Restoration of Riparian Forests and Riparian Ecosystem Processes and Implications for Salmon Restoration

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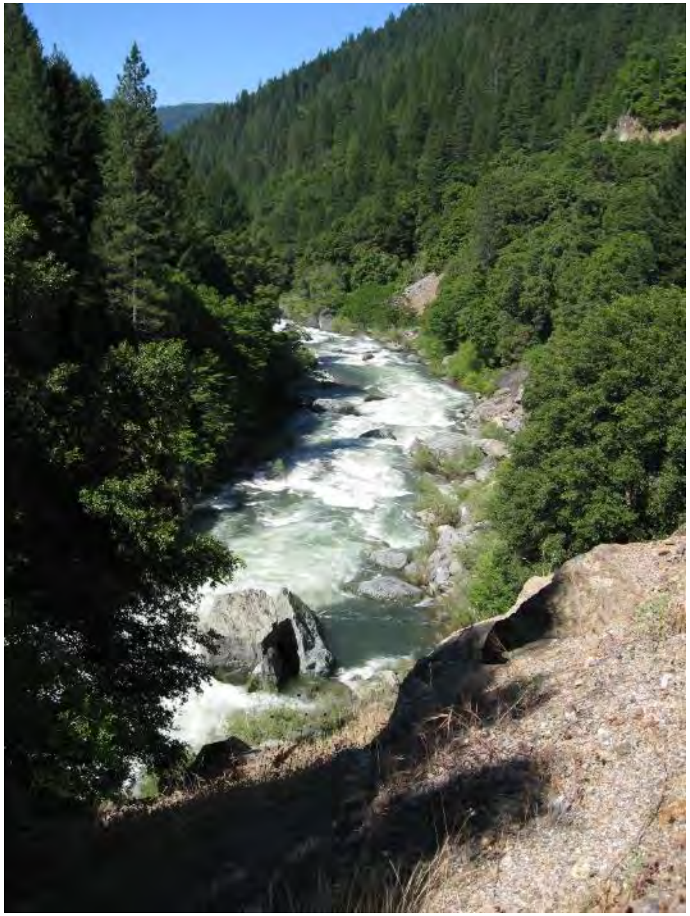
Jennifer Hammond

Outline



- Background
  - California riparian communities
  - Riparian management
  - Riparian ecosystem functions
- Motivation
- Study
- Management Tools

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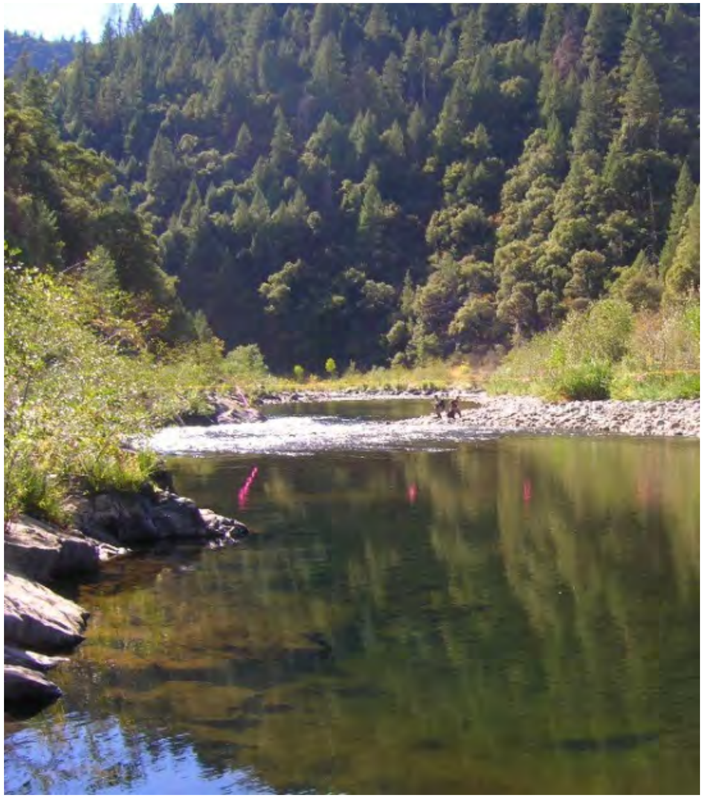
Background
Riparian Communities in California

- > Represent a small fraction of lands in the landscape
  - – Comprise 9% of California's total wetland acreage
  - – Comprise 0.1-1% of landscape in Sierra Nevada Mountains
- > Loss of > 90% of pre-European riparian habitat in California
- > Support disproportionately high diversity of wildlife and aquatic species



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Background
Riparian Management

Restoration Project/ Management Goals and Objectives

> Specific
  - Reduce bank erosion
  - Increase cover/shade
  - Increase buffer width

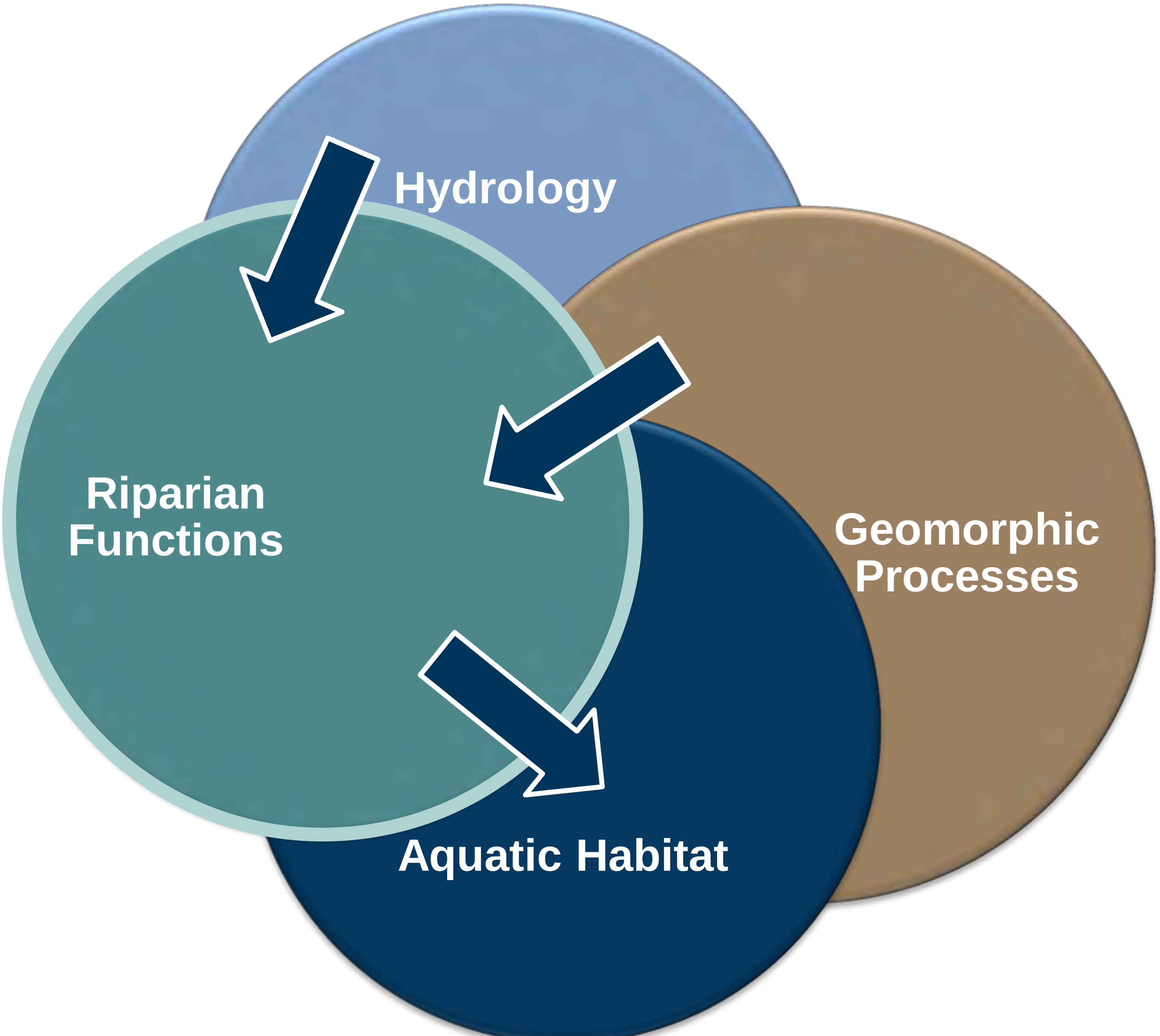
> Broad
  - Provide/ restore self-sustaining riparian functions & values now & into the future
  - Maintain/ restore important ecological linkages throughout the landscape

Background

Riparian Management

- Understand the factors that influence successful recruitment and survival of woody riparian species in order to restore riparian ecosystem functions

Background


Hydrology
Riparian Functions
Geomorphic Processes
Aquatic Habitat

Background

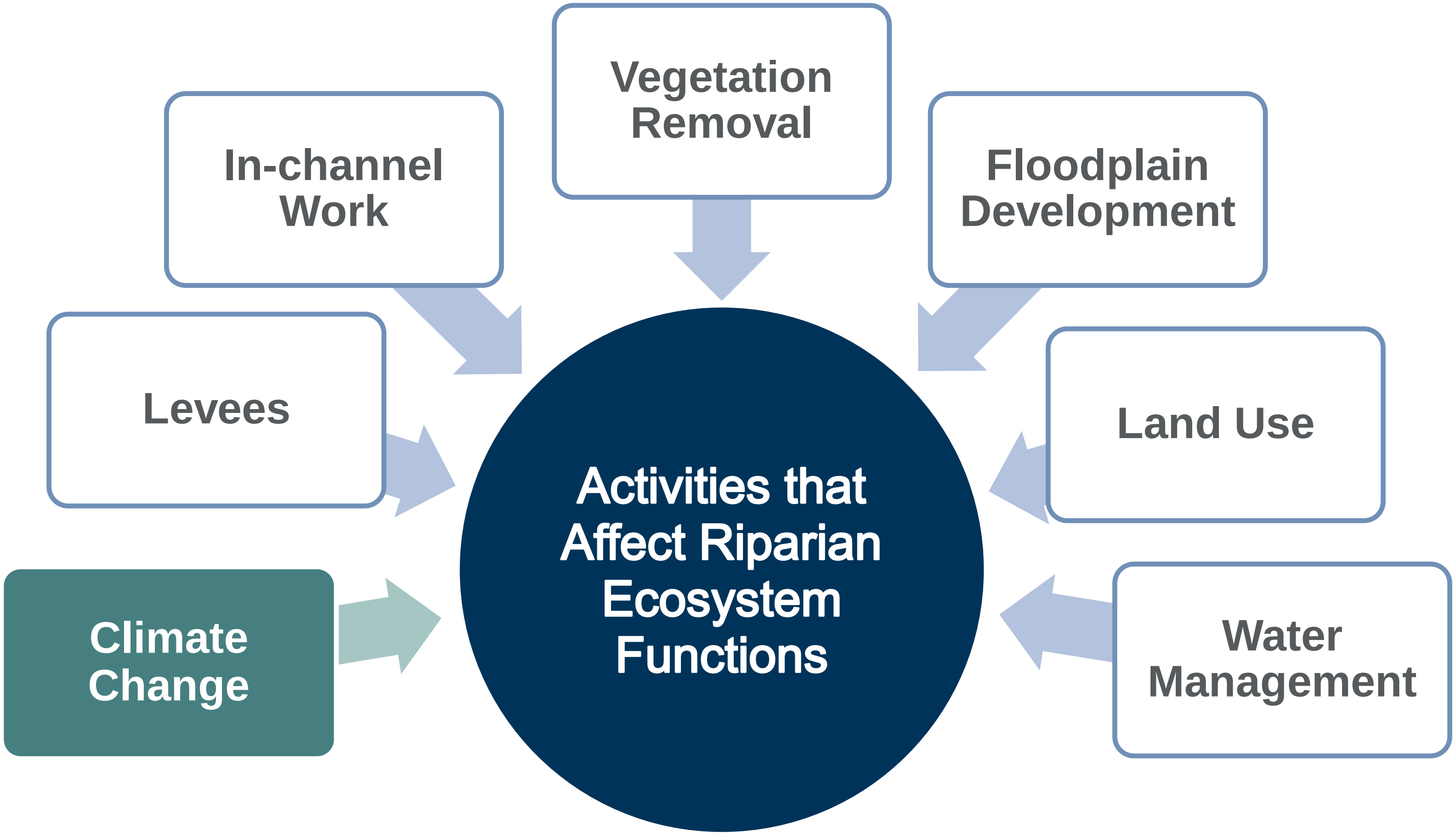
Riparian Ecosystem Functions

Key Riparian Ecosystem Functions that Affect Aquatic Habitat

- Large wood delivery & retention
- Water quality maintenance
  - Fine sediment, pollutant trapping
  - Bank/soil stability
- Attenuation of flood peaks
- Groundwater recharge
- Nutrient delivery & retention
- Fish & wildlife habitat
- Food source
- Shade (water temperature)

Background

Riparian Ecosystem Functions



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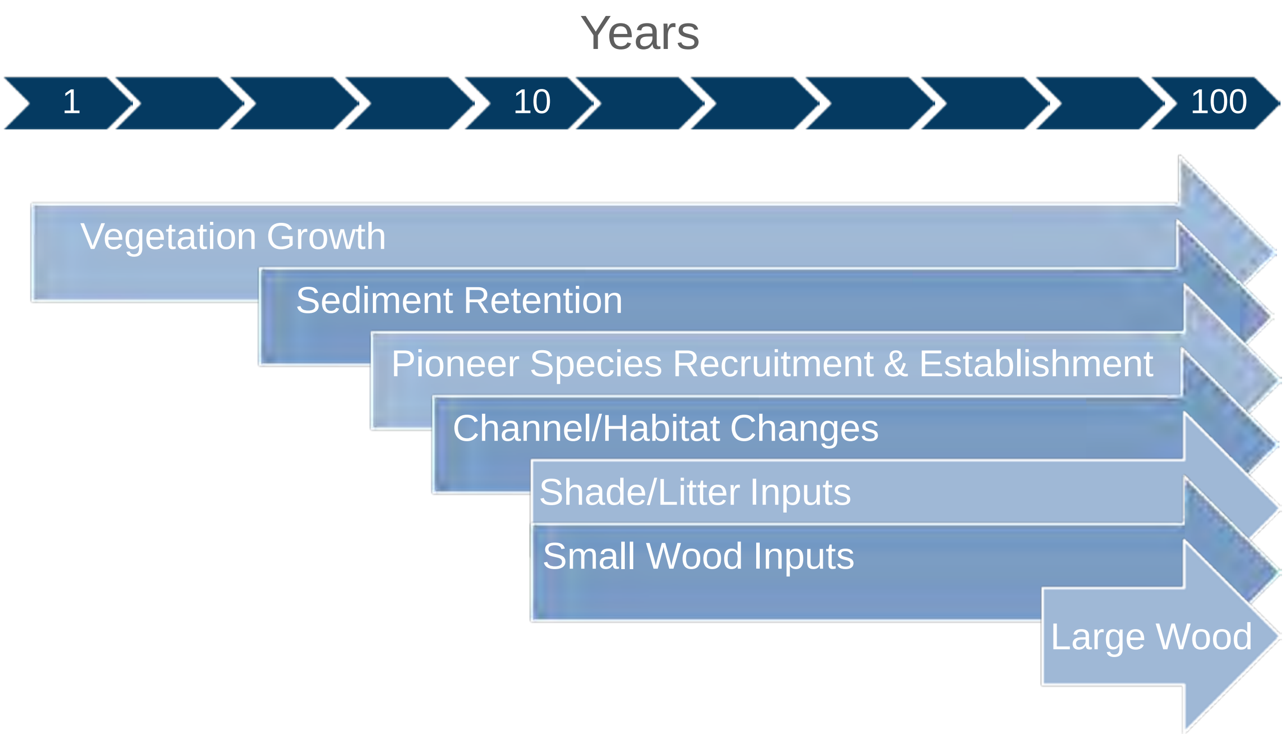
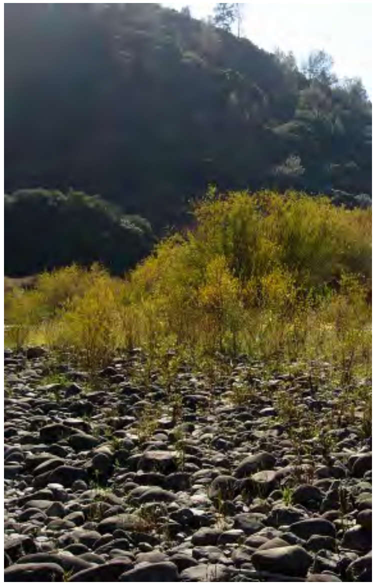
Background

Riparian Ecosystem Functions

Recovery times (years) for restoring selected riparian ecosystem functions:





Adapted from Beschta and Kauffman 2000

Motivation

- Why isn't there much riparian habitat?
- Why is there no recent cottonwood regeneration?
- If flows are increased, how will this enhance the riparian habitat?
  - Low flows
  - Spring flow magnitude
- What will the wetland/ riparian response be to changes in groundwater?

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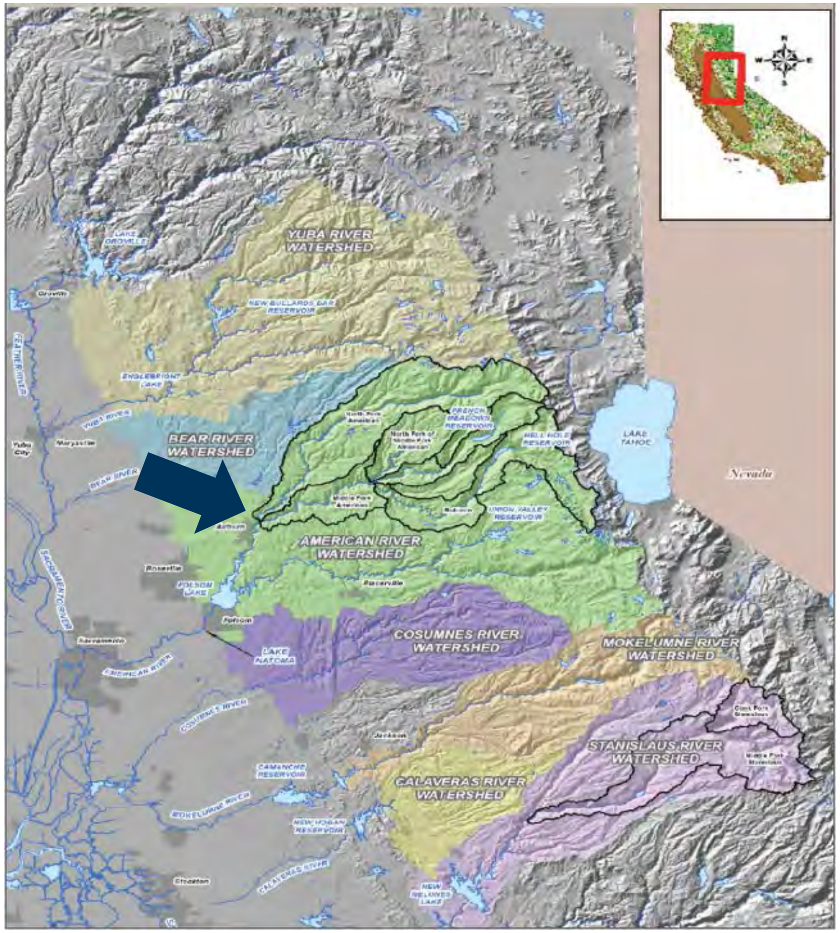
Motivation

> Identify key determinants for successful riparian recruitment (hydrologic and geomorphic)
  – Using an example from studies from recent hydroelectric relicensing projects

> Used this information to develop tools to:
  – Guide aspects of flow management for long-term sustainability of riparian forests
  – Guide restoration decisions

Study Area



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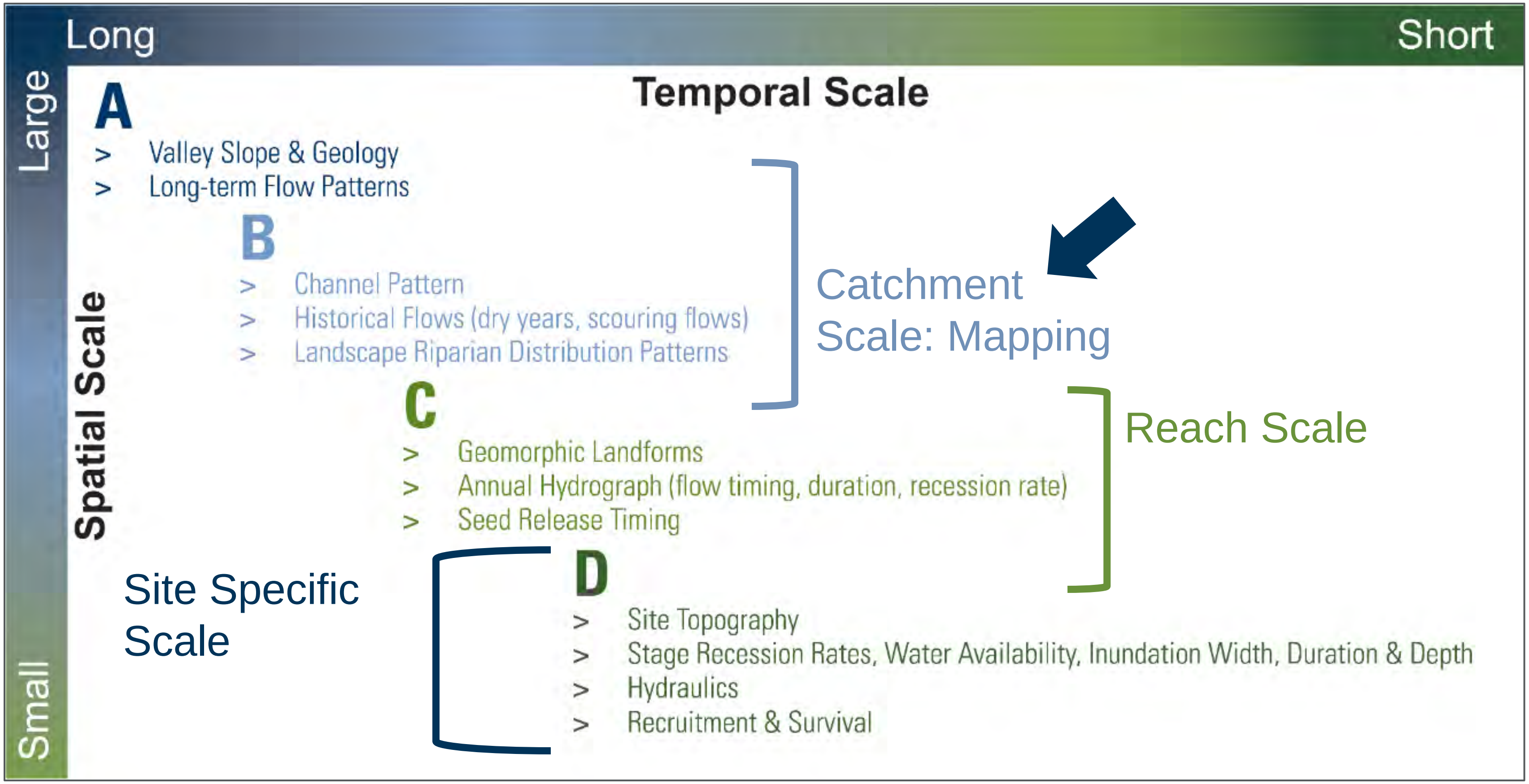
Approach
Processes & Scales Considered



Adapted from Richards et al 2002

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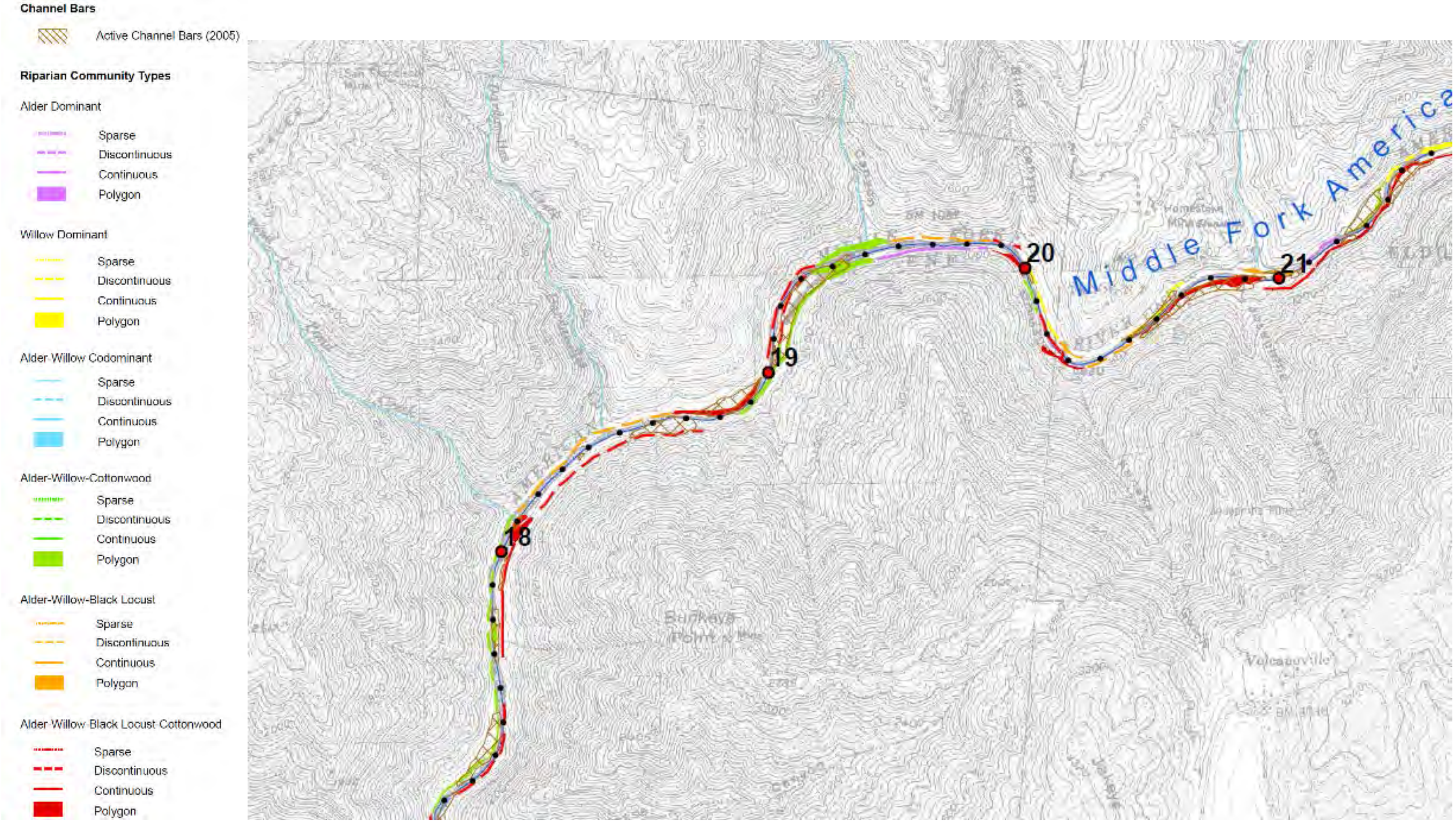
Catchment Scale

Vegetation Landscape Distribution Patterns



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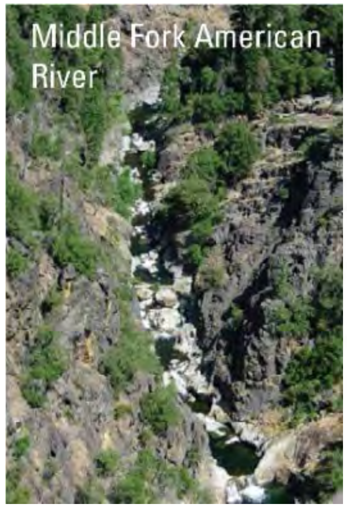
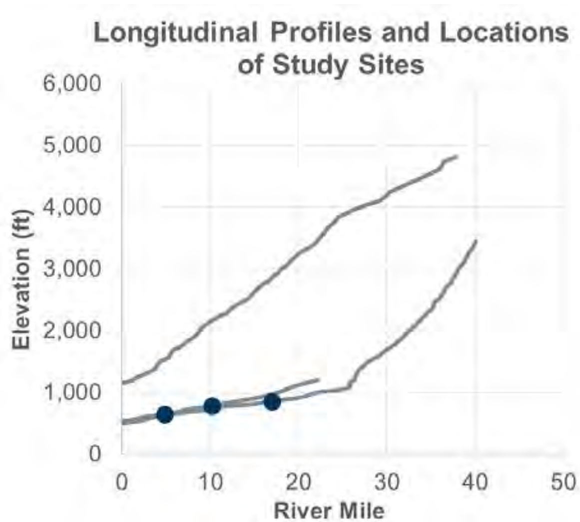
Catchment Scale

Watershed Characteristics





- > **Study Area Geology and Slope** – Steep upper watersheds with granitic headwaters; highly entrenched within wide canyons further downstream
- > **Channel Pattern** – Meandering wide point bar and side bar deposits

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Catchment Scale
Watershed Characteristics

Potential Locations for Riparian Species to Establish

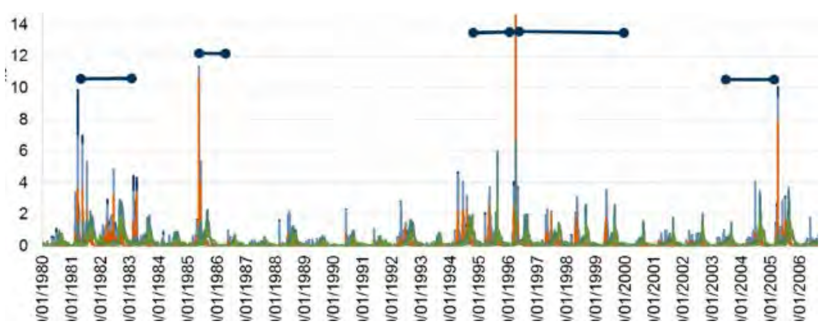
> Open, moist substrate for germination

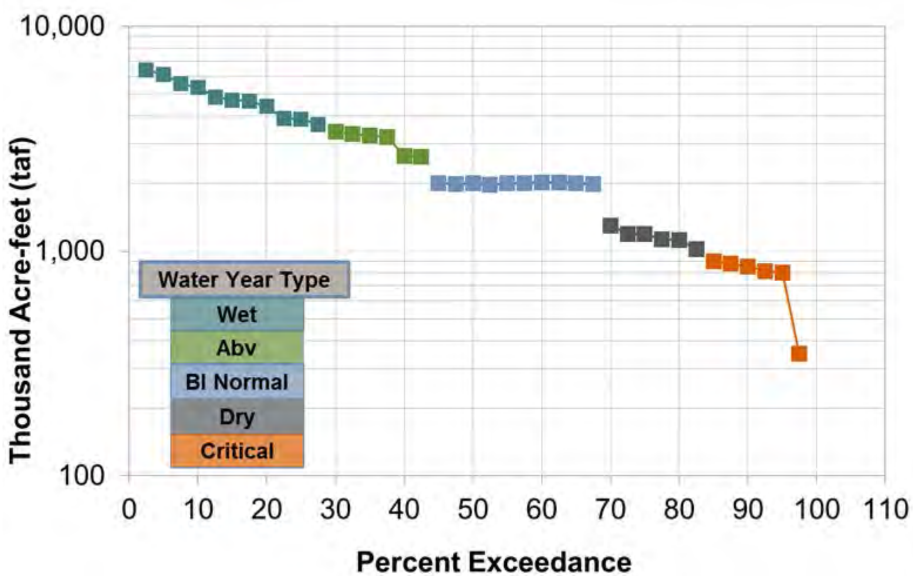
Catchment Scale
Long-term Flow Patterns

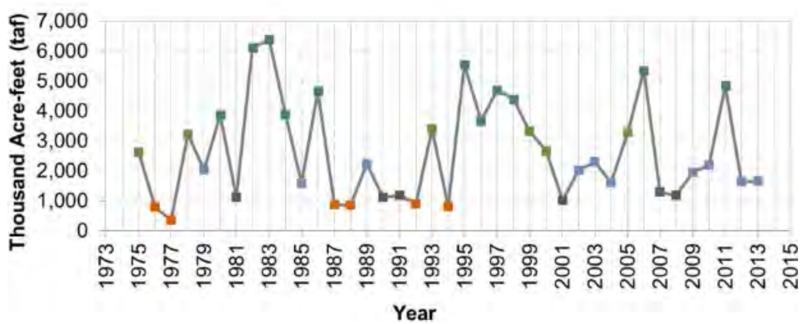
> **Wet Winters/ Springs and Hot Dry Summers:** Unimpaired Inflow Folsom Reservoir (1975-2013) Exceedance

> **Multiple Years with Low Precipitation:** Unimpaired inflow Folsom Reservoir (1975-2003) Time Series

> **Infrequent High Magnitude Flows**







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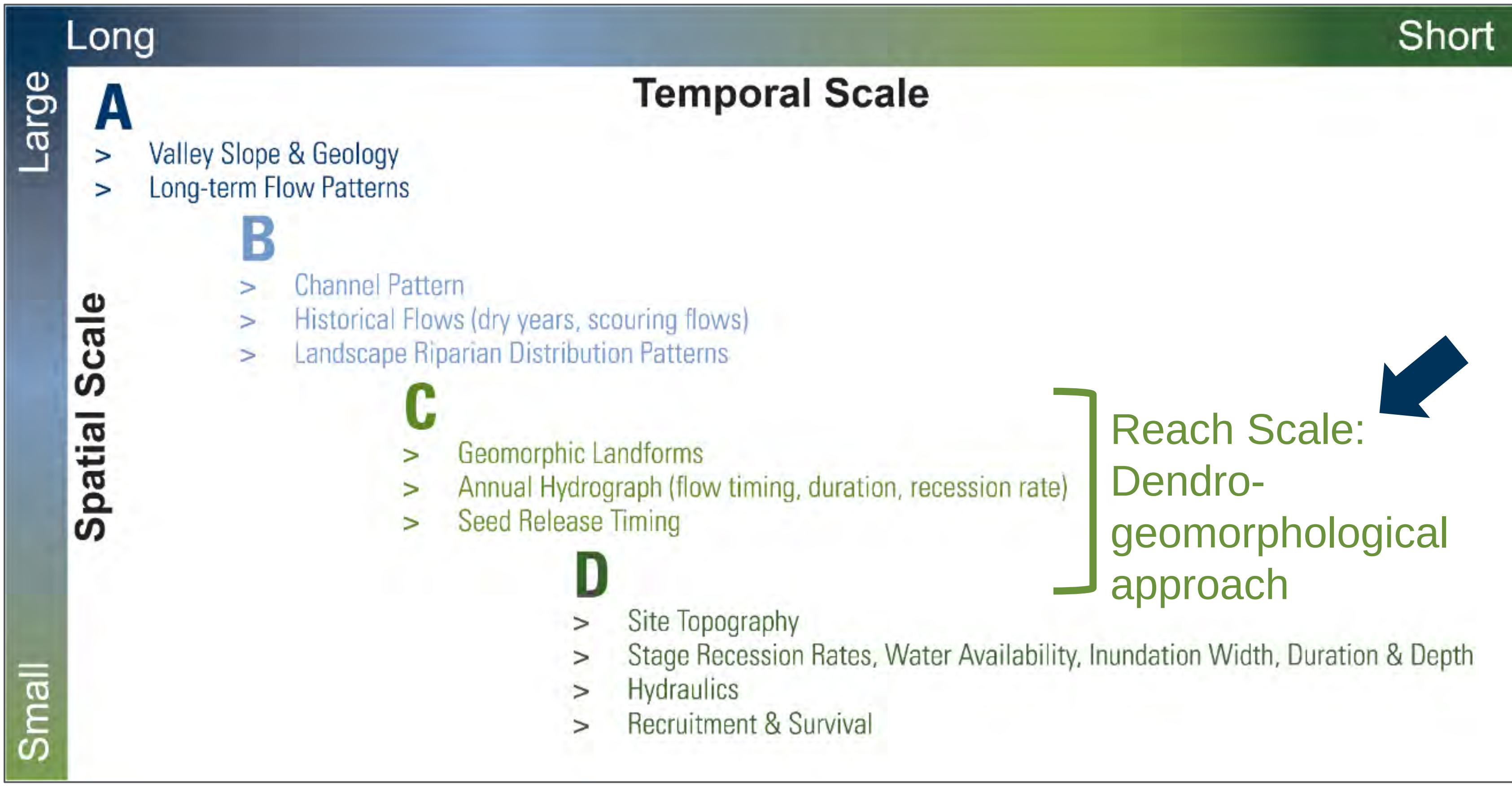
Catchment Scale

- Key determinants for riparian patterns (or amounts of vegetation) at the catchment scale
  - Geology and slope
  - Channel pattern
  - Hydrology
    - Inter-annual variability in flows (infrequent high flows; multiple years wi low flows)

Approach

Processes & Scales Considered



Adapted from Richards et al 2002

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Reach Scale

Riparian Establishment

80 cfs

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Reach Scale
Riparian Establishment

1,018 cfs

- ALRH
- ALRH, SALIX
- POFR
- POFR, SALIX
- SALIX

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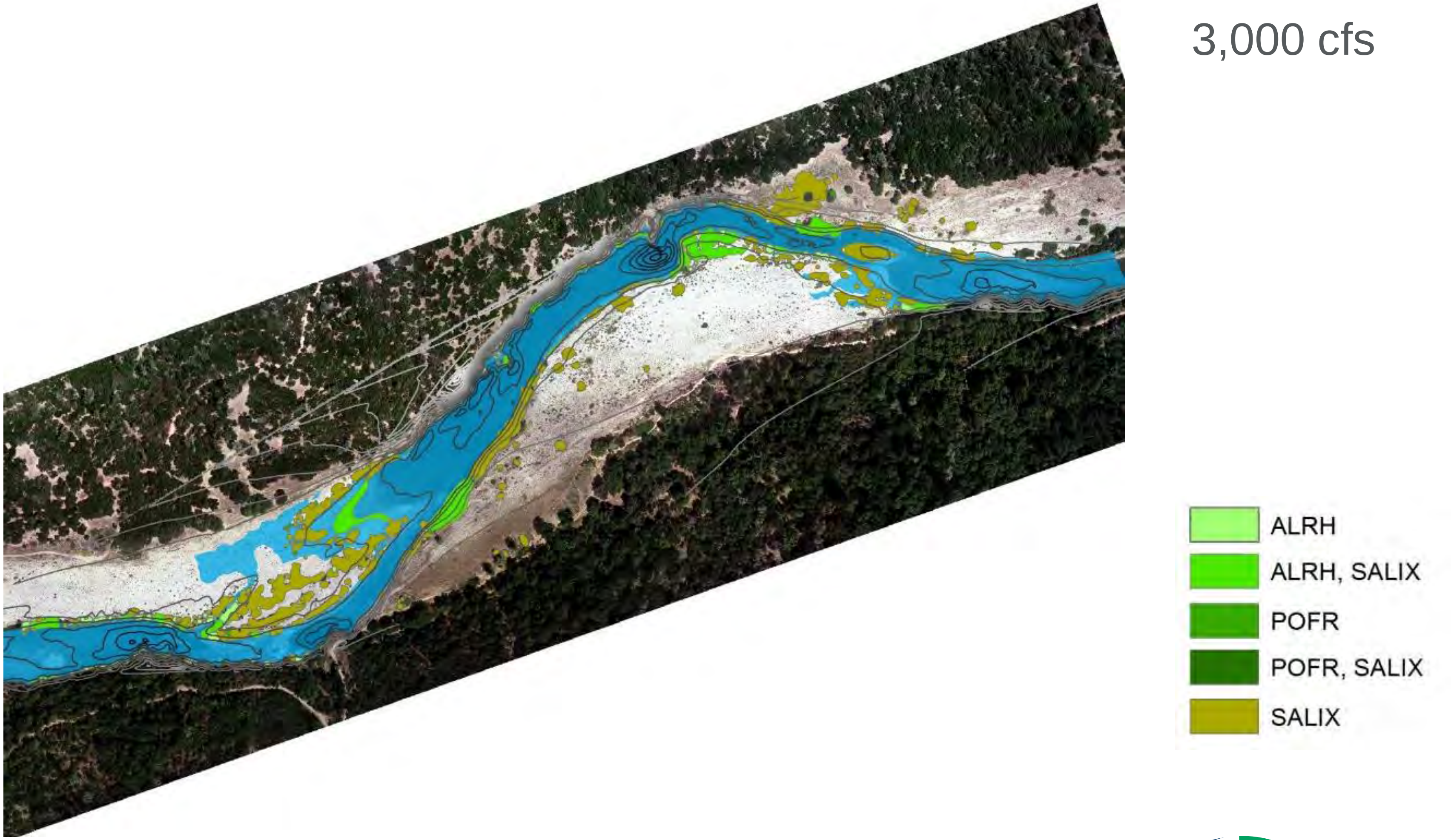
Reach Scale
Riparian Establishment

3,000 cfs



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Reach Scale

Riparian Establishment

6,000 cfs

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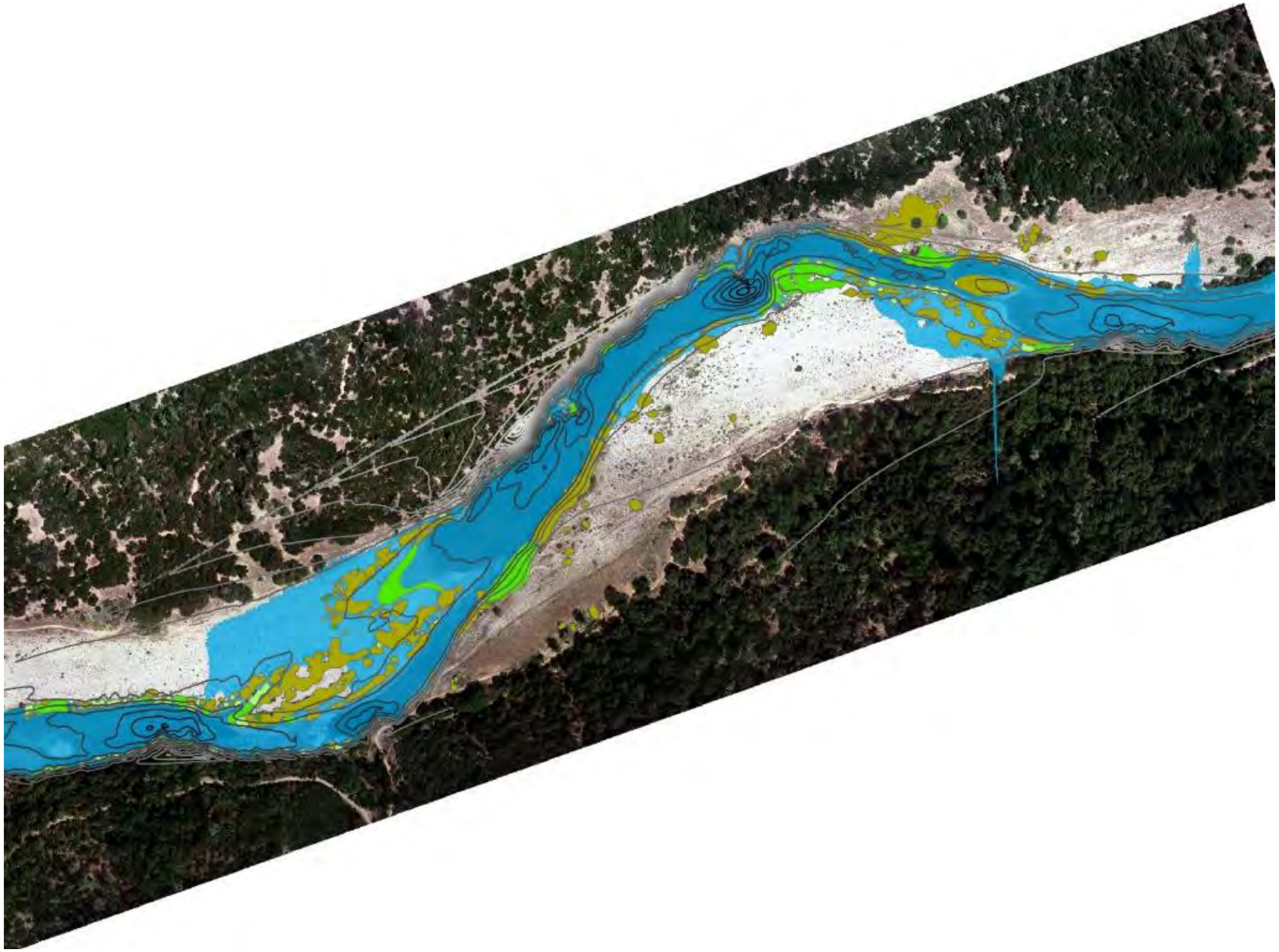
Reach Scale

Riparian Establishment

8,000 cfs



	ALRH
	ALRH, SALIX
	POFR
	POFR, SALIX
	SALIX

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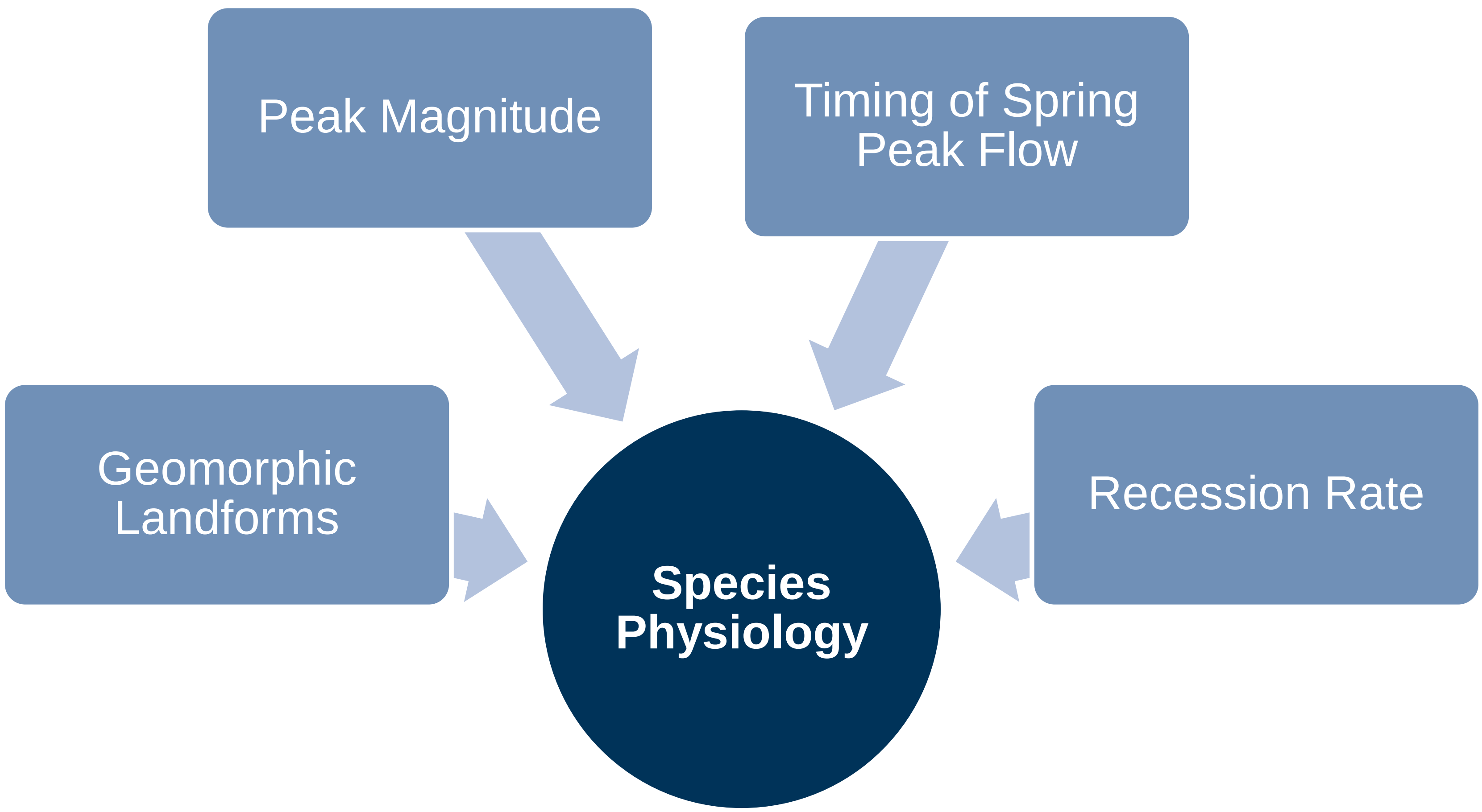
Reach Scale


Peak Magnitude
Timing of Spring Peak Flow
Geomorphic Landforms
Recession Rate
Species Physiology

Reach Scale

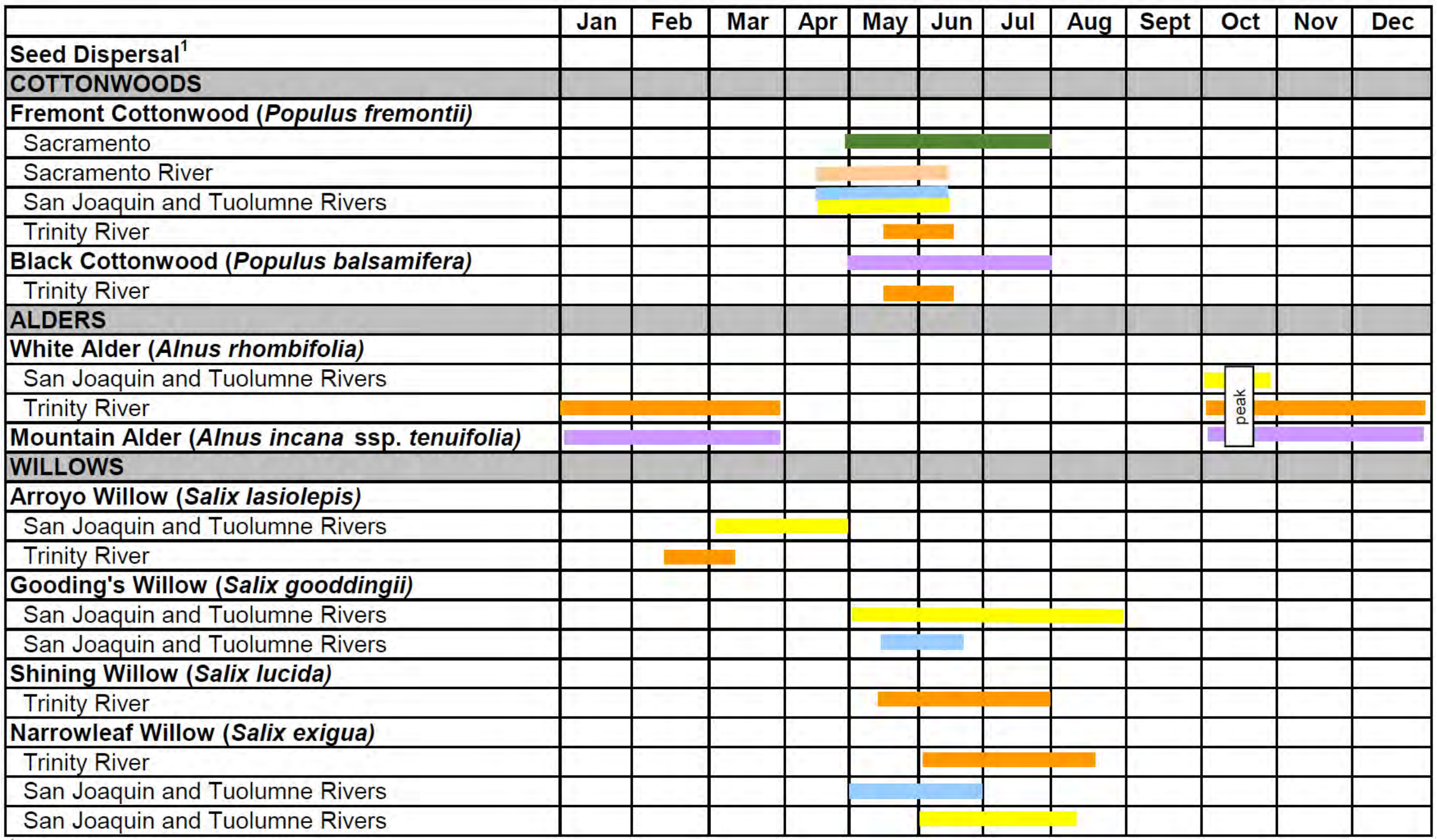
Life History Strategies

Life History Strategies Adapted to Riverine Processes

- Seed dispersal timing
- Seed viability
- Substrate & light
- Asexual traits
- Germination – depth to groundwater
- Seedling root growth rates
- Root depths after 1st growing season
    - Also ground layer wetland species
- Root depths of mature species
- Seed dispersal mechanism

Reach Scale

Life History Strategies



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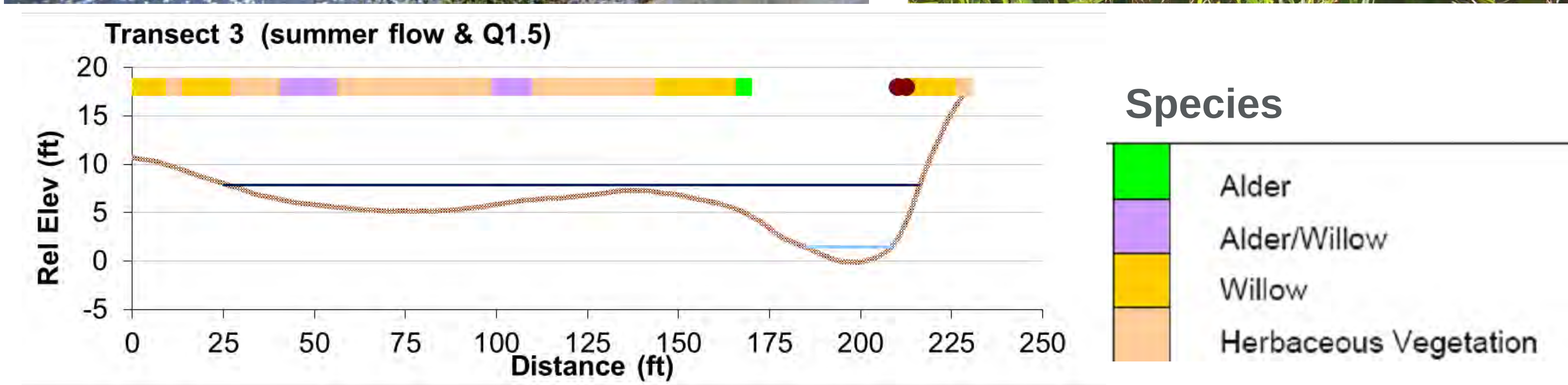
Reach Scale

Geomorphic Landforms



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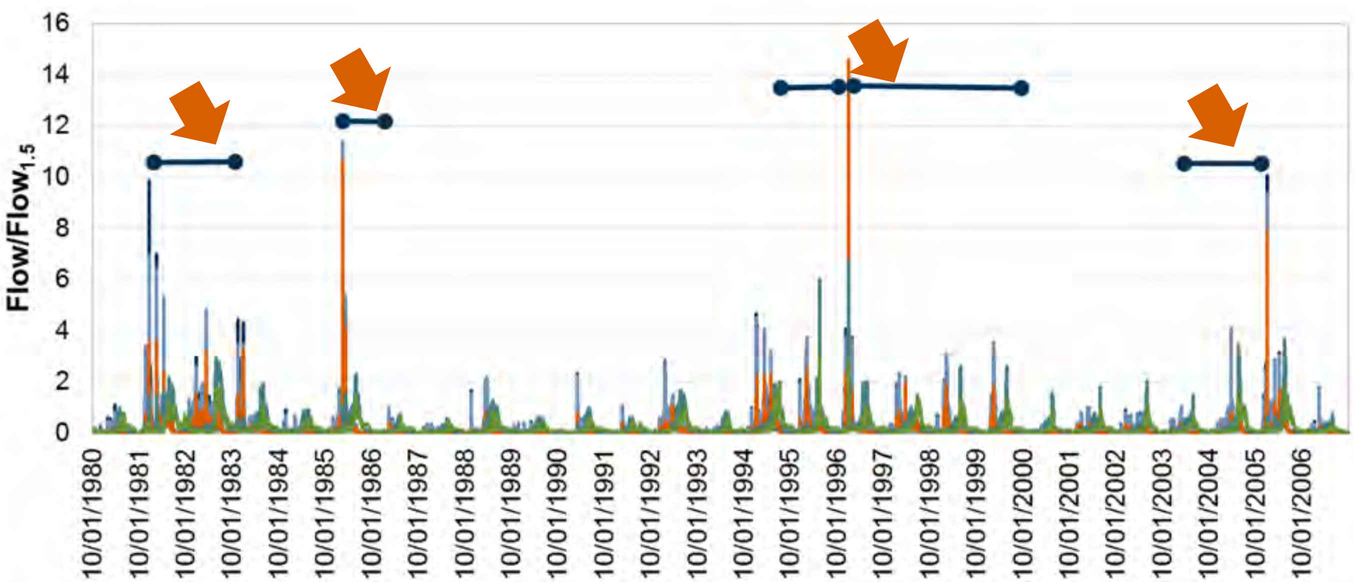
Reach Scale

Flow Magnitude and Frequency



> Recruitment occurred in "wetter" years after the high, magnitude scouring events

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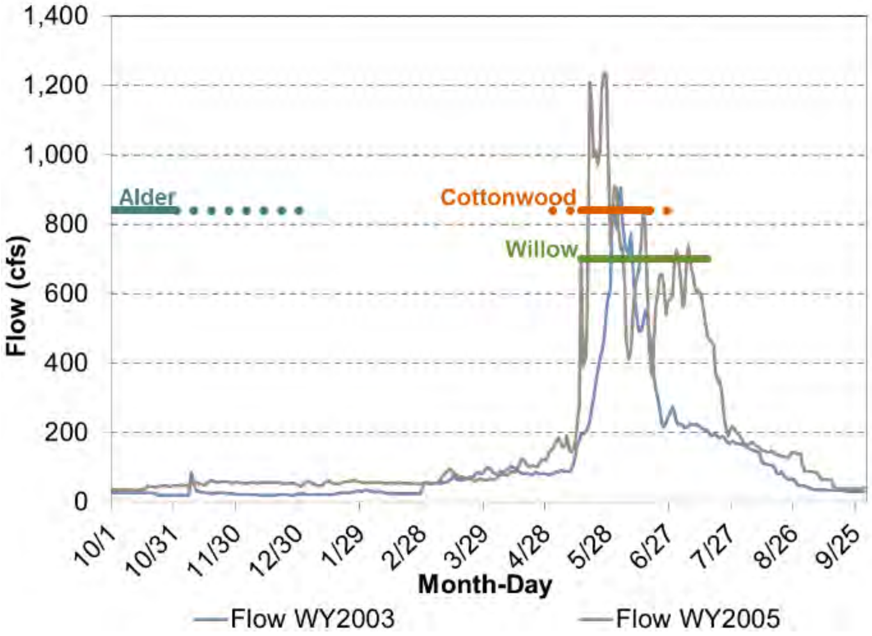
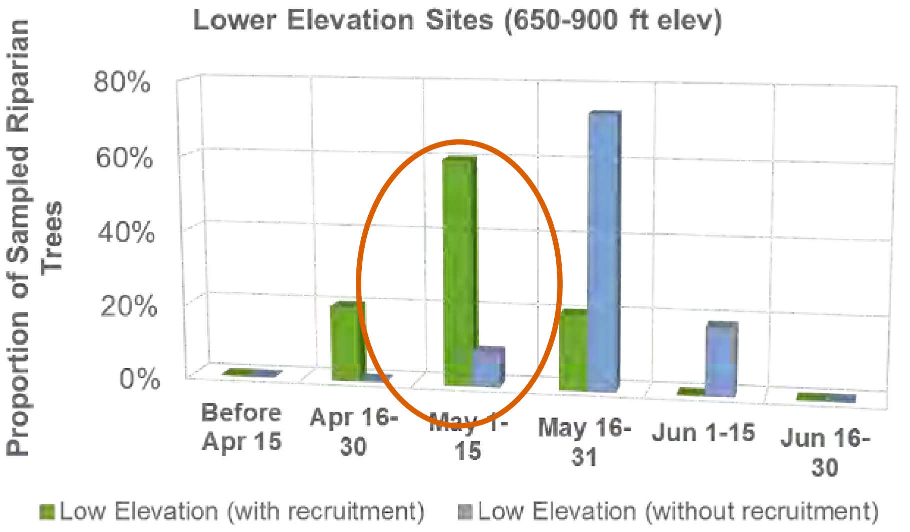
Reach Scale

Annual Hydrograph & Seed Release Timing





37 trees (impaired and unimpaired sites)

Reach Scale

> Key determinants at the reach scale:
  - Different species assemblages are associated with geomorphic landforms
  - Recruitment initiated by large scouring floods
    - Create suitable seed beds (set stage)
  - Recruitment occurred in wetter subsequent years
    - Hydrograph components
  - Species physiologies – timing of seed release, viabiliy

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Approach

Processes & Scales Considered

Long — Short

Large — Small

Spatial Scale

Temporal Scale

A

- Valley Slope & Geology
- Long-term Flow Patterns

B

- Channel Pattern
- Historical Flows (dry years, scouring flows)
- Landscape Riparian Distribution Patterns

C

- Geomorphic Landforms
- Annual Hydrograph (flow timing, duration, recession rate)
- Seed Release Timing

D

- Site Topography
- Stage Recession Rates, Water Availability, Inundation Width, Duration & Depth
- Hydraulics
- Recruitment & Survival

Site Specific Scale: Hydraulic modeling with tree cores

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Site Specific Scale

Species Physiology & Site Specific Topography

Site Specific Topography

> Channel and floodplain geometries
  – Inundation width, depth, duration
  – Summer water availability

> Stage recession rates

Species Physiology

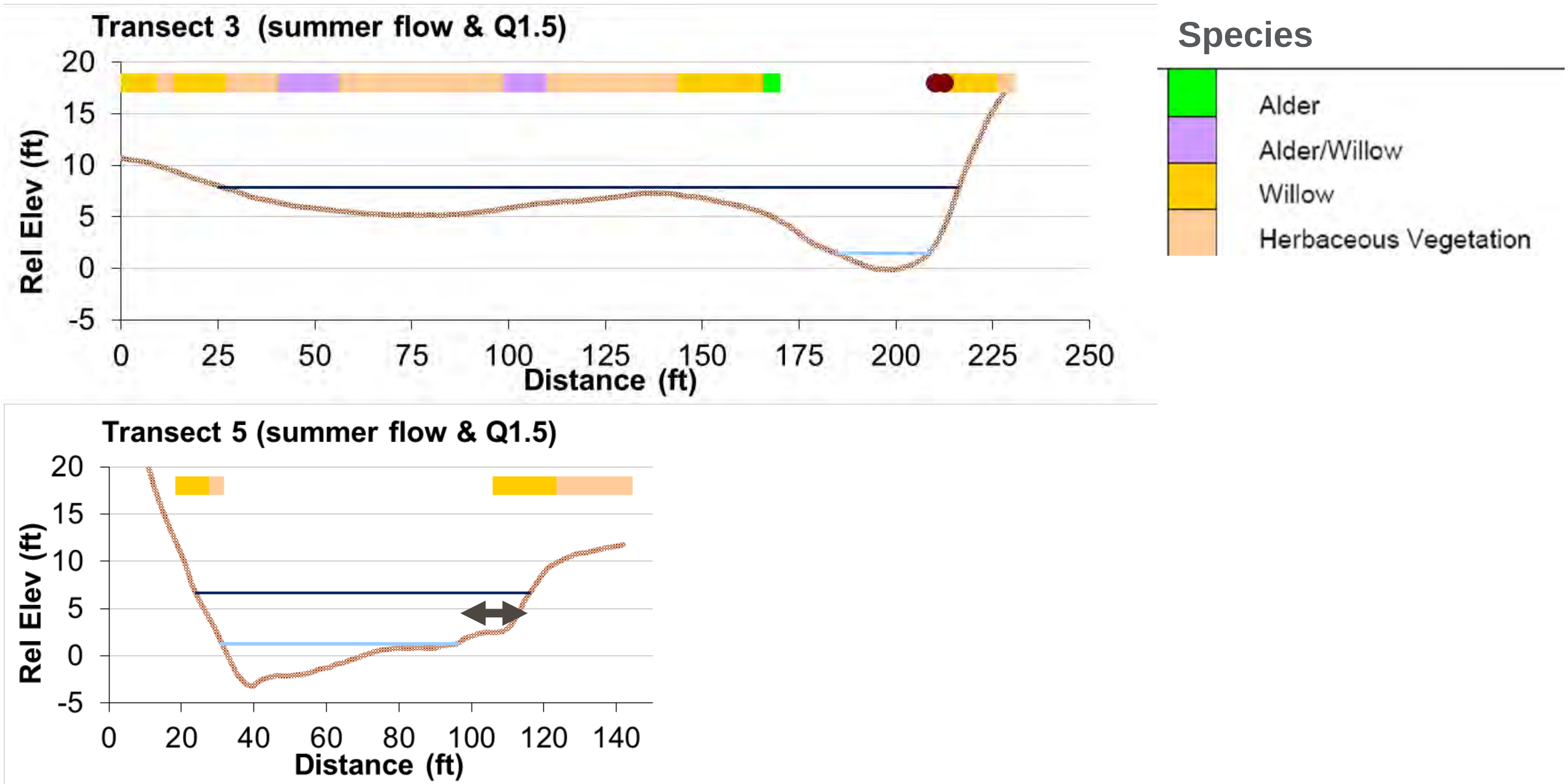
> Root depths

> Root growth rates

> Seed release timing

Site Specific Scale

Topography



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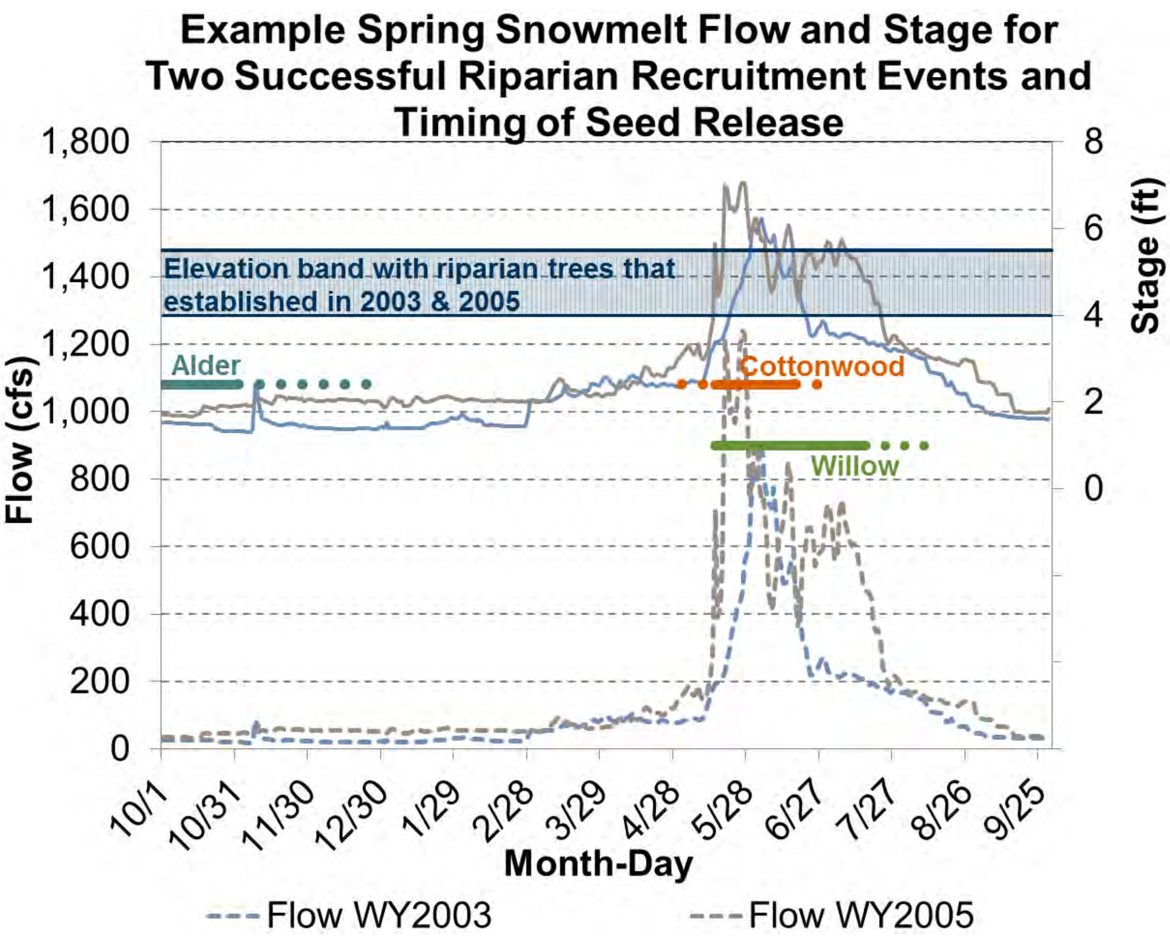
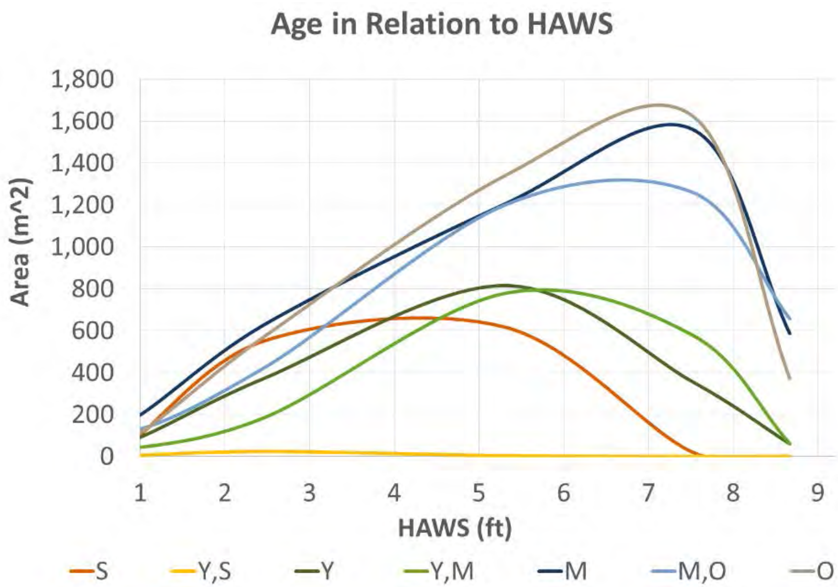
Site Specific Scale

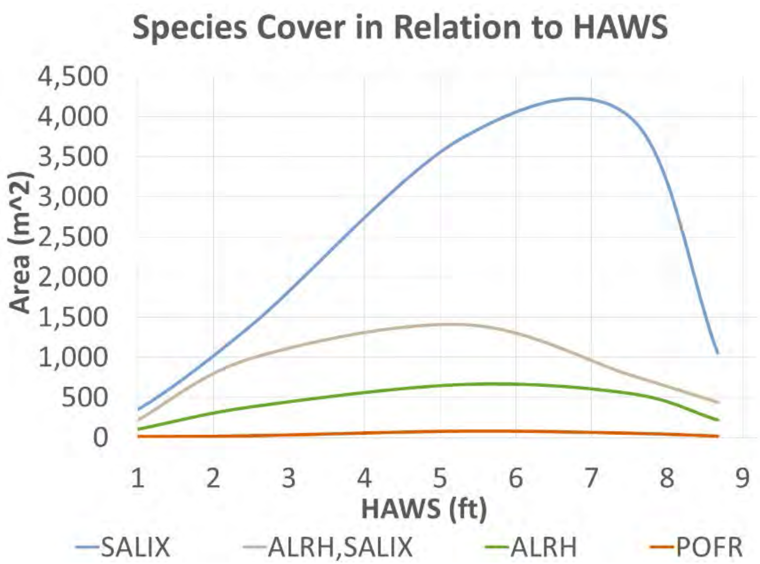
Elevation



Site Specific Scale

Elevation





Age and species patterns in relation to height above water surface (HAWS)

> Flow magnitudes before the surveys (where seeds set)
> Susceptibility to scour at lower elevations
> Rooting depths at maturity

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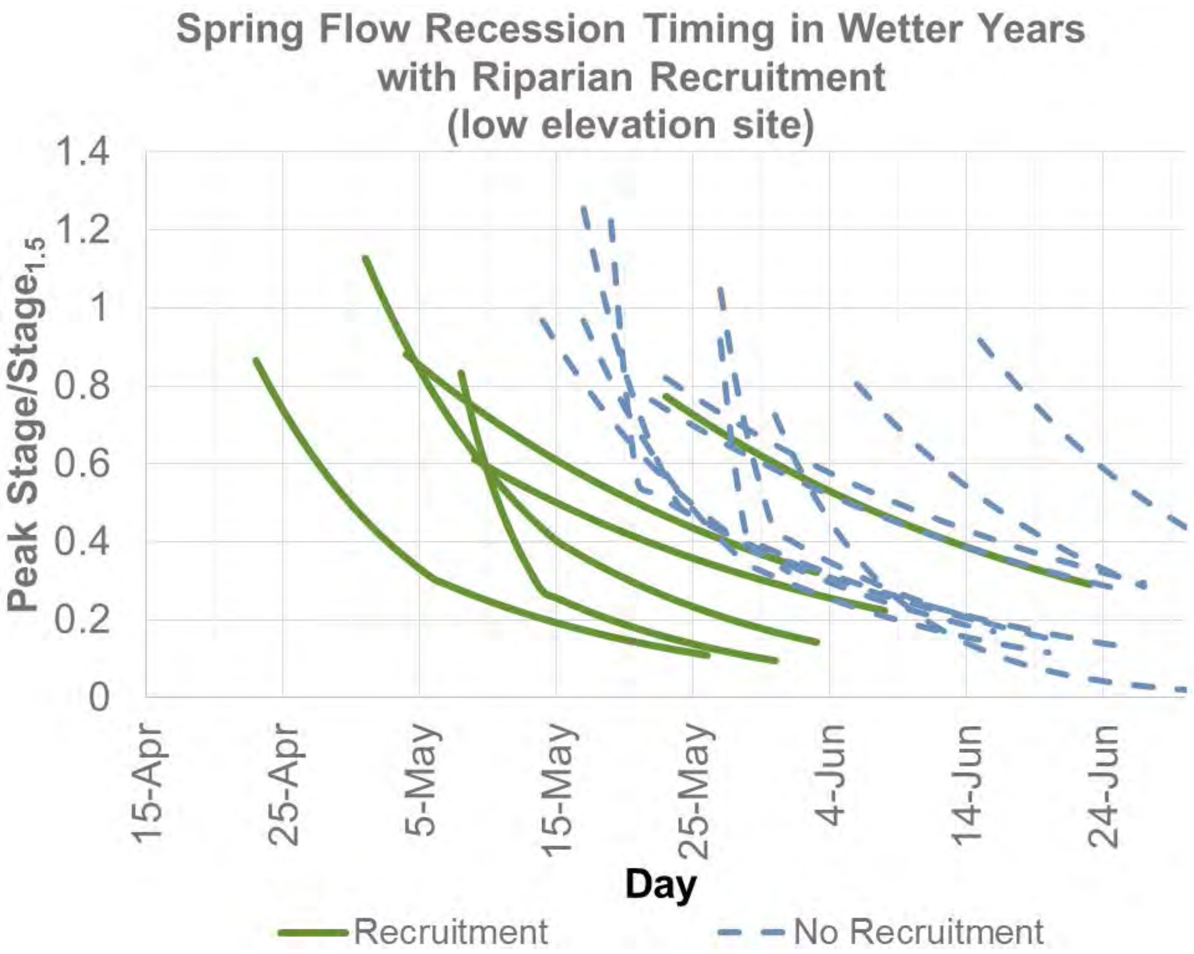
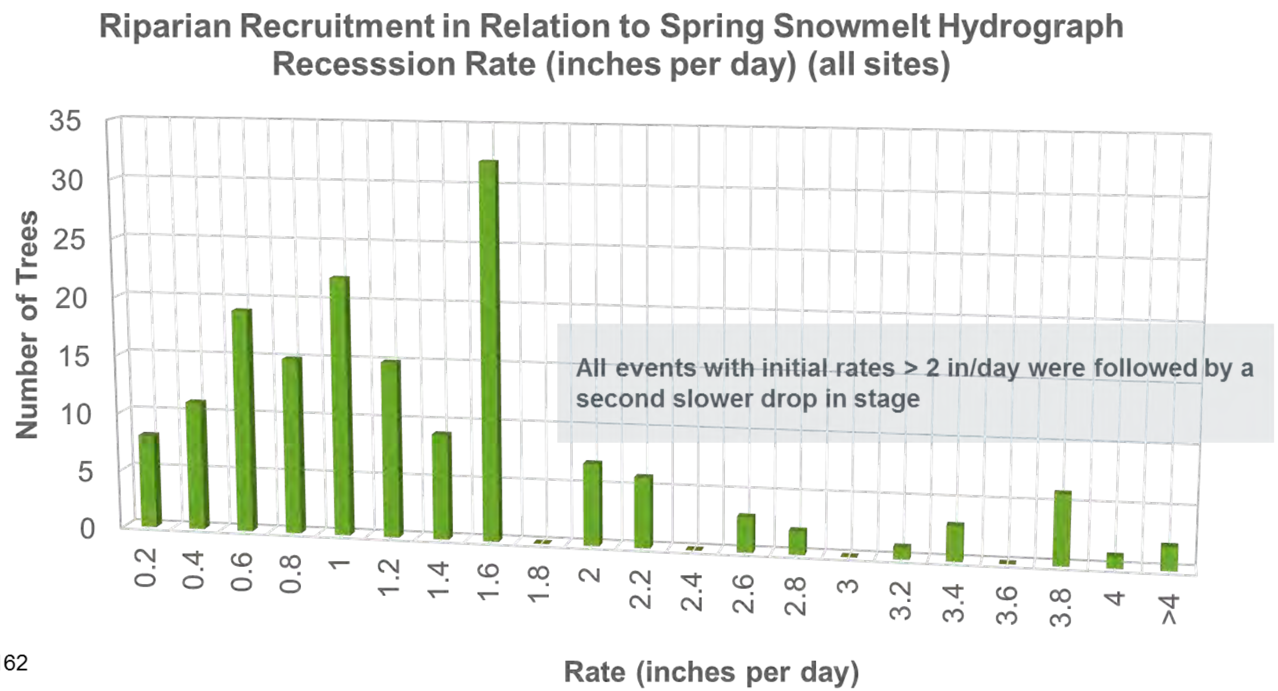
Site Specific Scale

Change in Stage & Peak Flow Timing



Site Specific Scale

Change in Stage (inches/day)



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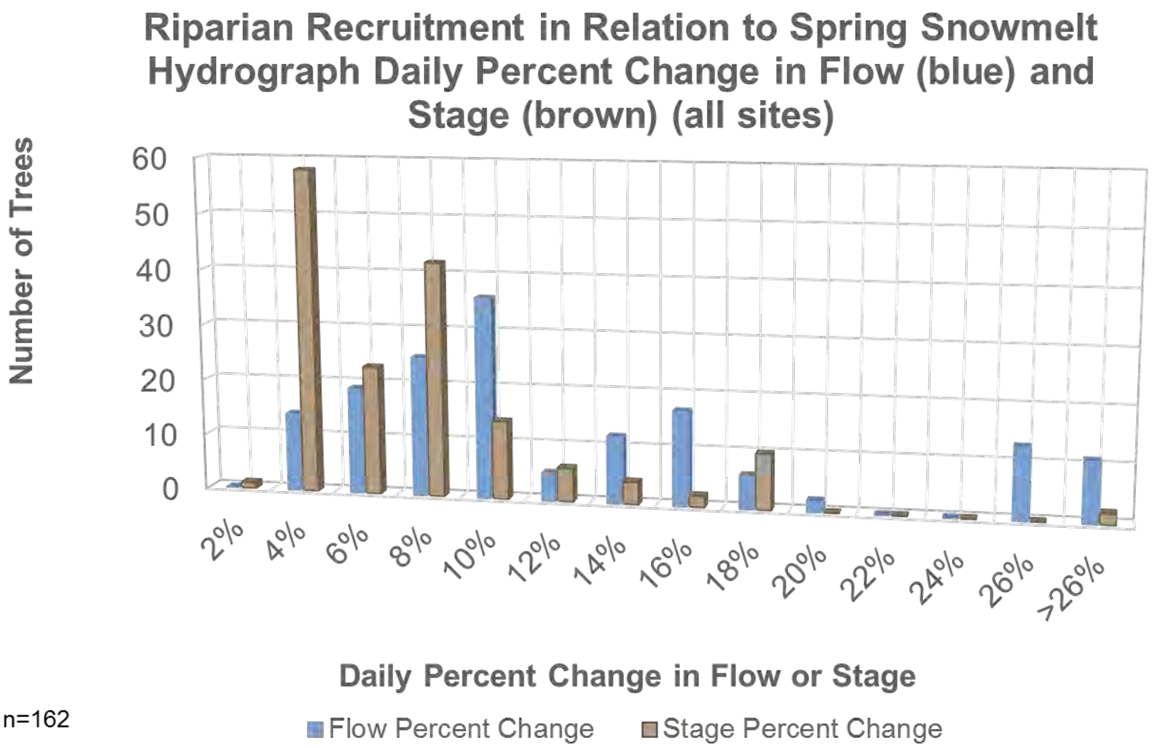
Site Specific Scale

Daily Percent Change in Stage



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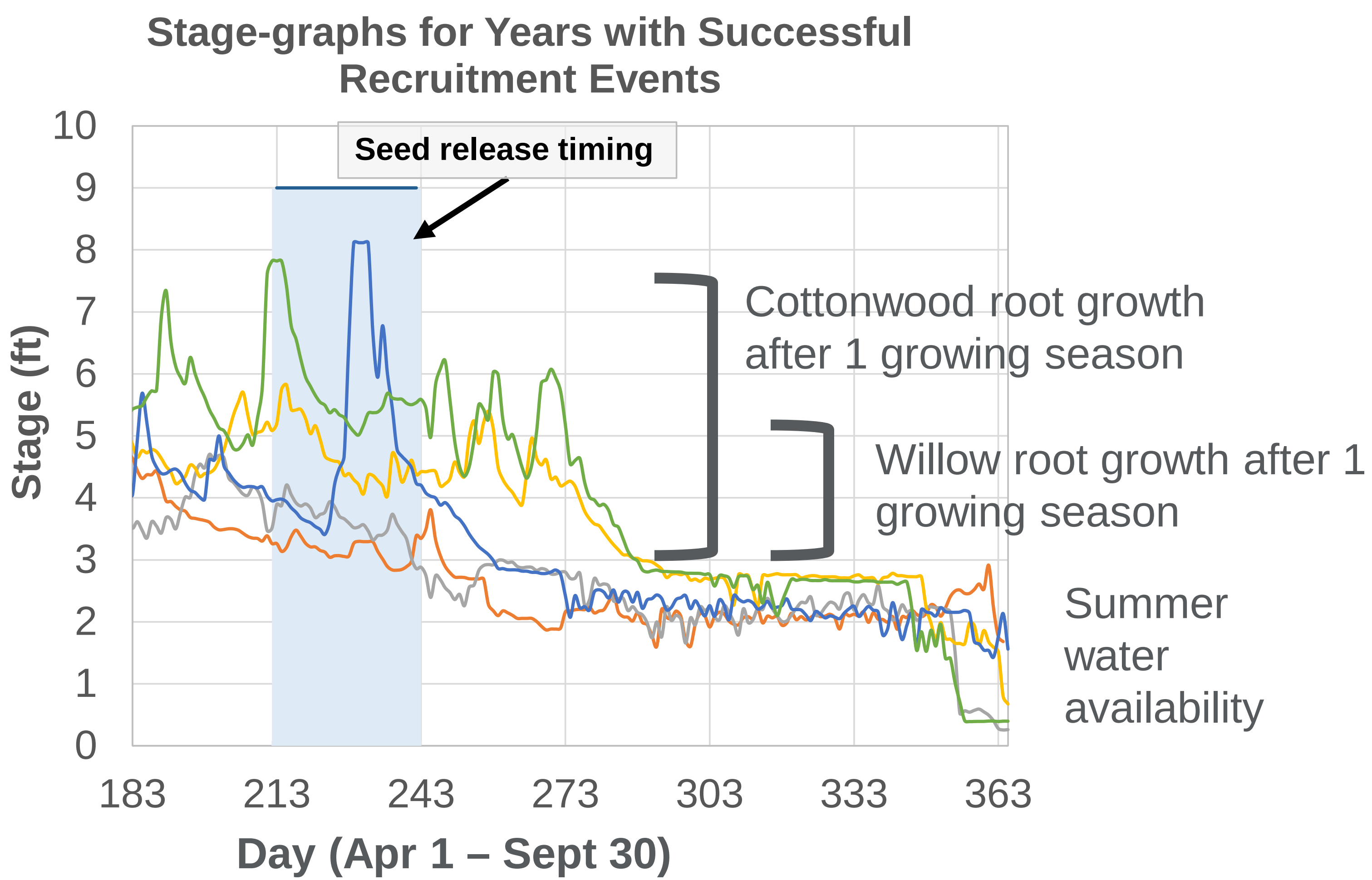
Site Specific Scale

Elevation - Summer Water Availability



Site Specific Scale

- Key determinants recruitment and establishment at the site specific scale:
  - Channel geometry
    - Stage recession rates
    - Summer water availability
    - Potential areas for establishment (wetted widths, depths)
  - Species physiologies
    - Seed release timing
    - Root depths

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Key Determinants

- Geomorphic and hydrologic processes at a hierarchy of spatial and temporal scales interacting with woody riparian species physiologies

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Riparian Management

- How can we use this information in the management or restoration of riparian systems?

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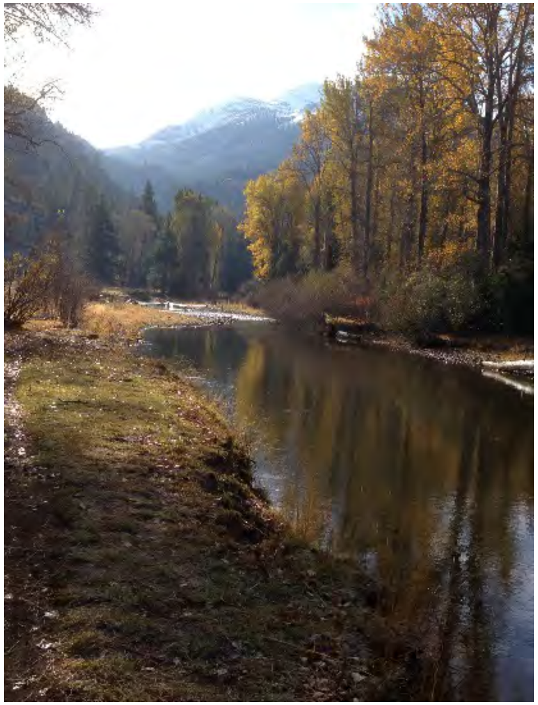
Riparian Management

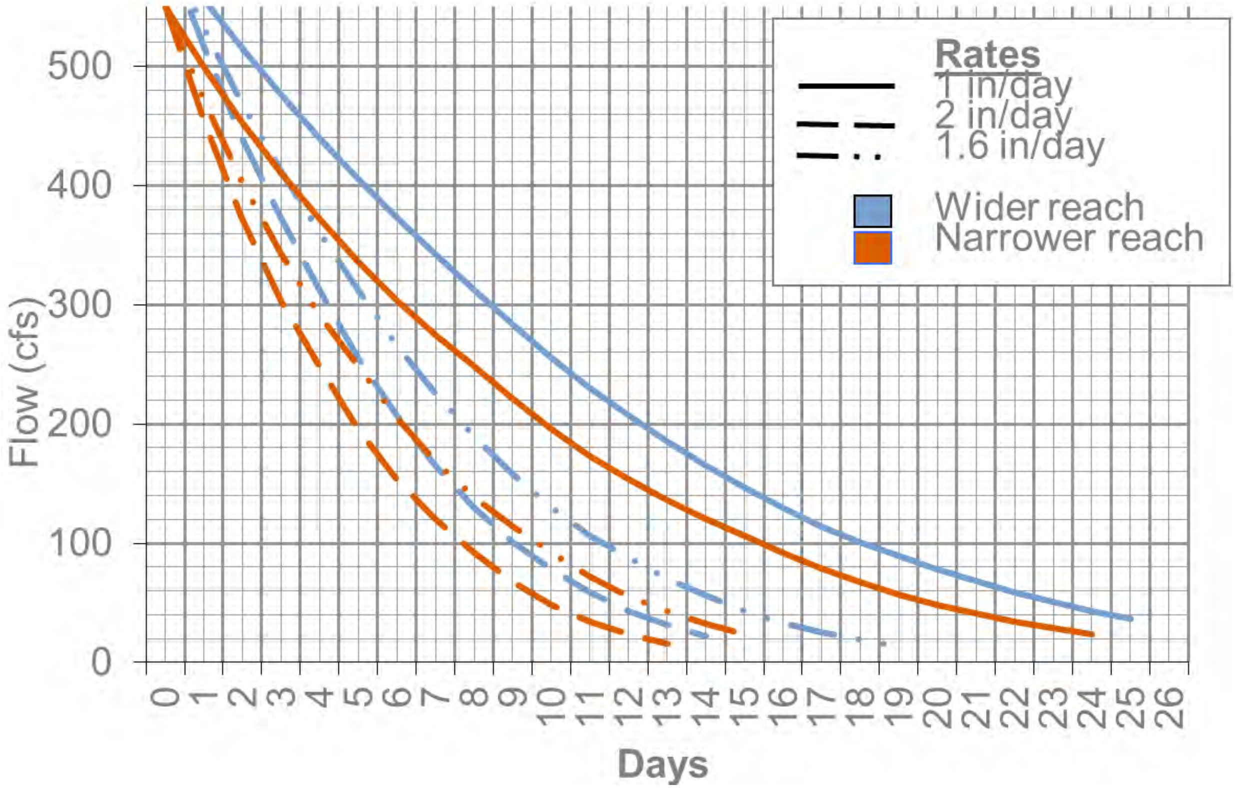
> Use regional data on past successful recruitment events and life history information for key riparian species with hydraulic modeling to:
  - Anticipate and adapt to the future
    - Evaluate potential vegetation responses to changes in hydrologic and geomorphic processes at different spatial and temporal scales (e.g., climate change, water management, floodplain re-connectivity, groundwater availability)



Management Tools

Environmental Flow Schedules

Recession rate, duration & timing



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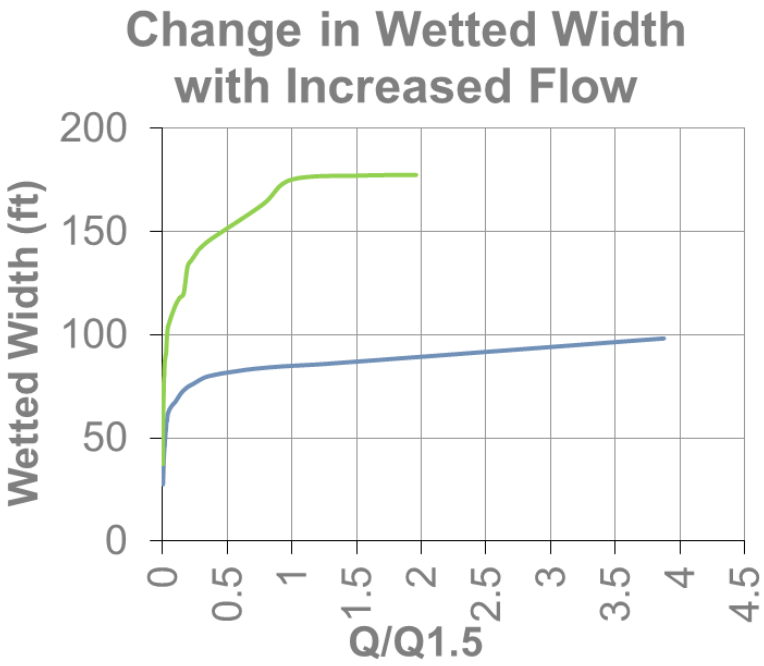
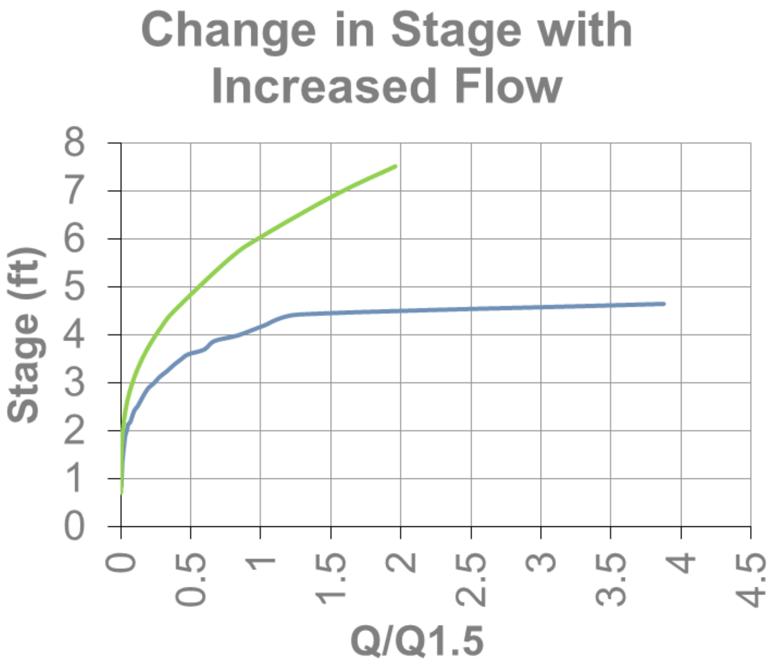
Management Tools

Environmental Flow Schedules & Restoration Design

Flow magnitude and wetted width, depth





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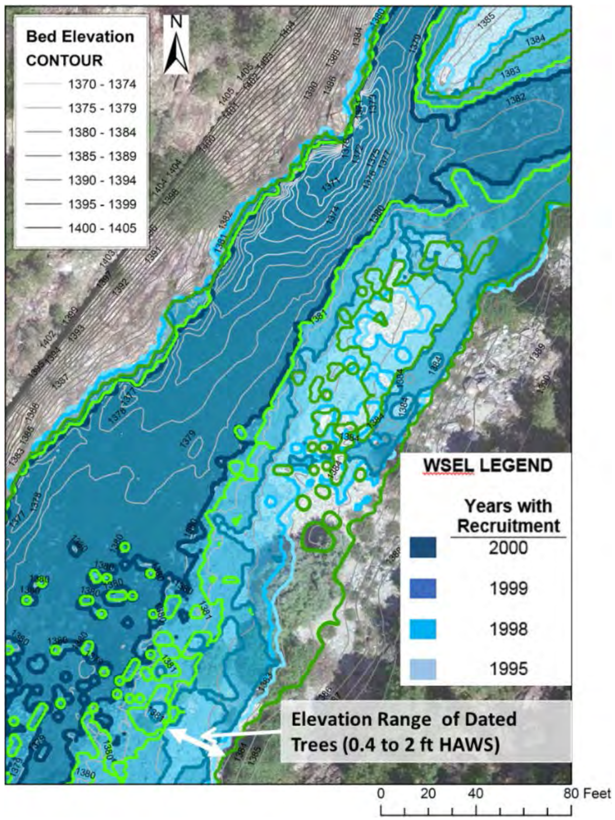
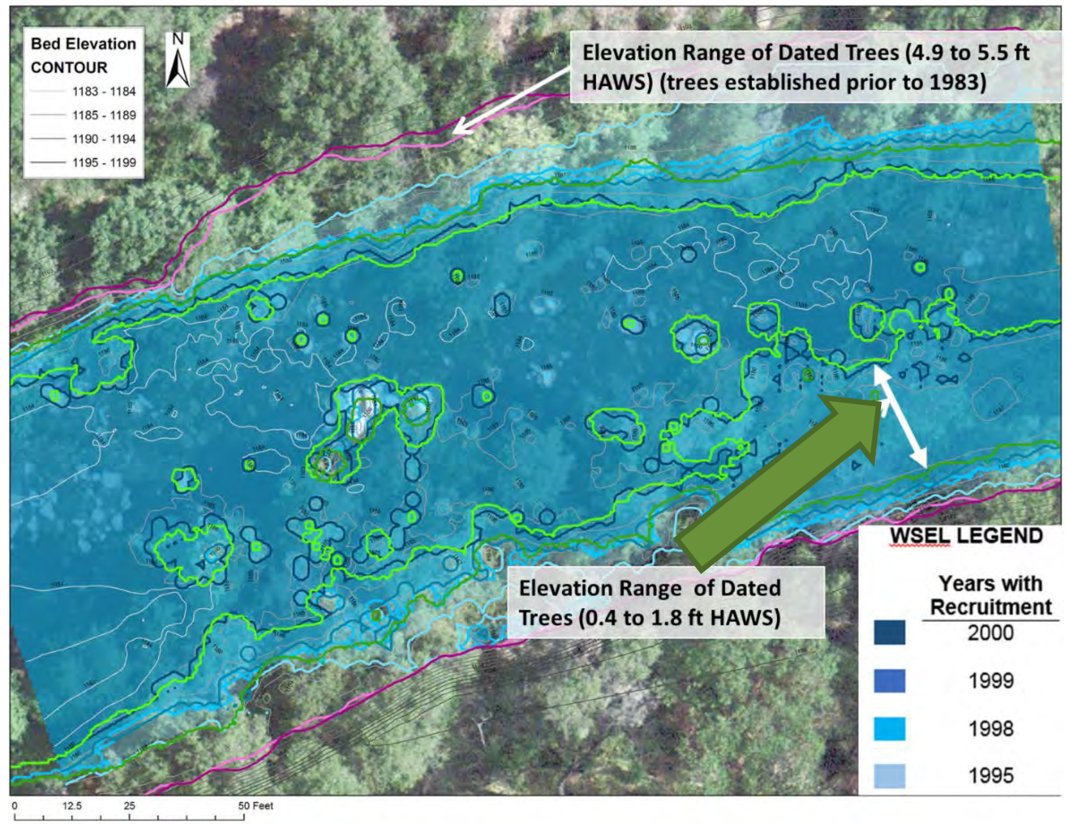
Management Tools

Environmental Flow Schedules & Restoration Design

Flow magnitude and inundated area





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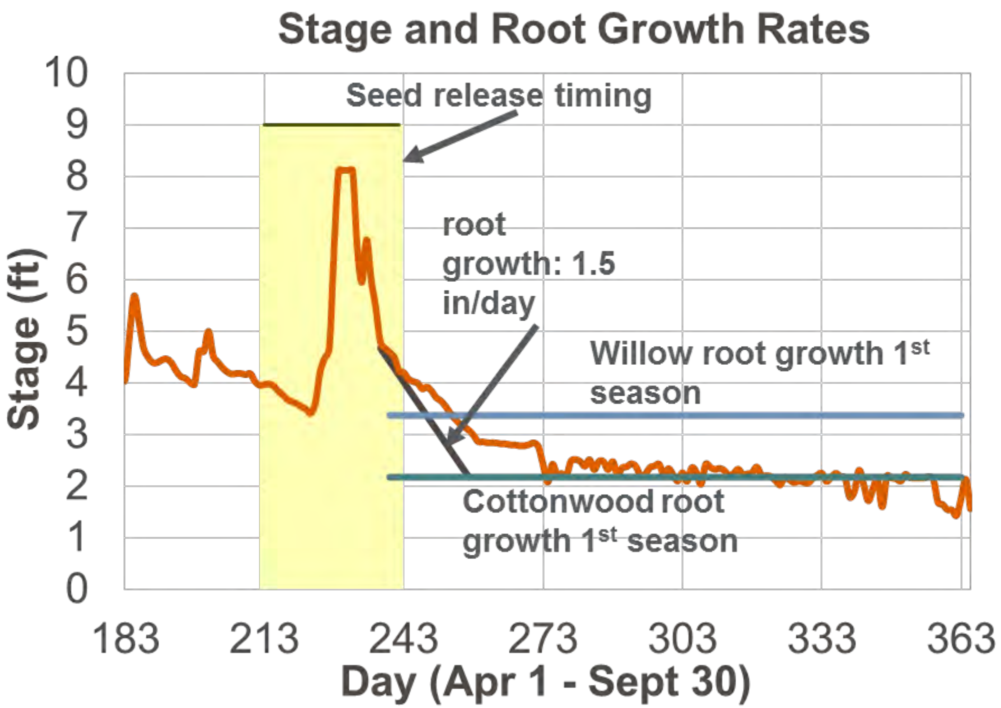
Management Tools

Water Management & Restoration Design

> Predict vegetation response to changes in water availability
  - First growing season for new recruits (1st year root depths)
  - Typical growing season for sustaining existing woody species and other wetland species (mature root depths)



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Management Tools

Environmental Flows & Restoration Design

- Analysis of floodplain or bar scour
  - Identify areas susceptible to scour during high flows
  - Evaluate potential to scour encroached vegetation

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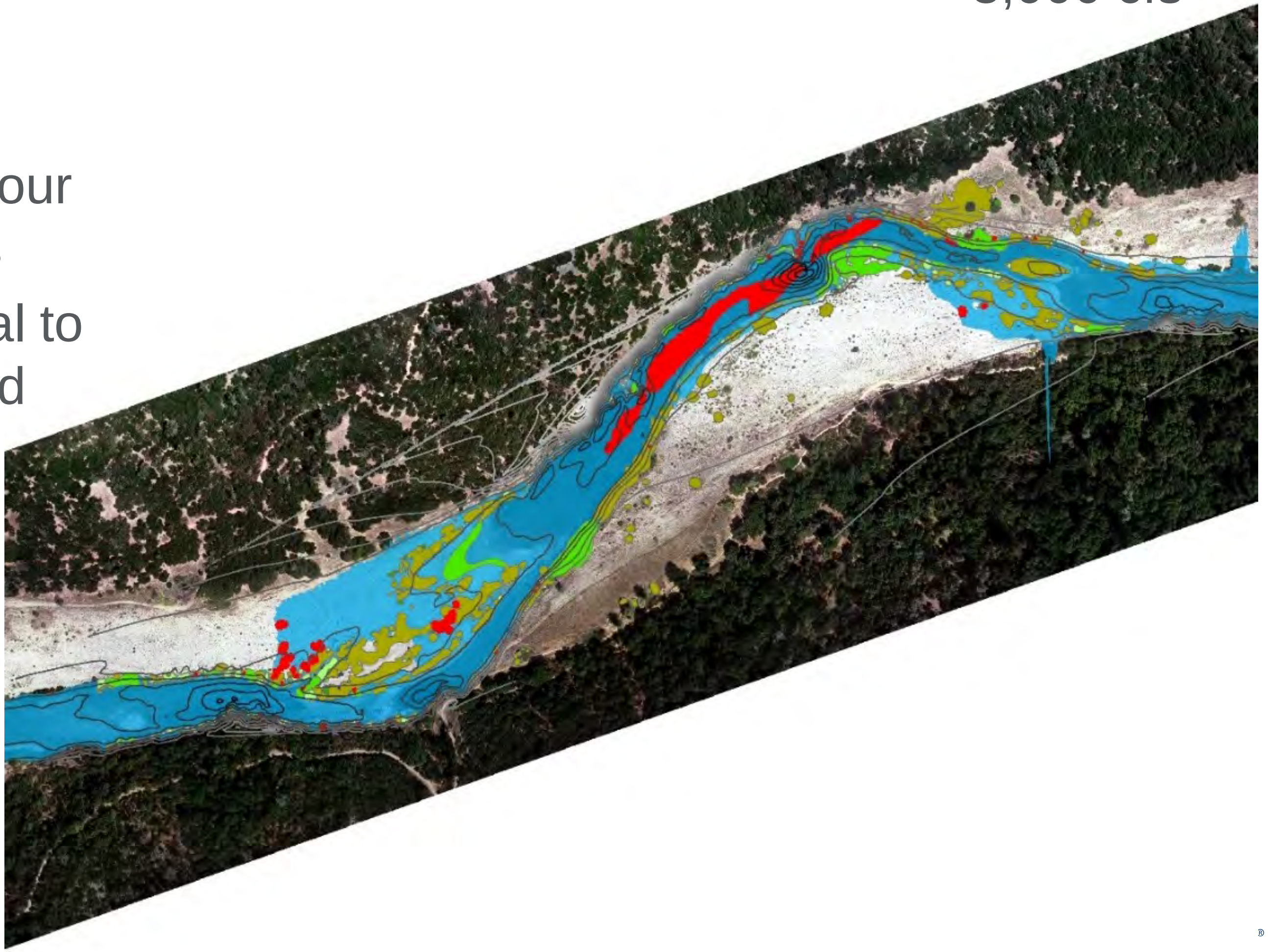


Management Considerations

Understanding the key determinants that influence riparian recruitment and survival is important for:

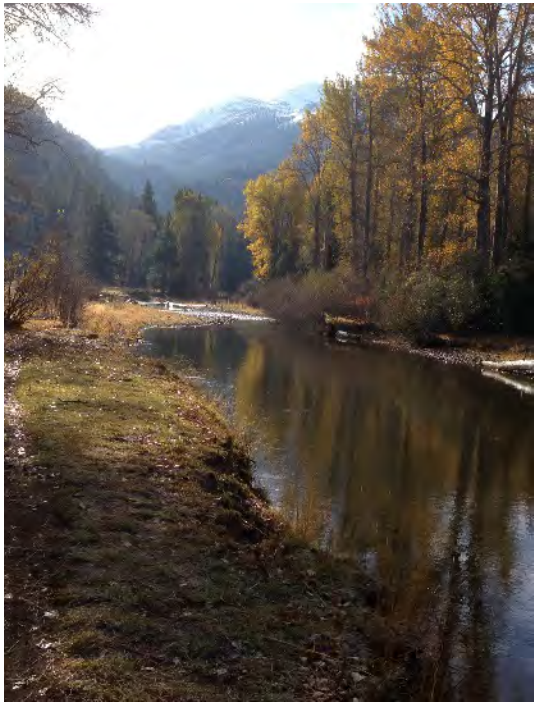
> Meeting riparian goals for restoration/mitigation projects

> Maintaining and restoring riparian functions

– Facilitating passive restoration; guiding design

> Guiding environmental flow development

> Anticipating and adapting to the future



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Questions?

Acknowledgements

> Support for this work was provided by Placer County Water Agency.

> Numerous people assisted the authors with data collection and hydraulic modeling: C. Addley, P. Graf, K.A. Colgate, S. Ebrahim, I. Parr