

An accessible, data-driven approach for robust regional FVS calibration for improved stand structure and carbon density modeling

John Field, Oak Ridge National Laboratory

Ben Bagdon, Bureau of Indian Affairs

Tony Vorster, Colorado State University

Trung Nguyen, Queensland University of Technology, Brisbane

ORNL is managed by UT-Battelle LLC for the US Department of Energy



U.S. DEPARTMENT OF
ENERGY

Managing Central Rockies lodgepole pine forests

- Interest in lodgepole forest salvage harvest
 - Value recovery
 - Infrastructure protection
 - **Fuels reduction**
- How does biomass removal affect:
 - Stand carbon storage?
 - Species composition?
 - Ladder fuels?

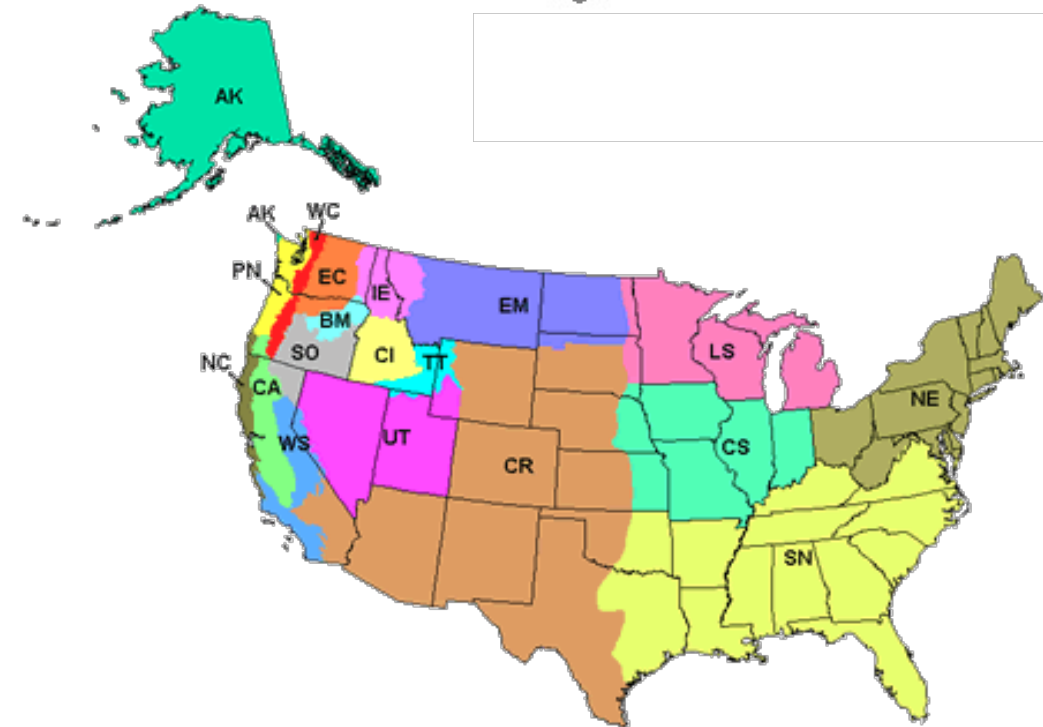
<https://billingsgazette.com/news/state-and-regional/montana/bark-beetle-epidemic-reshapes-debate-on-logging/>



<https://www.denverpost.com/2020/12/07/colorado-logging-forests-wildfires/>

Forest Vegetation Simulator (FVS)

- Individual-tree, distance-independent, growth & yield model
 - USFS “national standard” since early 1980s
- Simulates stand structure, timber volume, C (fuels & fire extension)
- Central Rockies variant sub-models:
 - Diameter increment
 - Height increment
 - Mortality (background & density-dependent)



<https://www.fs.fed.us/fvs/whatis/index.shtml>

FVS for carbon accounting



- Common in academic research
- Approved growth & yield model under U.S. Forest Protocol
- FVS Out of the Box– Assembly Required (Vandendriesche 2010)
 - *“FVS tends to concentrate substantial growth on few survivor trees”*
- Similarly, our own exploratory analysis showed:
 - Very high stand growth (300+ Mg C ha⁻¹)
 - Some unexpected species composition shifts

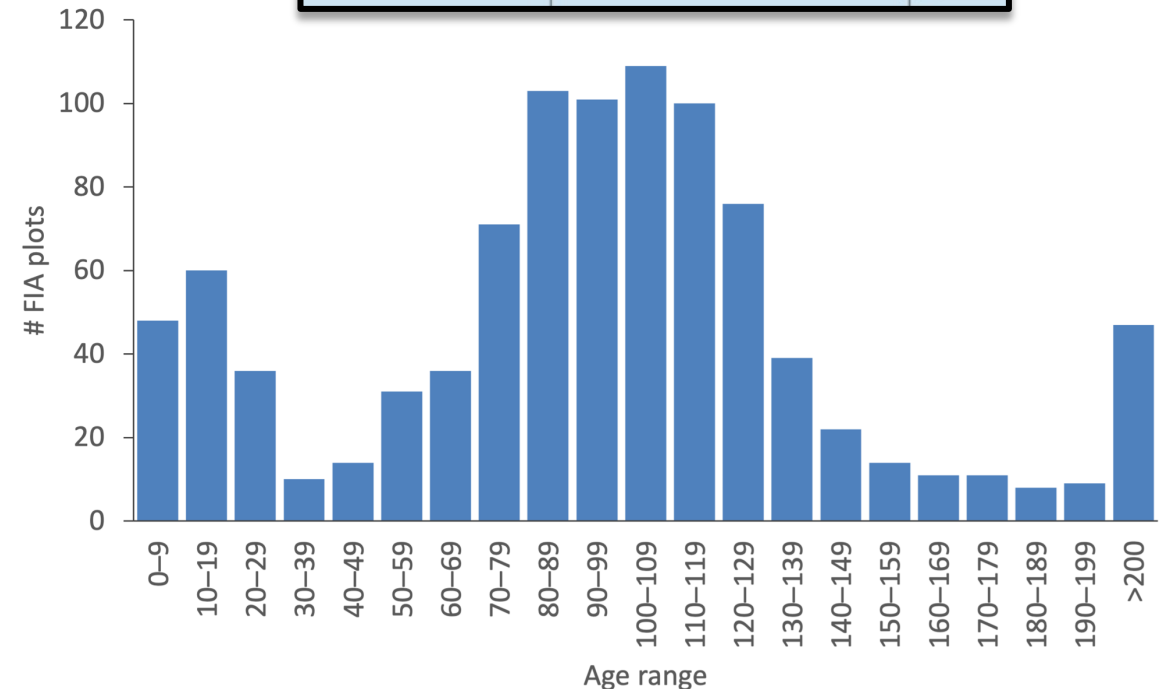
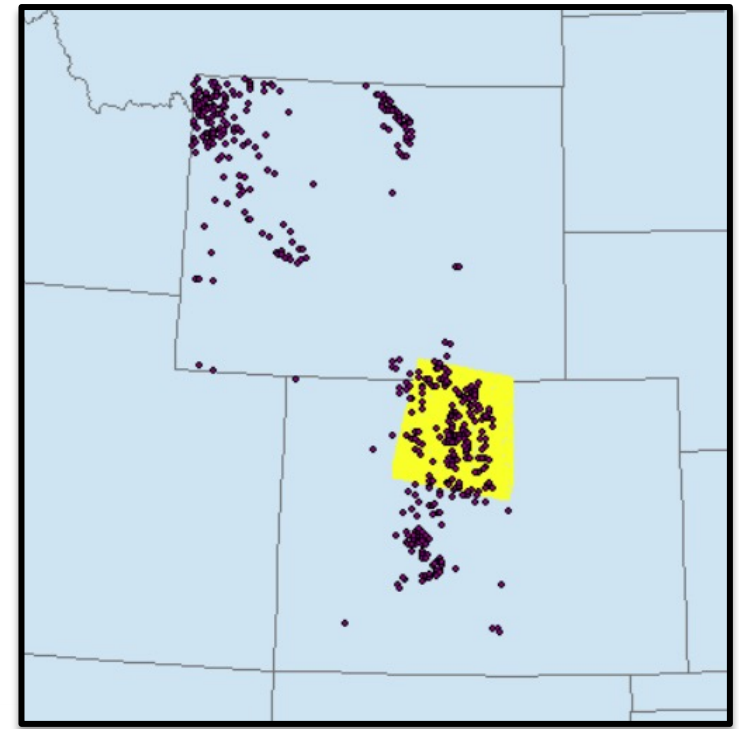
Model evaluation

Bagdon et al. (2021). A model evaluation framework applied to the Forest Vegetation Simulator (FVS) in Colorado and Wyoming lodgepole pine forests. *Forest Ecol. & Mgmt.*, 480, 118619

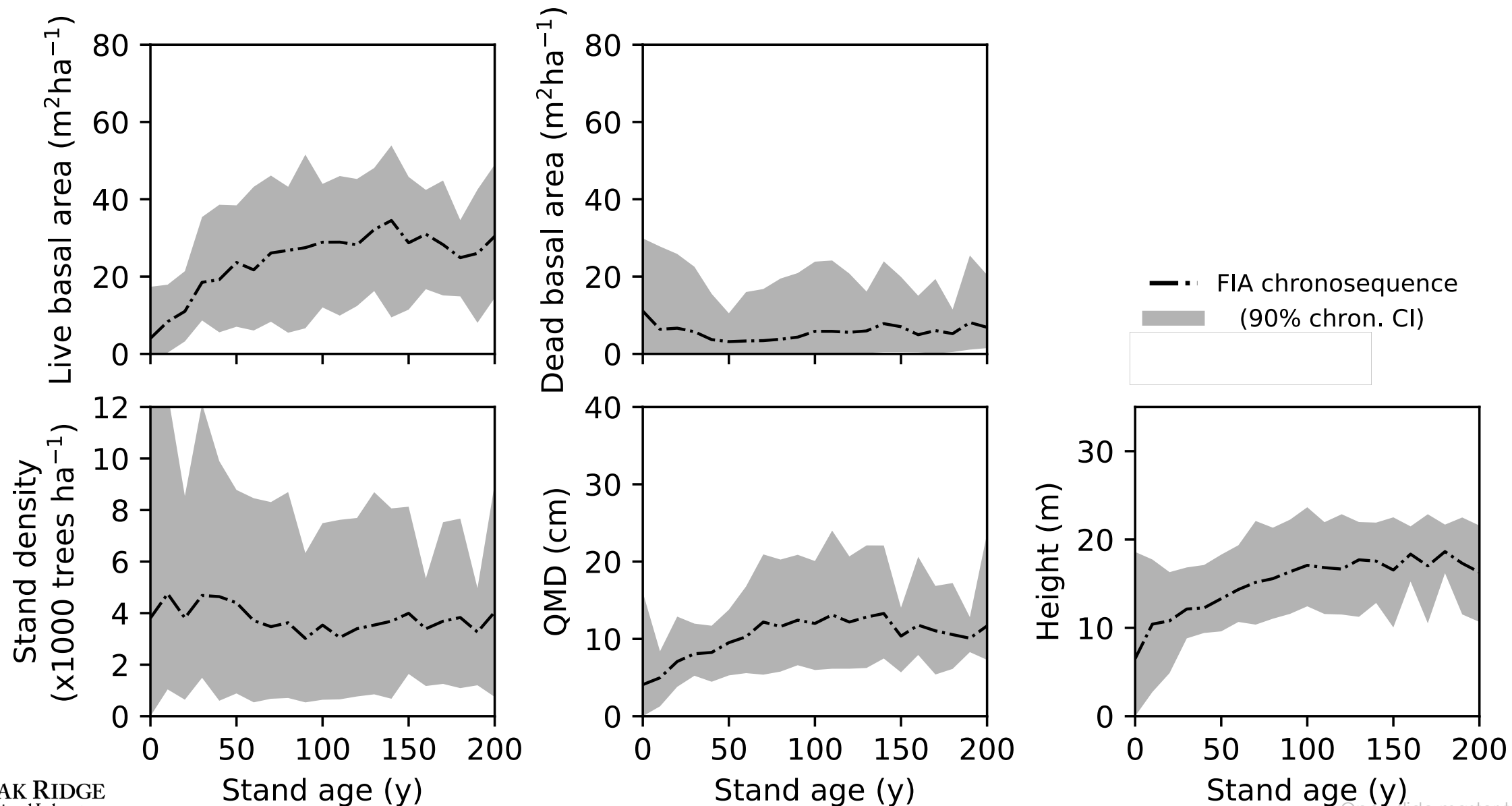
- **Sensitive parameters:** Initial species mix, site index, large-tree diameter increment, BA_{\max}
- **Equivalence testing** using ~3800 Forest Inventory & Analysis (FIA) program tree diameter re-measurements showed:
 - No evidence of bias in lodgepole pine
 - Under-estimation of spruce–fir & over-estimation of aspen

Chronosequence development

- Selected all FIA plots collected from 2002–2017 in CO & WY coded as lodgepole forest
- Filtered out:
 - Plots <65% lodgepole pine by basal area
 - Plots coded for wildfire disturbance
- Grouped the remaining 956 plots into 10-year age bins



FIA-derived chronosequence



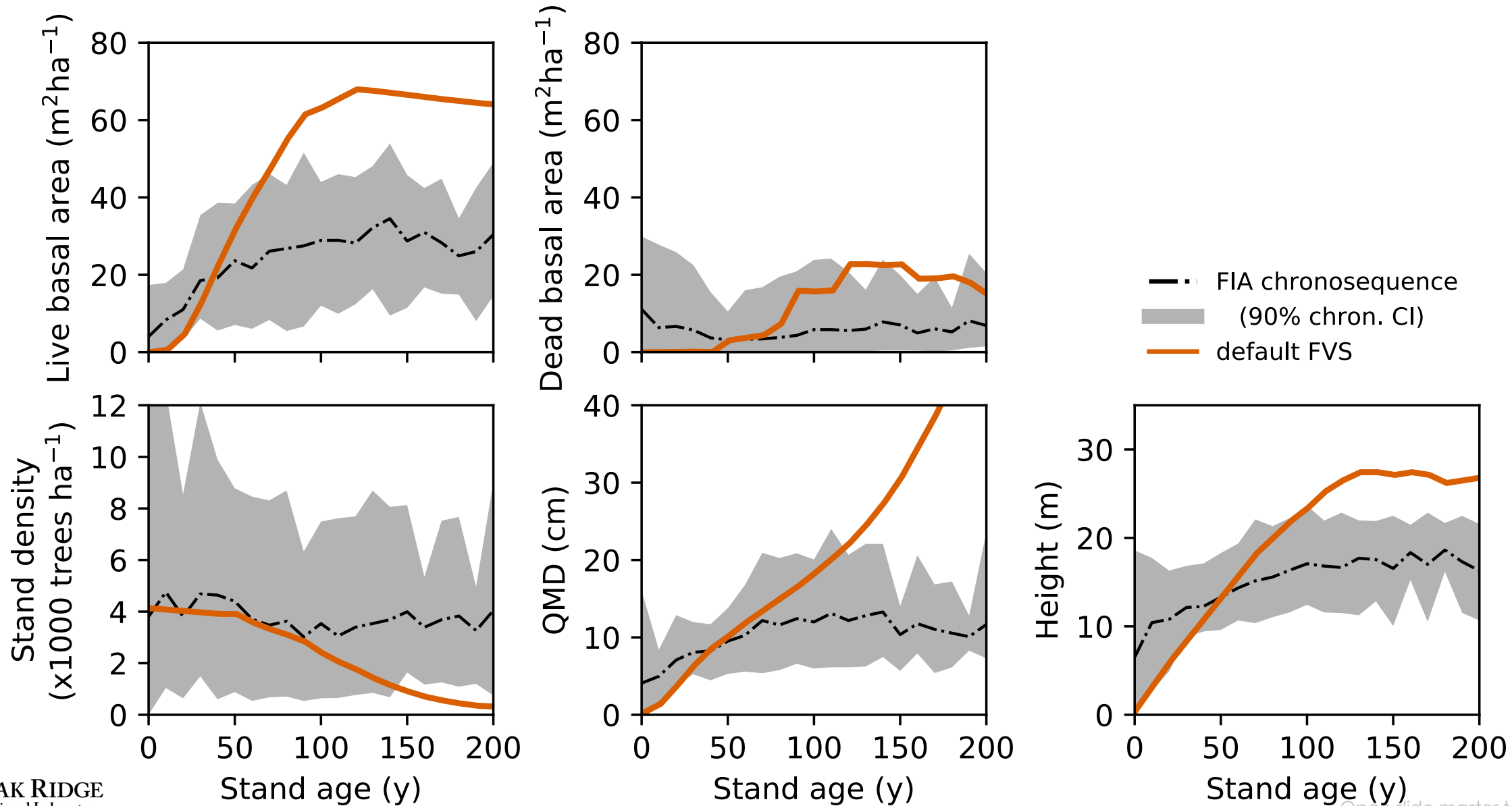
FVS stand simulations

- Bare-ground regrowth of single lodgepole stand
- Initial seedling density (3800 seedlings ha⁻¹) from mean of 0–9 y FIA age group
- Other species introduced through conditional regen
 - Triggered when stand density falls below 2700 TPH



https://commons.wikimedia.org/wiki/File:Lodgepole_pine_seedlings_Yellowstone.jpg

Default model



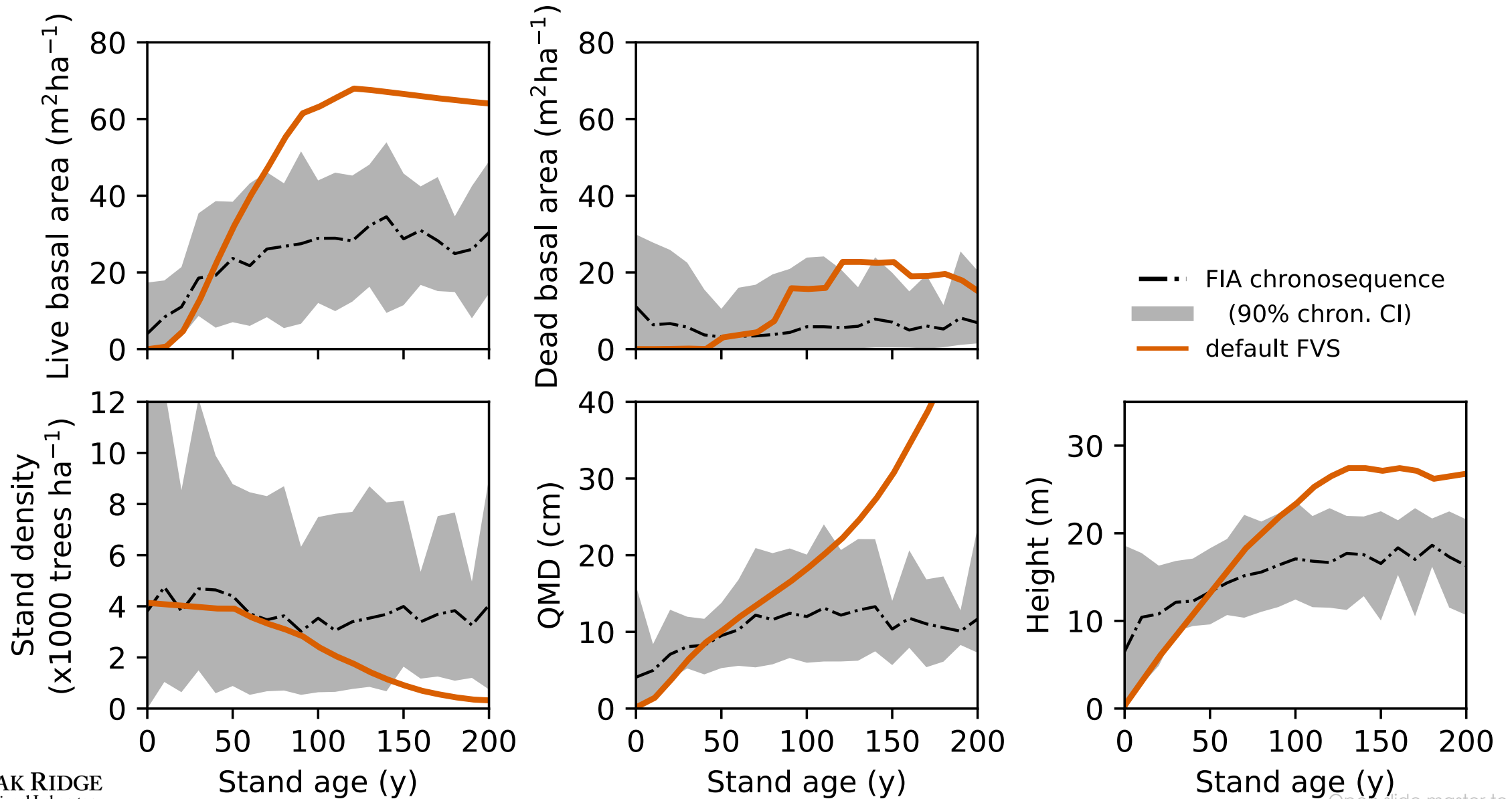
Regional adjustment

- Disabled aspen resprouting
- Site index adjusted from default value (19.8 m, base age of 100y) to mean value observed in FIA dataset (16.0 m)

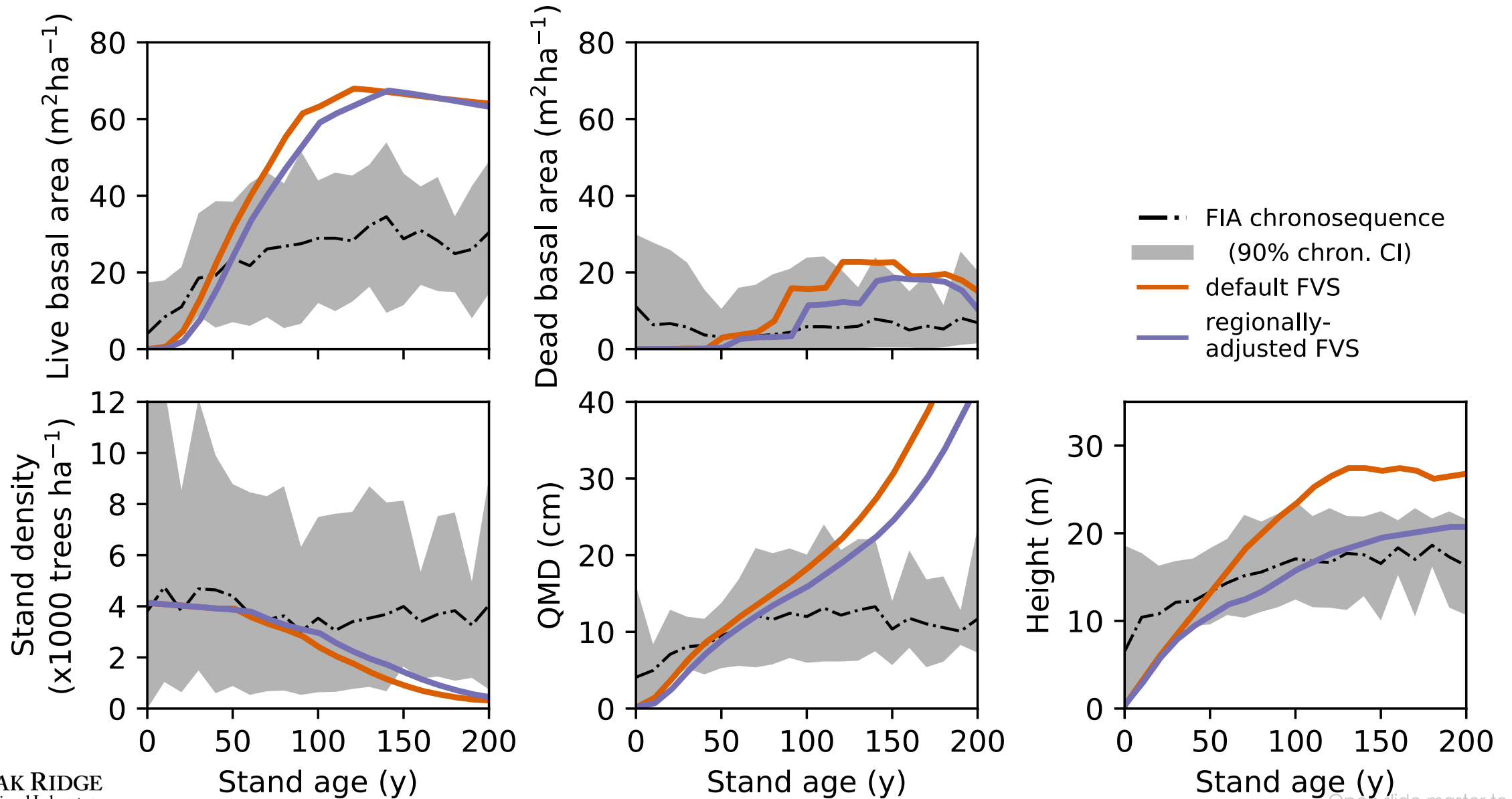


<https://gobotany.nativeplanttrust.org/species/populus/tremuloides/>

Regional adjustment



Regional adjustment



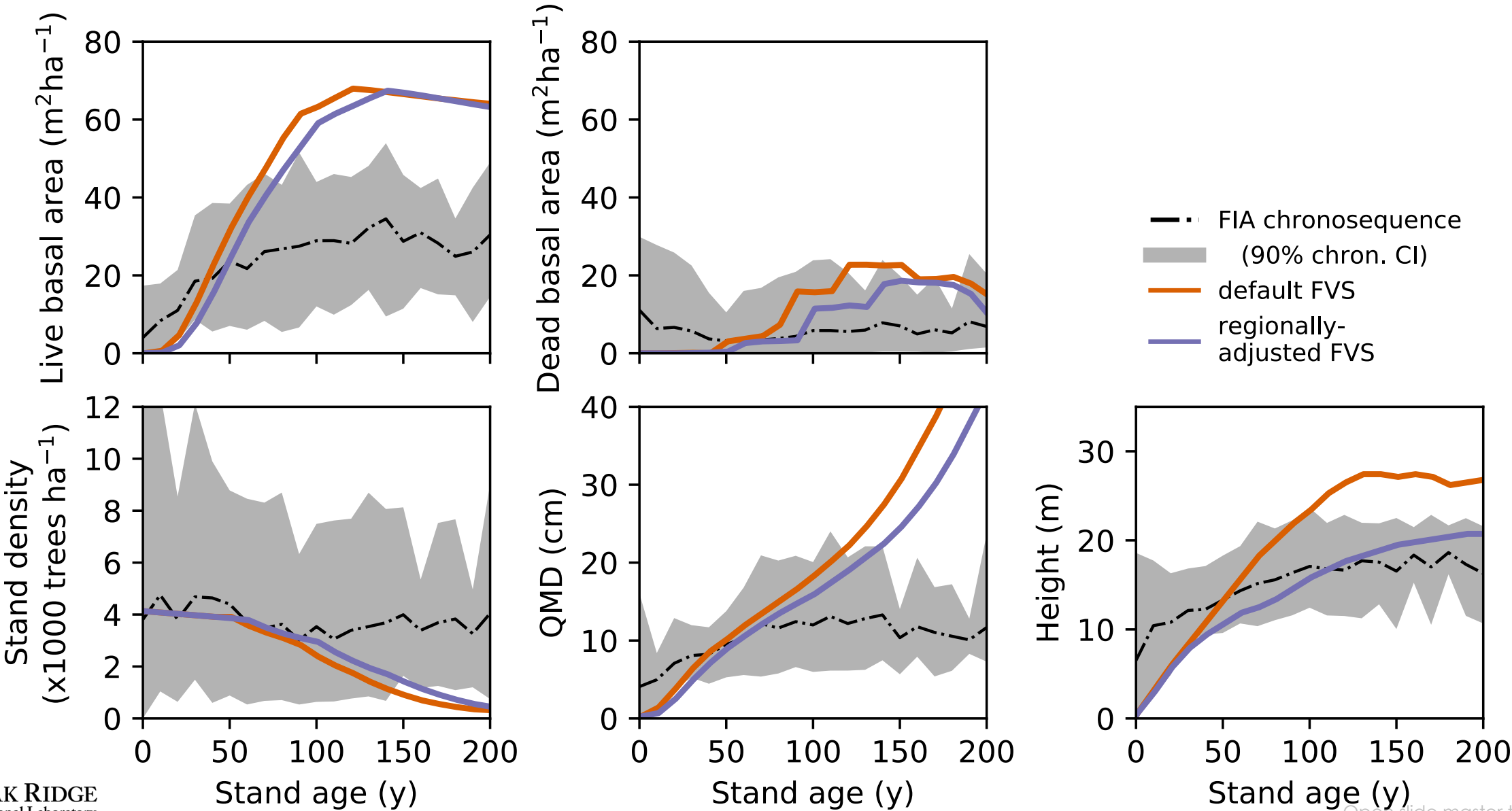
Recalibration strategy

- Parameter values set from external data sources where possible
 - Site index
 - Diameter increment & max
 - BA_{max} ($46 \text{ m}^2 \text{ ha}^{-1}$; 95th pctl.)
- Other sensitive parameters manually adjusted for best chronosequence fit
 - Height growth multipliers
 - Background mortality multipliers

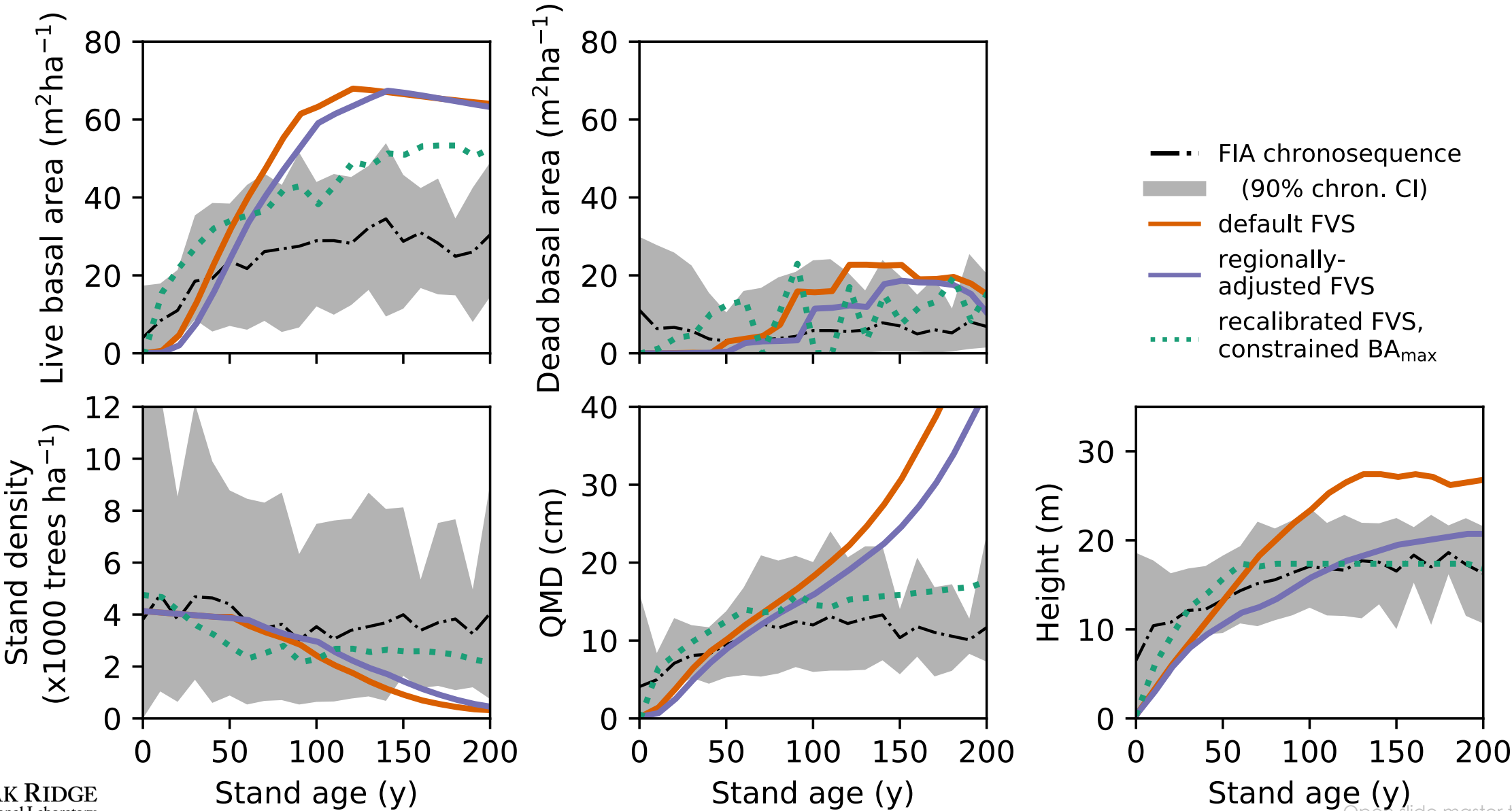


https://en.wikipedia.org/wiki/Tree_girth_measurement#/media/File:Double_trunked_Cherry_Tree.jpg

Recalibration



Recalibration



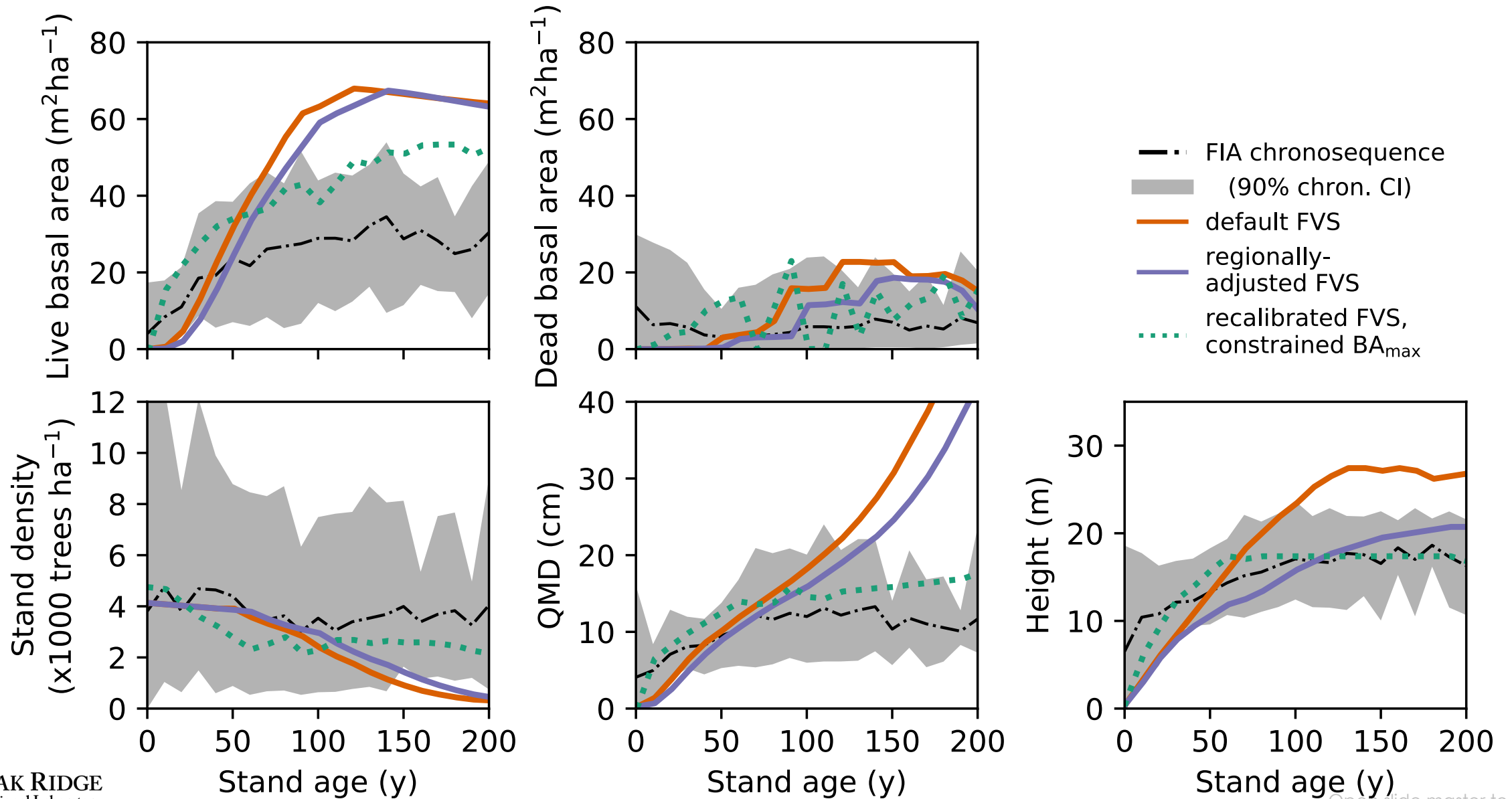
Updated strategy

- Conflict when setting both diameter increments & BA_{\max} via external data
- Opted to release BA_{\max} constraint, tune for best fit
 - $34 \text{ m}^2 \text{ ha}^{-1}$; $\sim 75^{\text{th}}$ pctl. of FIA observations

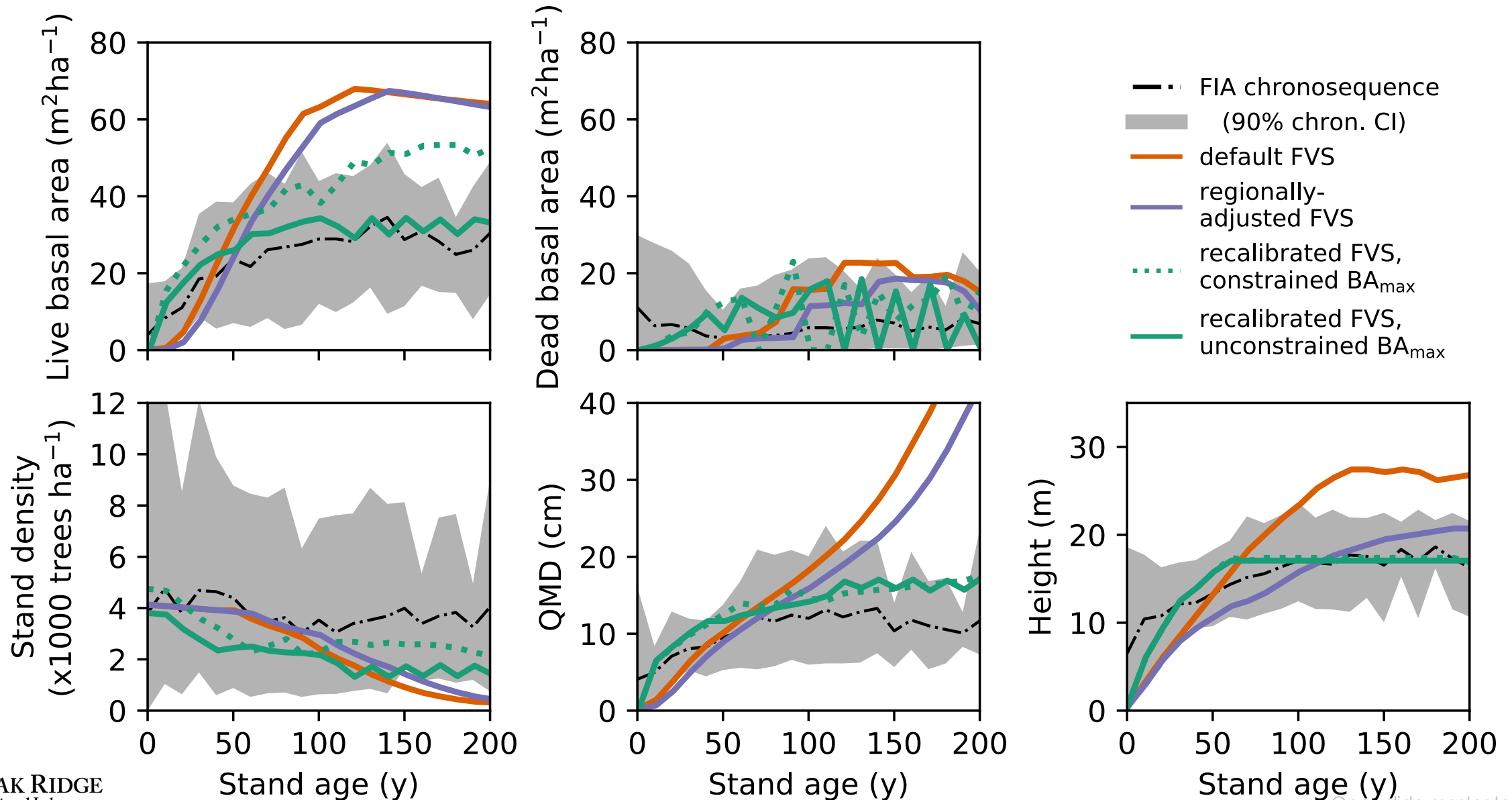


<https://sites.psu.edu/mgeppingerpassionblog/2015/09/10/two-roads-diverged-in-a-yellow-wood/>

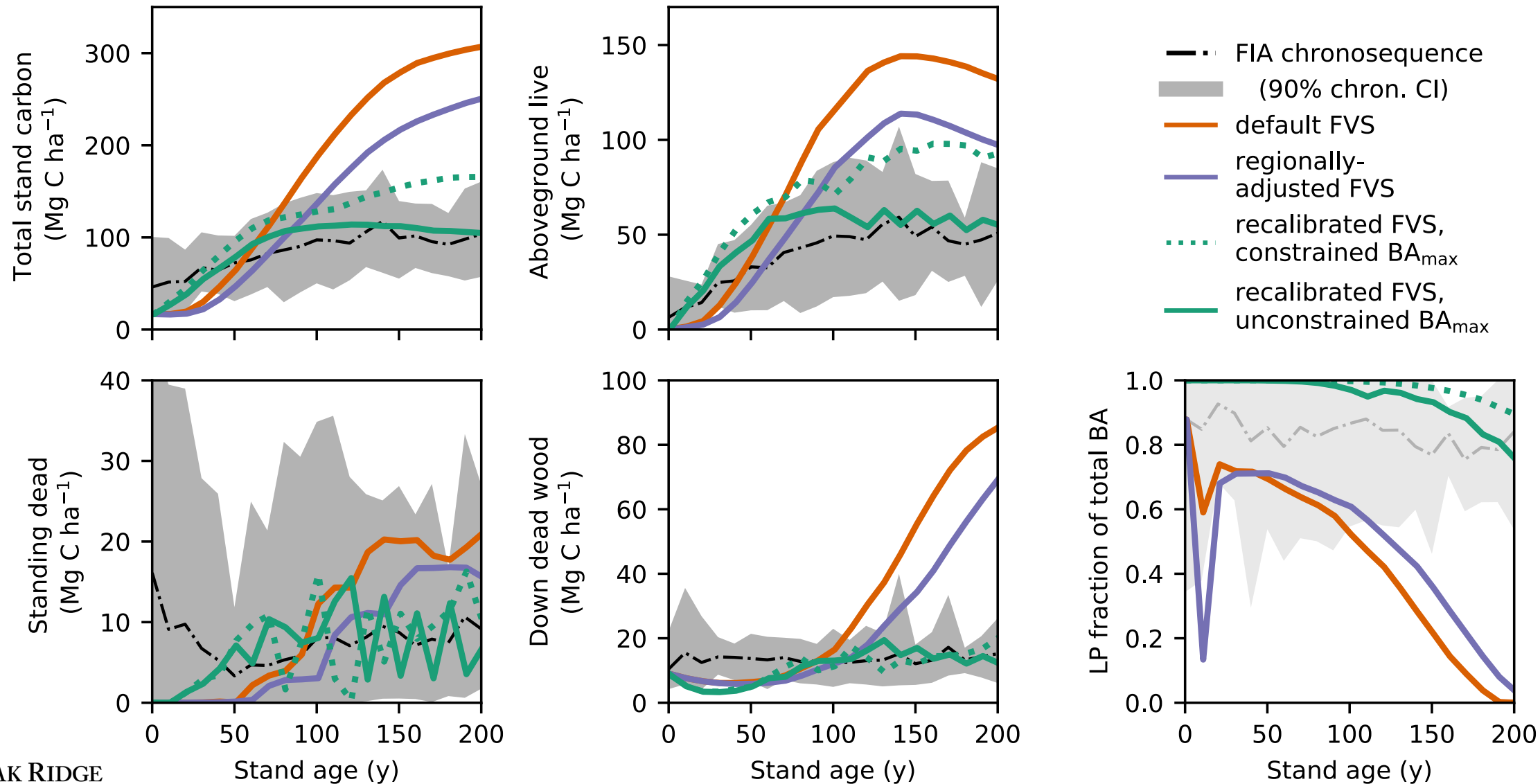
Recalibration—Unconstrained BA_{max}



Recalibration—Unconstrained BA_{max}



Post hoc C evaluation



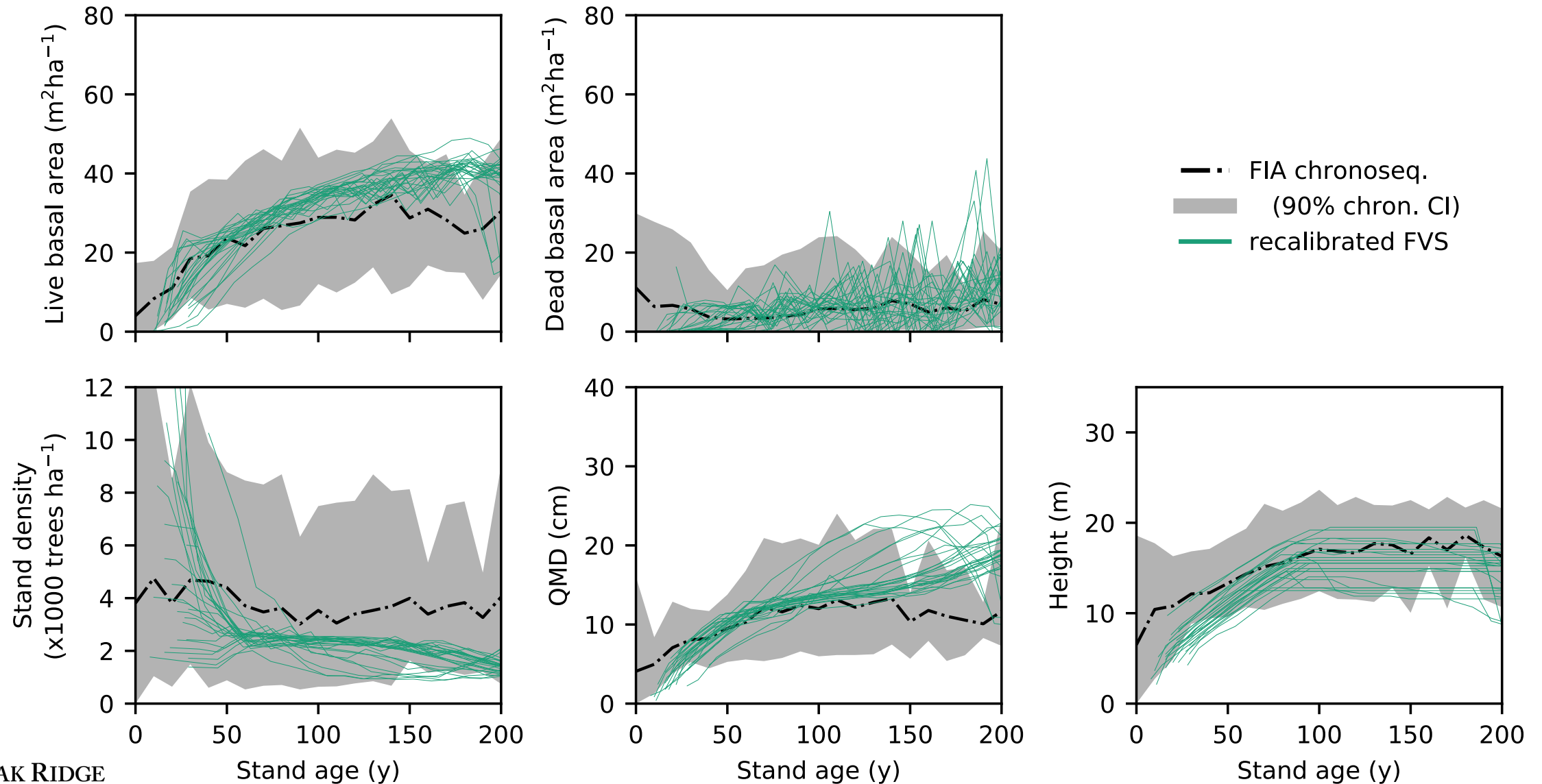
Sensitivity to initial conditions

- Independent data:
27 regen plots from
Colorado State Forest
(CSF)
 - Post clear-cut seedling
density ($8200 \text{ trees ha}^{-1}$)
 - Majority lodgepole,
with some aspen,
spruce & fir
 - No site index (used
model default instead)



<https://www.coloradodirectory.com/antlersinn/>

Sensitivity to initial conditions—Recalibrated model



Conclusions

- Default model settings questionable for carbon accounting
- “*accessible, data-driven approach for robust regional calibration*”
 - Possible to parameterize a well-fitting, robust model using public FIA data
 - Manual parameterization was highly iterative, time consuming
 - Learned about model structure & behavior

Thank you!



BANR

BIOENERGY
ALLIANCE
NETWORK OF THE
ROCKIES

FieldJL@ornl.gov

<https://banr.nrel.colostate.edu/>



NATURAL
RESOURCE
ECOLOGY
LABORATORY

Colorado
State
University

