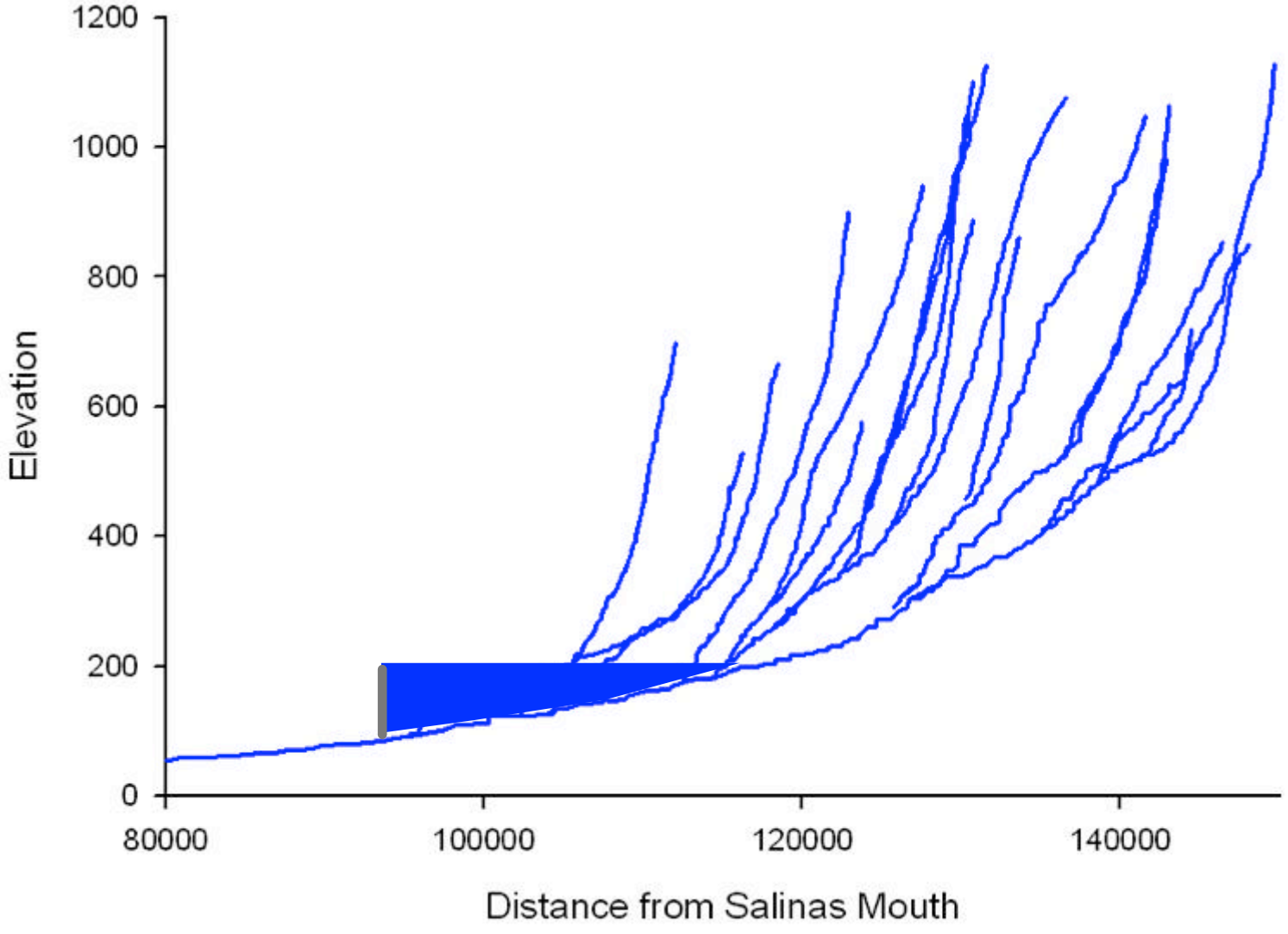
Self-Organization



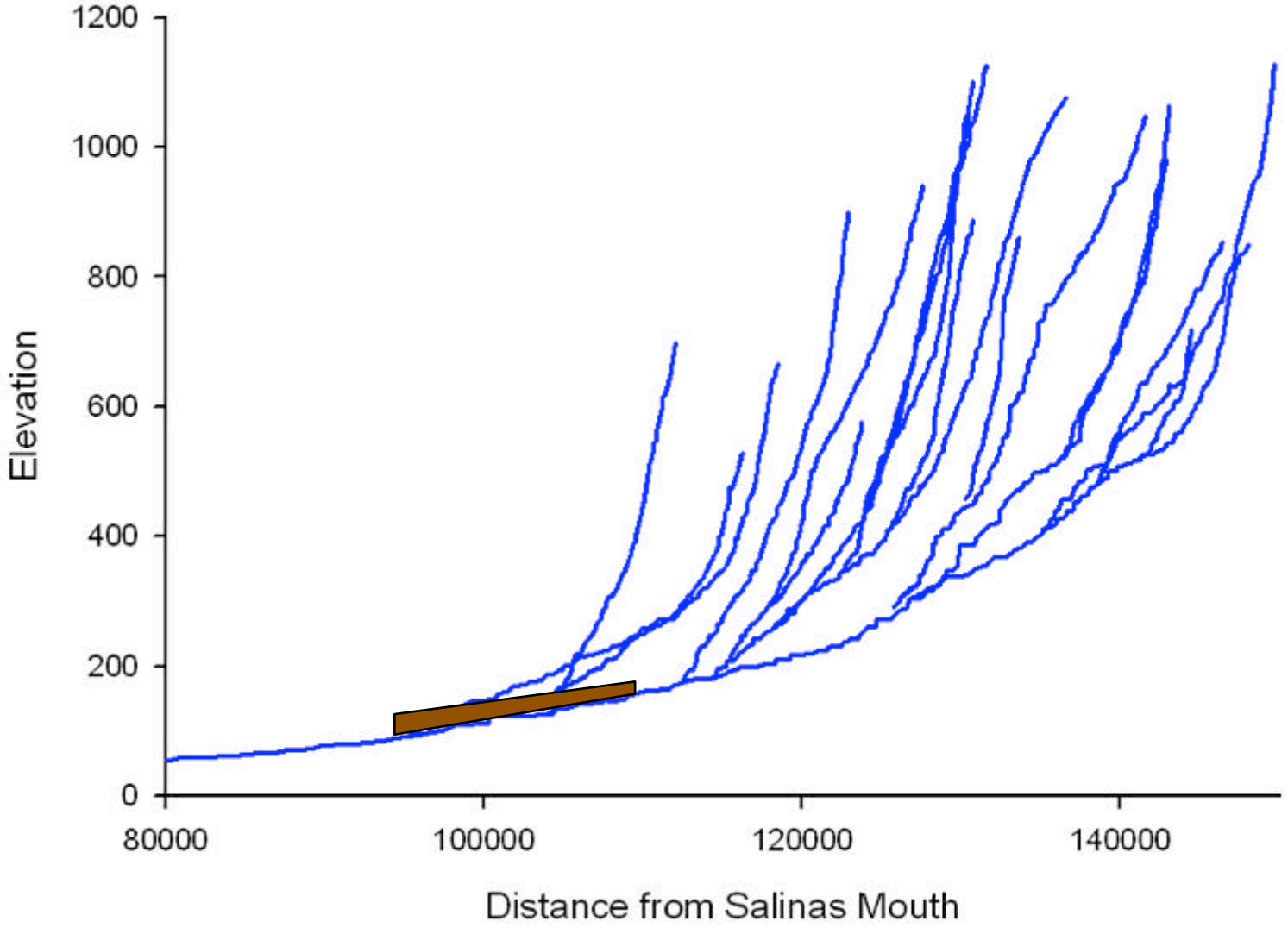
Self-Organization

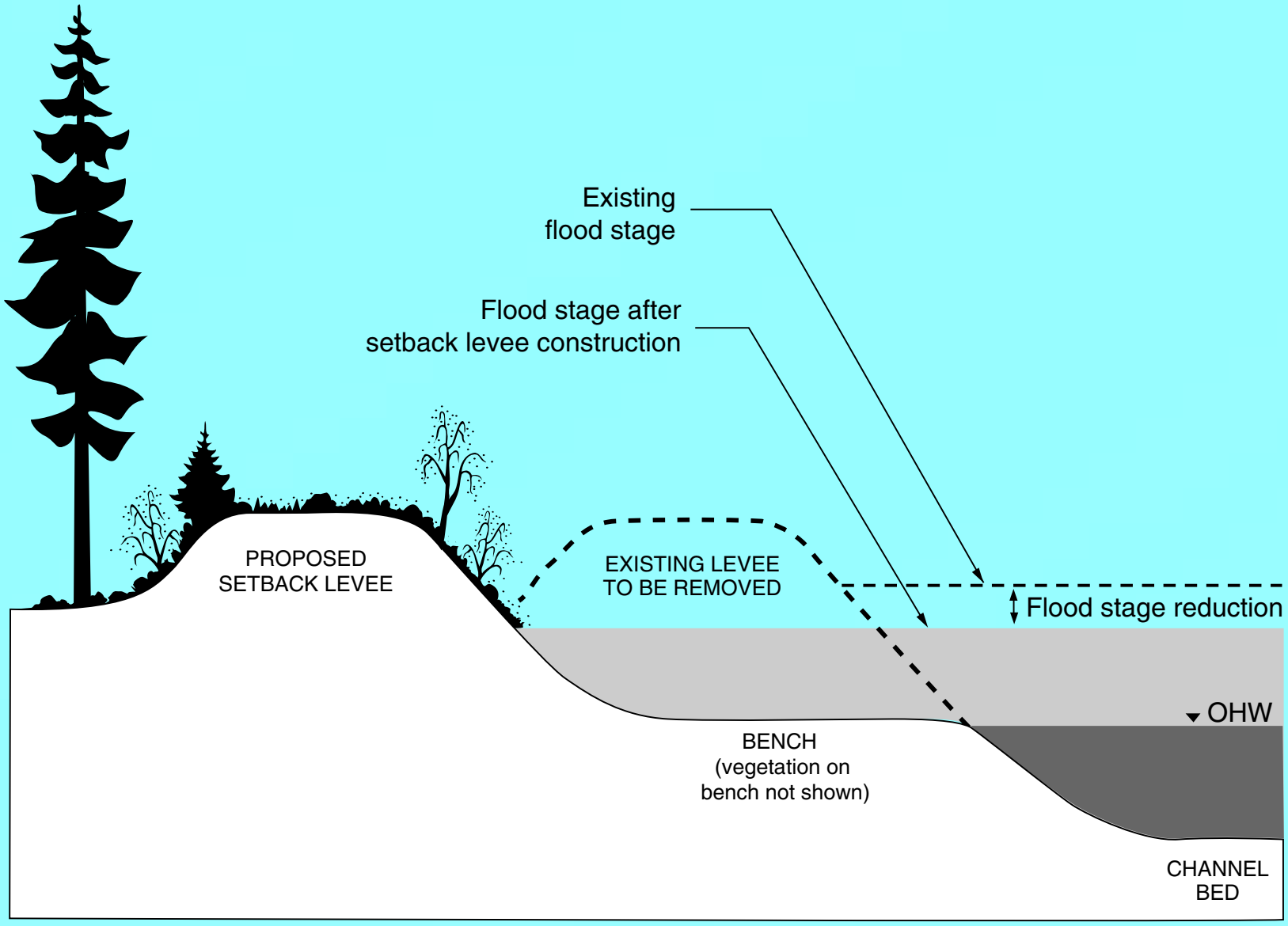


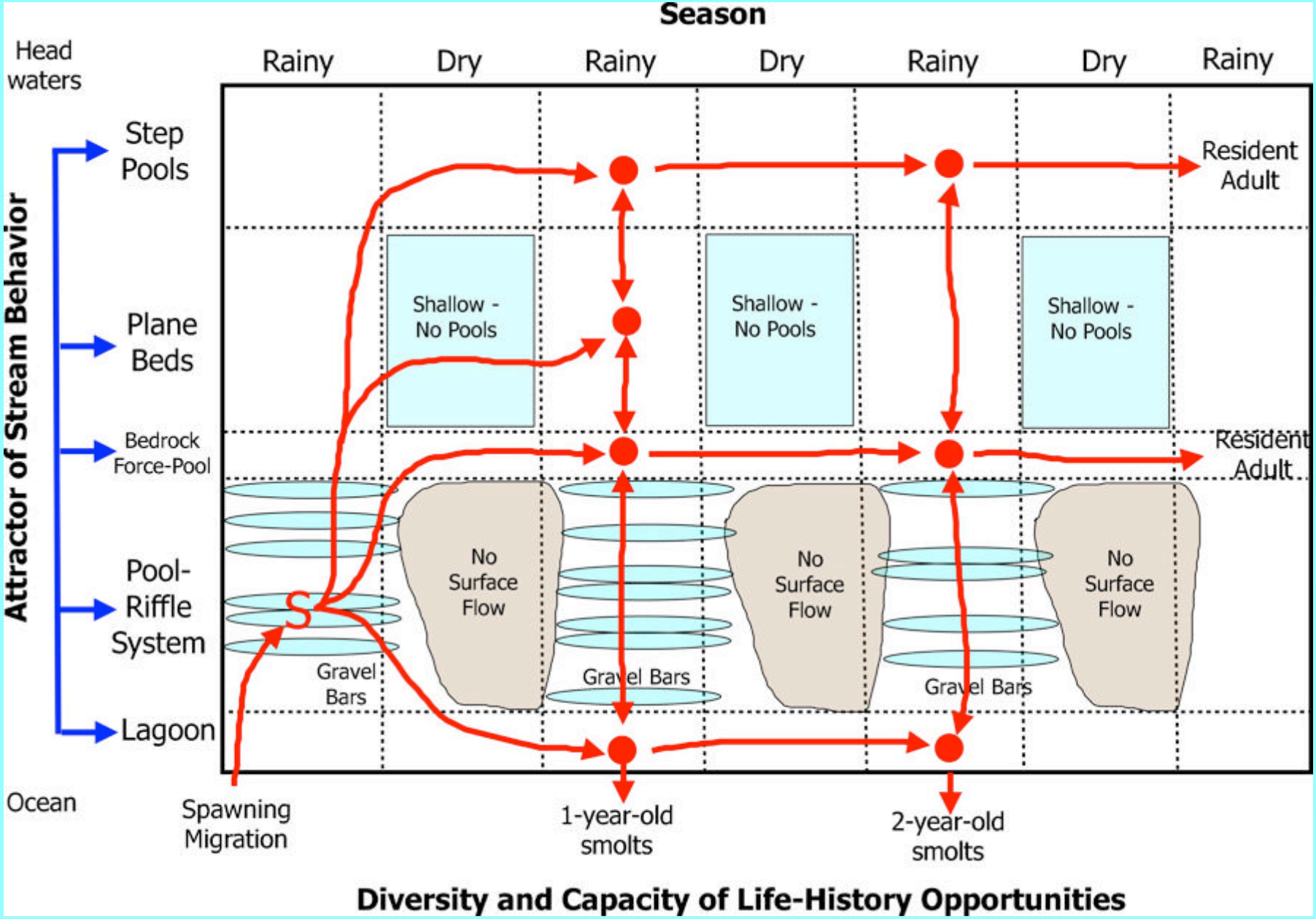
Self-Organization



Self-Organization




Existing
flood stage
Flood stage after
setback levee construction
PROPOSED
SETBACK LEVEE
EXISTING LEVEE
TO BE REMOVED
Flood stage reduction
OHW
BENCH
(vegetation on
bench not shown)
CHANNEL
BED


Season
Rainy
Dry
Rainy
Dry
Rainy
Dry
Rainy
Head waters
Step Pools
Plane Beds
Bedrock Force-Pool
Pool-Riffle System
Lagoon
Ocean
Attractor of Stream Behavior
Shallow - No Pools
Shallow - No Pools
Shallow - No Pools
Resident Adult
Resident Adult
No Surface Flow
No Surface Flow
No Surface Flow
Gravel Bars
Gravel Bars
Gravel Bars
S
Spawning Migration
1-year-old smolts
2-year-old smolts
Diversity and Capacity of Life-History Opportunities

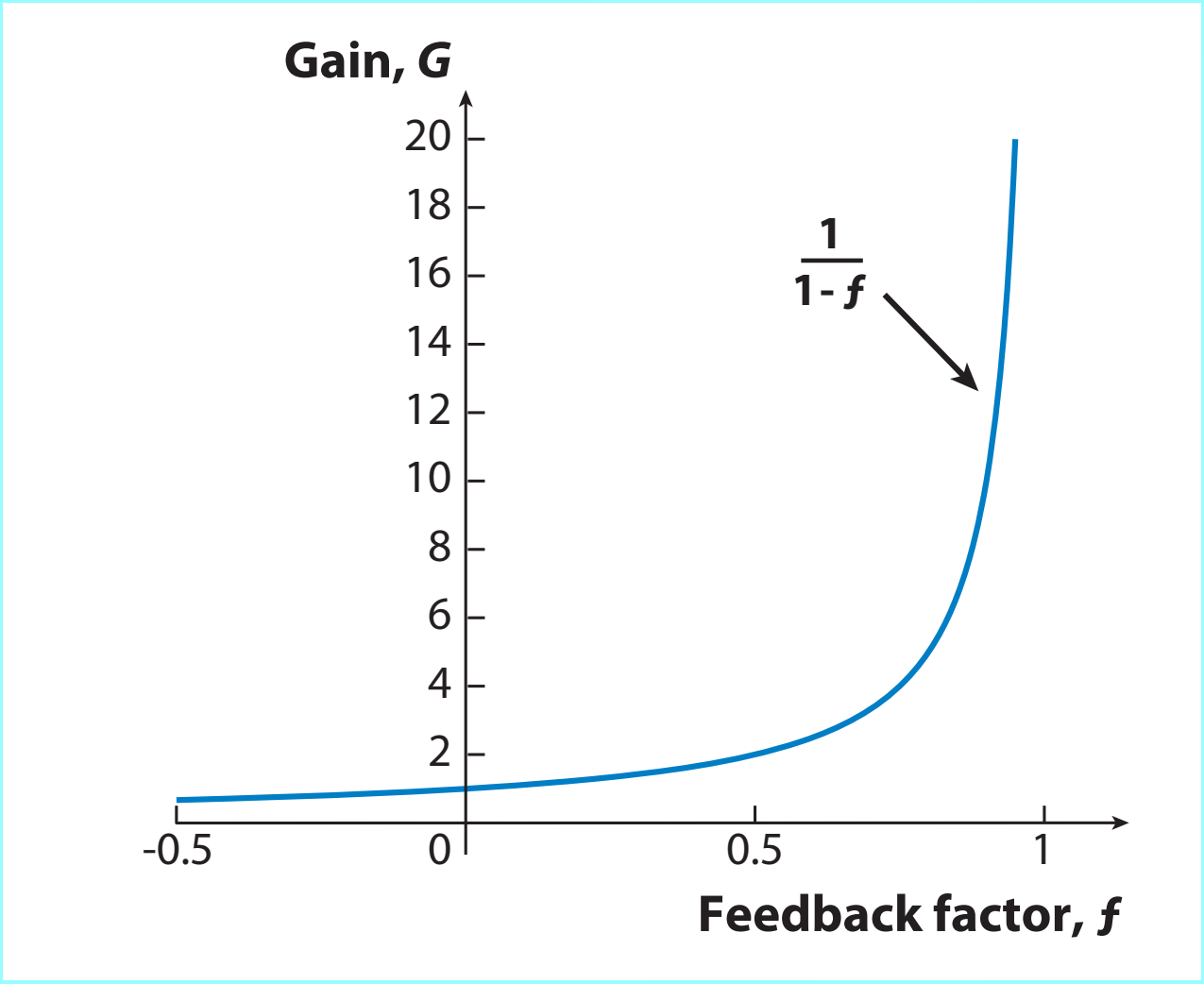
Ramping of Greenhouse Gasses

Anthropogenic:

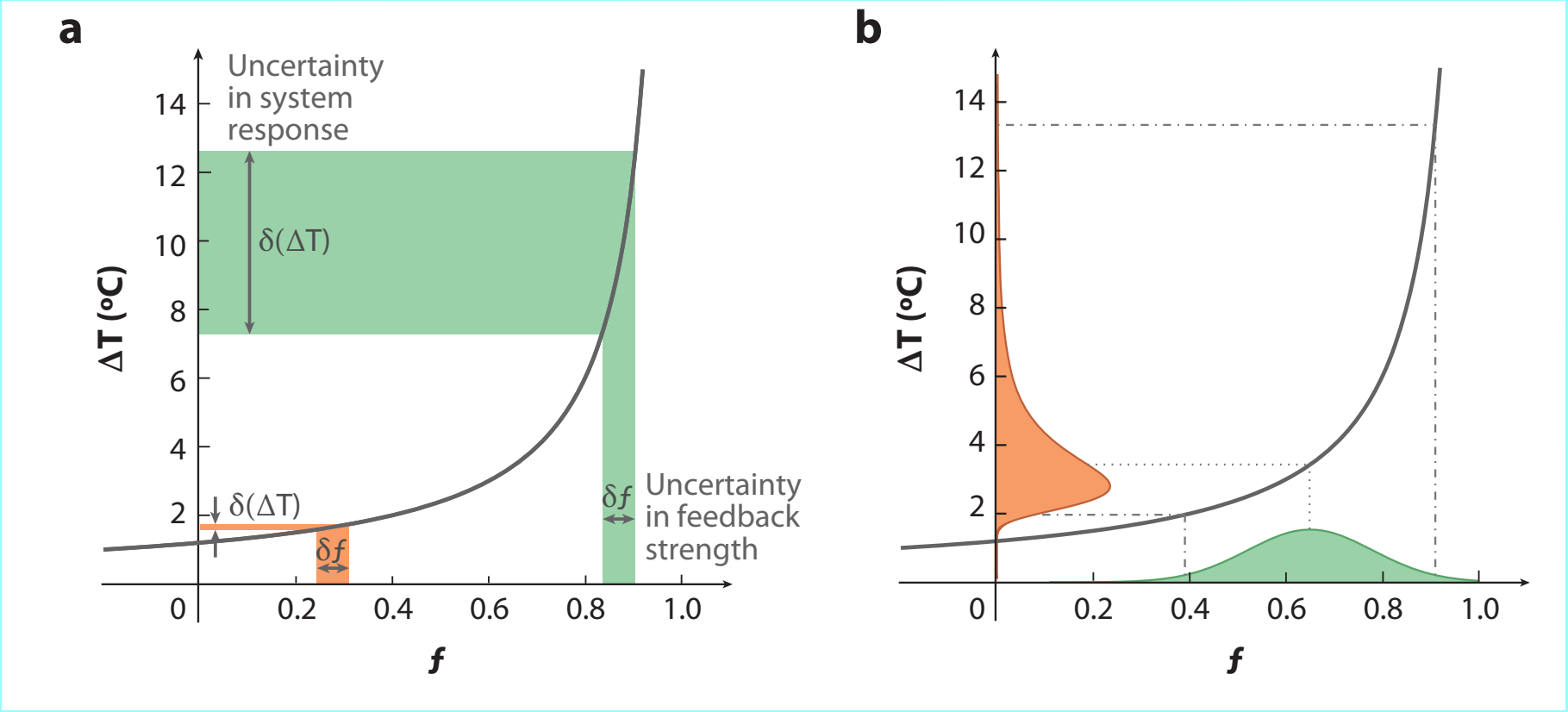
- CO_2
- Methane
- etc.

Feedbacks:

- Polar Albedo (+)
- More Methane (+)
- Water Vapor (+/-)
- Sulfate Aerosols (-)
- etc.

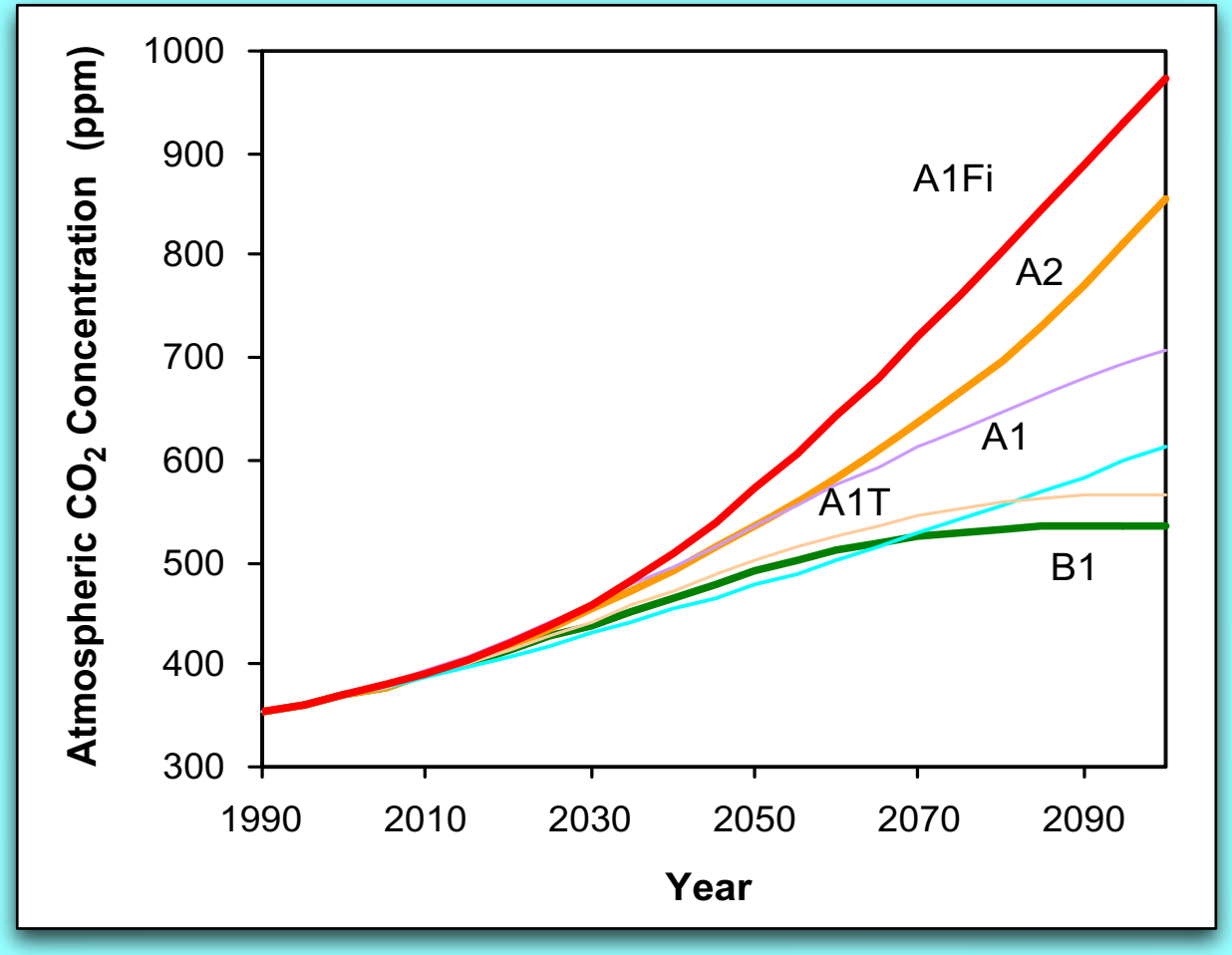


G. Roe, Ann. Rev. Earth Planet. Sci 37:93-115



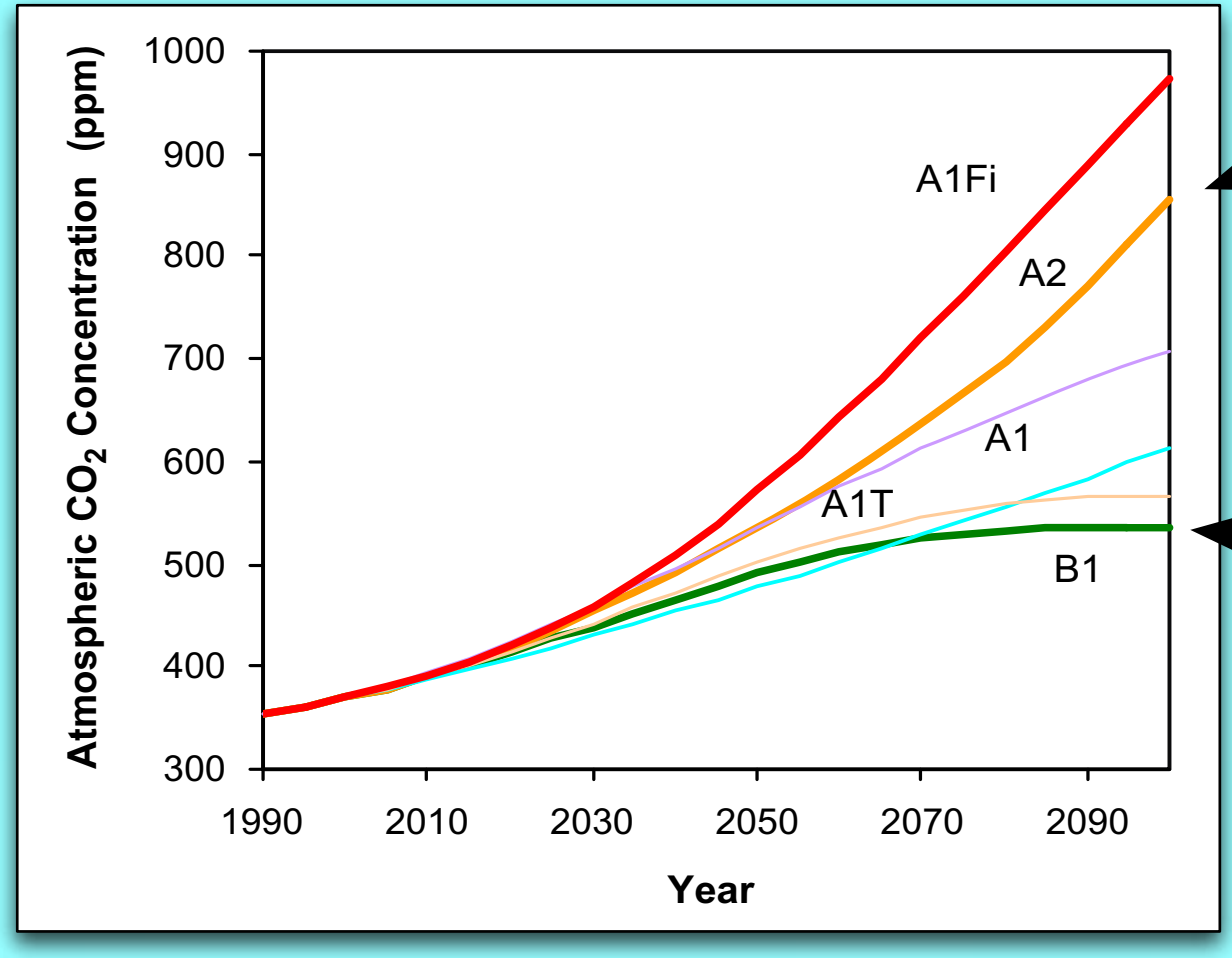
G. Roe, Ann. Rev. Earth Planet. Sci 37:93-115

Scenarios...



From Cayan et al, Climatic Change 87(S1):21-42 (2008)

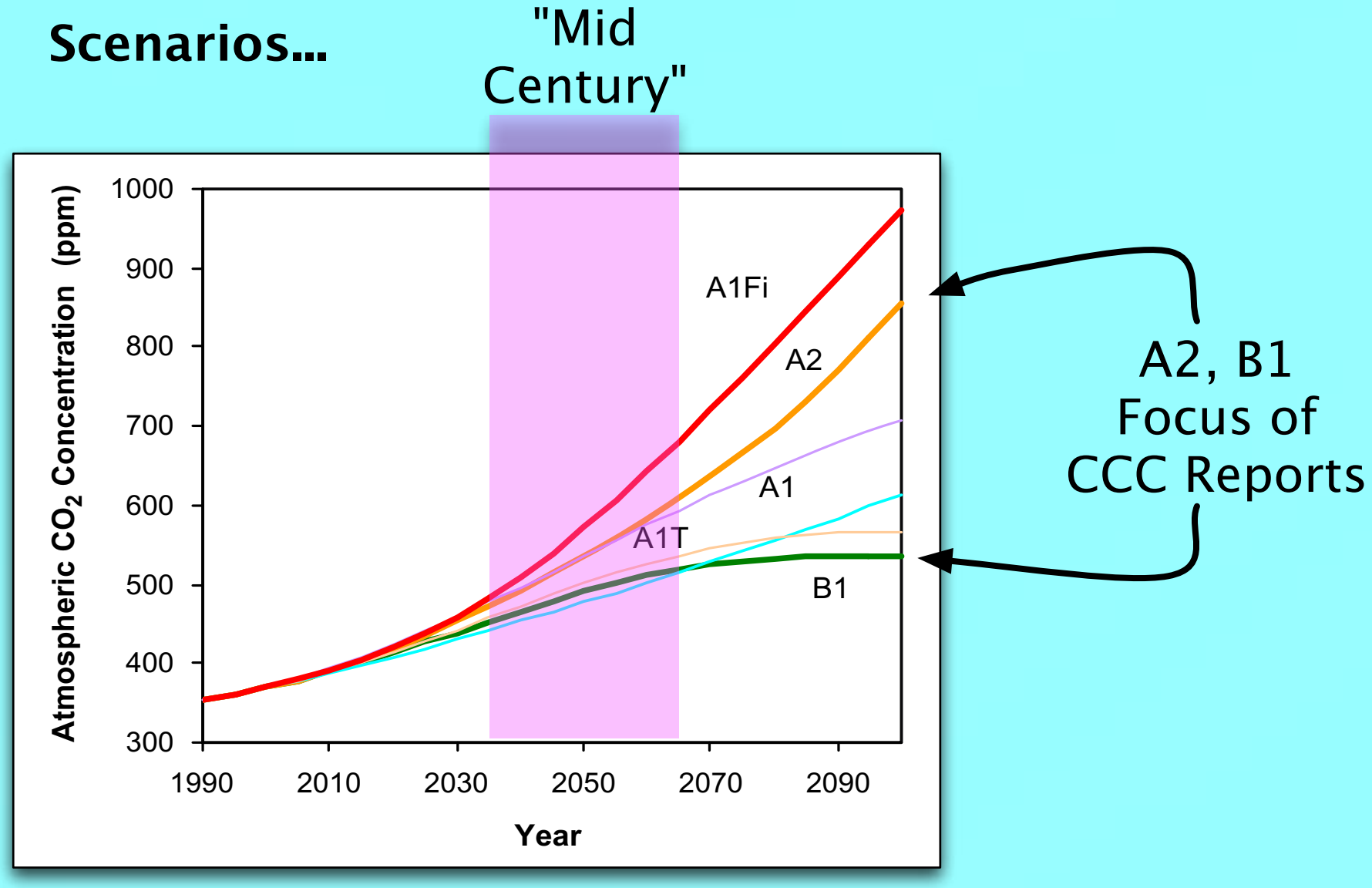
Scenarios…



A2, B1
Focus of
CCC Reports

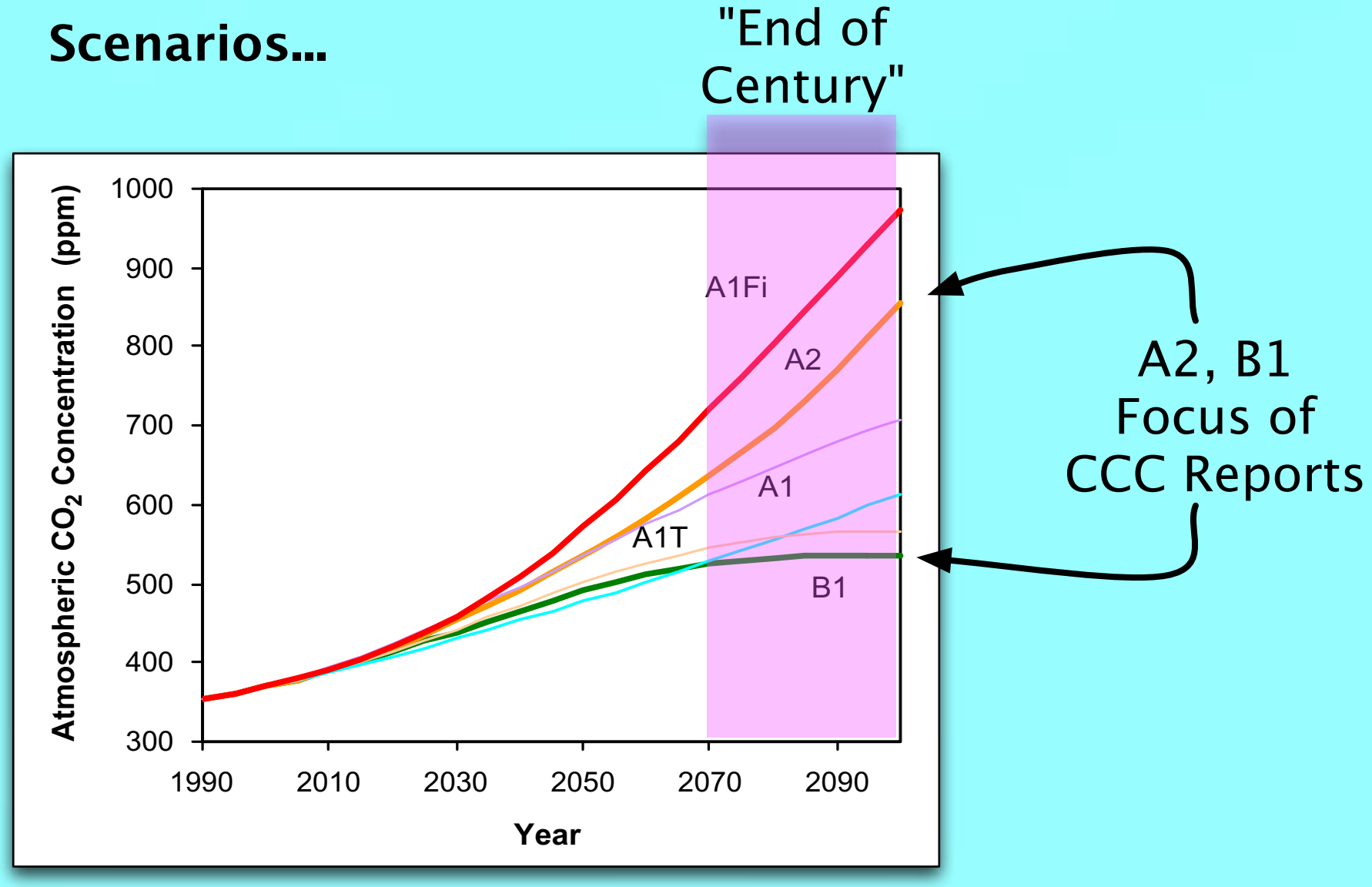
From Cayan et al, Climatic Change 87(S1):21-42 (2008)

Scenarios...

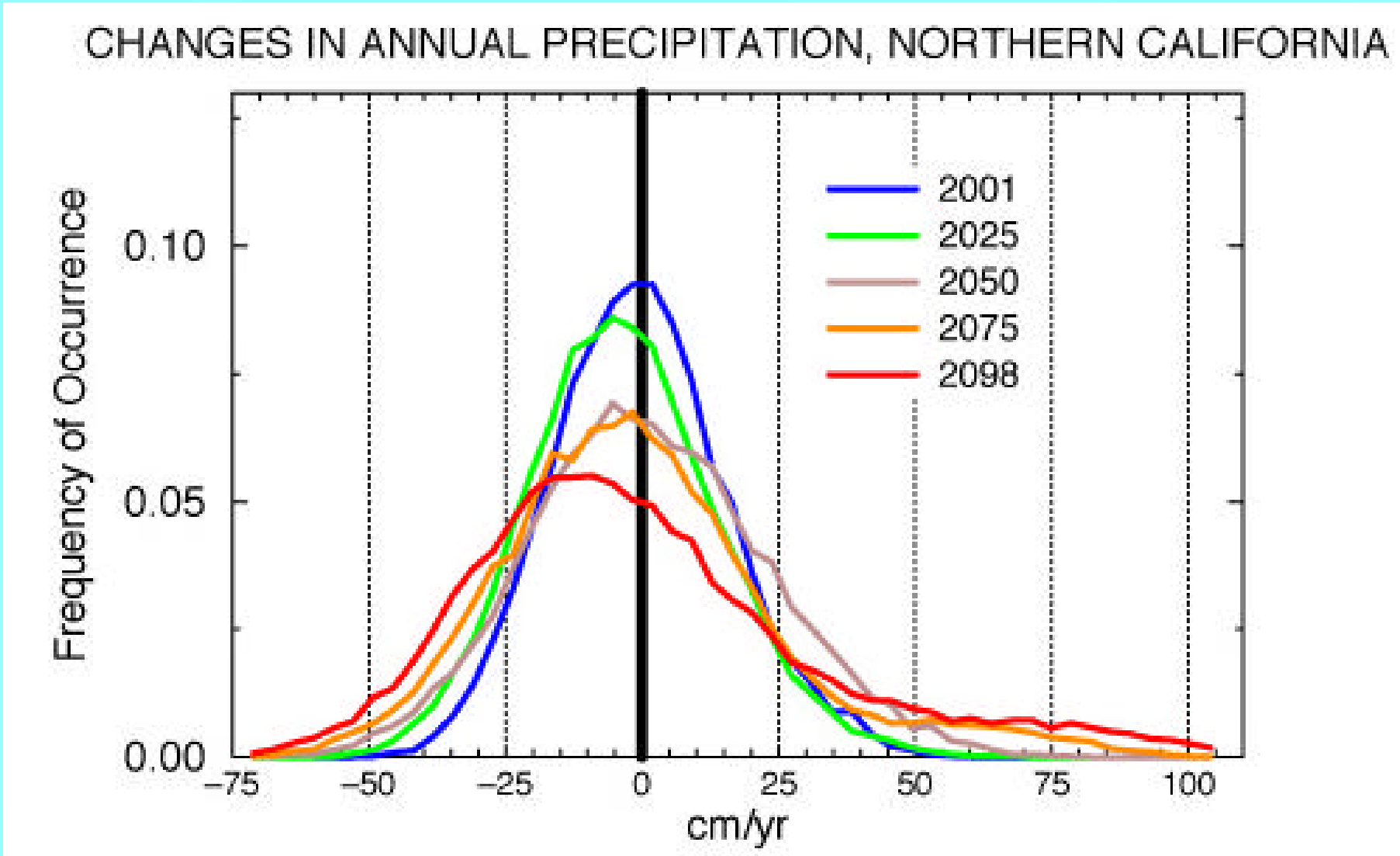


From Cayan et al, Climatic Change 87(S1):21-42 (2008)

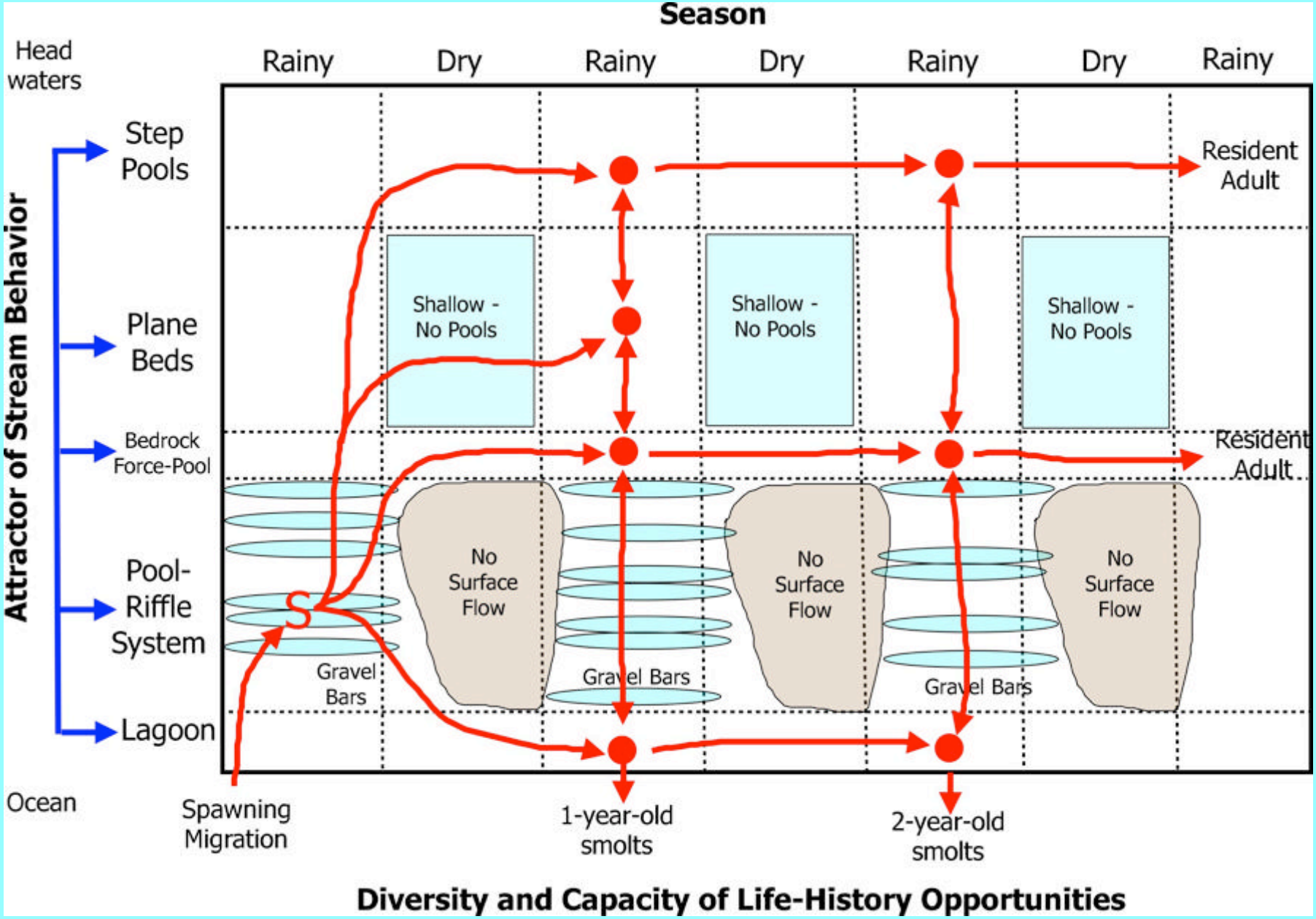
Scenarios...



From Cayan et al, Climatic Change 87(S1):21-42 (2008)



From Dettinger, SF Estuary & Watershed Sci 3(1), Art 4 (2005)


Season
Rainy
Dry
Rainy
Dry
Rainy
Dry
Rainy
Head waters
Step Pools
Plane Beds
Bedrock Force-Pool
Pool-Riffle System
Lagoon
Ocean
Attractor of Stream Behavior
Shallow - No Pools
Shallow - No Pools
Shallow - No Pools
Resident Adult
Resident Adult
No Surface Flow
No Surface Flow
No Surface Flow
Gravel Bars
Gravel Bars
Gravel Bars
S
Spawning Migration
1-year-old smolts
2-year-old smolts
Diversity and Capacity of Life-History Opportunities

The Dynamic Stream Corridor

The Dynamic Stream Corridor

Investment Strategy

The Dynamic Stream Corridor

Investment Strategy

Rebuild infrastructure after each catastrophe?
Construct hatcheries for fish?
(Labor & resources as adaptive capacity)

The Dynamic Stream Corridor

Investment Strategy

Rebuild infrastructure after each catastrophe?
Construct hatcheries for fish?
(Labor & resources as adaptive capacity)

Predict the future and optimize for it?
(Intellectual capital as adaptive capacity)

The Dynamic Stream Corridor

Investment Strategy

Rebuild infrastructure after each catastrophe?
Construct hatcheries for fish?
(Labor & resources as adaptive capacity)

Predict the future and optimize for it?
(Intellectual capital as adaptive capacity)

Design resilience for whatever comes?
(Intellectual capital and
natural capital as adaptive capacity)