Quantitative Approaches to Riparian Restoration in California (USA)

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Restauración de Ríos
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Outline

1. Riparian forests in California's Mediterranean climate zone

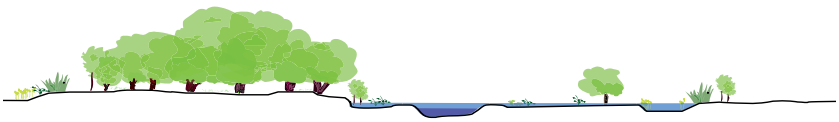
2. Historical human impacts to the ecosystem

3. Deciding what to restore--processes or structure?

4. Quantitative approaches to restoring riparian forests

    -restoring ecological processes efficiently

    -restoring riparian structure effectively

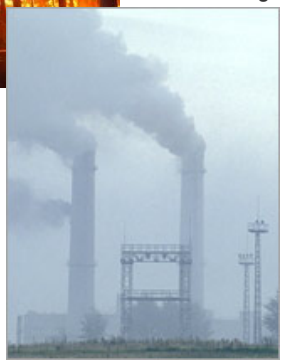


Non-Equilibrium Ecosystems: Multiple Disturbances and Drivers of Change

Floods

Fire

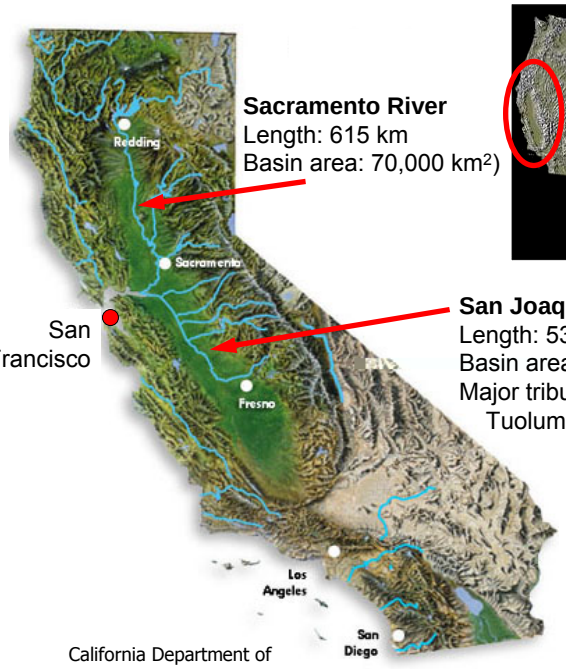
Climate change



Landscape modification

Sacramento River
Length: 615 km
Basin area: 70,000 km^2)

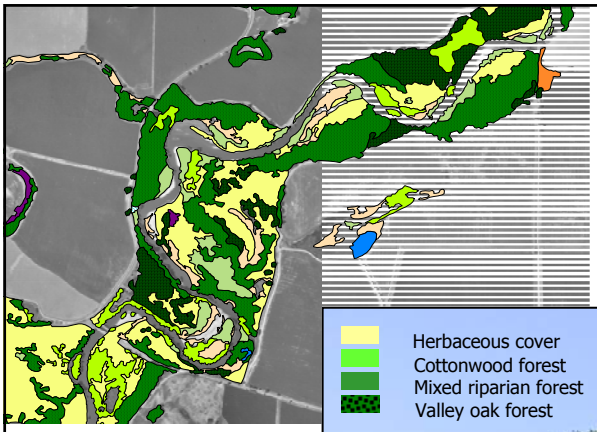
San Joaquin River
Length: 530 km
Basin area: 83,000 km^2
Major tributaries:
Tuolumne, Merced, Stanislaus Rivers



Major California River Systems

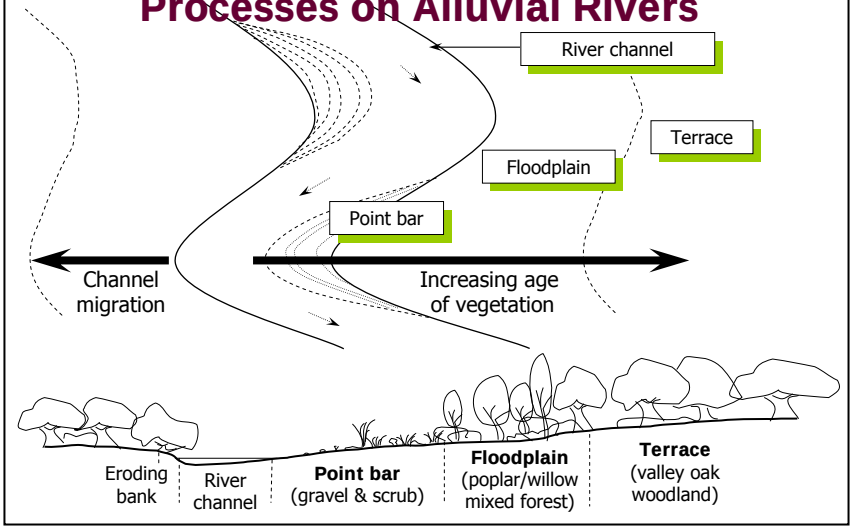
California Department of Water Resources.

Riparian Structure and Pattern



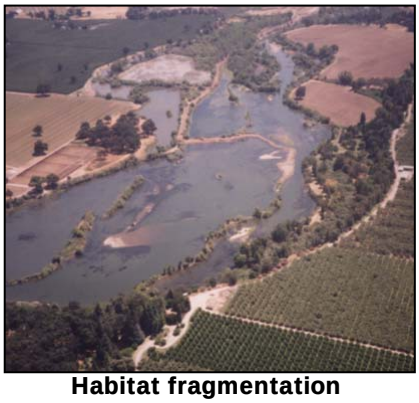
- High structural complexity
- Patchy distribution
- Important terrestrial and in-stream habitat (litter, large woody debris, shade)

Riparian Vegetation Establishment Processes on Alluvial Rivers



Human Impacts in Riparian Zones

Floodplain development



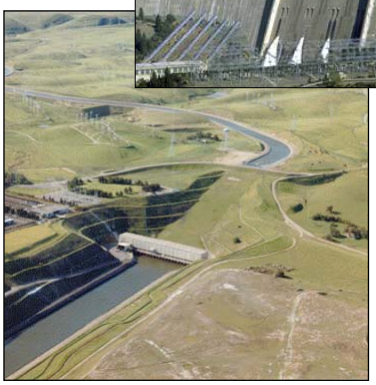
Habitat fragmentation

Channelization and bank stabilization

Water Development in California's Central Valley

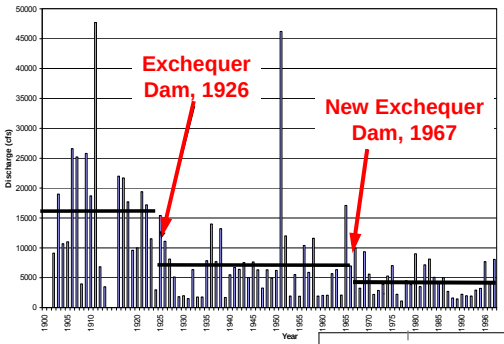
Major Water Projects
(CA Dept of Water Resources)

Shasta Dam, Sacramento River



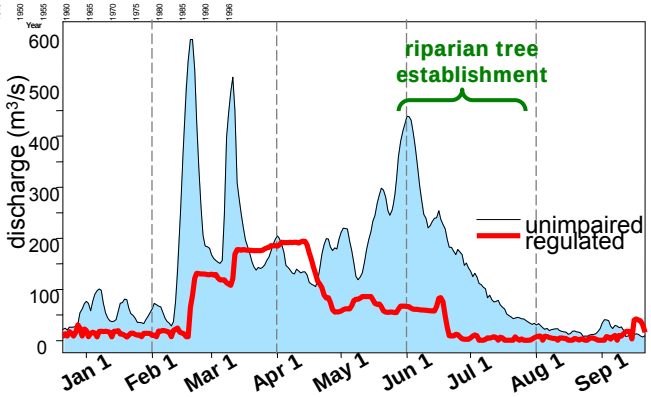
California Aqueduct

Flow Regime Modifications



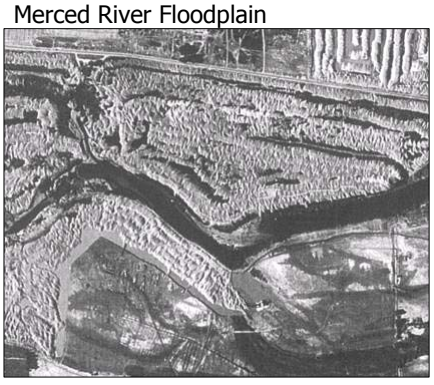
Reduction in annual flood magnitude

Reduced flow volume and altered timing



Floodplain Destruction: Gold Dredging, 1900-1950

Merced River Floodplain



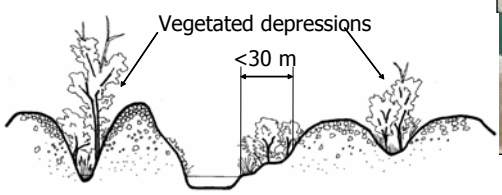


Image courtesy of Stephen Johnson

Ecological Impact:

- few remnant forest patches
- no seedling establishment
- conversion to other vegetation types

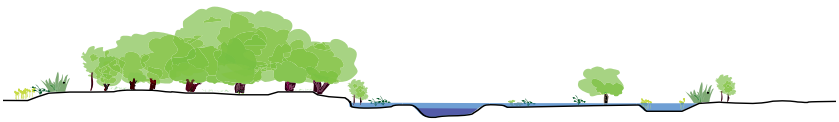
What Should We Restore in a Disturbance-Dependent Ecosystem?

1. Ecological processes:

(e.g., flow variability, sediment transport, channel migration)

2. Habitat structure and pattern

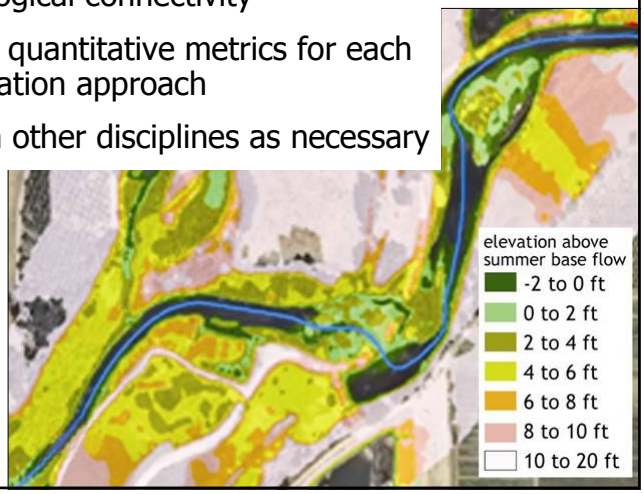
(e.g., species composition, canopy configuration, age structure)



General Restoration Approach

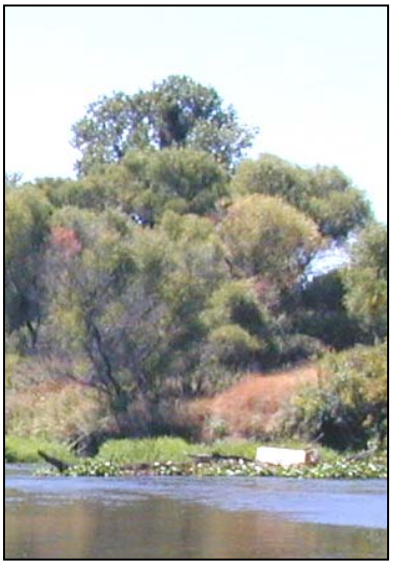
- understand hydrologic dependencies of riparian and aquatic species
- model hydrology and stratify floodplain by degree of hydrological connectivity
- choose meaningful quantitative metrics for each restoration approach
- adapt analyses from other disciplines as necessary

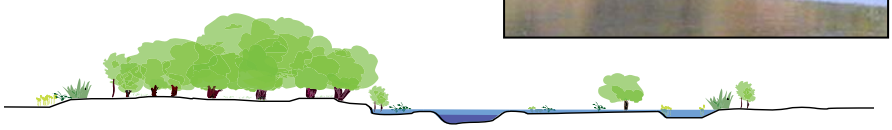
San Joaquin River Hydraulic and Topographic Model



Seedling Recruitment Processes for Riparian Populus and Salix

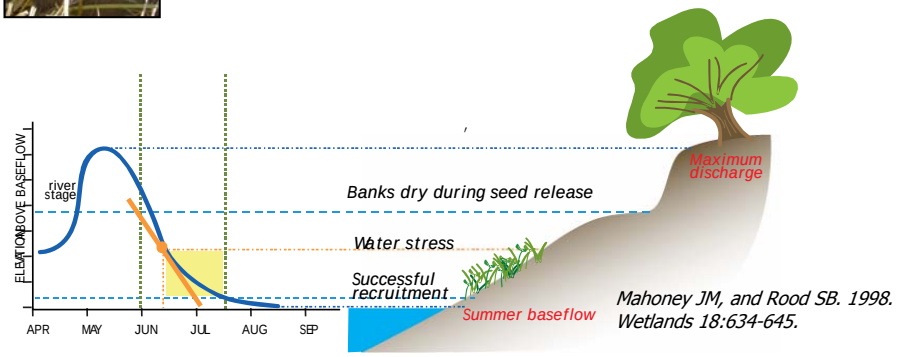
- Populations limited by seedling recruitment
- Short-lived seeds; no seed bank
- Reproduction timing coincides with regular spring floods
- Seedlings establish in high-flow years





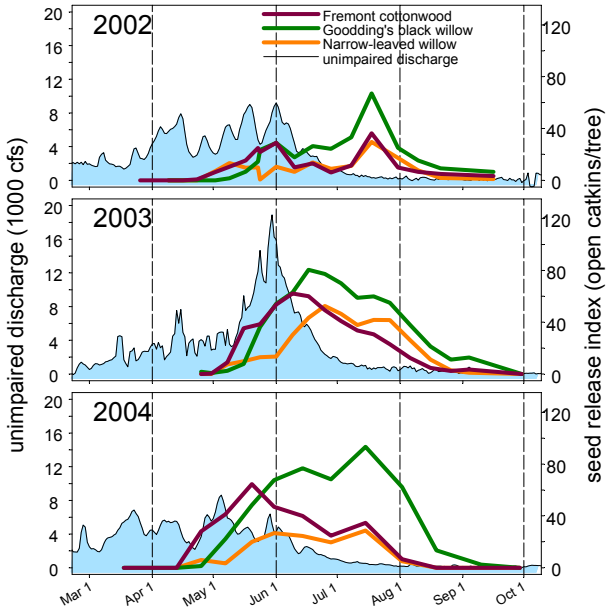
Critical Ecological Processes for Seedling Establishment

- river flow regime
- seed release timing
- seedling water stress thresholds



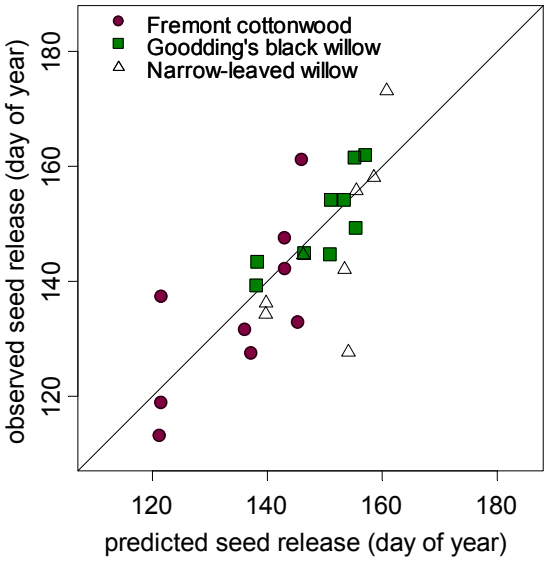
Mahoney JM, and Rood SB. 1998. Wetlands 18:634-645.

Seed Release Timing and Spring Floods



- Peak seed release coincides with snowmelt recession
- Annual timing influenced by temperature

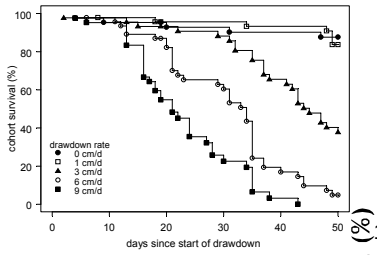
Modeling Seed Release Timing From Seasonal Heat Sums

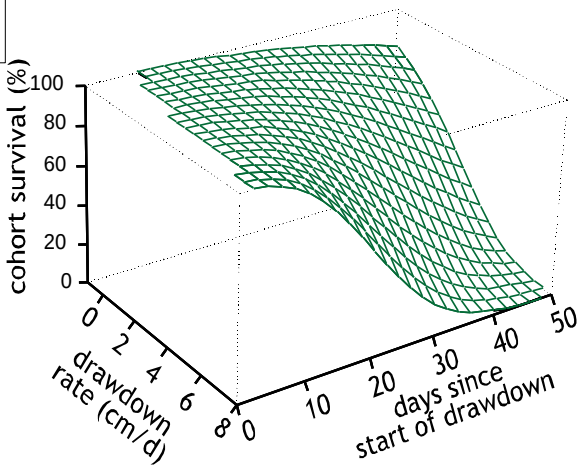


Seedling Water Stress Experiment

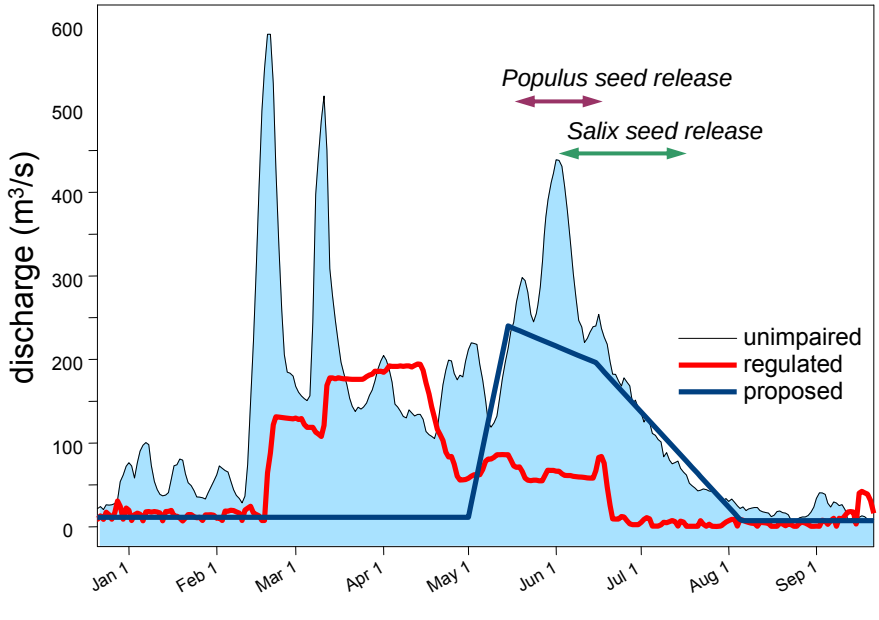
- seedlings grown in tanks
- 5 water table reduction treatments
- measured seedling survival, growth, and physiology

Modeling Cohort Survival from Empirical Data

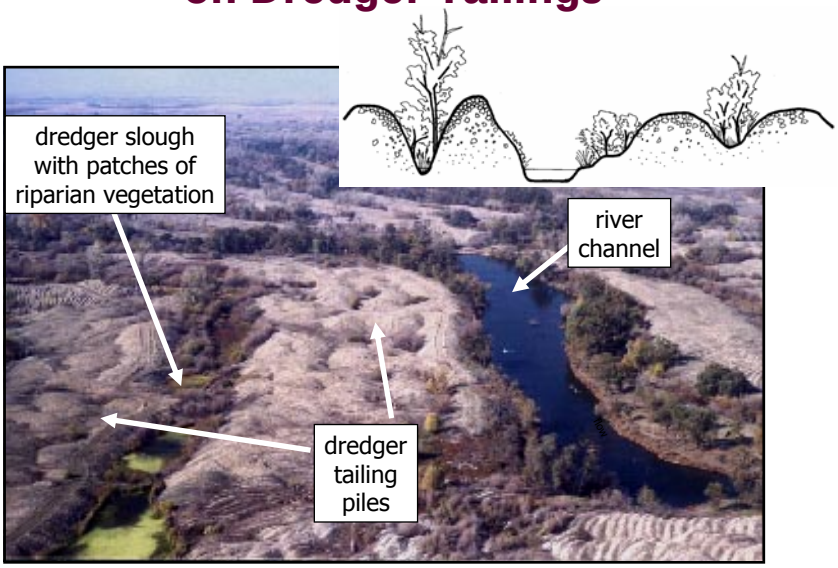




Flow Requirements for Successful Recruitment



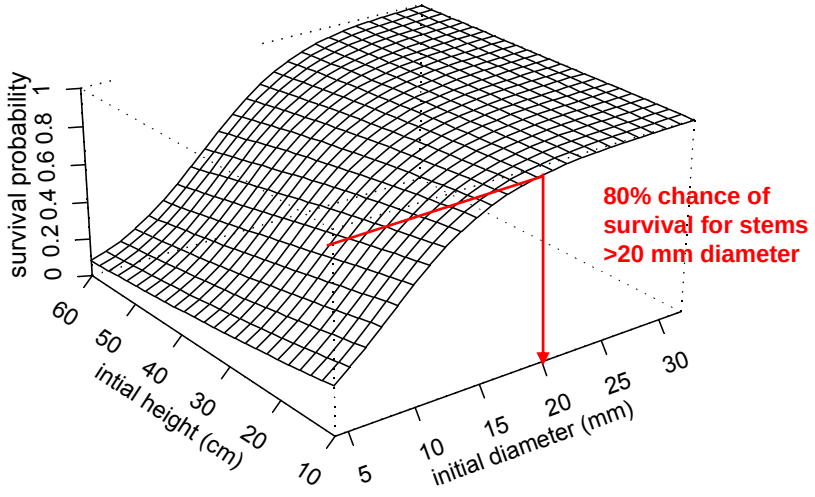
Restoring Riparian Habitat Structure on Dredger Tailings



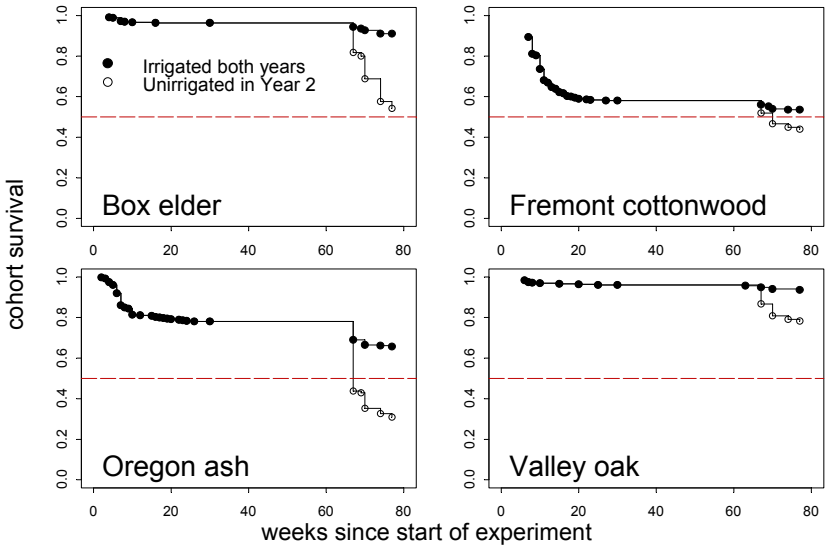
Merced River Riparian Tree Planting Experiment

- 4 native species
- 3 elevation levels
- irrigation (+/-)
- survival and growth analysis

Predicting Survival in Year 1 from Initial Planting Size
(Logistic Regression Models)



Species Survival Differences and Irrigation Effectiveness
(Cox Proportional Hazard Models)



Conclusions

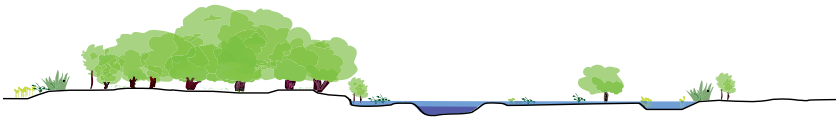
1. Restoring non-equilibrium ecosystems requires novel approaches.

2. Choose what to restore: processes and/or habitat structure.

3. Restoring processes efficiently requires understanding key ecological mechanisms.

4. Restoring habitat effectively requires controlled studies to isolate treatment effects from covariate factors.

5. Developing meaningful quantitative metrics is critical.



Thank you for your attention!

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Joe McBride, Dept of ESPM, UC Berkeley
Matt Kondolf, Dept of LAEP, UC Berkeley
Stillwater Sciences, Berkeley CA

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University of California, Berkeley

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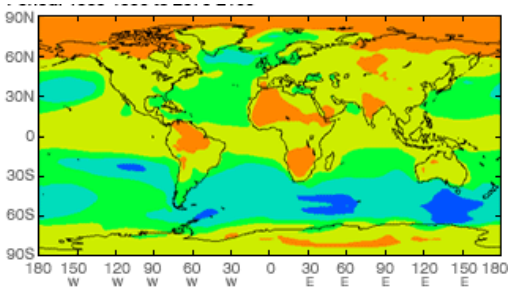
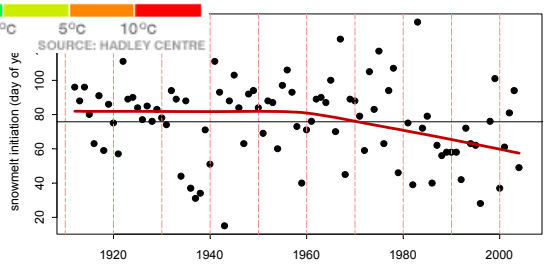
Climate change…. a wildcard



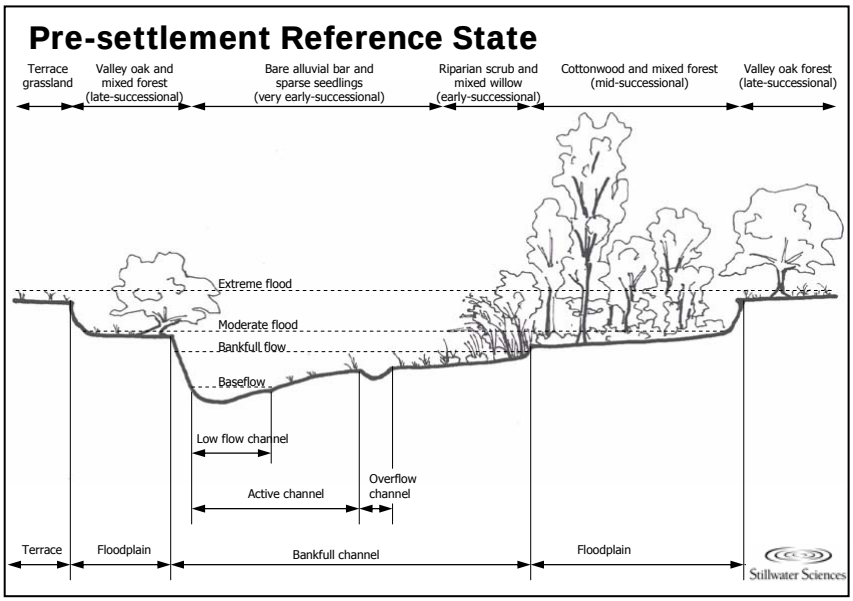
Expected in California:

- More precip falling in winter (rain and rain-on-snow events)
- Earlier snowmelt

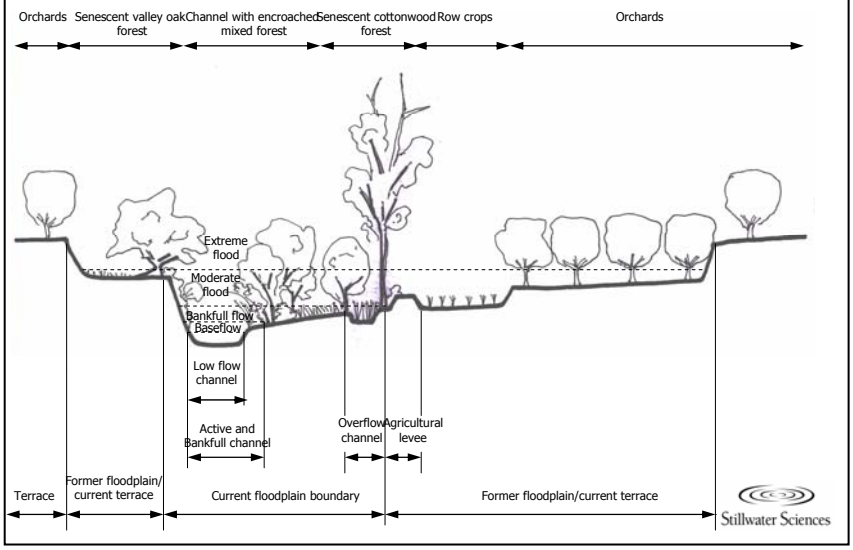


Question: How much can trees adapt?

Pre-settlement Reference State

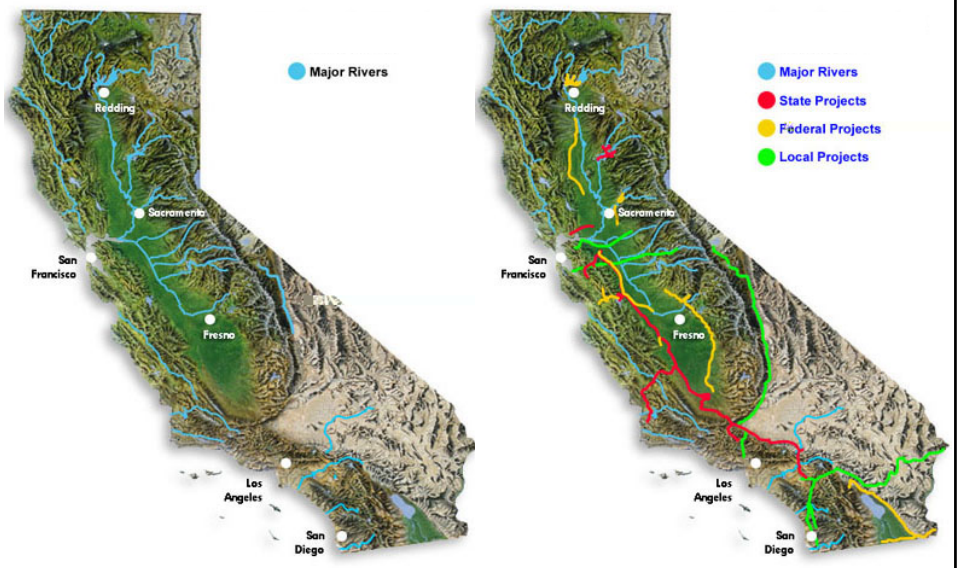


Current Conditions

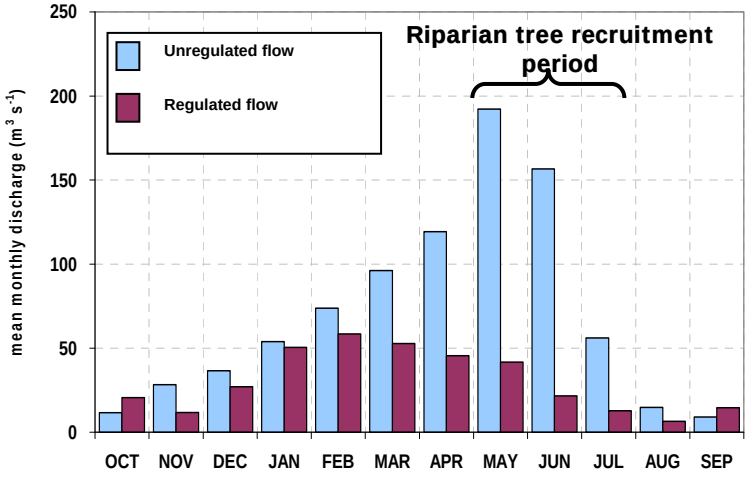


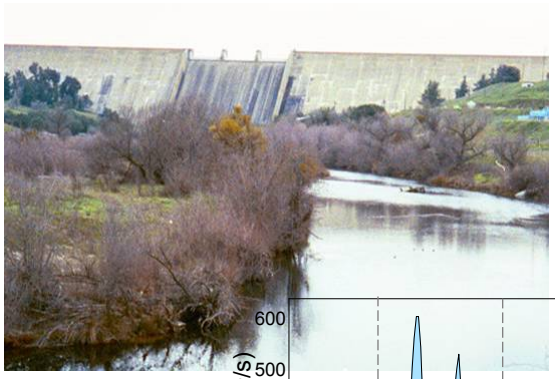
California rivers and water projects

Maps courtesy of California Department of Water Resources.



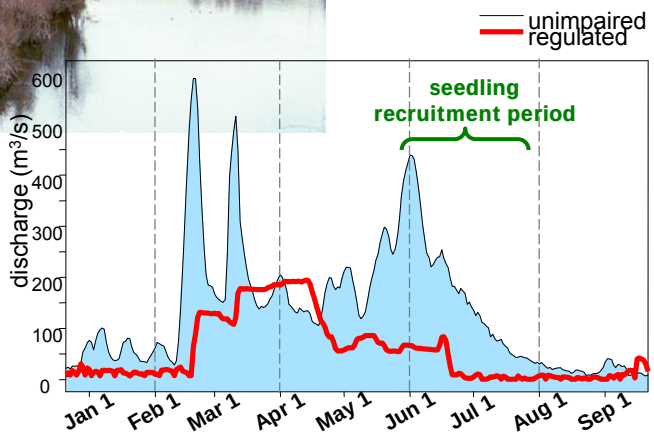
Flow Timing and Magnitude



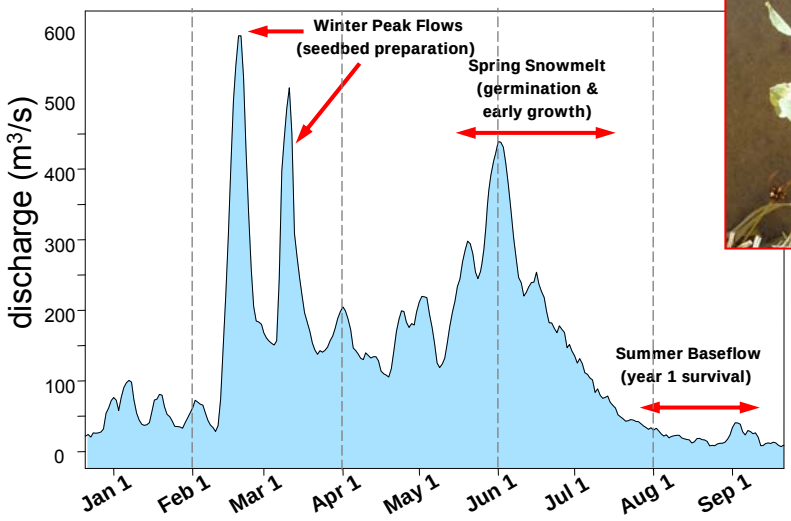


Central Valley Water Development

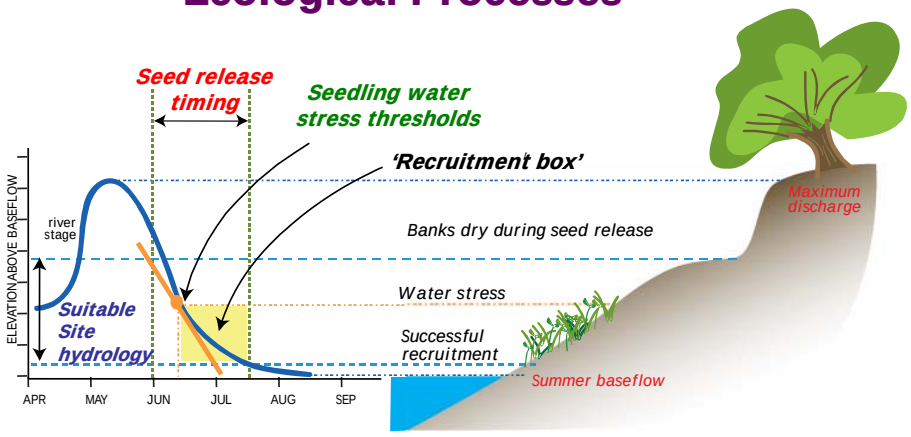
Friant Dam
(San Joaquin River)



Biologically-important flow characteristics



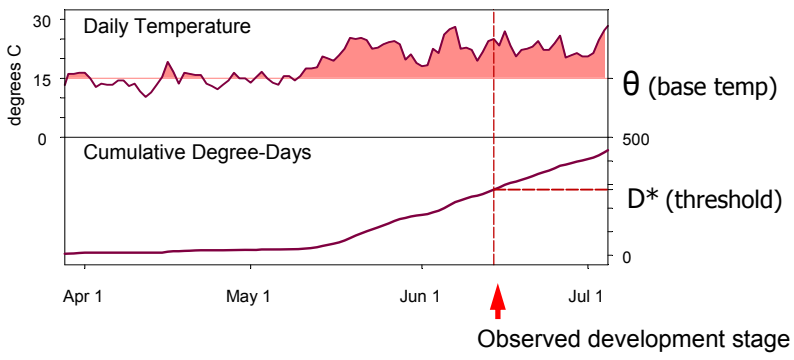
Conceptual Model of Key Ecological Processes



Adapted from: *Mahoney JM, and Rood SB. 1998. Streamflow requirements for cottonwood seedling recruitment--an integrative model. Wetlands 18:634-645.*

Using Degree-Days to Predict Timing

- Degree-days are an alternative way to mark development time
- Established method in agriculture and pest management
- Experimental vs. empirical models
- Daily degree-days: $D_d = T_m - \theta$;
- Cumulative degree-day threshold: $D^* = \sum^{\circ} D_d$



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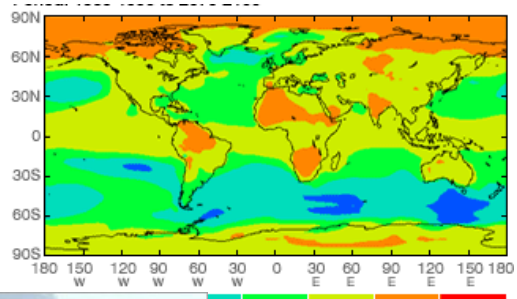

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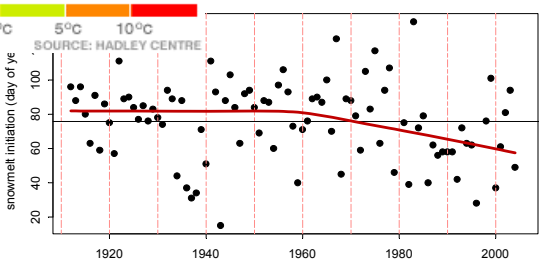

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