



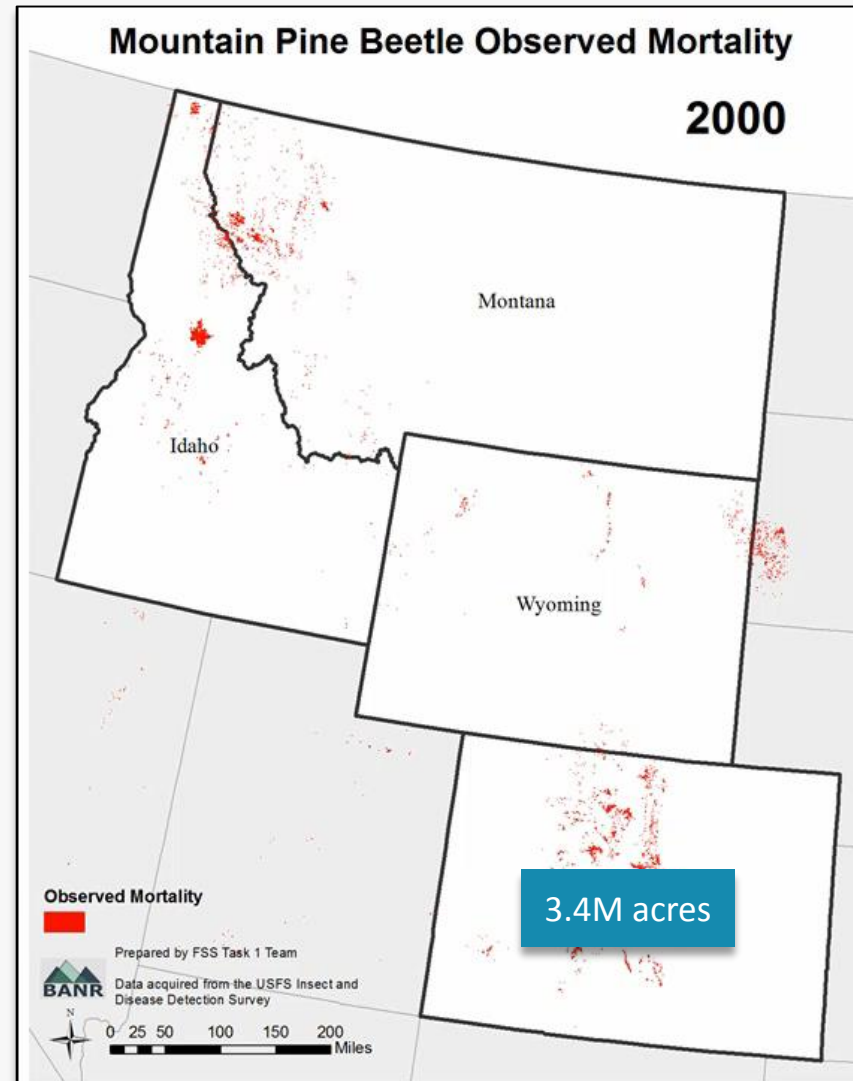
High-resolution Mapping the Carbon Debts from Harvesting Beetle-killed Lodgepole Pine (*Pinus contorta*)

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Natural Resource Ecology Lab
Colorado State University

This project was supported by the Agriculture and Food Research Initiative Competitive Grant no. 2013-68005-21298 from the USDA National Institute of Food and Agriculture.

MOUNTAIN PINE BEETLE OUTBREAK

The expansion of MPB induced mortality in CO, WY, ID, and MT from 2000 to 2012.



Ideal bioenergy feedstock?

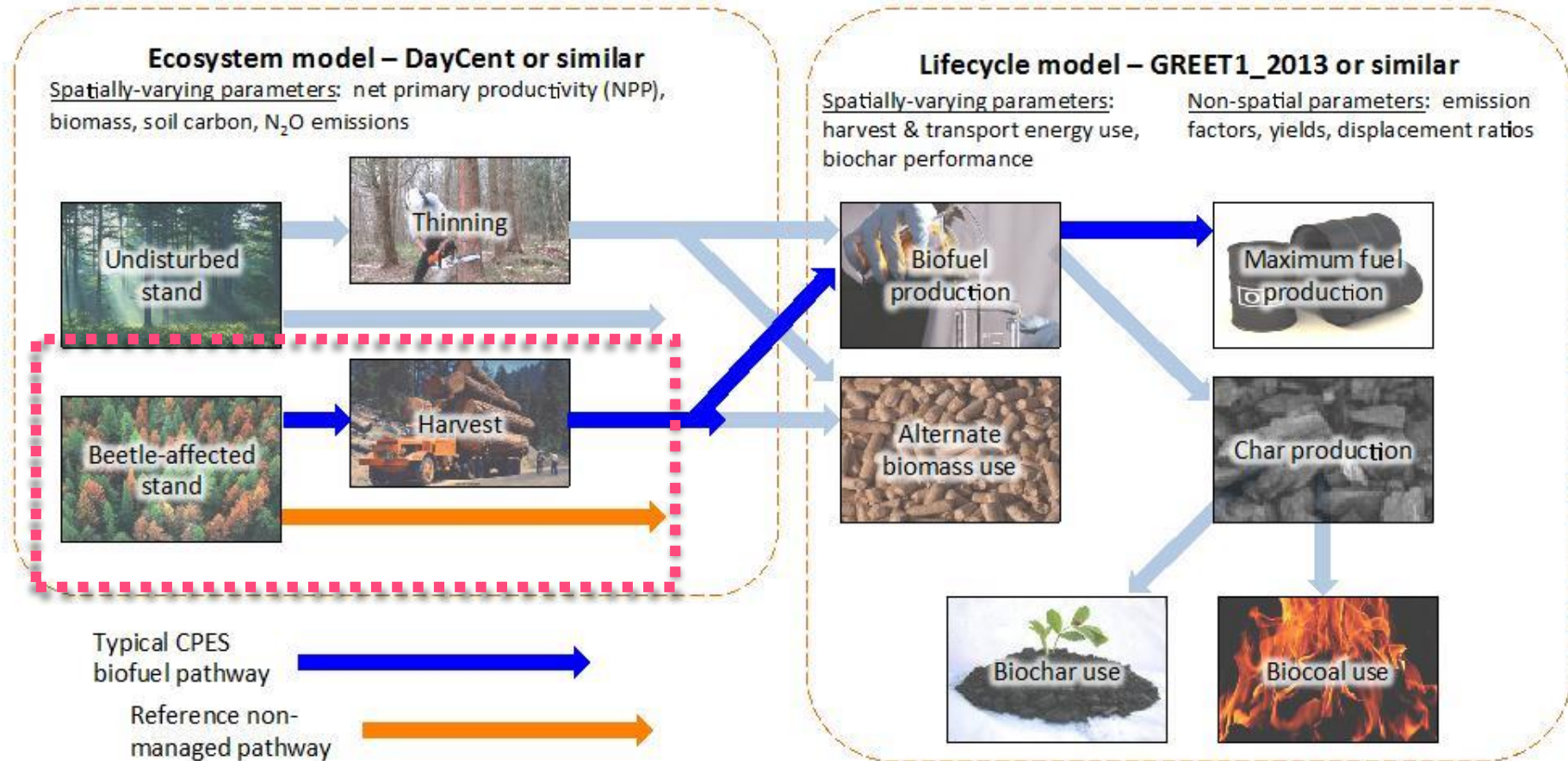
- No cultivation
- Better C balance

THE BIOENERGY ALLIANCE NETWORK OF THE ROCKIES (BANR)

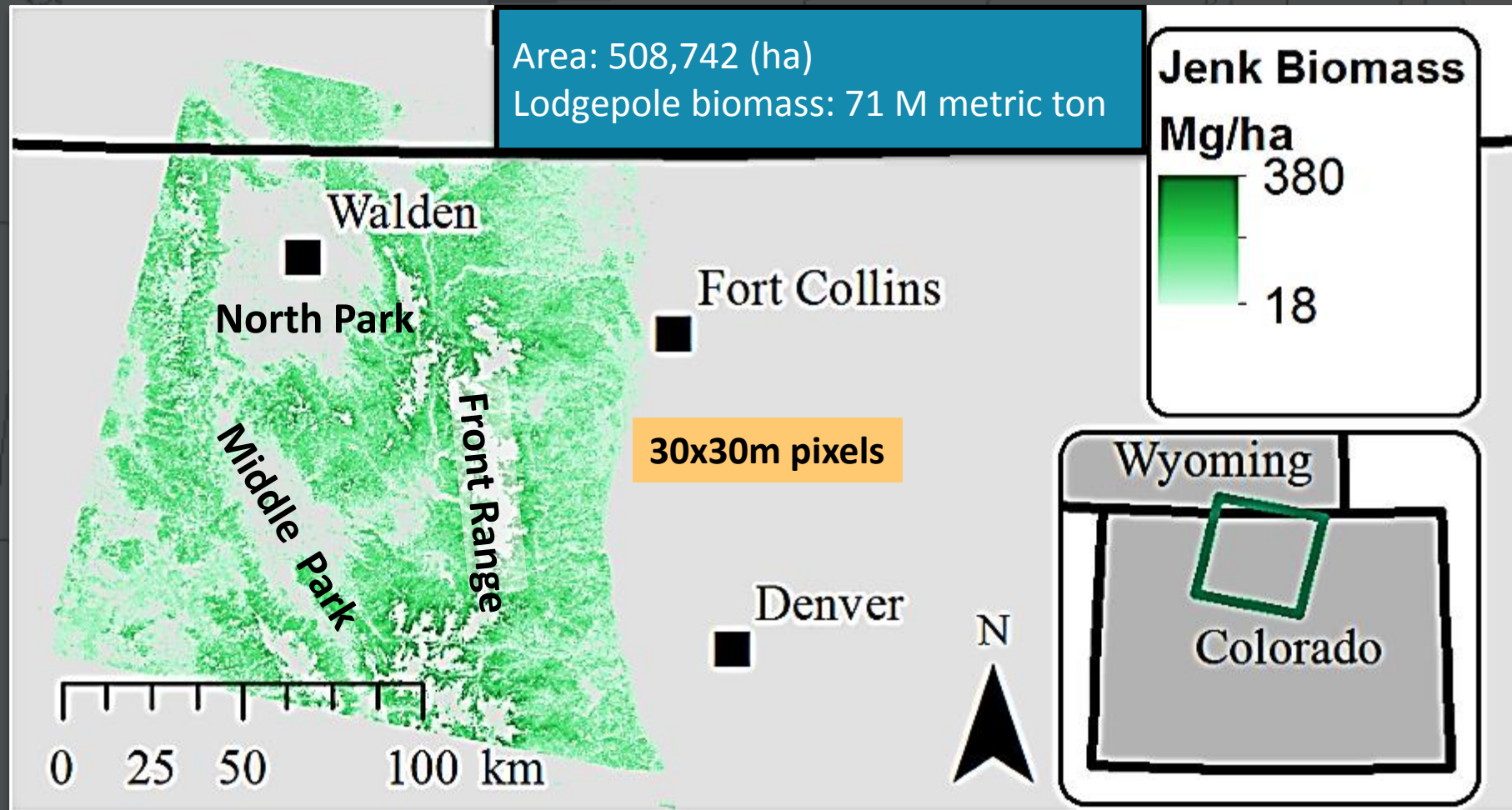


System Performance & Sustainability

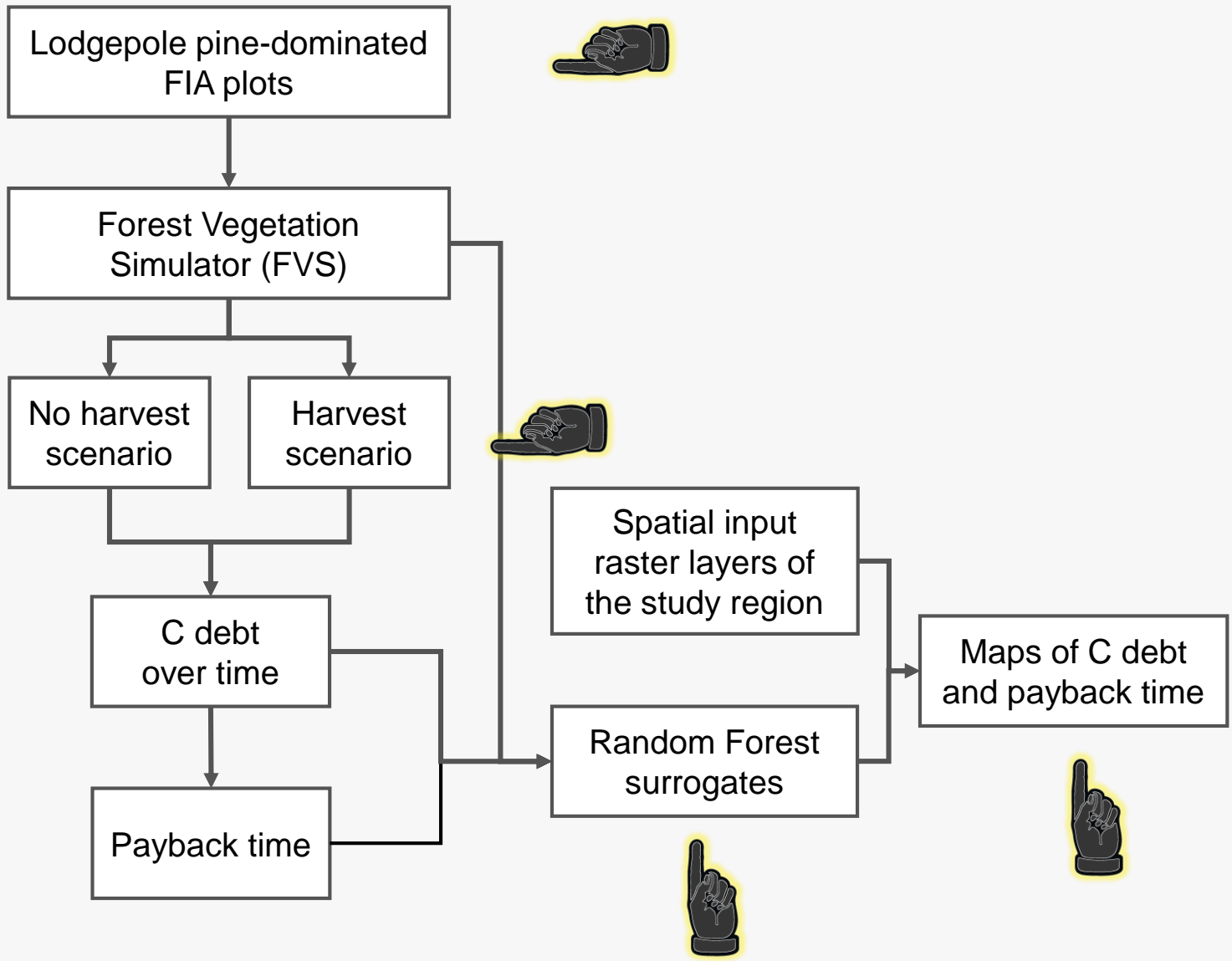
Carbon impacts of salvage logging?



CASE STUDY



- Explore the **carbon debts** due to salvage logging and the **payback time**



METHOD OVERVIEW

Lodgepole pine-dominated FIA plots

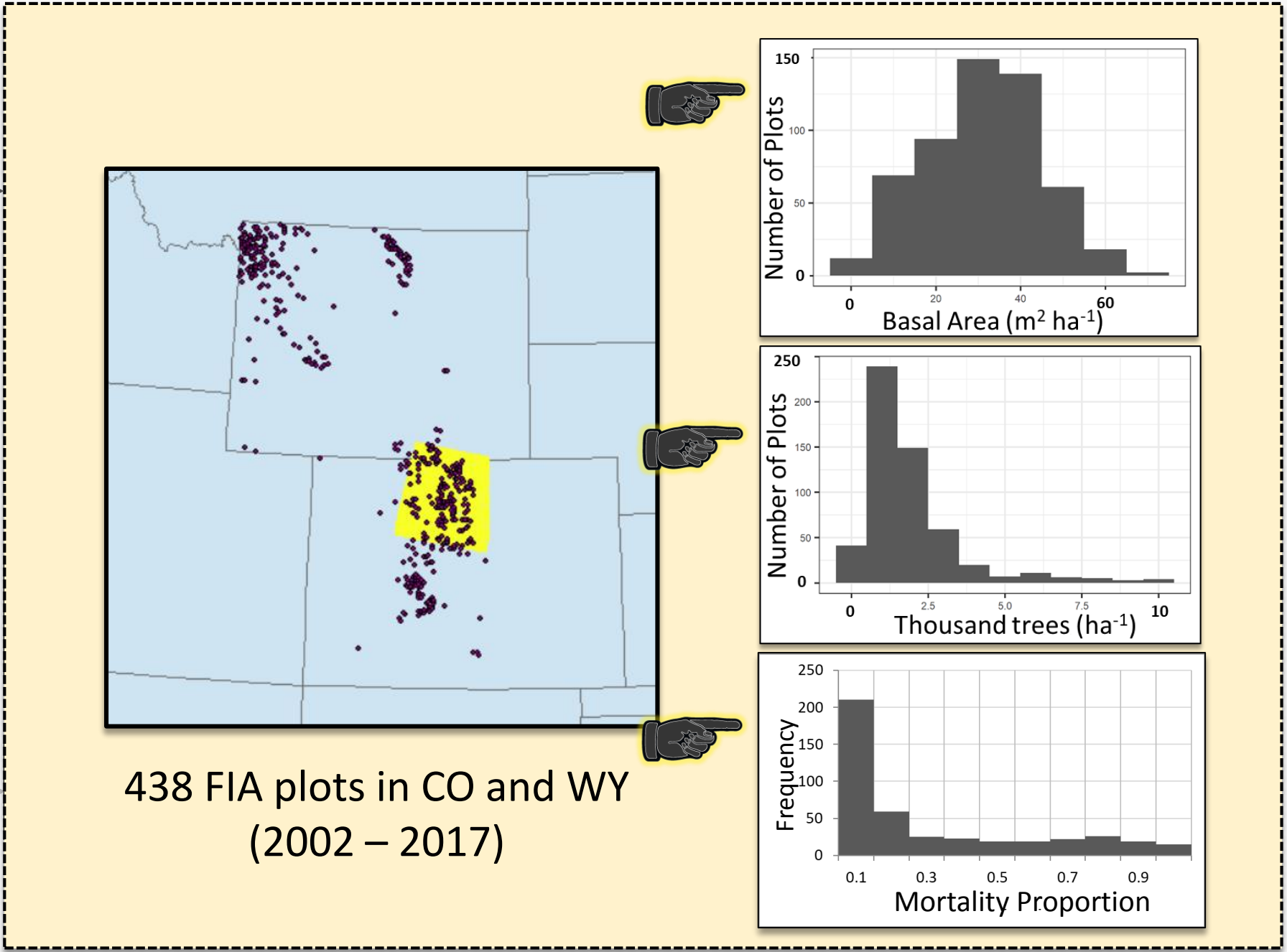
Forest Vegetation Simulator (FVS)

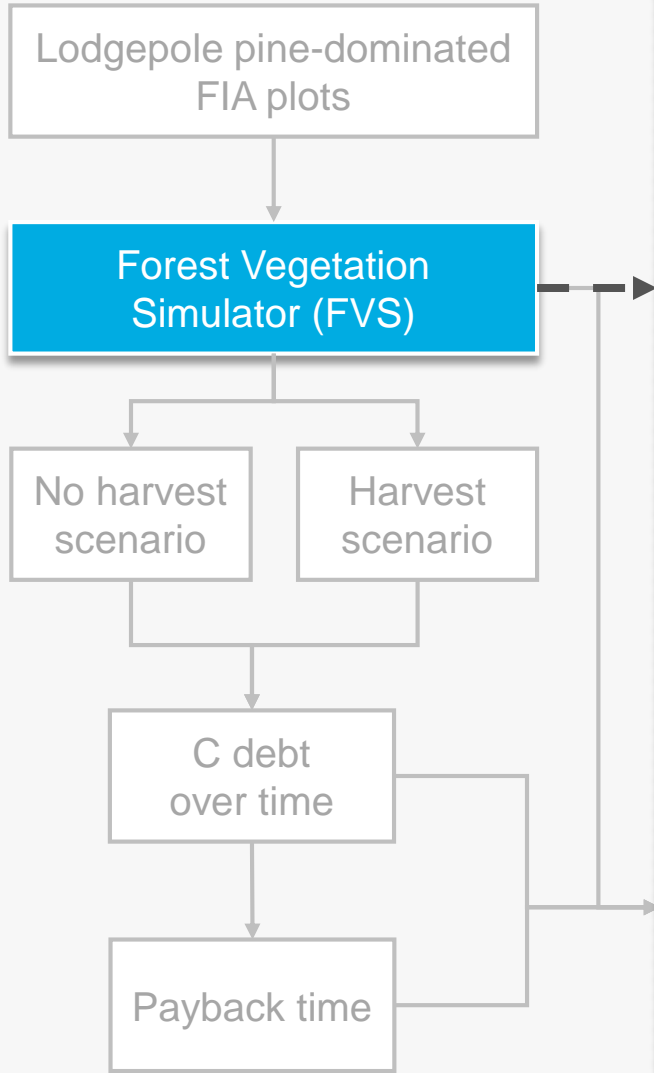
No harvest scenario

Harvest scenario

C debt over time

Payback time

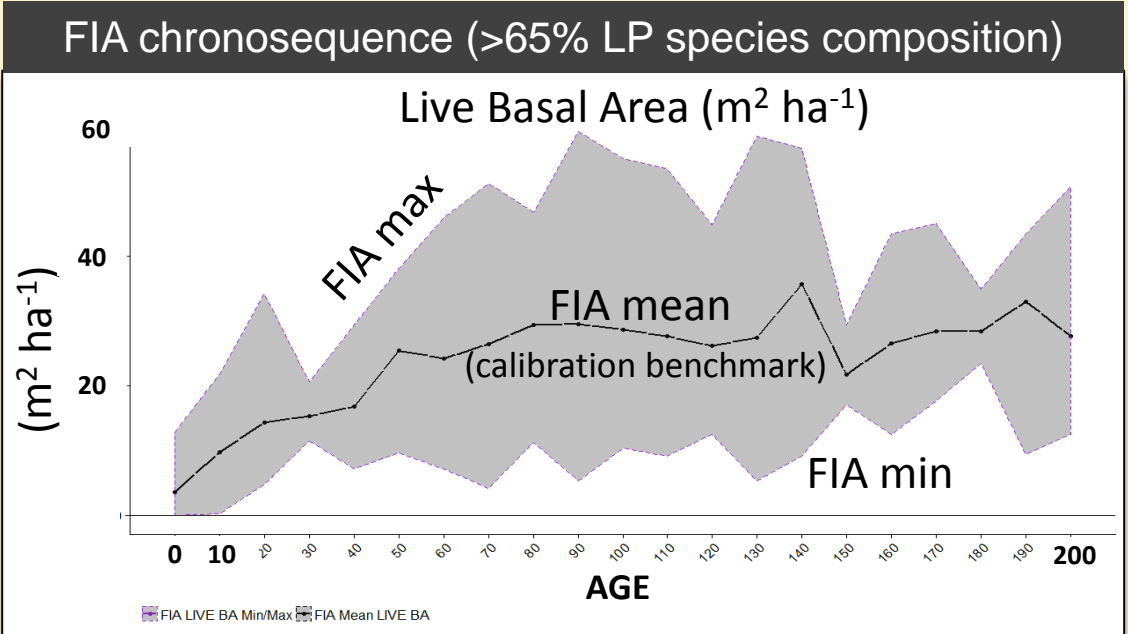
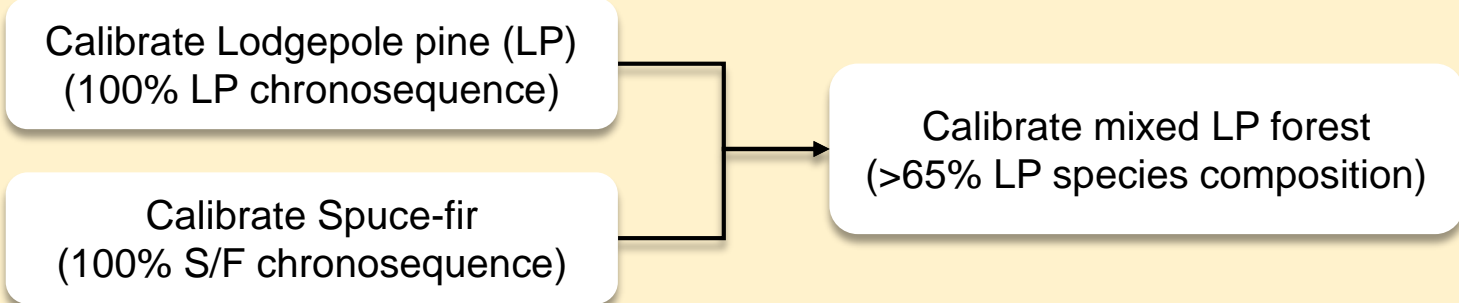


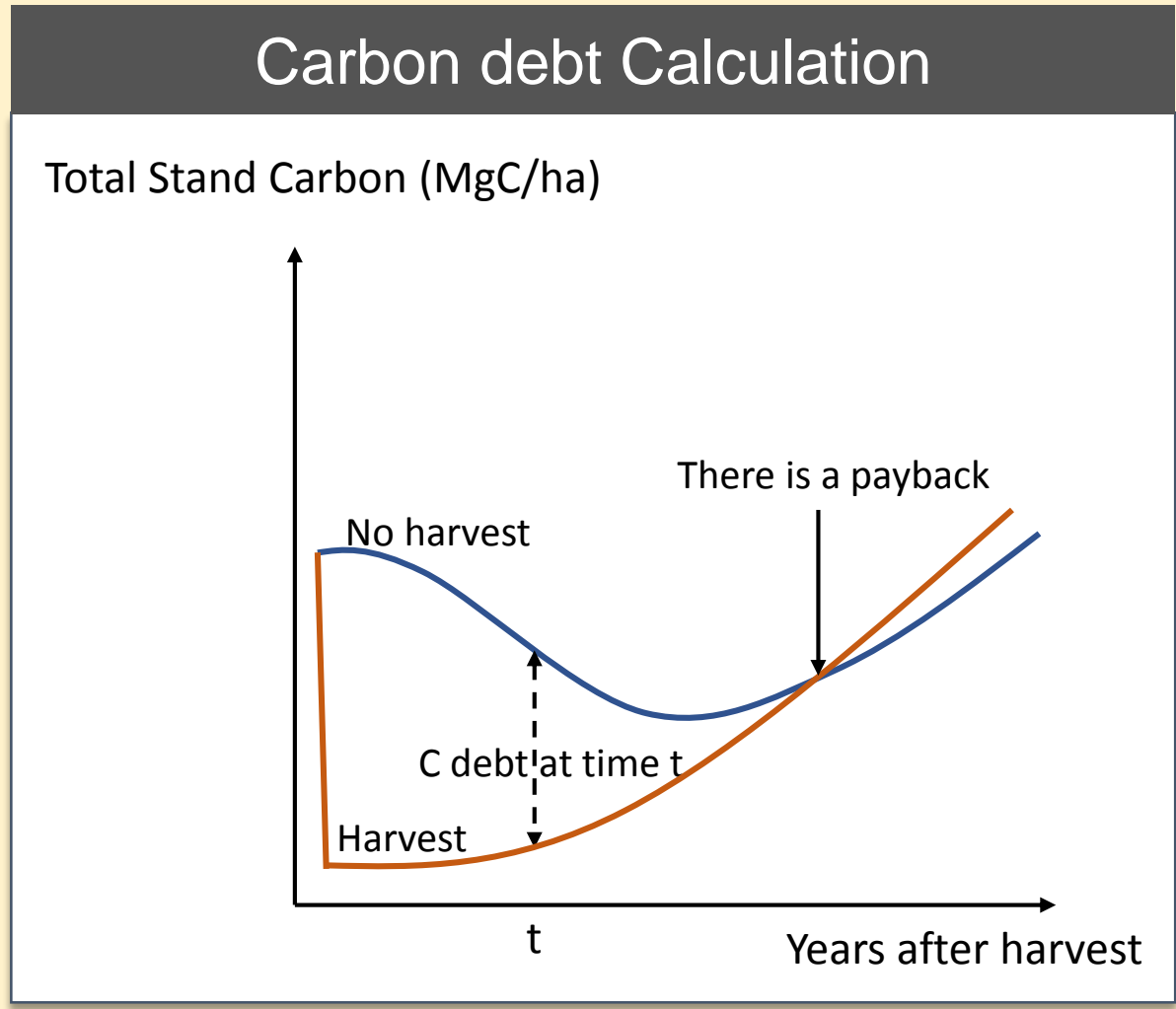
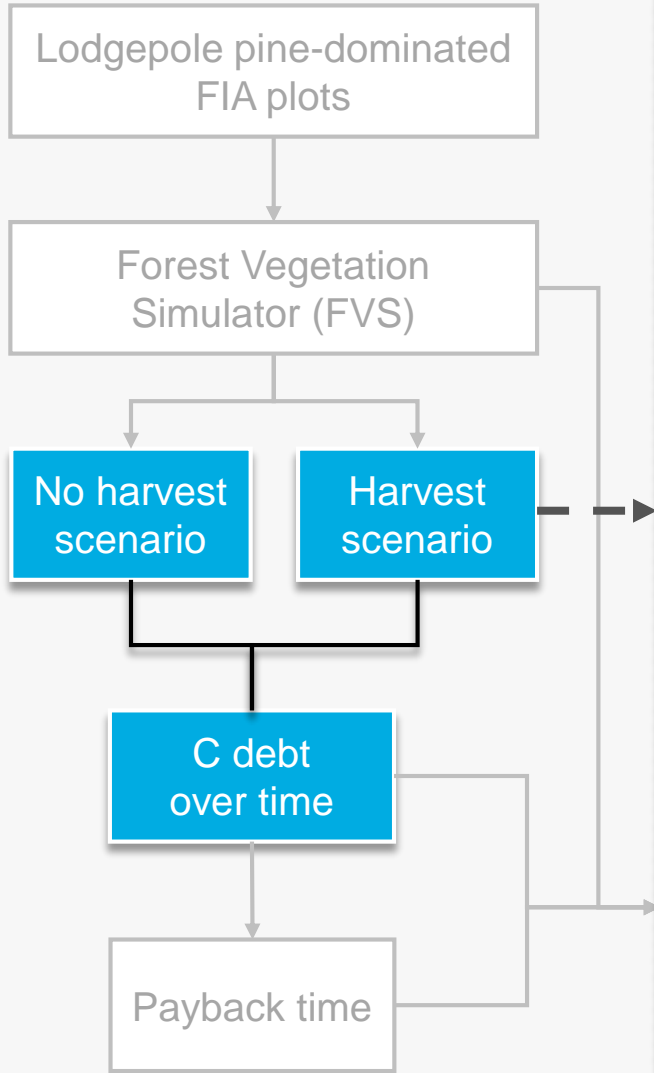


- Evaluate FVS's growth models:

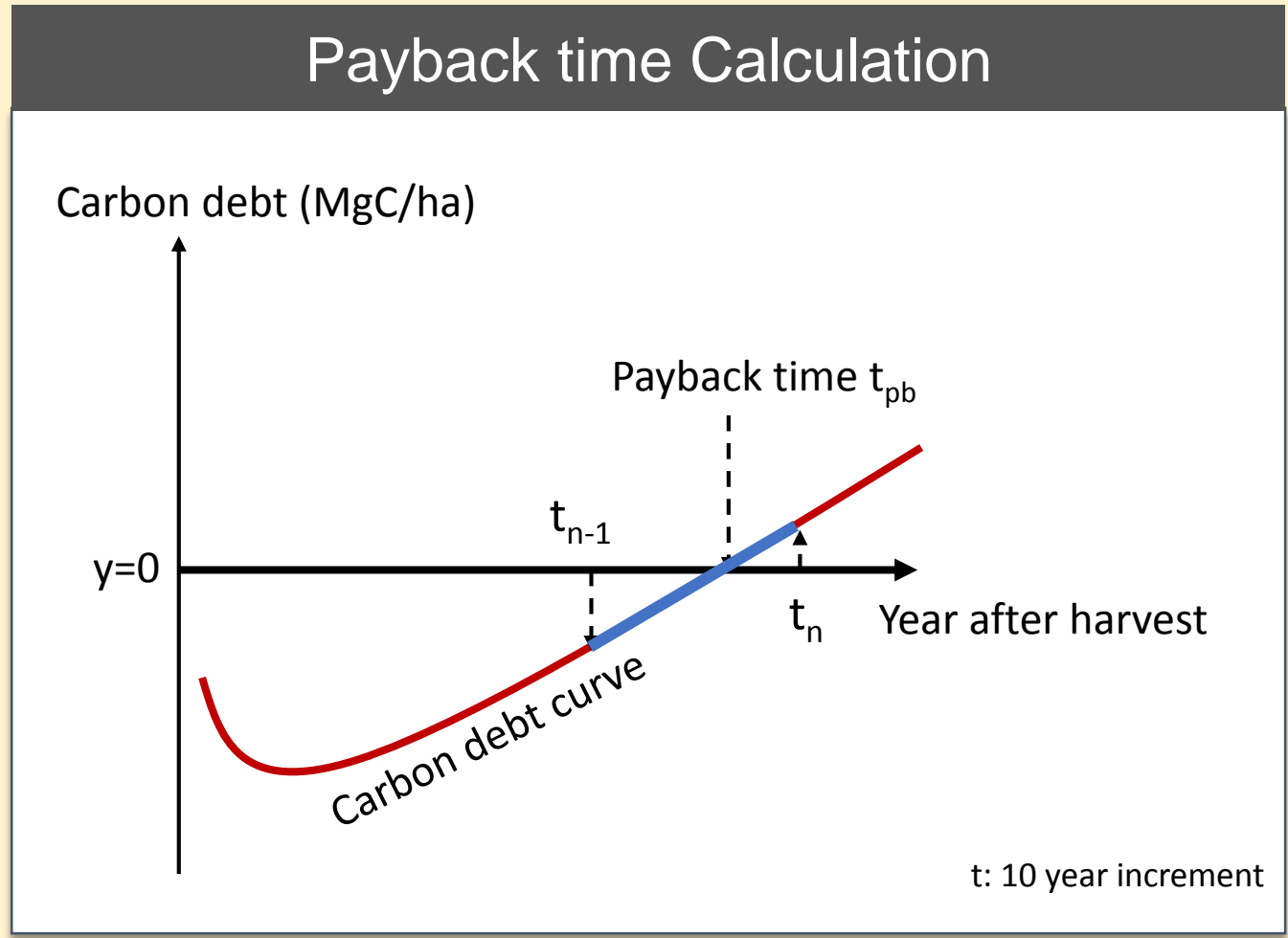
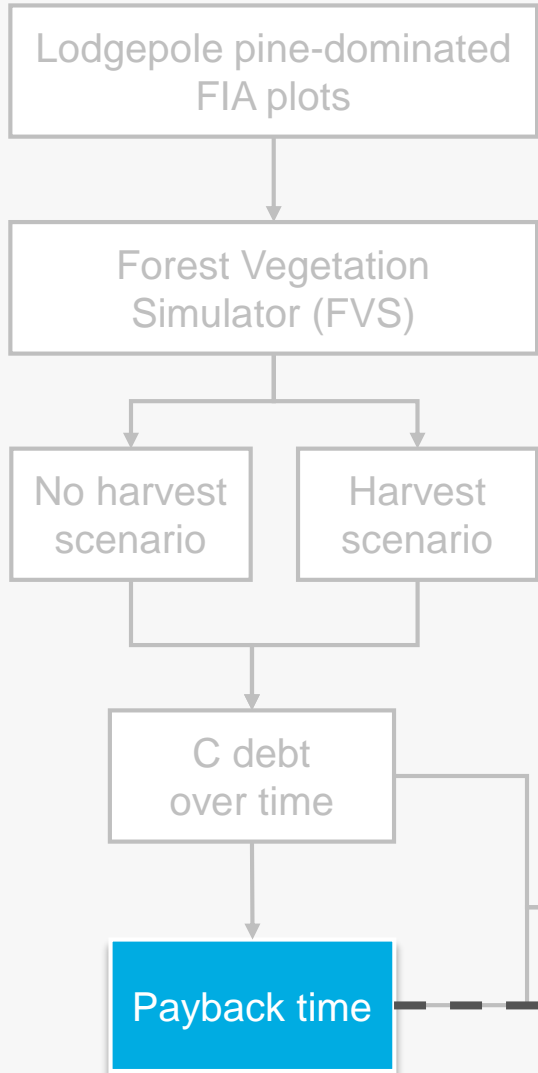
FVS tends to **overpredict** growth of lodgepole pine, spure, fir, and aspen in the study region

- Calibrate FVS's growth model

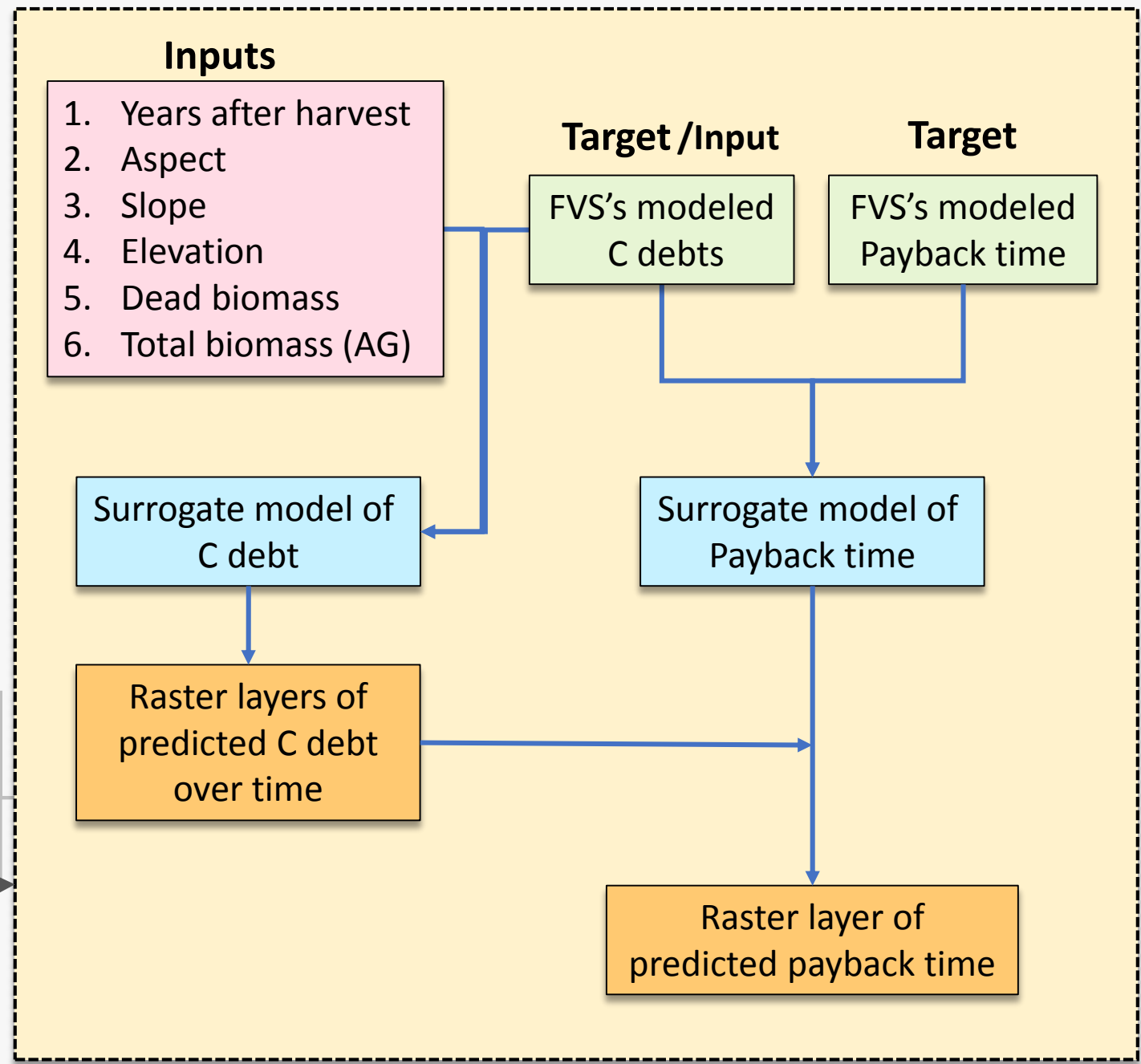
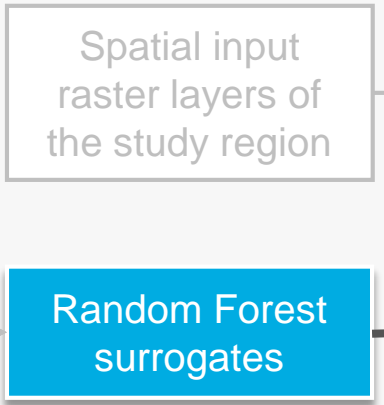
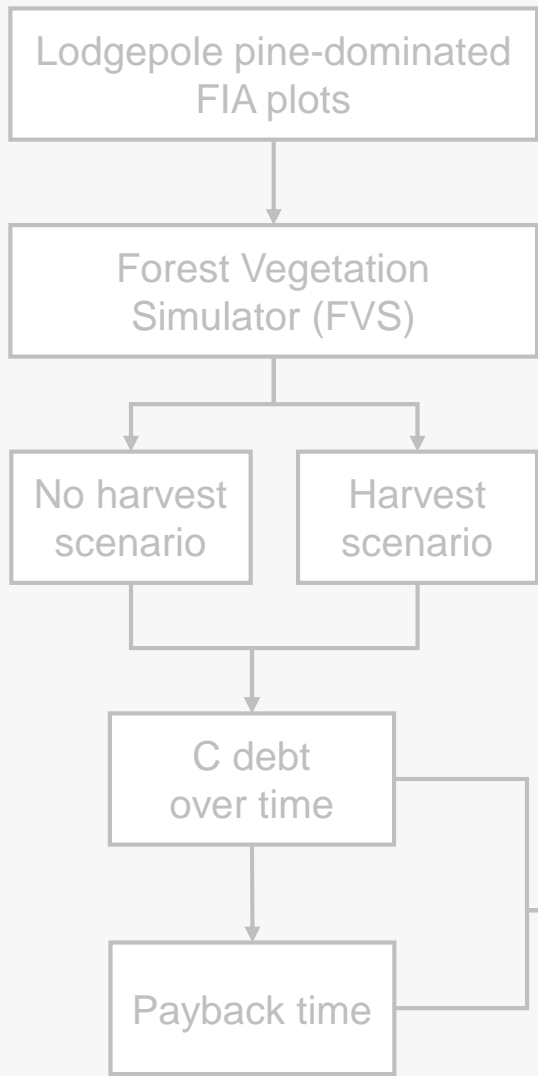




$$C \text{ debt } (t) = (\text{Total C of harvested stand} - \text{Total C of no harvest stand}) \text{ at time } t$$



Linear interpolation between the last negative and the first positive C debts



Lodgepole pine-dominated
FIA plots

Forest Vegetation
Simulator (FVS)

No harvest
scenario

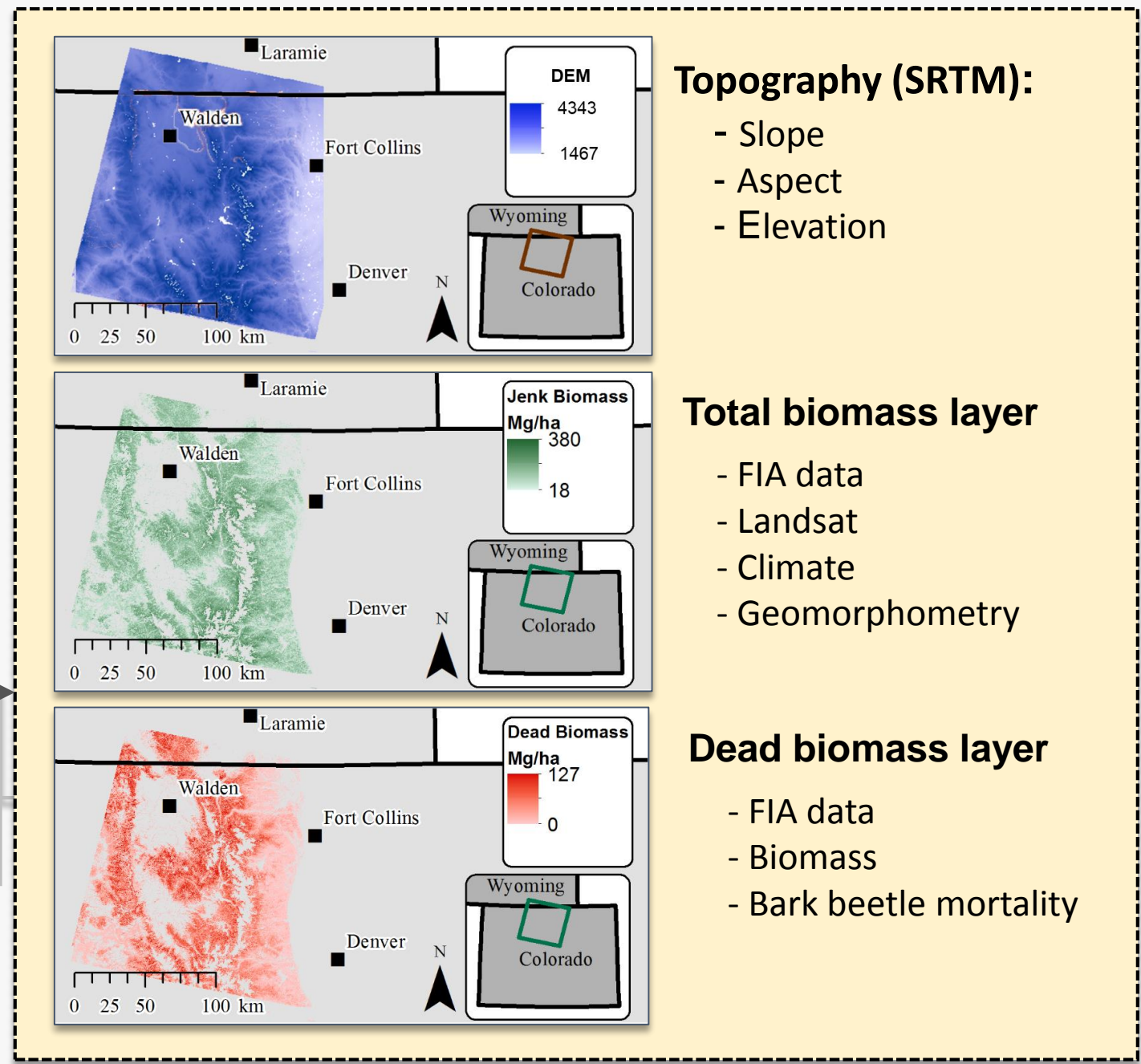
Harvest
scenario

C debt
over time

Payback time

Spatial input
raster layers of
the study region

Random Forest
surrogates



Topography (SRTM):

- Slope
- Aspect
- Elevation

Total biomass layer

- FIA data
- Landsat
- Climate
- Geomorphometry

Dead biomass layer

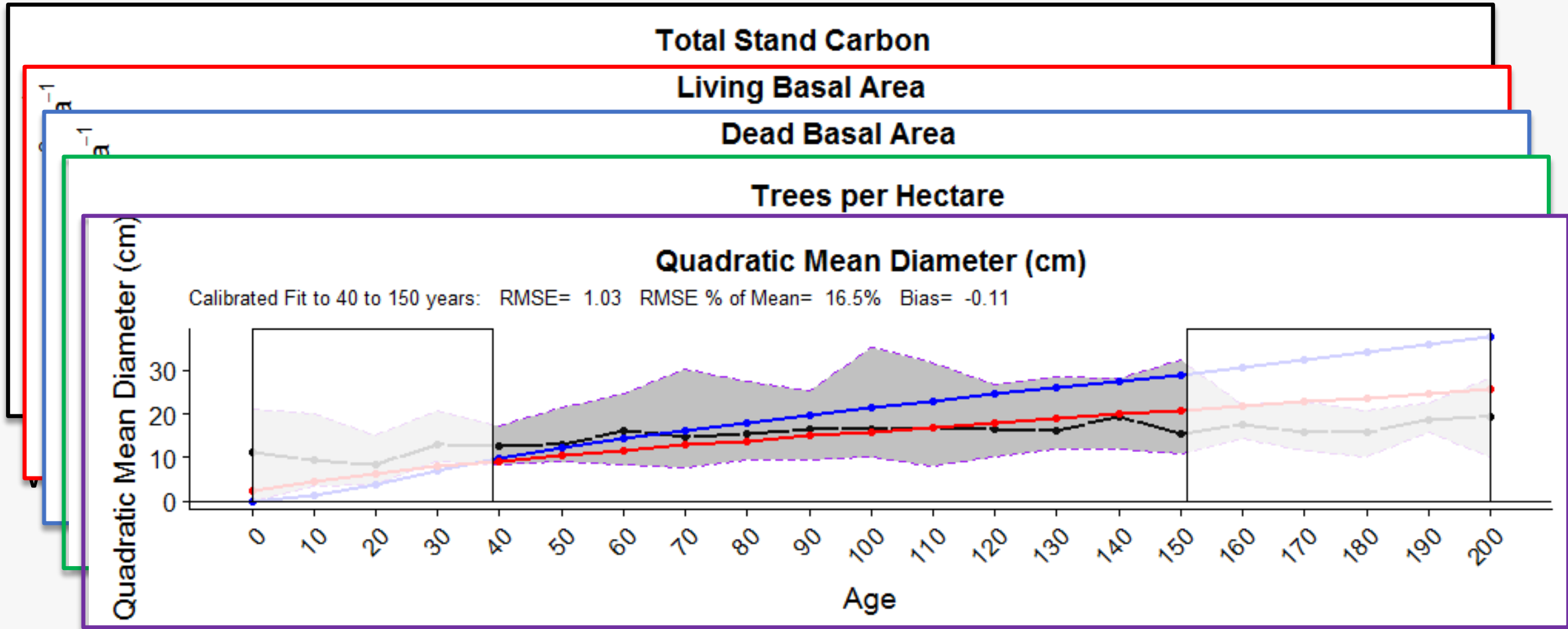
- FIA data
- Biomass
- Bark beetle mortality

RESULTS

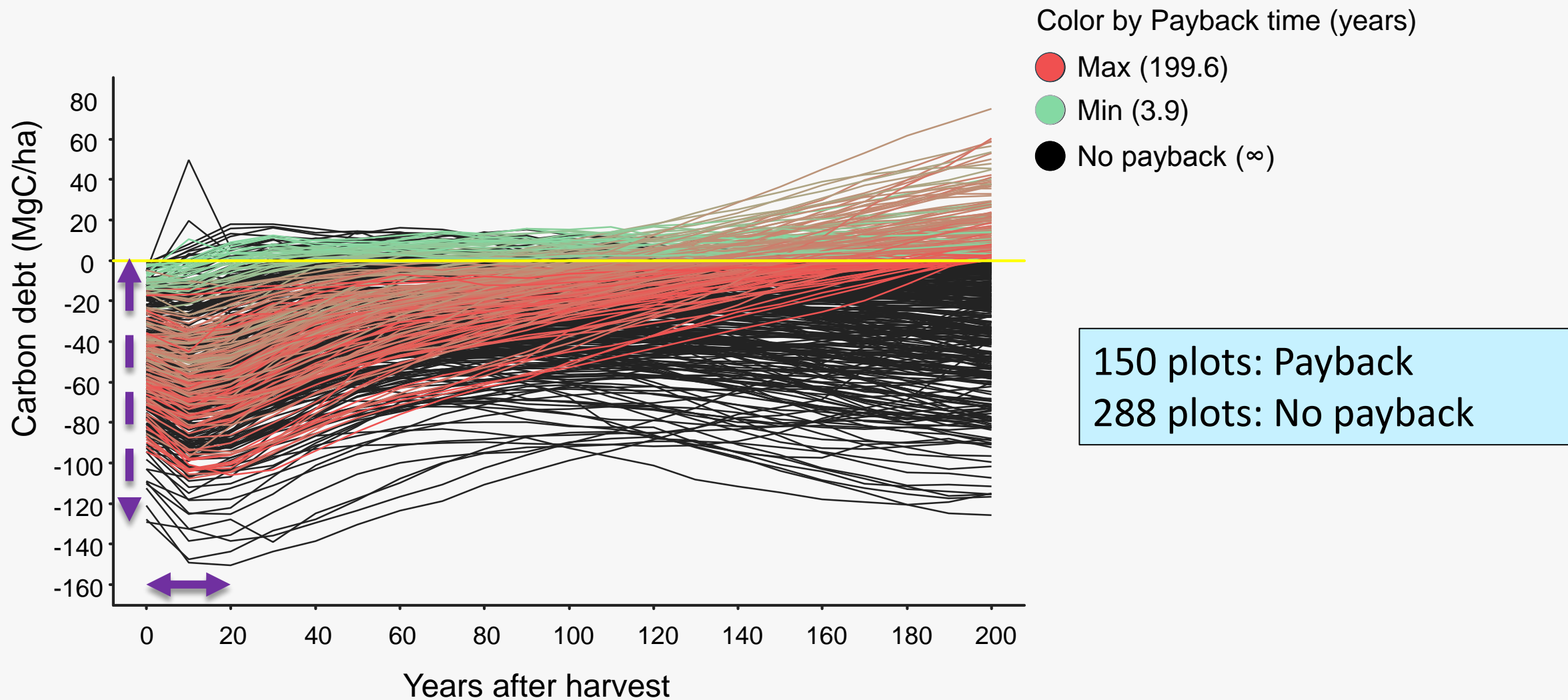
- 1 FVS model Calibration
- 2 Stand characteristics vs. C debt and payback time
- 3 Random forest surrogate model of C debt
- 4 Mapping of C debts for the study region

FVS MODEL CALIBRATION

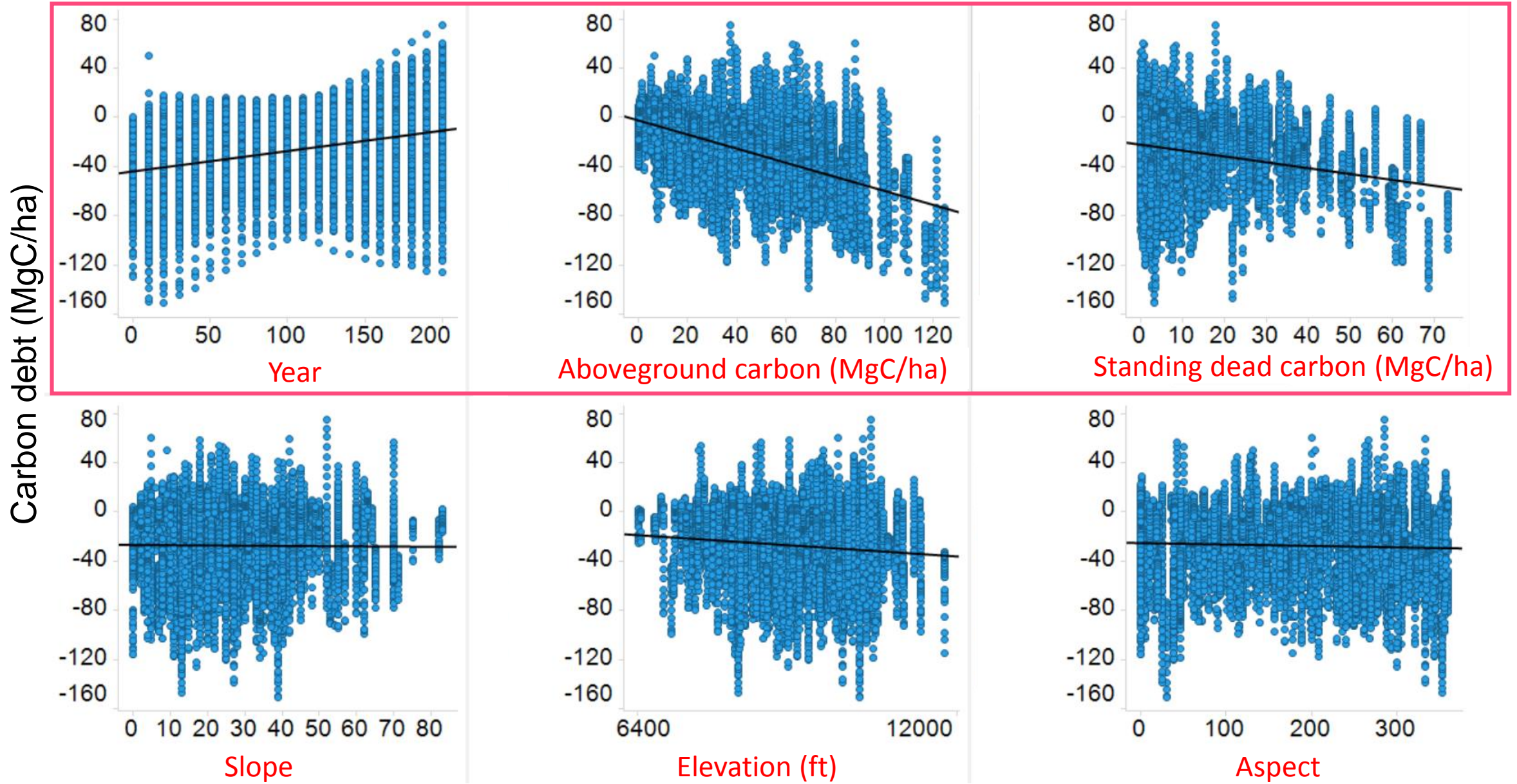
— FVS default model — FIA mean — Calibrated FVS



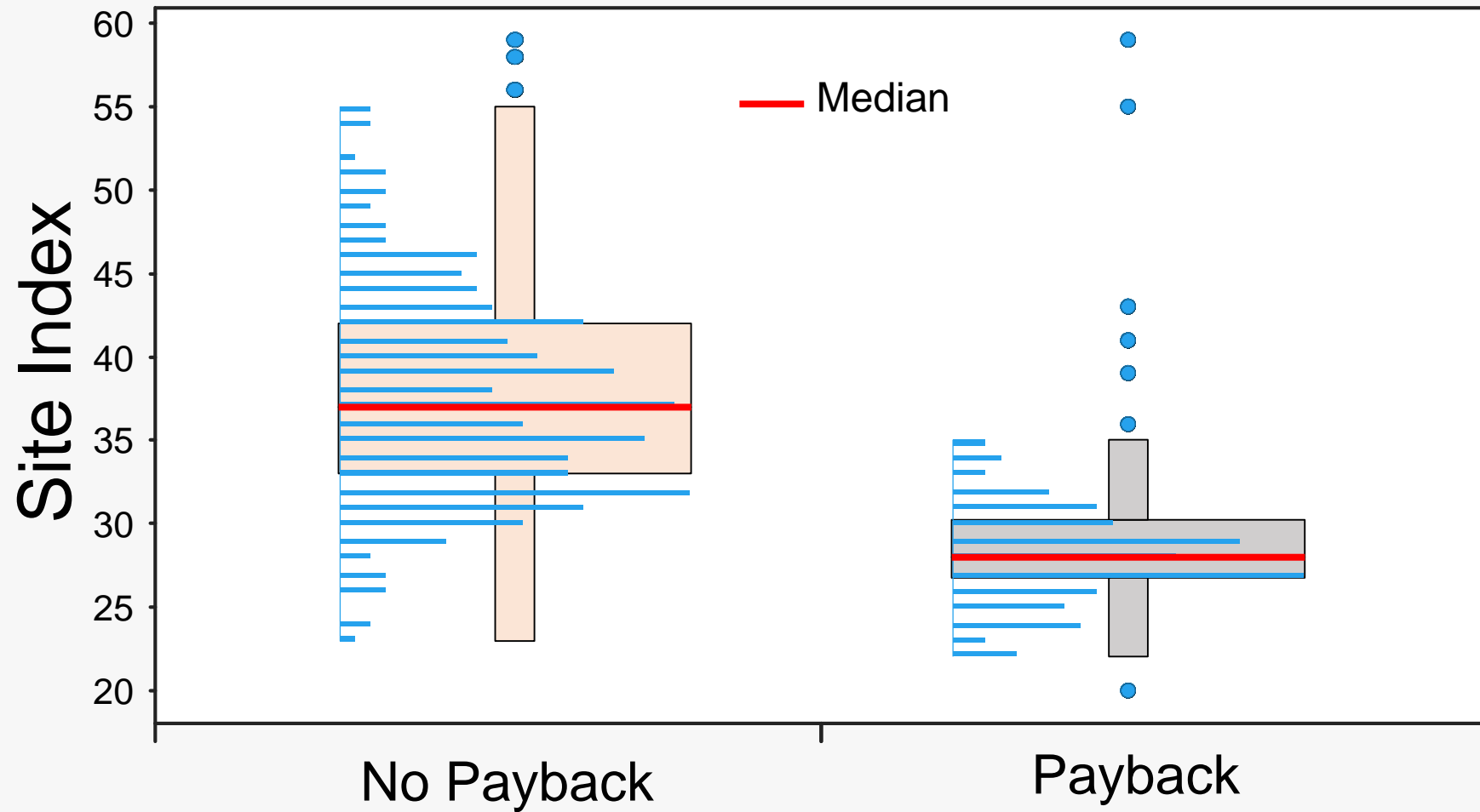
CARBON DEBT OVER TIME



INPUTS VS. CARBON DEBT

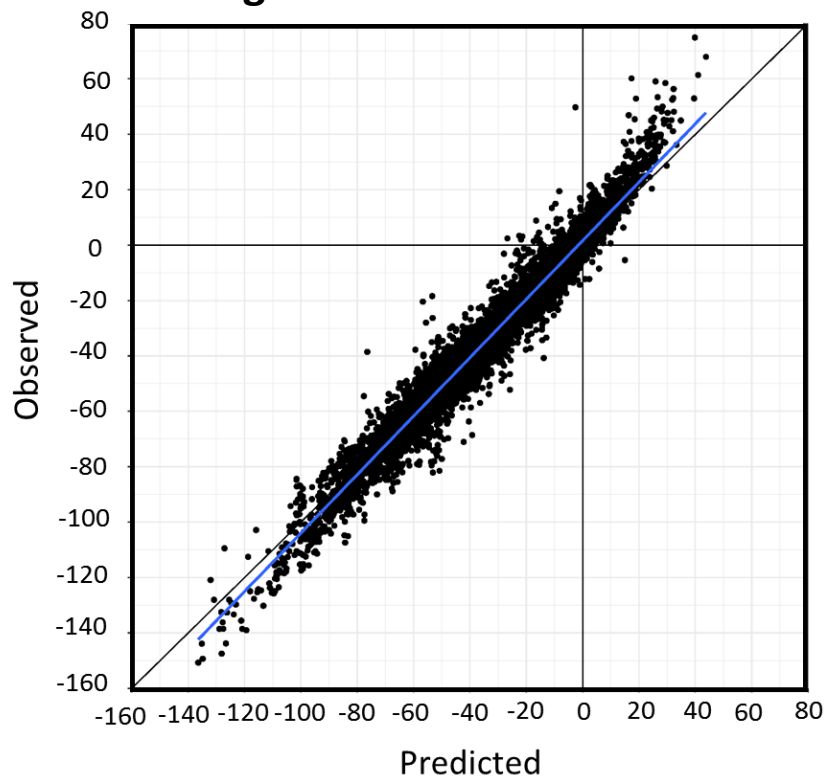


SITE INDEX VS. PAYBACK TIME



RANDOM FOREST SURROGATE MODEL

Surrogate Model of Carbon Debt



Spatial Model evaluation stats:

$$R^2 = 0.97$$

$$\text{RMSE} = 5.6 \text{ Mg C/ha}$$

Surrogate Model Variable Importance

Aboveground biomass

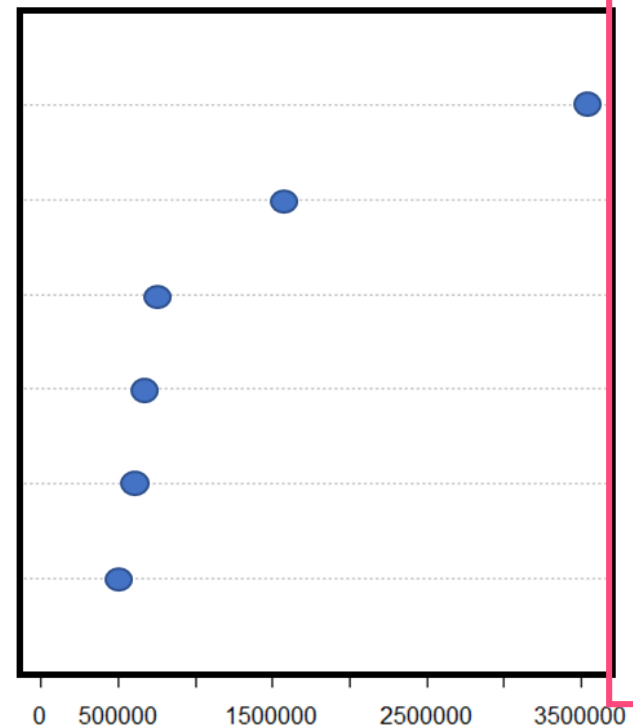
Year after harvest

Dead biomass

Elevation

Aspect

Slope



Spearman's Rank correlation

+0.52

-0.35

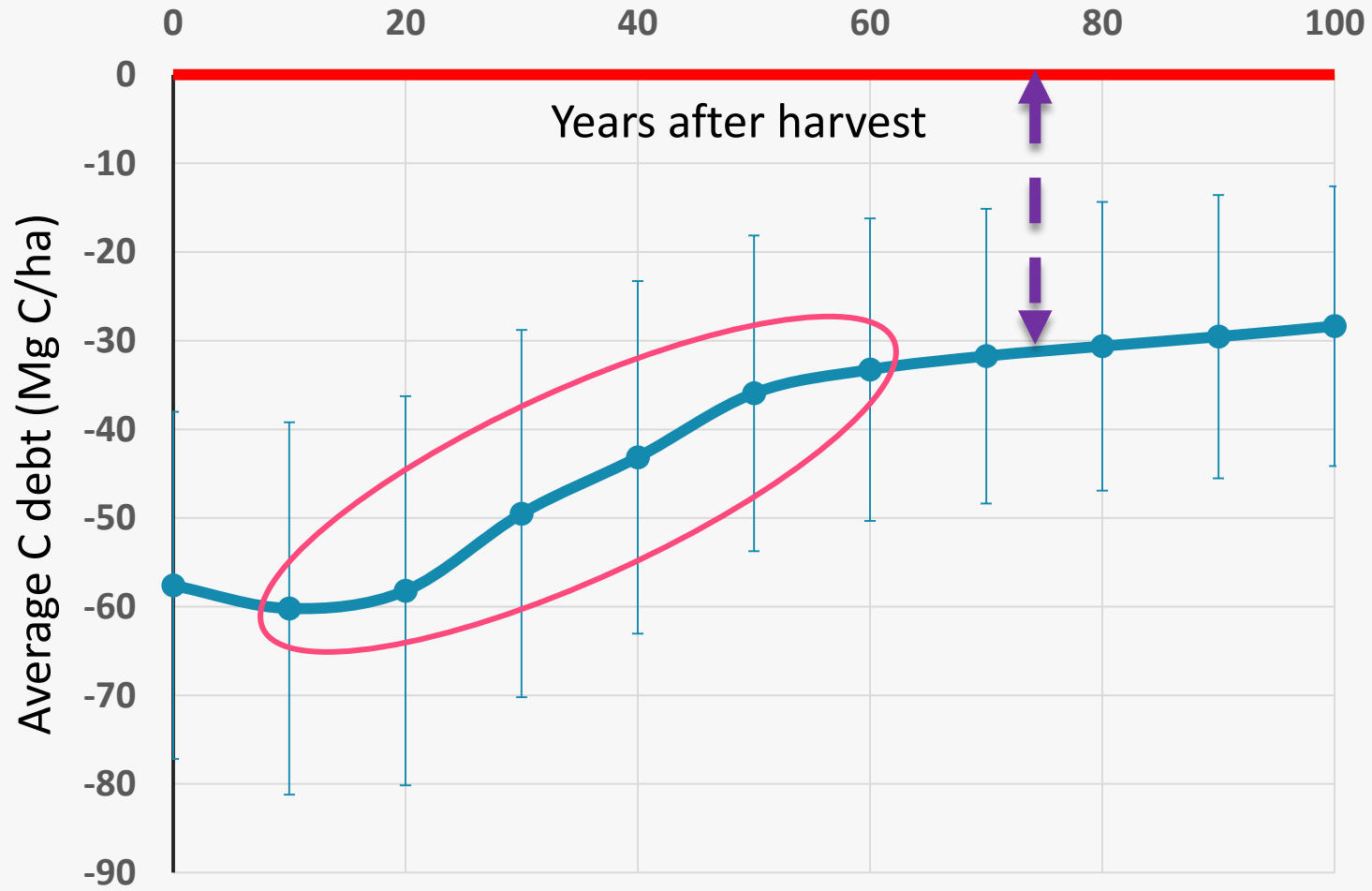
+0.25

+0.11

+0.04

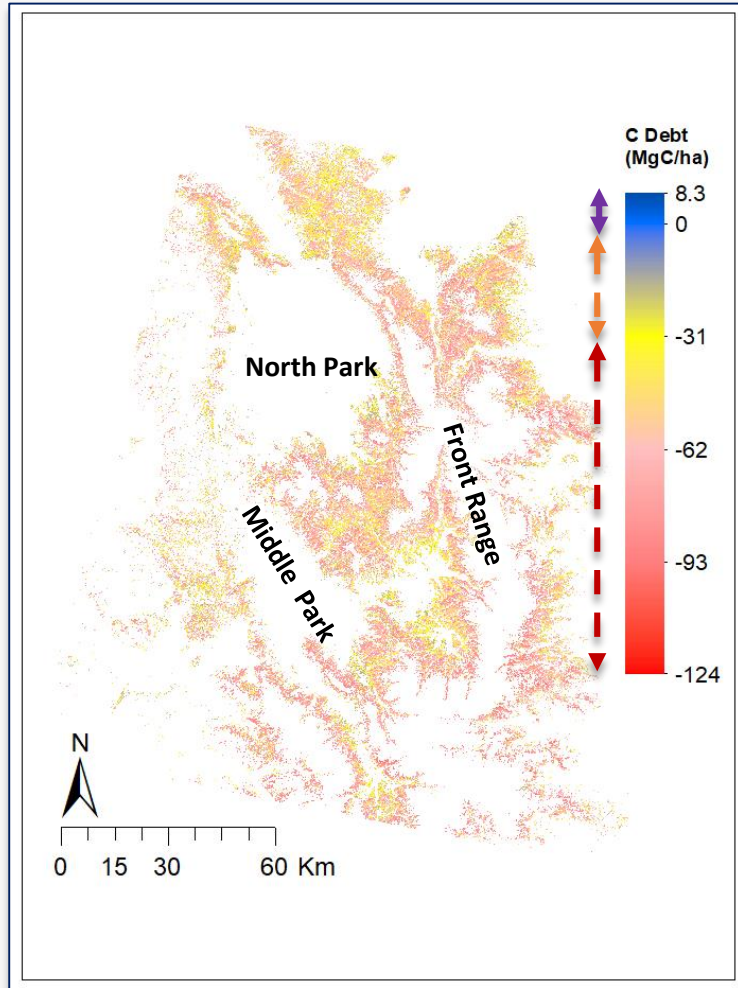
+0.03

LANDSCAPE AVERAGE OF CARBON DEBT

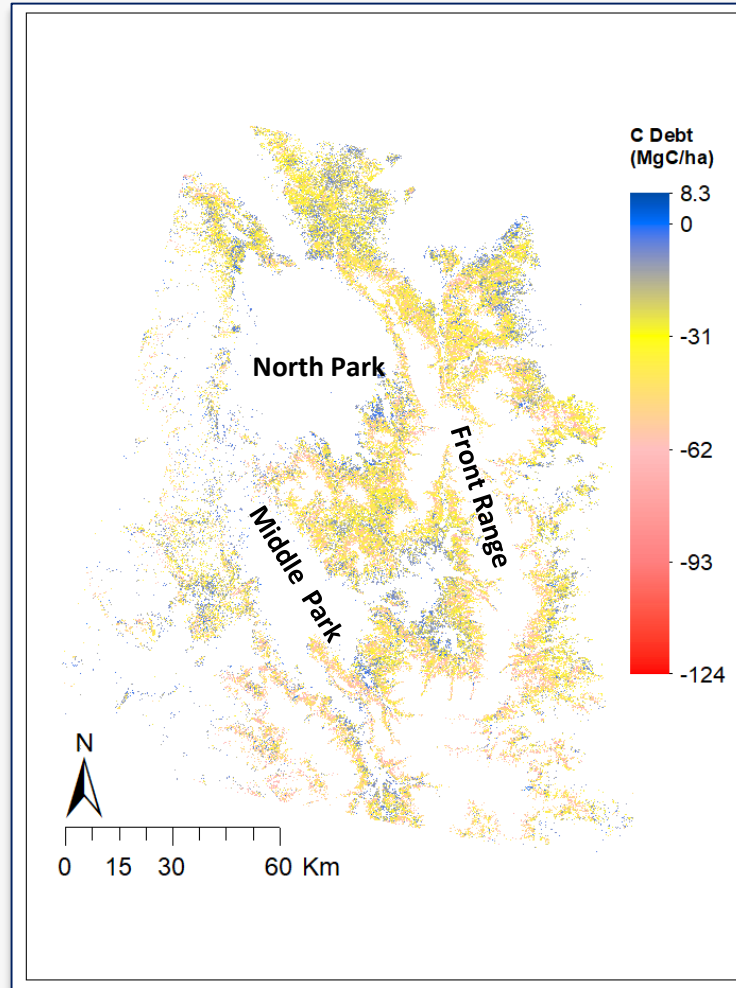


MAPPING OF CARBON DEBT

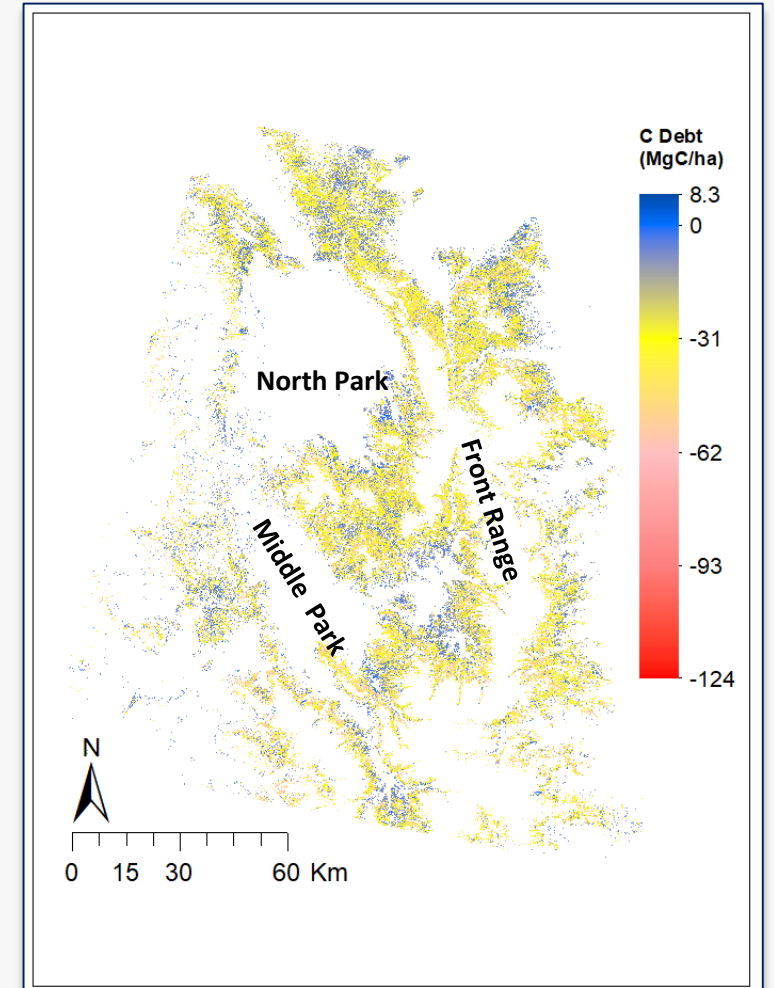
Year 0



Year 50



Year 100



1. Mapping of payback time due to salvage logging
2. Clearcut vs. Slash-and-burn?
3. Spatial optimization of feedstock harvest for biofuel production
4. Life cycle and supply chain assessment

FUTURE DIRECTIONS



ACKNOWLEDGEMENT

This project was supported by the Agriculture and Food
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