Coevolving floodplain and riparian forest dynamics on the Middle Sacramento River, CA

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Image: Sacramento River Conservation Area Forum

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Funding:

CALFED/Sea Grant Science Program
CNRS PICS Grant Program

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Hydrology (flow magnitude, frequency, timing)

Geomorphology (sediment transport, channel & floodplain morphology)

Riparian Vegetation (plants, patches, populations, communities)

Motivating Questions

- *How does riparian vegetation respond to physical drivers in river ecosystems?*
- *How can we use this knowledge to design cost-effective riparian conservation and restoration?*

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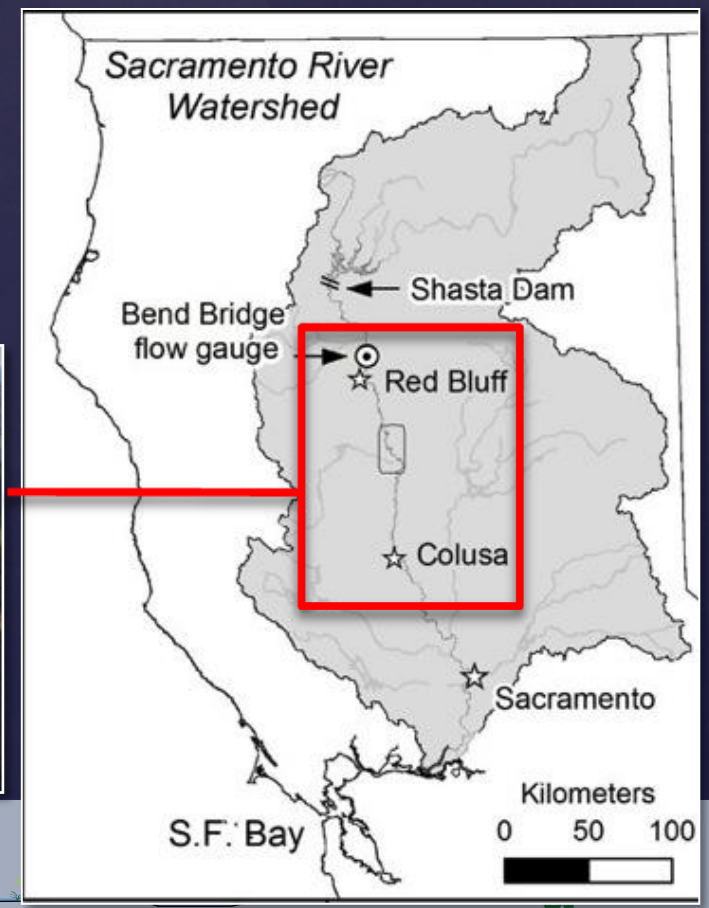
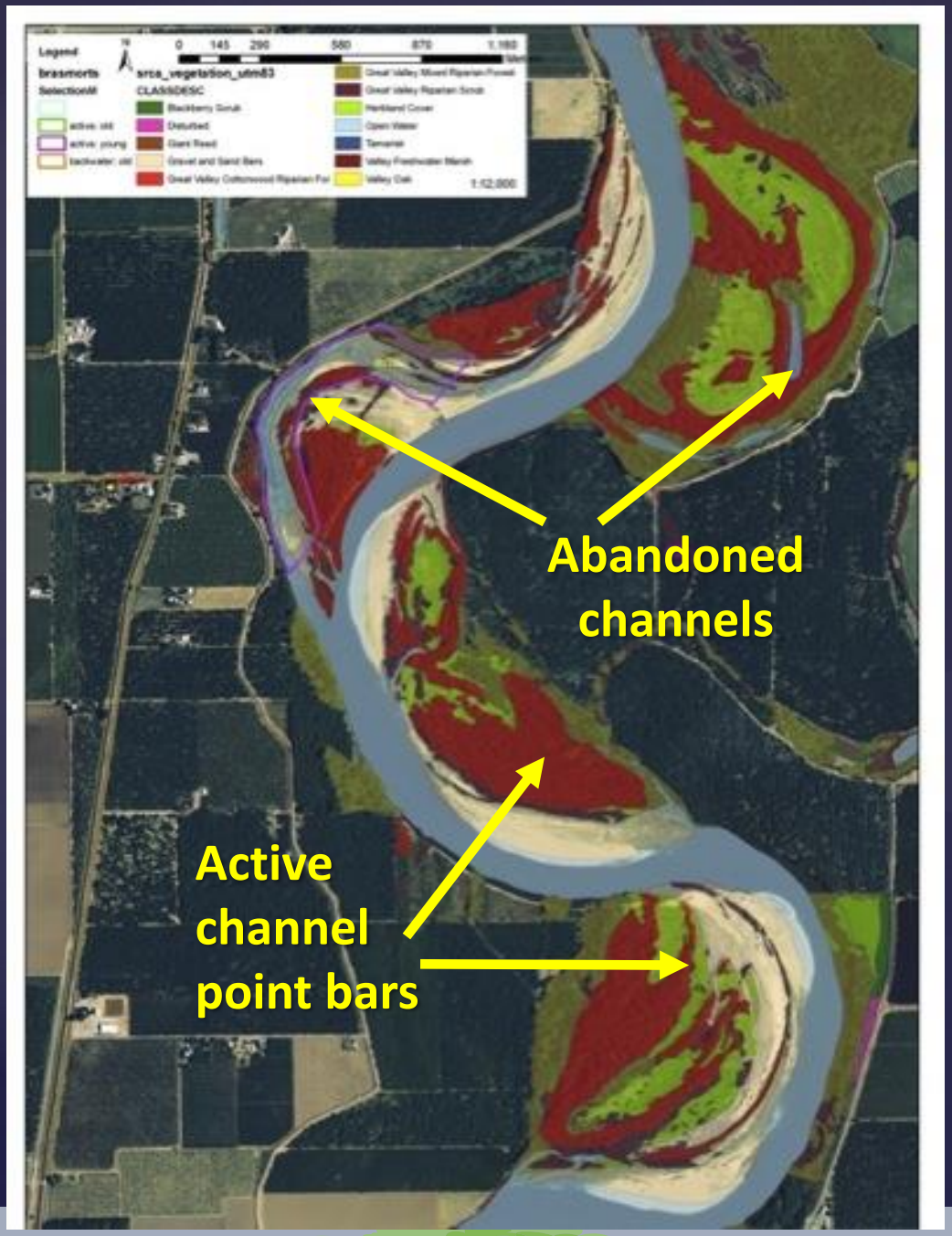
What is the ecological status of riparian forests on the Sacramento River?

- Largest California river basin: 75,000 km^2
- Flow controlled by Shasta Dam (1942)
- Reduced channel migration downstream *(Michalková et al., 2010)*
- Large remnant riparian forest stands along the river *(Stella et al. 2011)*

Middle Reach
(Red Bluff → Colusa)





Importance of remnant forest stands

- Foundational role in ecosystem and food web
- High biomass, structure, productivity
- Stands establish in multiple floodplain environments → habitat complexity
- Long-term record of ecosystem change (land use, flow regulation, climate)
- Reference conditions for restoration and future change

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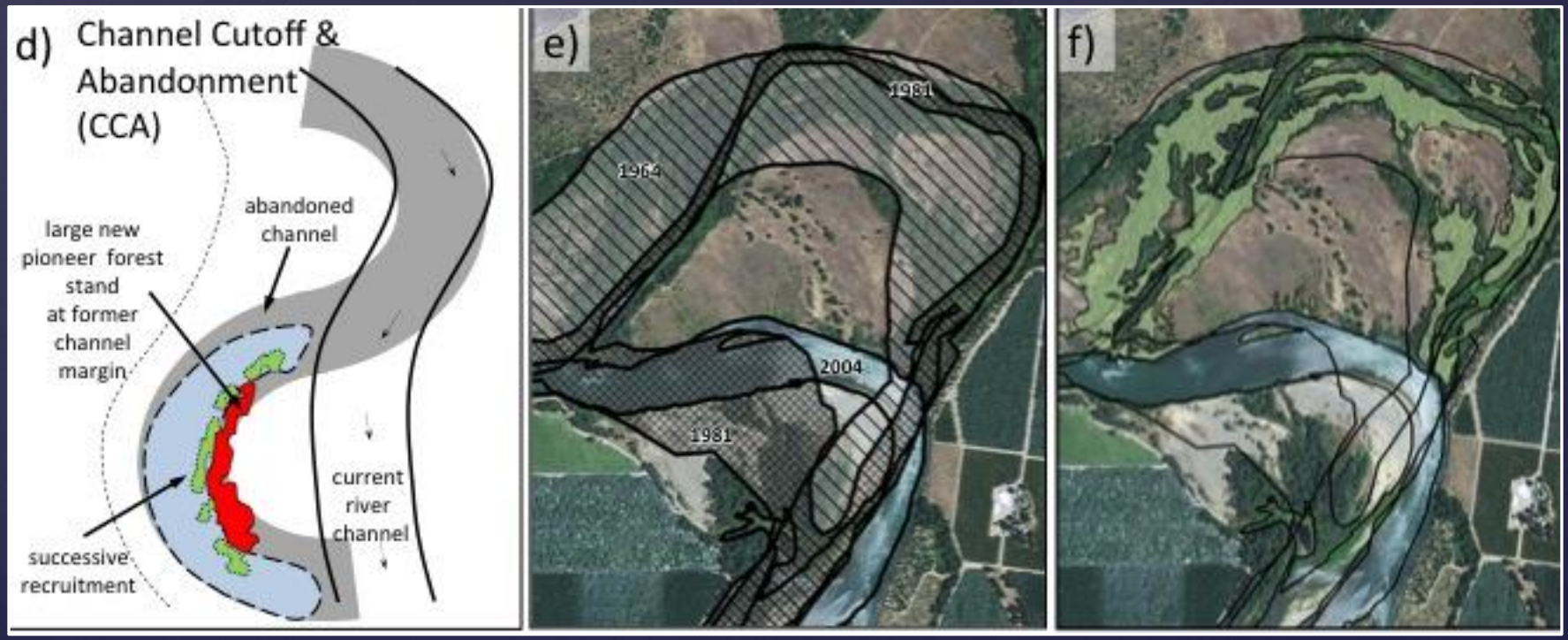
Abandoned channels are an important forest initiation pathway (50% of all forest)

Channel cutoff and blockage

Sediment filling and terrestrialization

Forest regeneration within former channel



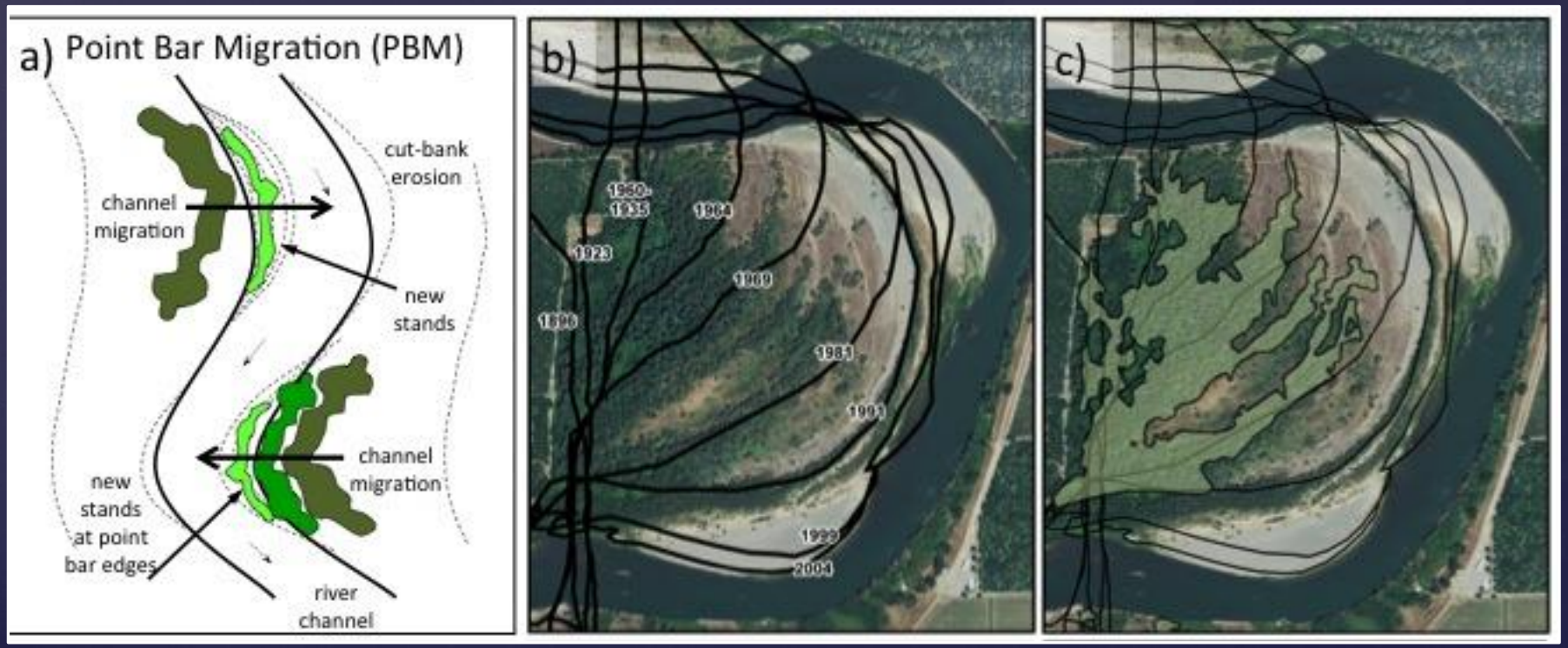
Stella, Hayden, Battles, Piégay, Dufour & Fremier. 2011 Ecosystems 14:776-790.

What factors drive forest development along the active river channel?

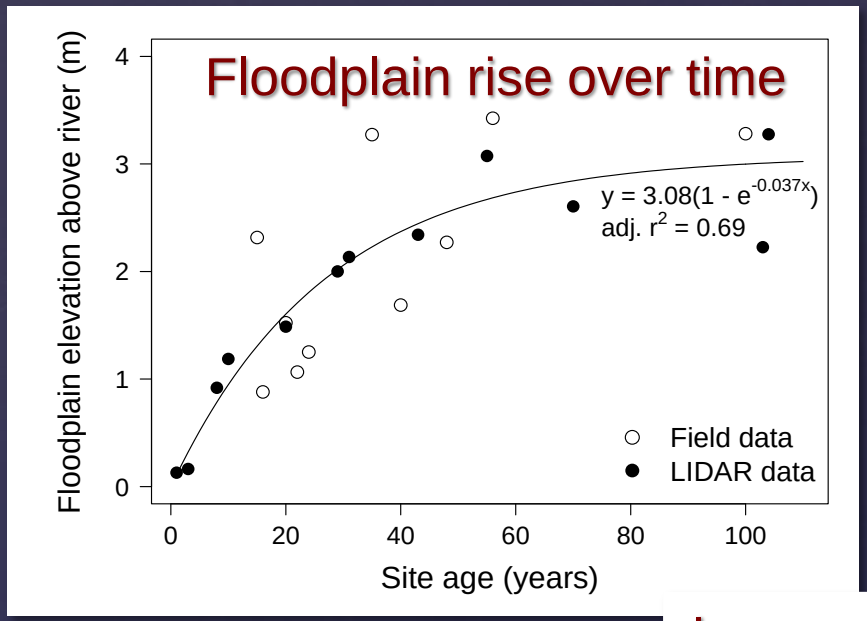
Channel migration

Successive stages of point bar formation

Riparian trees colonize in parallel stands



Clear pattern: successive tree cohorts on rapidly accreting floodplains



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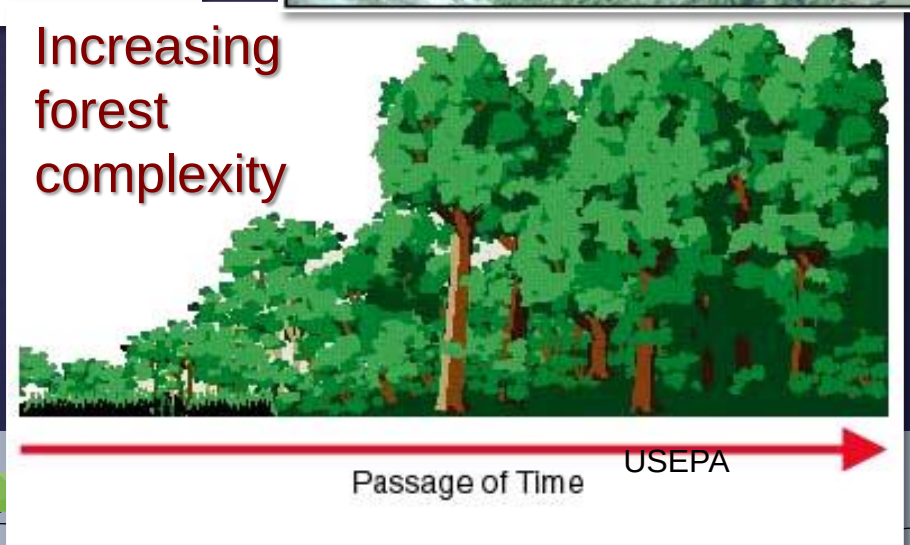

Pioneer Willow/Cottonwood forest

Mid-successional mixed riparian forest

Late-successional valley oak woodland

Riparian Forest Study Objectives

- Thoroughly document riparian forest composition and structure
- Floodplain chronosequence of forest succession and geomorphic conditions
- Provide baselines for forest change and restoration targets

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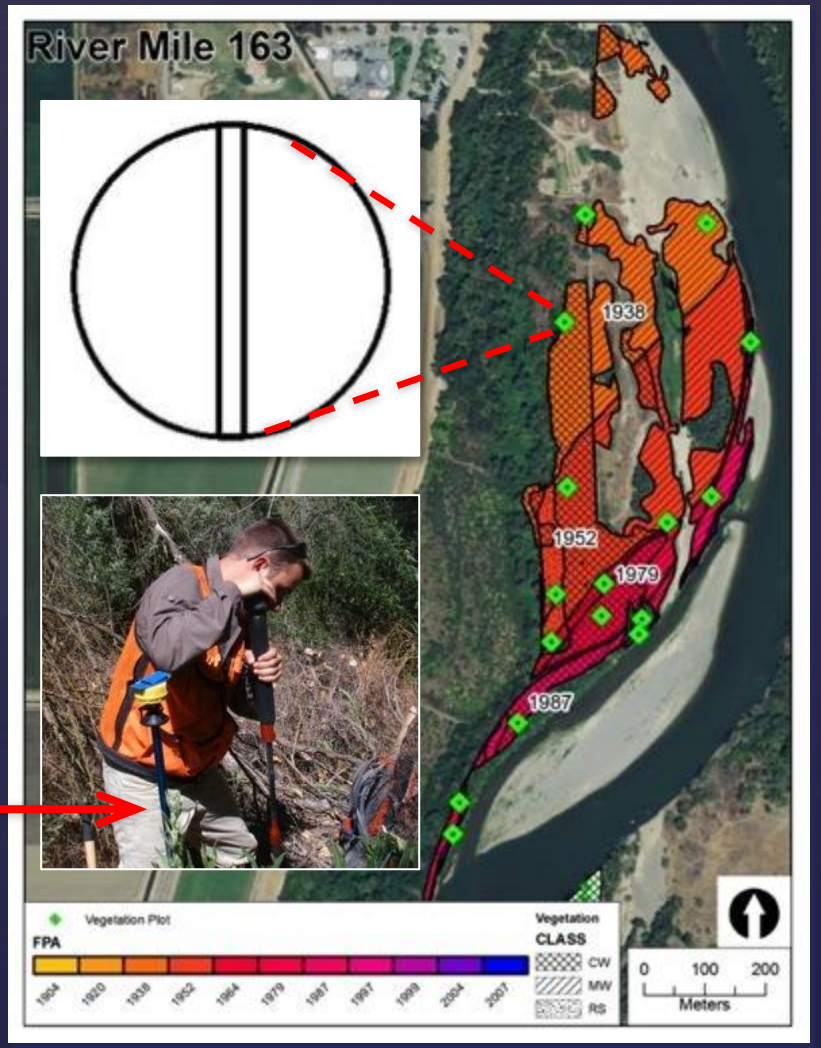
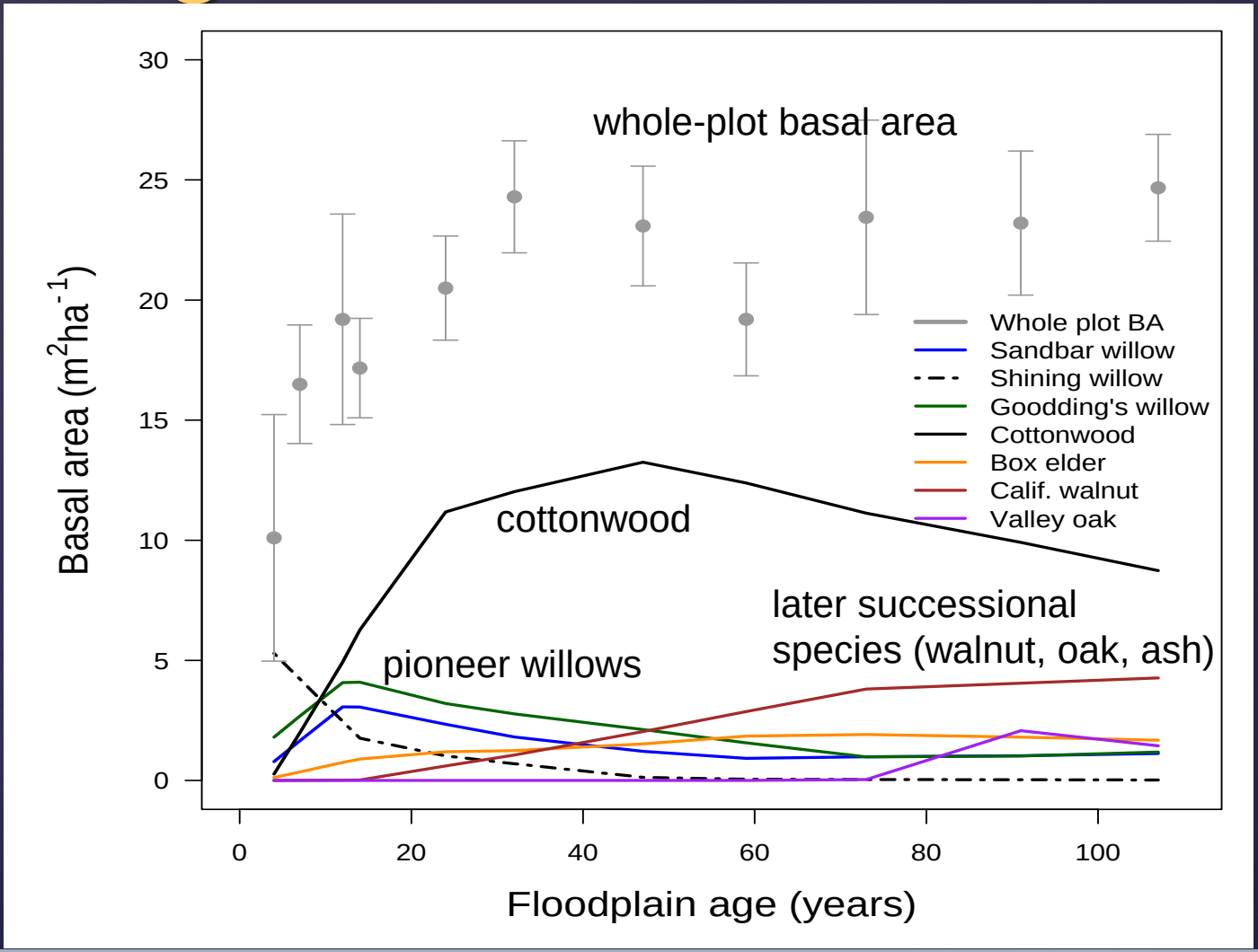
2010 – 2012 Field Sampling

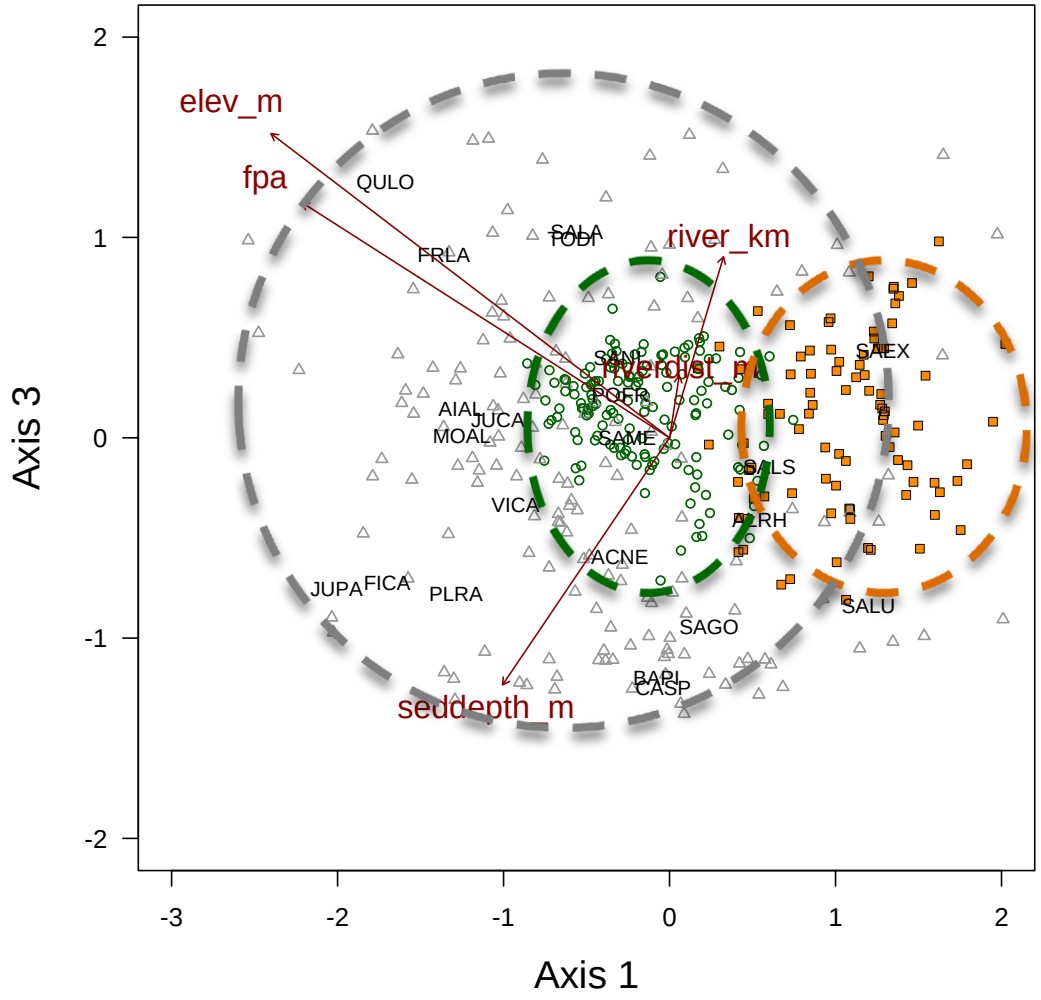
- 19 large point bars from Red Bluff to Colusa
- 430 plots (500 m^2) in patches stratified by
  - vegetation type (TNC 2007)
  - floodplain age (Greco et al.)
- Tree composition, size, health, snags
- Fine sediment accumulation over the former gravel bar

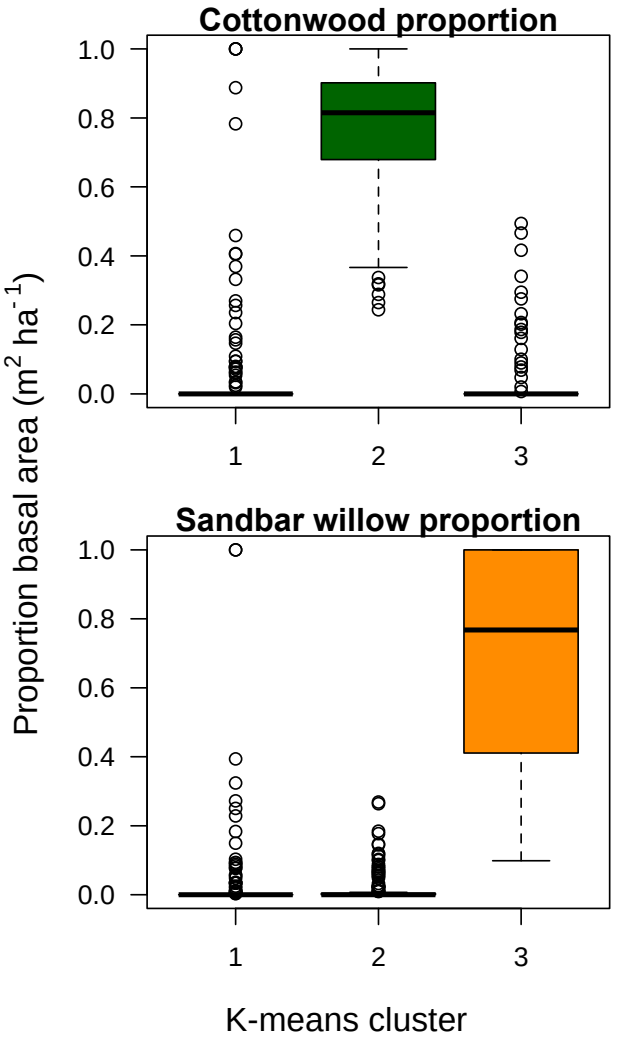


Vegetation Chronosequence: Shifting tree dominance over time



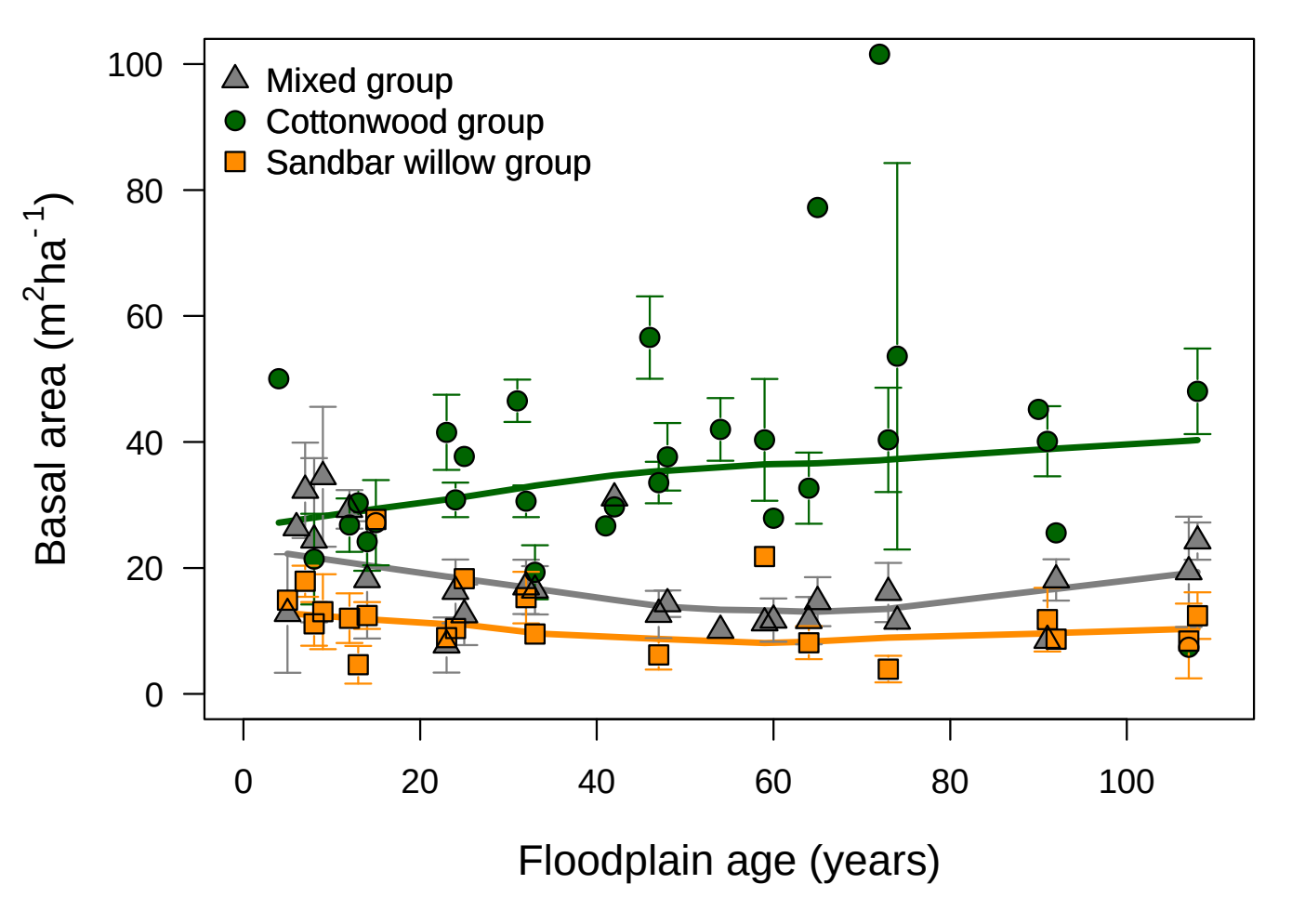
NMS ordination and cluster analysis shows 3 groups of plots



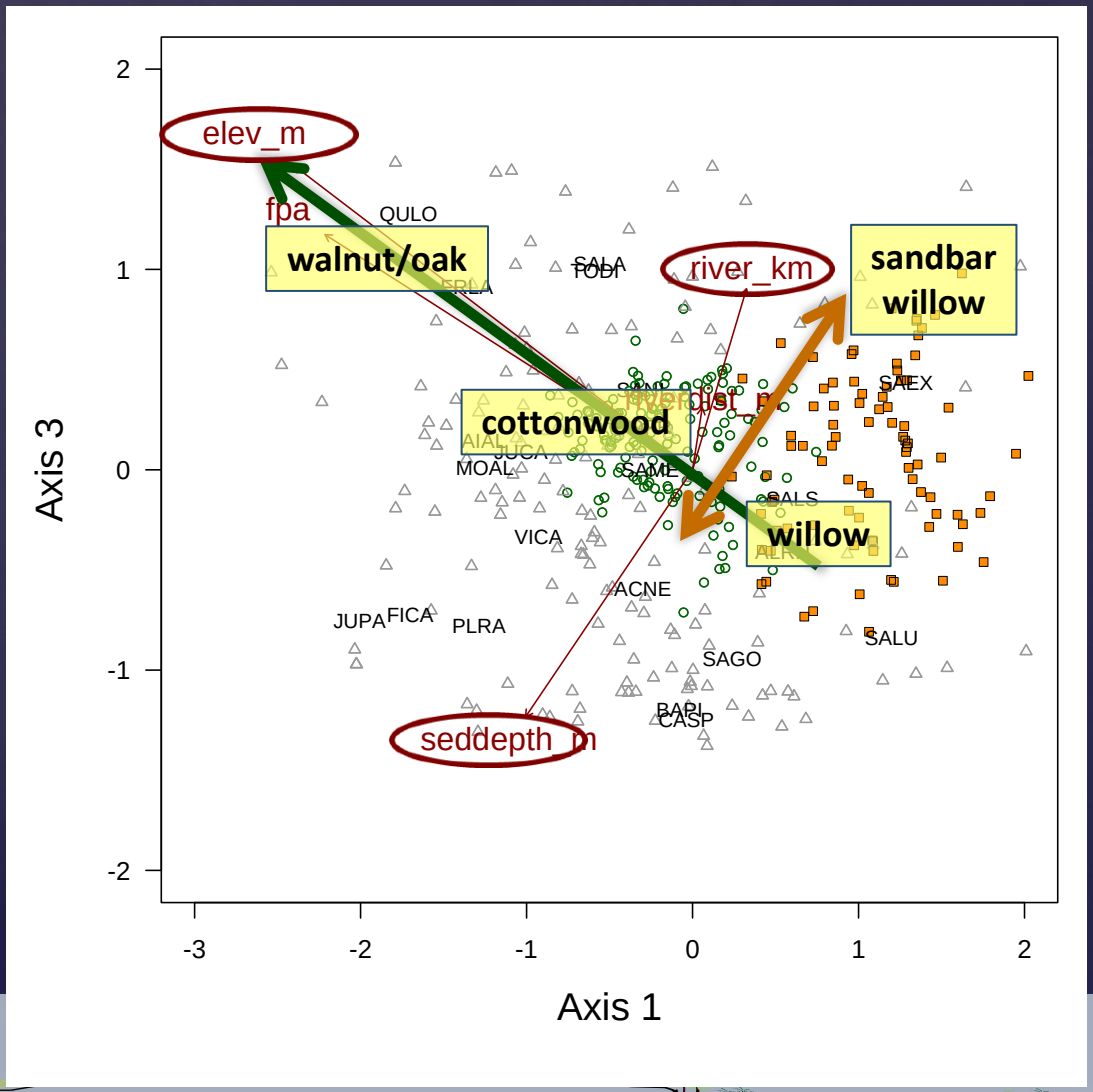



Cottonwood forest stands
Sandbar willow thickets

Cottonwood plots had highest basal area for a given age



Two distinct successional trajectories



- *Path 1:* progressive succession: willow (*Salix*)-> cottonwood(*Populus*)-> walnut/oak (*Juglans/Quercus*)
- *Path 2:* arrested succession; shrub willow for >70 years
- Different environmental correlates

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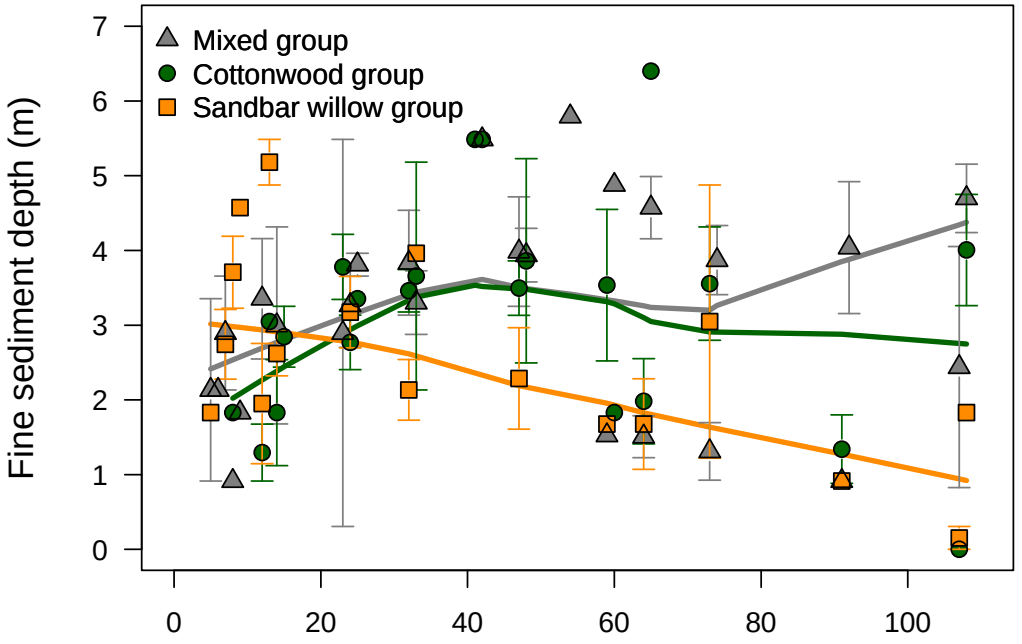
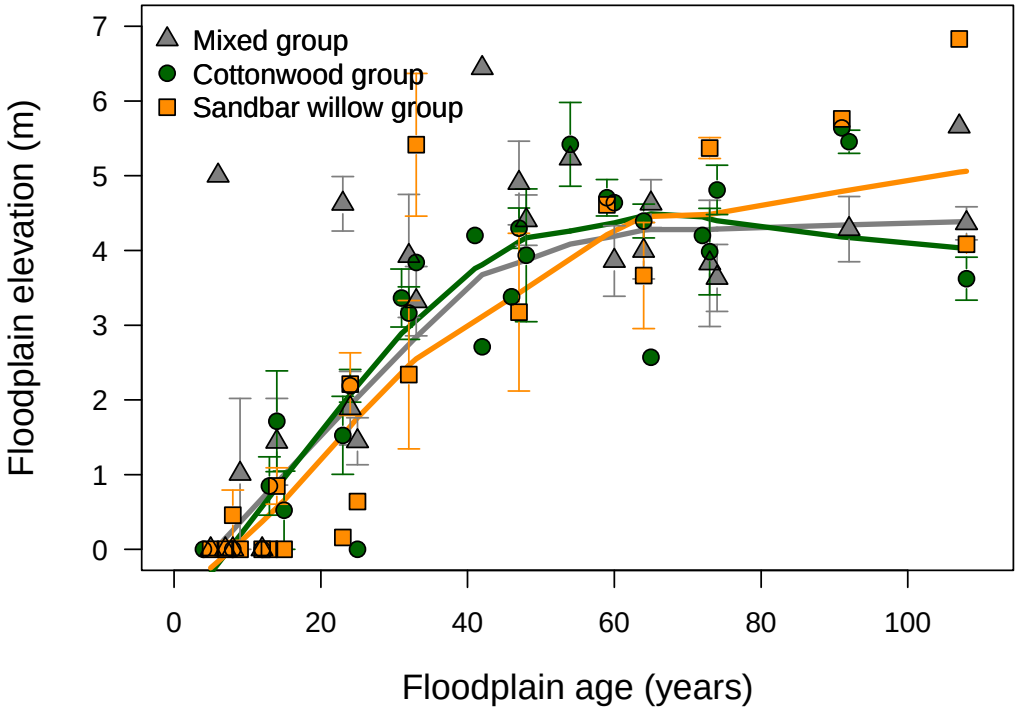
Geomorphic Patterns

- Both fine sediment accumulation and floodplain elevation were *lower in sandbar willow patches*

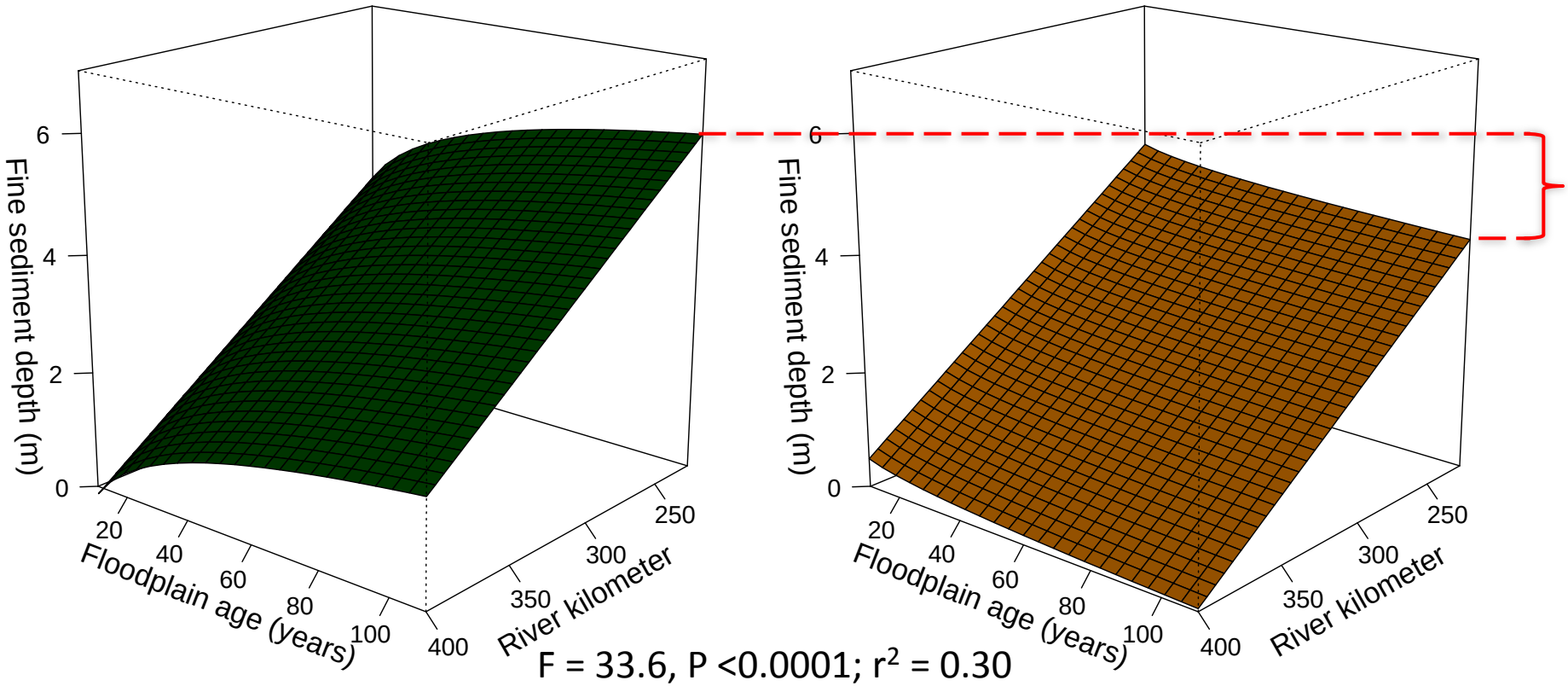




Fine sediment depth varies with vegetation type and distance from dam

Forest groups

Sandbar willow group



$F = 33.6$, $P < 0.0001$; $r^2 = 0.30$

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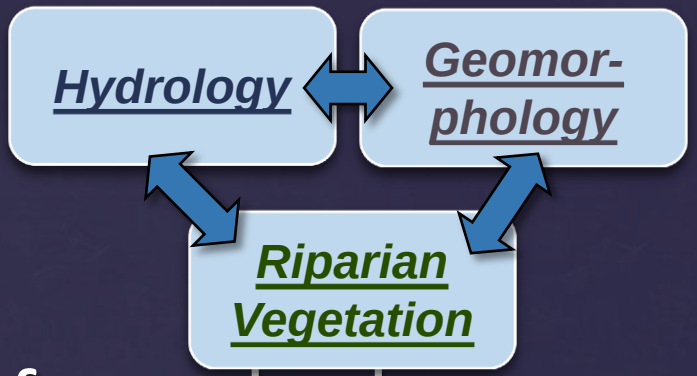
Possible drivers



- High-energy environments favor shrub willows over trees
- Shrub willows induce less flow resistance and lower sedimentation
- Sediment depth gradient suggests strong longitudinal driver
  - Reduced bedslope and transport capacity
  - Sediment starvation from Shasta Dam

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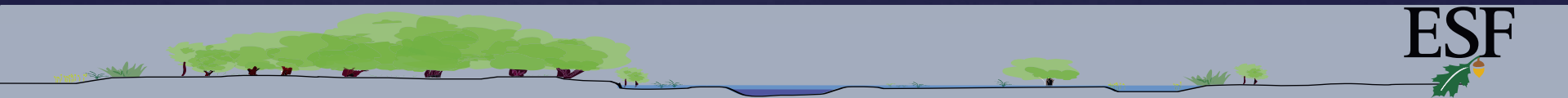
Take Home Points

- The Middle Sacramento has some of the largest remnant riparian areas in California
- Flow regulation reduces channel migration and threatens initiation of new forest stands
- Two forest development pathways:
  - Increased complexity over time: willow-> cottonwood-> walnut/oak
  - Permanent shrub willow patches
- Dynamic forest development associated with rapidly accreting floodplains



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Conservation Points

- Middle-aged stands (40-60 years) are dominant
  - Highest biomass, tree size, and woody species diversity.
  - Largest area of the floodplain – a temporary post-dam effect?
- Allow channel movement
  - Creates early successional habitat on point bars
  - Maintains diversity, balanced age and size distribution.
- Encourage channel cutoffs – an important forest regeneration pathway (and possible refugia)

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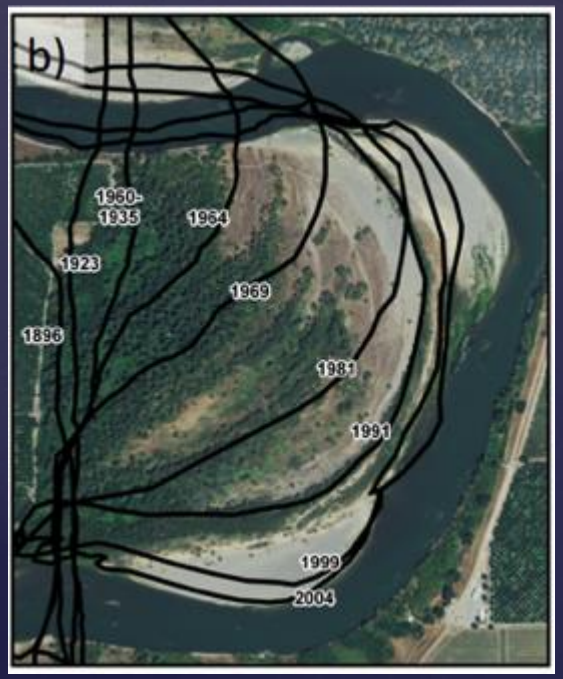
Future Directions



- Model forest succession to infer impacts of Shasta Dam and future climate change
- Quantify riparian habitat needs for wildlife (with J. Viers, UC Davis & N. Seavy, PRBO)
- Assist TNC, agencies and stakeholders to prioritize riparian management actions
- Use the forest inventory study as a baseline to set restoration targets
- Compare Sac River riparian management to other Mediterranean-climate rivers (Rhône River, 2014).

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Thank you.

Research homepage:
www.esf.edu/fnrm/stella/