Modeling riparian forest development for predicting large woody debris inputs to a large, meandering river ecosystem

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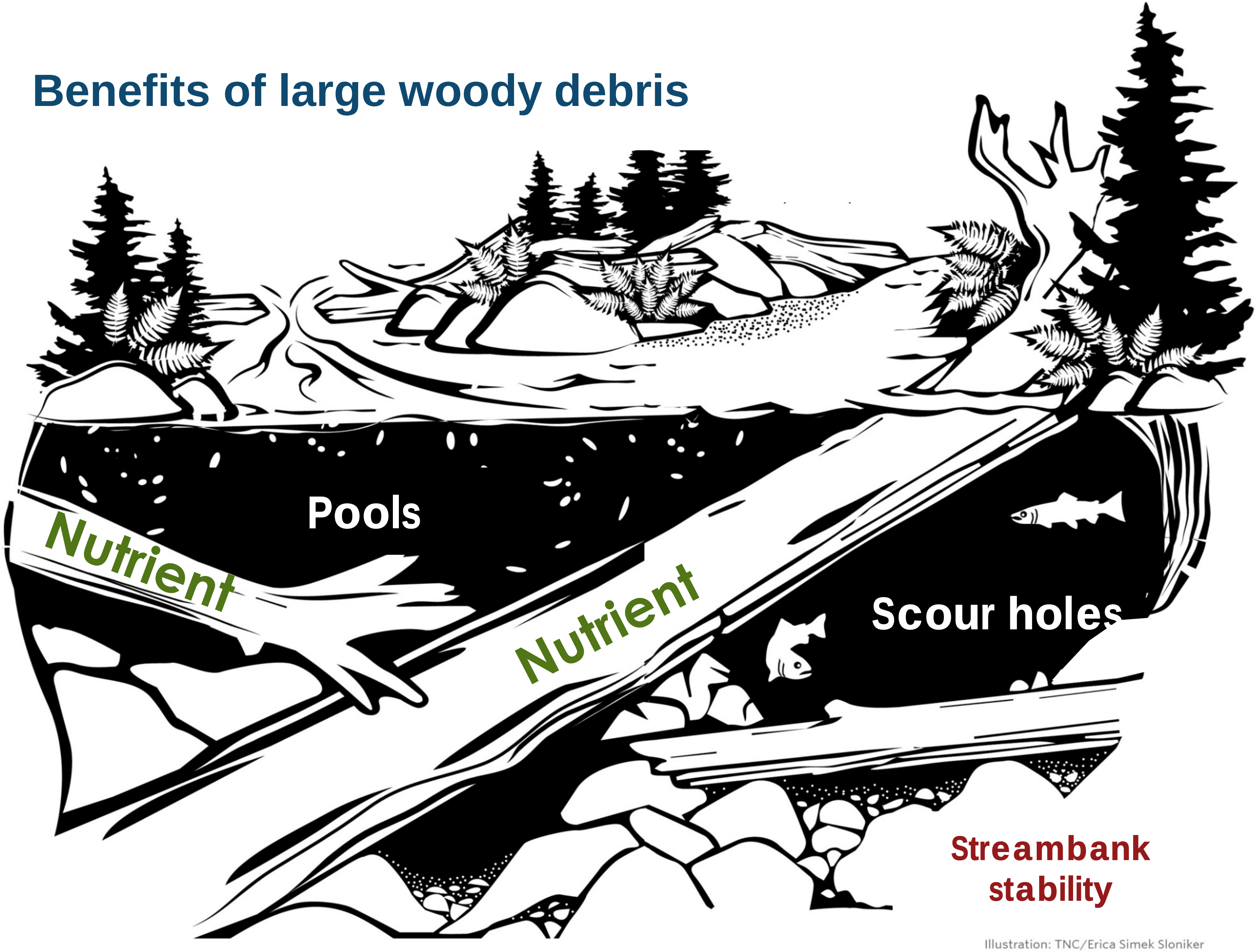
Benefits of large woody debris



Introduction Where does woody debris come from? Riparian forest

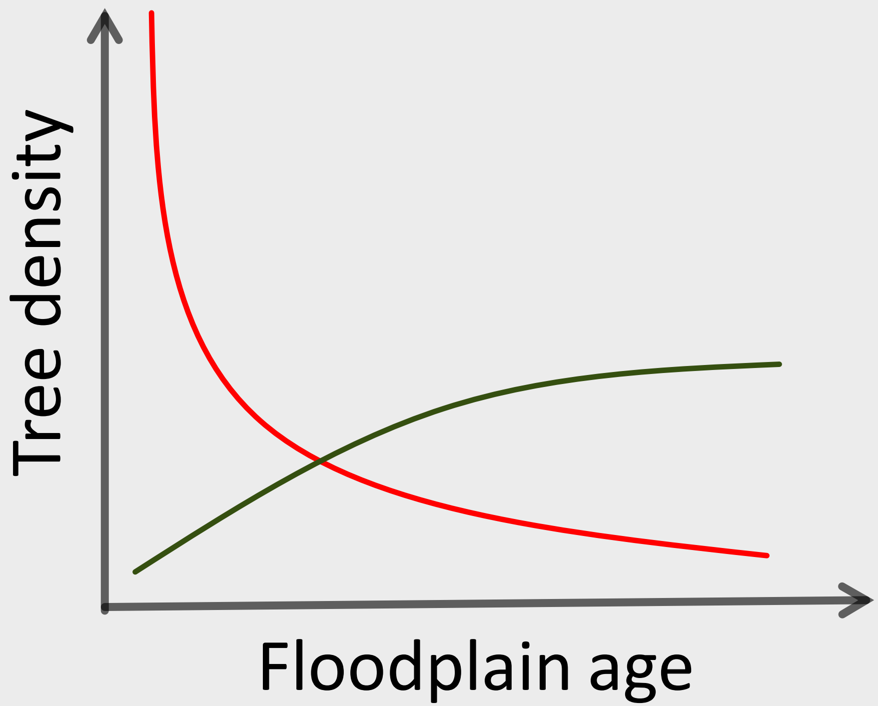
Disturbance events:

- ➢ Flooding
- ➢ Landslide and erosion
- ➢ Fire
- ➢ Beaver activity
- ➢ Disease

Introduction How to increase woody debris recruitment?

Objectives

- Understand the tree distribution on the floodplains
- Develop quantitative relationships between stem density, tree size, and floodplain age (FPA).
- Produce predictions of large woody debris (LWD) metrics (number of trees and size distribution).



Methods

- Vegetation map for characterizing land cover (vegetation types)
- Tree inventory data for defining functional groups (early or late successional species)
- Floodplain maps for understanding sandbar creation and floodplain age (FPA)

https://en.wikipedia.org/wiki/Sacramento_River

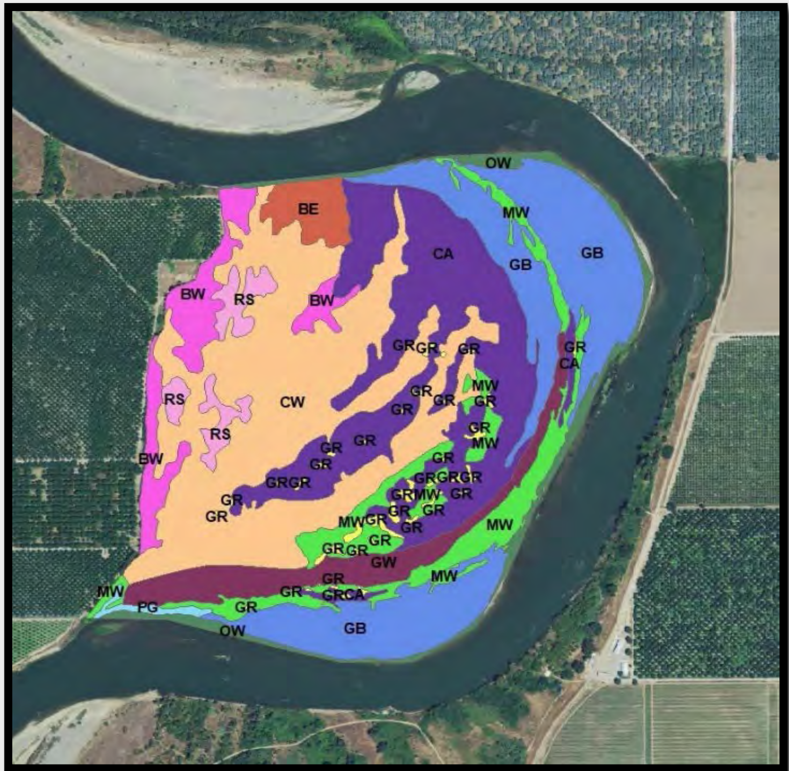
Methods

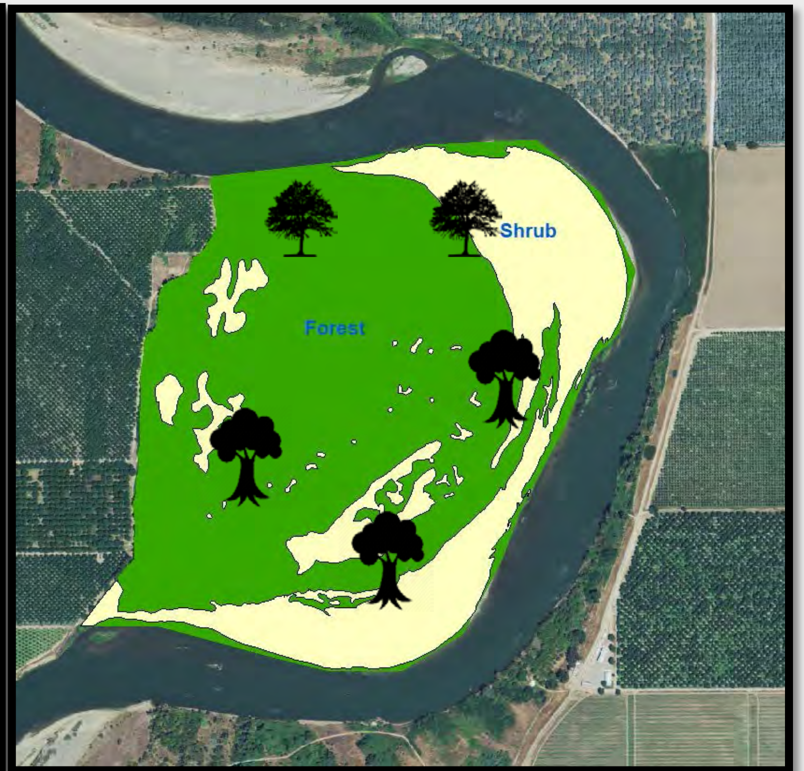
Classify land cover into two vegetation types

Forest: pioneer and late successional trees **Shrub:** perennial grass and shrub

Four functional groups of species

- Group 1: Early successional shrub willows (S. exigua, S. lasiolepis, and S. lucida ssp. Lasiandra)
- Group 2: Early successional large trees (S. gooddingii and P. fremontii)
- Group 3: Late successional small trees (F. carica and S. nigra, syn. S. mexicana)
- Group 4: Late successional large trees (A. negundo, F. latifolia, J. californica ssp. hindsii , P. racemosa)

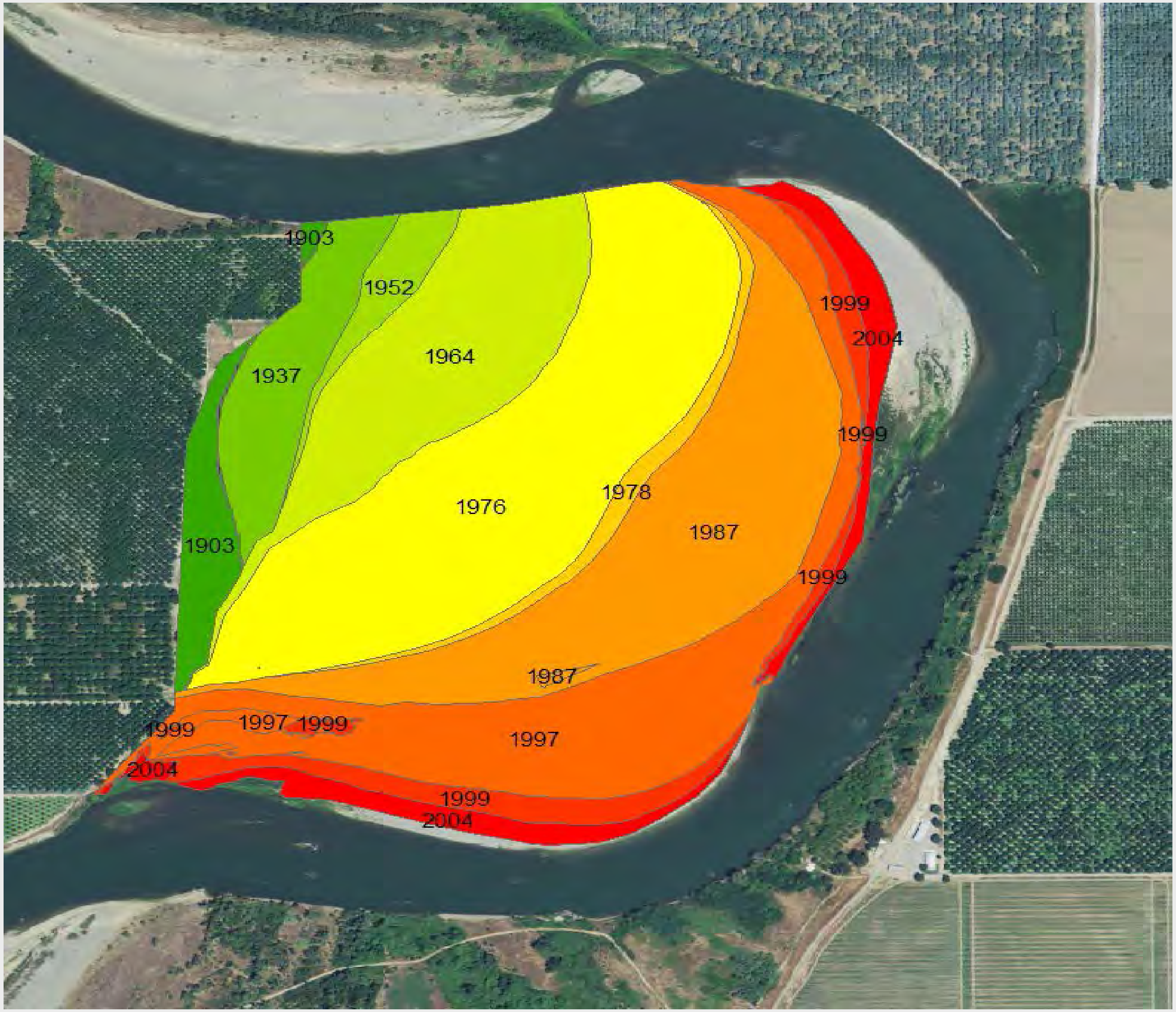




- Nelson C., M. Carlson and R. Funes. 2008. Rapid Assessment Mapping in the Sacramento River Ecological Management Zone – Colusa to Red Bluff. Sacramento River Monitoring and Assessment Program. Geographical Information Center, California State University, Chico.
- Viers, J.H., A.K. Fremier, and R.A. Hutchinson. 2010. Predicting map error by modeling the Sacramento River floodplain. Proceedings from the 2010 ESRI International User Conference, San Diego, California. 21 pp.

Methods

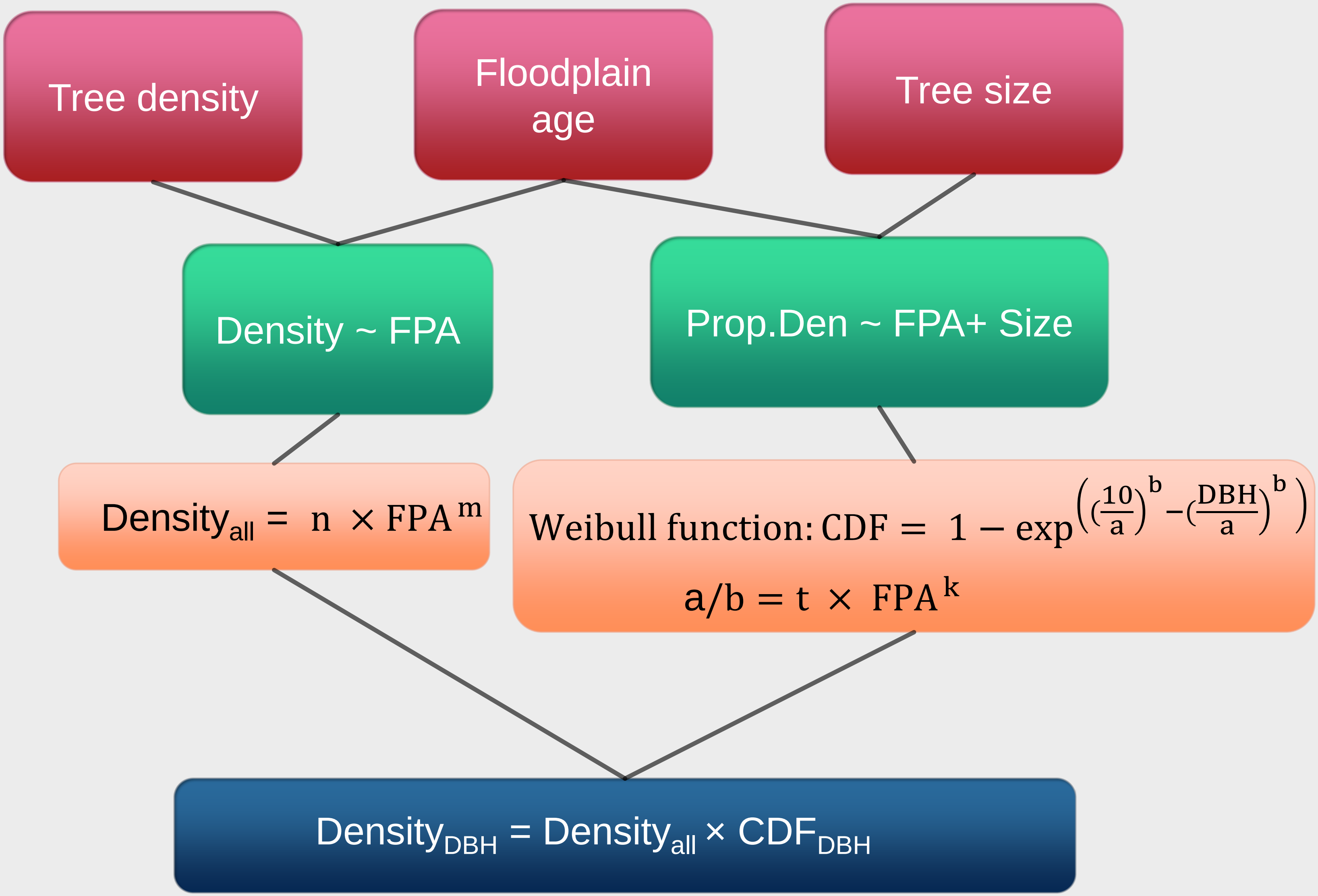
Floodplain age map was generated through historical river channel maps



Greco, S.E., A.K. Fremier, E.W. Larsen, and R.E. Plant. 2007. A Tool for Tracking Floodplain Age Land Surface Patterns on a Large Meandering River with Applications for Ecological Planning and Restoration Design. Landscape and Urban Planning 81(4):354-373.

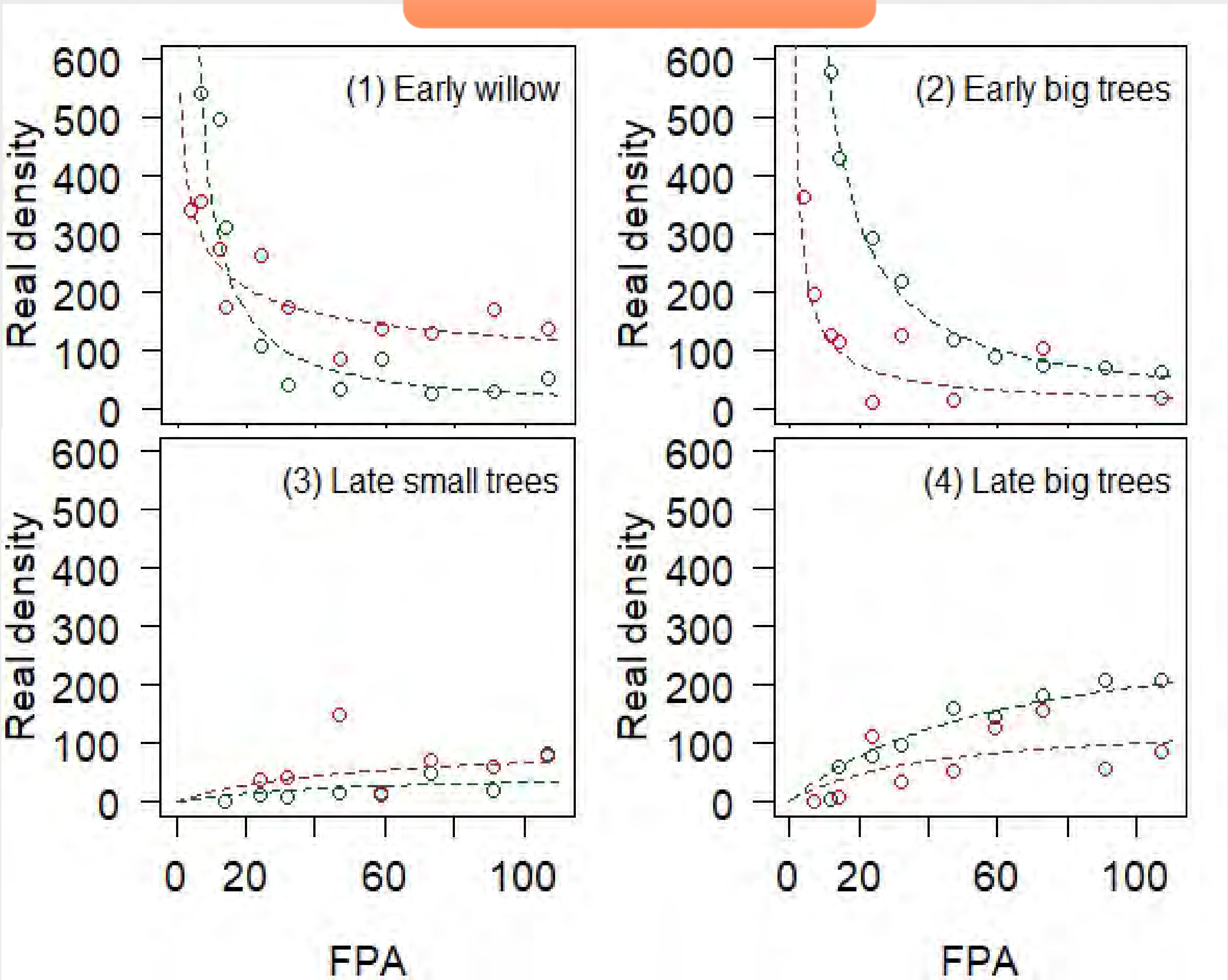
Methods

For each functional group in a vegetation type



Results & Discussion

$$\text{Density}_{all} = n \times FPA^{m}$$

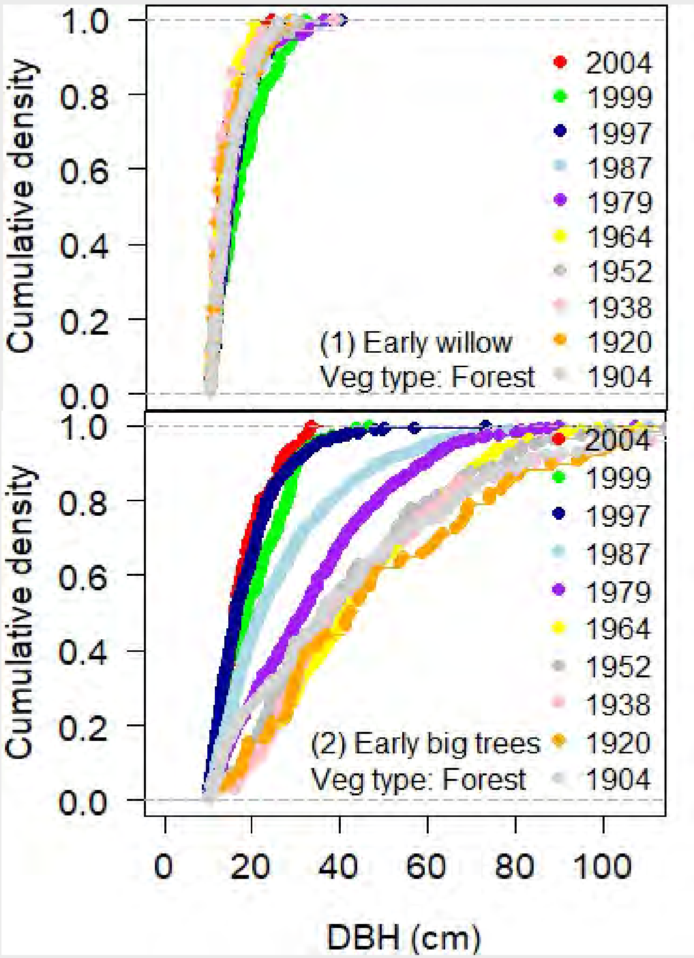


- Early successional species showed sharp decreases in density within the first 20-30 years since floodplain creation.
- The density of later-successional trees increased steadily over time

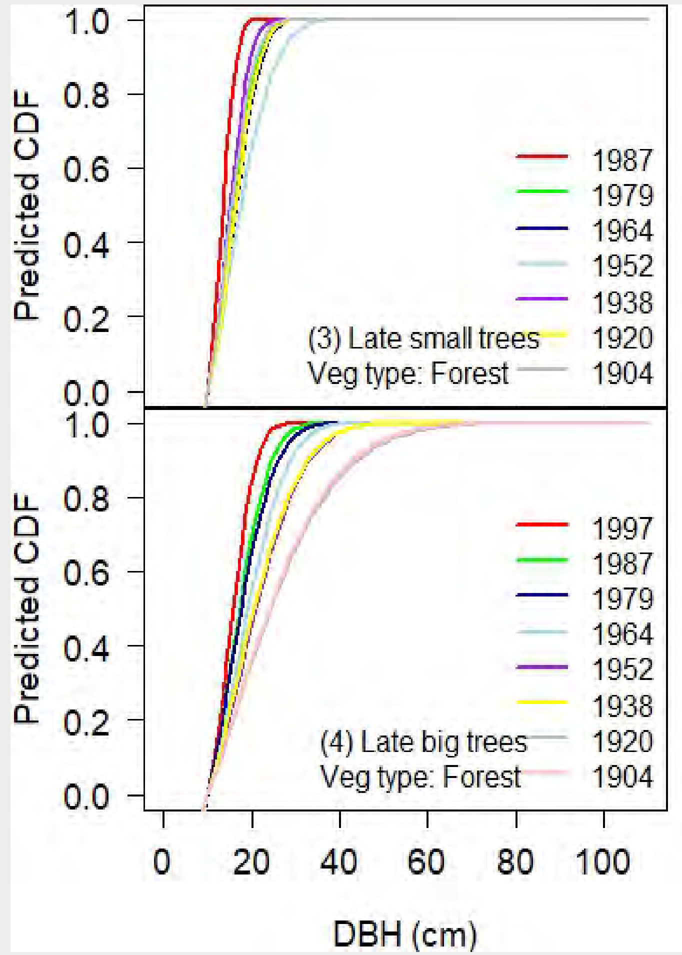
Results & Discussion

$$\text{Weibull function: CDF} = 1 - \exp^{\left(\left(\frac{10}{a}\right)^{b} - \left(\frac{DBH}{a}\right)^{b} \right)}$$

Raw data



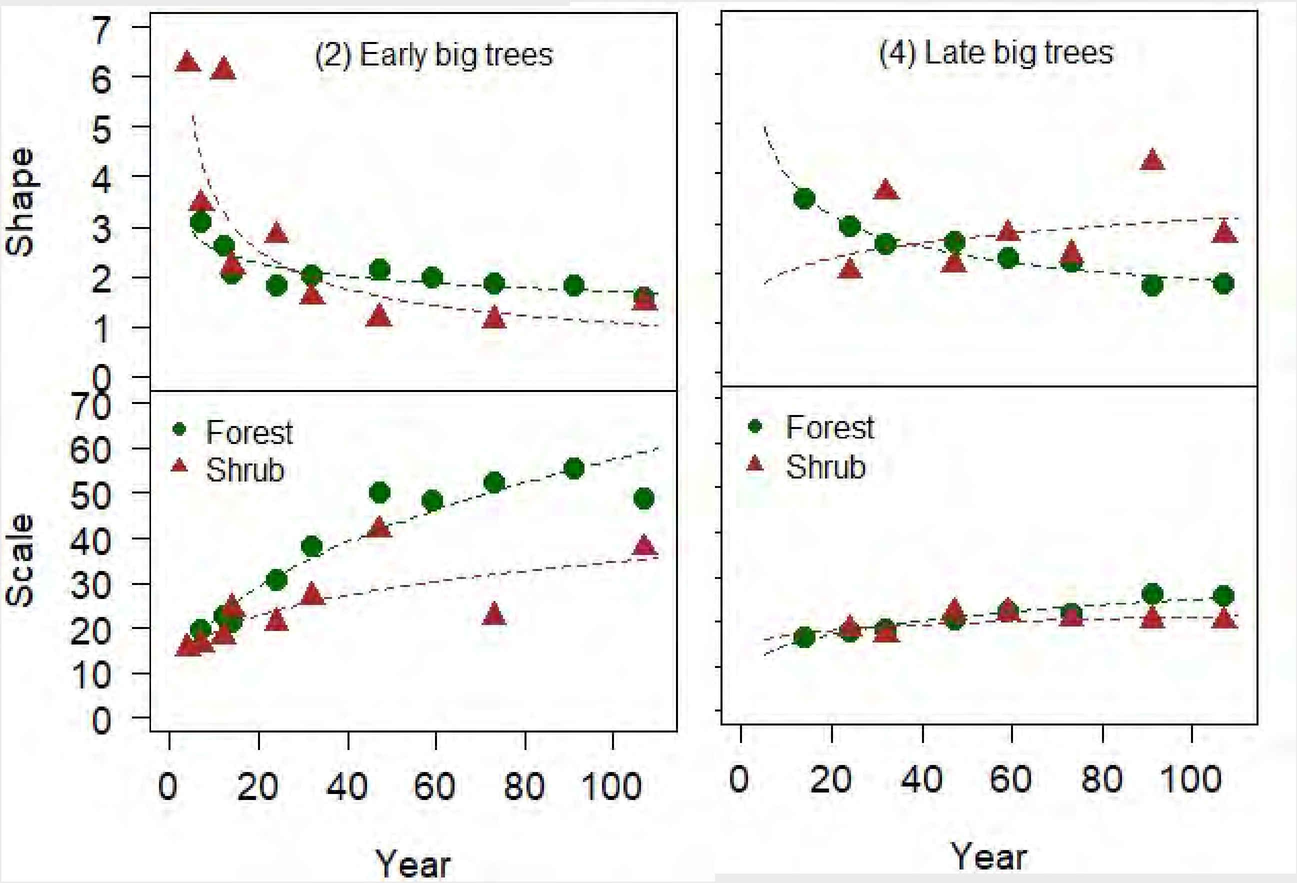
Predicted values



- The CDF curves for the tree diameter data from the inventory plots shifted to the right (i.e., included more large trees) with increasing floodplain age.
- Large tree species tended to have more large individuals on old floodplains, particularly for the early successional tree group

Results & Discussion

Weibull function parameters: $\text{shape}/\text{scale} = t \times \text{FPA}^k$



- Weibull parameters changed with floodplain age, modeling the temporal shifts in size distribution within each group.
- Pioneer species colonize soon after disturbance and do not regenerate in later years. In contrast, later-successional trees show less change in the Weibull parameters, maintaining a more stable size distribution across a range of floodplain ages.

Products

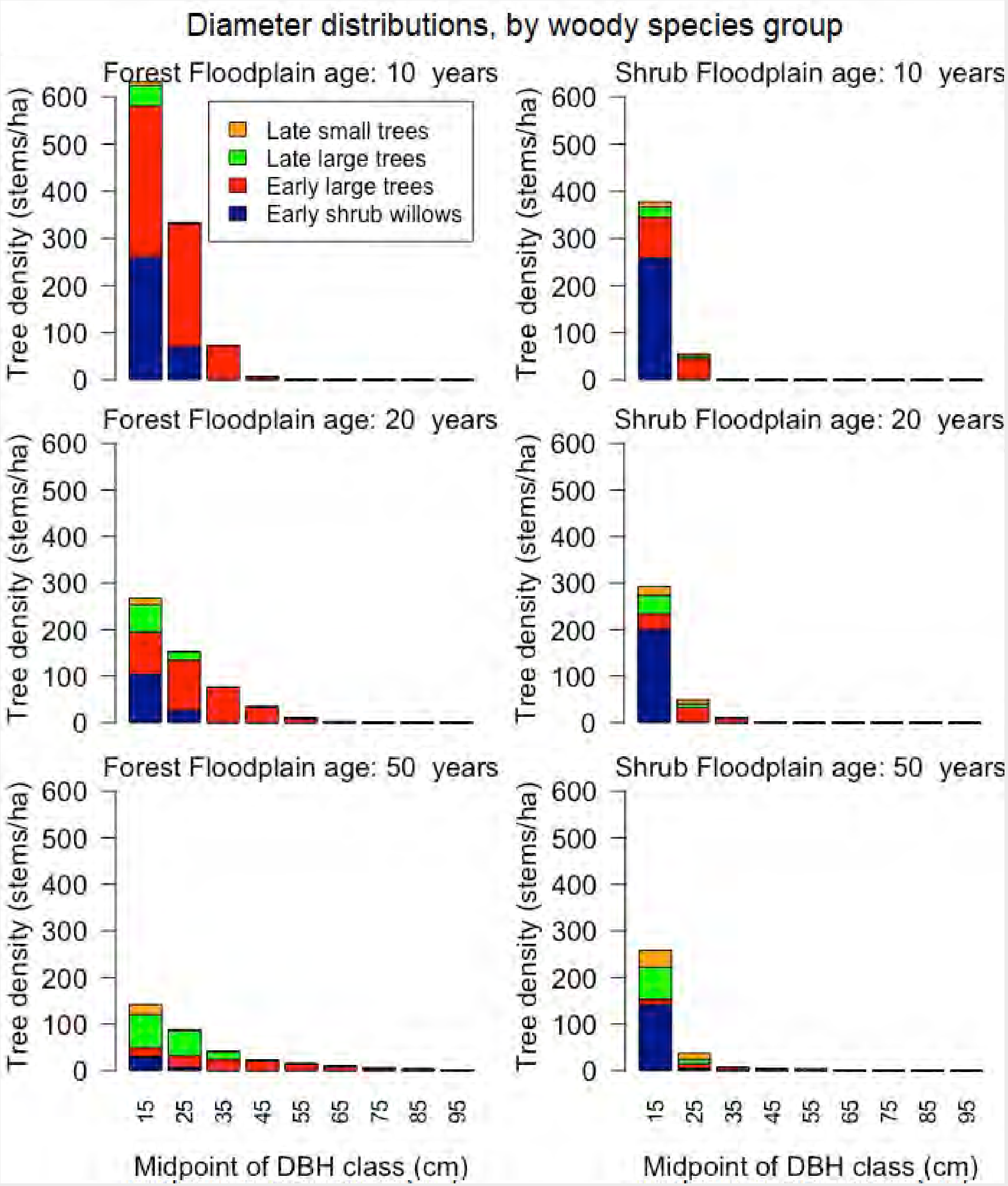
A function was generated to calculate density values (Program R)

Input:

1. Tree functional groups
2. Stand age (5-100 years)
3. Vegetation type (Forest or Shrub)
4. Lower and upper tree diameter (10-160 cm)

Output:

The predicted density of early successional large tree between 40 to 160 cm DBH is **45.48** per ha in 20 years on the forest land.



Conclusions:

- The density of the early successional trees dropped significantly whereas the late successional trees increased slowly and steadily.
- Cumulative density curve (CDF) shifted to the right and the rates of shifting over time were different among species groups and vegetation types.
- The variations of shape and scale in the Weibull functions were greater in the early successional trees than the late successional trees.

Applications:

- Determine woody species' successional pathways
- Predict large woody debris recruitment due to erosion
- Predict riparian vegetation density for river restoration projects

Acknowledgements

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Vegetation maps

- Nelson C., M. Carlson and R. Funes. 2008. Rapid Assessment Mapping in the Sacramento River Ecological Management Zone – Colusa to Red Bluff. Sacramento River Monitoring and Assessment Program. Geographical Information Center, California State University, Chico.
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Floodplain age map

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