The Alaska Variant

Photo by Chad Keyser

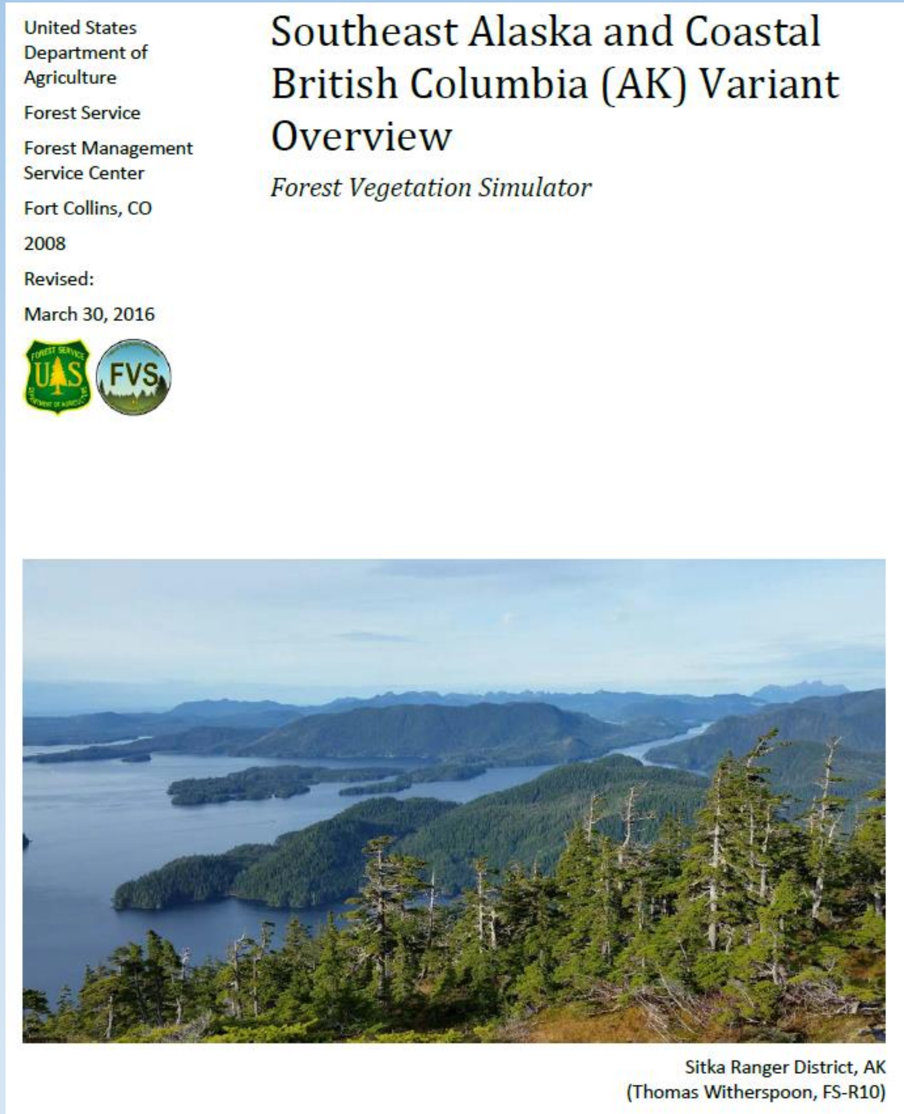
Overview of AK Variant

I. Background

II. Variant Development

III. Overview of diameter growth and mortality relationships

SEAPROG


United States Department of Agriculture

Forest Service

Forest Management Service Center

Fort Collins, CO

2008

Revised:

March 30, 2016

Southeast Alaska and Coastal British Columbia (AK) Variant Overview

Forest Vegetation Simulator

Sitka Ranger District, AK
(Thomas Witherspoon, FS-R10)

- USDA Forest Service requested that an AK variant be developed for forest planning in 1984

- Variant developed from a variety of sources
  - Juneau, Sitkine, and Sitka forest inventories (Tongass NF)
  - Young growth surveys (primarily questionnaires)
  - Long-term growing stock studies
  - Queen Charlotte Islands forest inventory (British Columbia)

- SEAPROG finalized in 1985

United States Department of Agriculture
Forest Service
Pacific Northwest Research Station
Research Paper PNW-RP-555
October 2003

Performance of the SEAPROG Prognosis Variant of the Forest Vegetation Simulator

Michael H. McClellan and Frances E. Biles

- SEAPROG has limited ability to predict results of silviculture systems outside of even-aged management
- Hemlocks tend to be eliminated from the stand when simulating mixed hemlock – sitka spruce stands
- Under prediction of mortality and diameter growth

Limited Geographic Extent

Species	Number
Western hemlock	5581
Sitka spruce	3276
Mountain hemlock	1357
Alaska cedar	880
Western red cedar	402
Pacific silver fir	98
Lodgepole pine	78
Other hardwoods	69
Black cottonwood	55
White spruce	22
Subalpine fir	1

USGS forest types: https://www.fia.fs.usda.gov/library/maps/docs/forestcover.pdf

- Little to no consideration of boreal species: white spruce, black spruce, paper birch, quaking aspen, balsam poplar

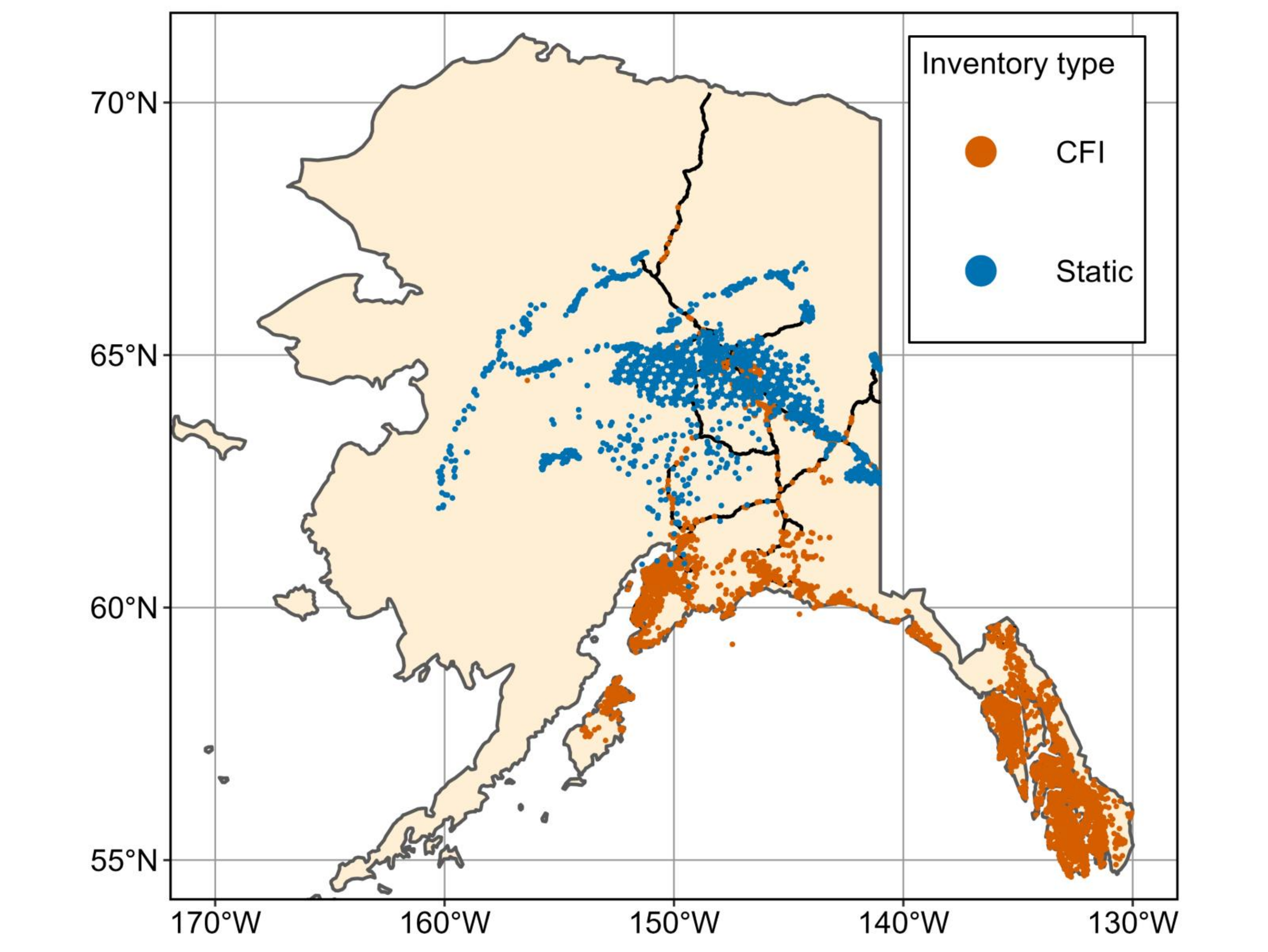
Development of New AK Variant

1. Refit all growth relationships for species in coastal forest types using new data

2. Develop new growth relationships for all tree species prevalent in the boreal forest region

3. Release unified Alaska Variant representative of all major forest types found in Alaska

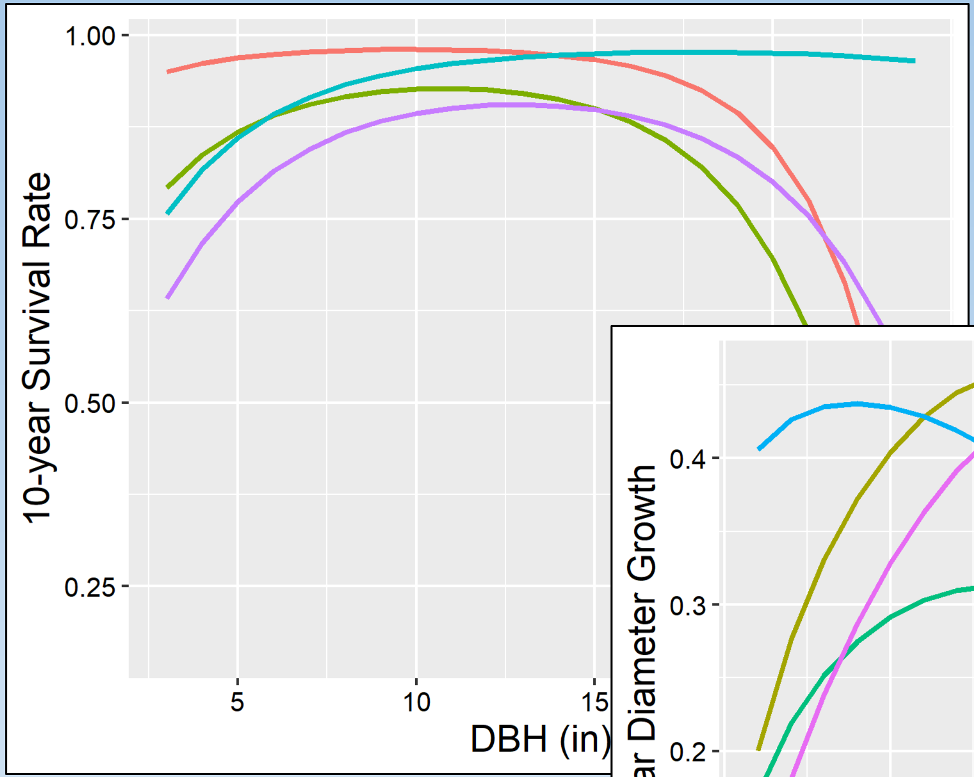
Data

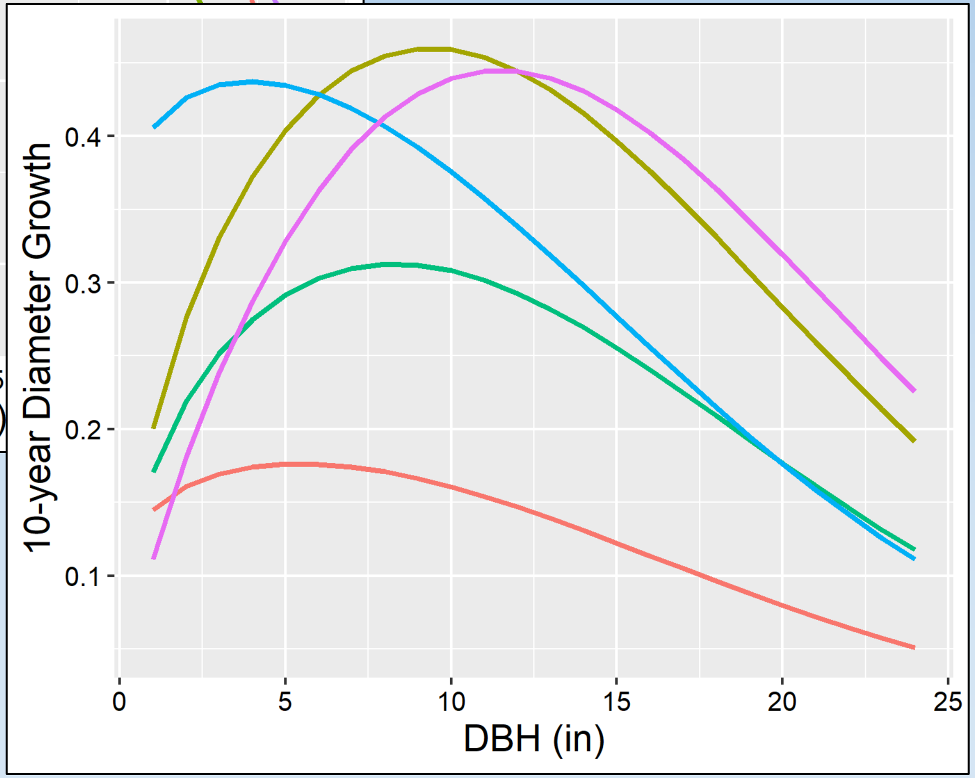


Data Source
CAFI CFI
DOD CFI
FIA CFI
Interior FIA inventory
TCC inventory
AK DNR inventories

Equation Development

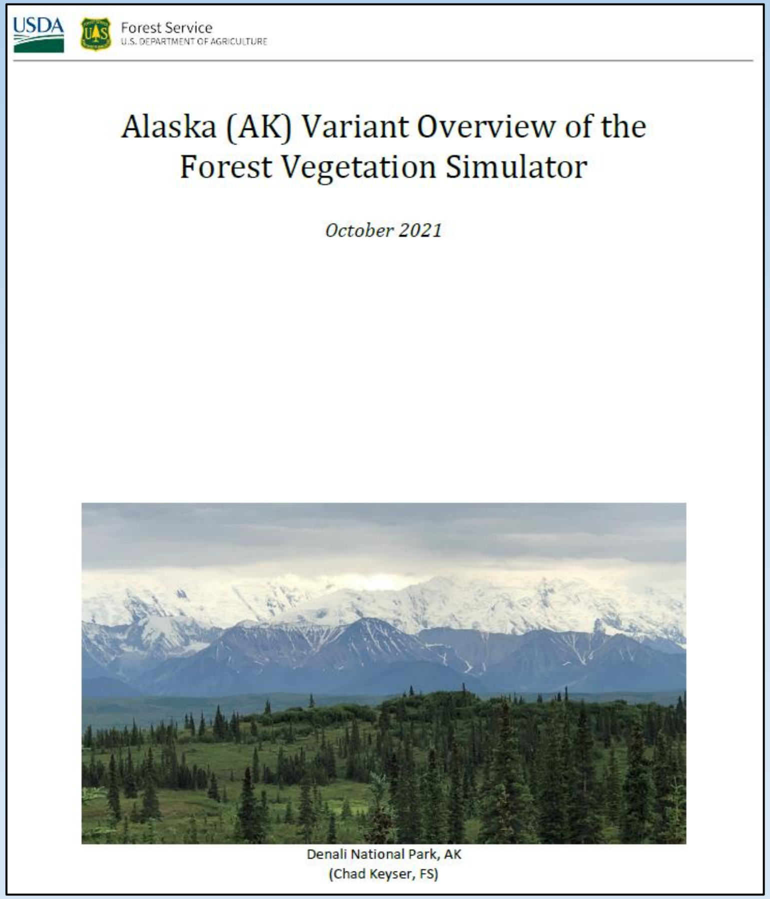
Relationship	
Height diameter	✓
Bark thickness	✓
Crown width	✓
Crown ratio	✓
Diameter growth	✓
Height growth	✓
Mortality	✓
Regeneration	✓





AK Variant Release

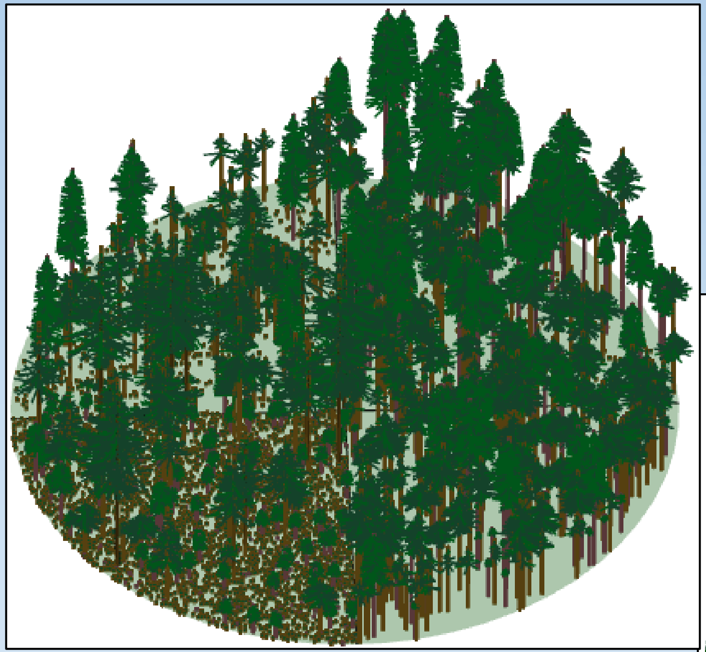
- AK Variant was released in June of 2021
- Recognizes 21 tree species commonly found in major forest types in Alaska

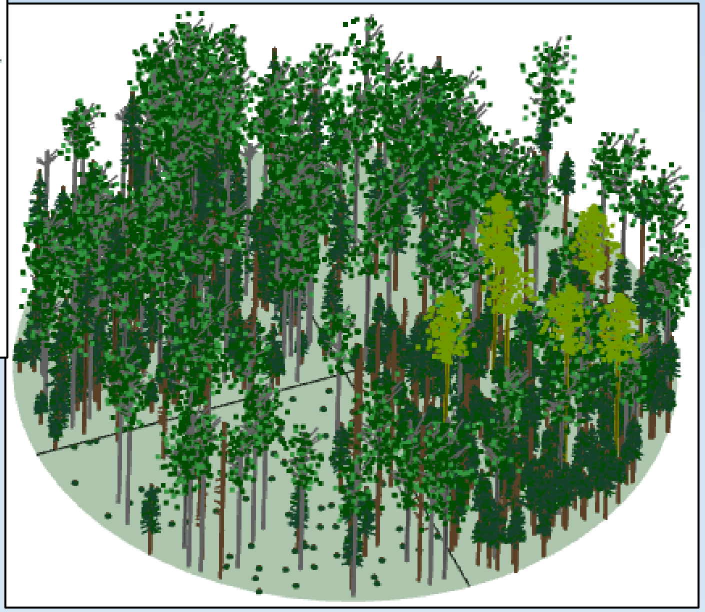

USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Alaska (AK) Variant Overview of the Forest Vegetation Simulator

October 2021

Denali National Park, AK
(Chad Keyser, FS)





Diameter Growth and Mortality

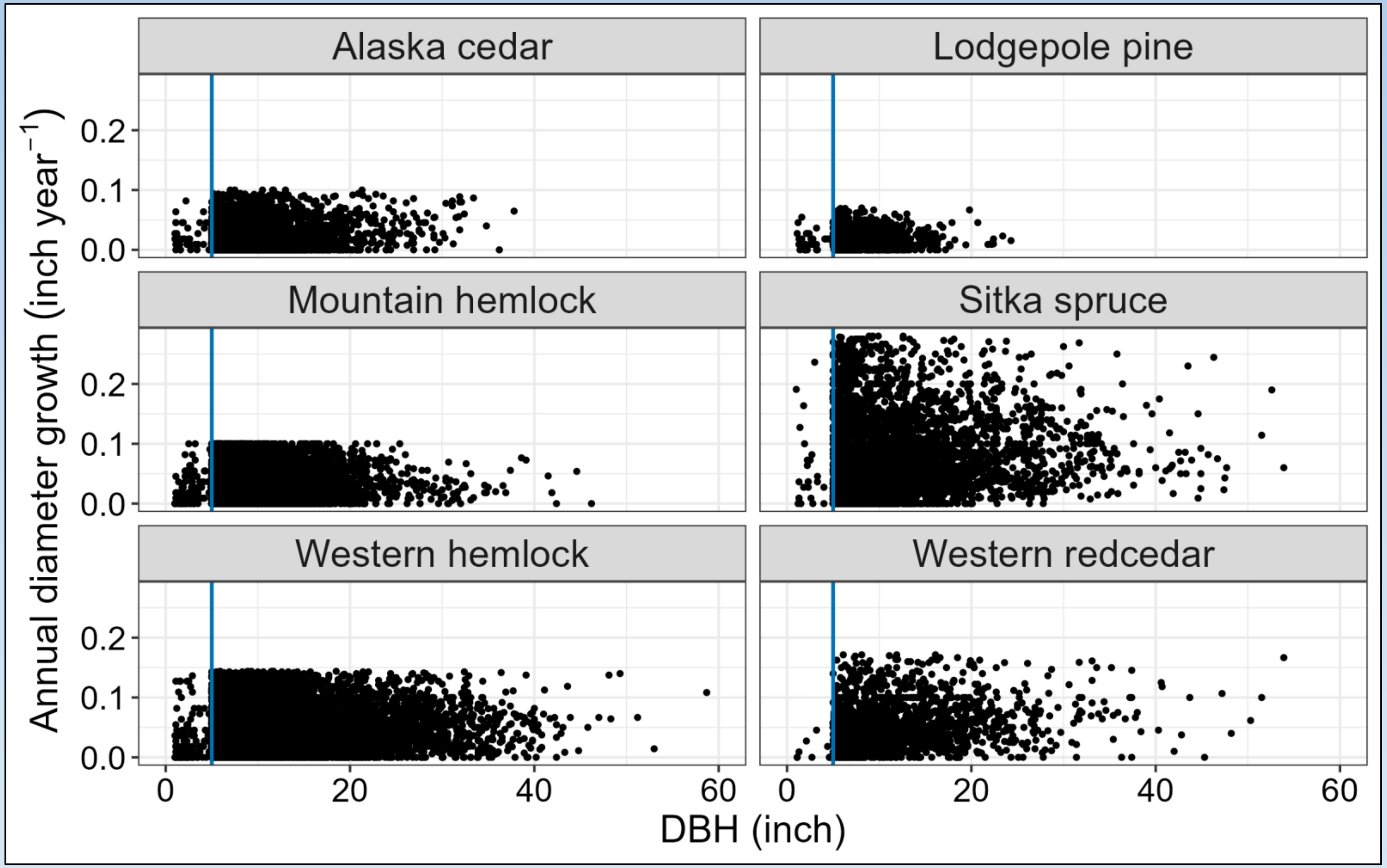
Relationship	
Height diameter	✓
Bark thickness	✓
Crown width	✓
Crown ratio	✓
Diameter growth	✓
Height growth	✓
Mortality	✓
Regeneration	✓

Diameter growth and mortality for species in Southeast Alaska

- Challenges
- Modeling Approaches
- Outcomes

Diameter Growth

- Inconsistent measurement intervals (mean = 11, min = 4, max = 18)
- Limited sample size in smaller and larger diameter classes



Species	Growth observations
YC	2781
LP	879
MH	5872
SS	4346
WH	10395
RC	1546
All	25819

Diameter Growth Modeling Approach

Challenge 1: Inconsistent measurement intervals

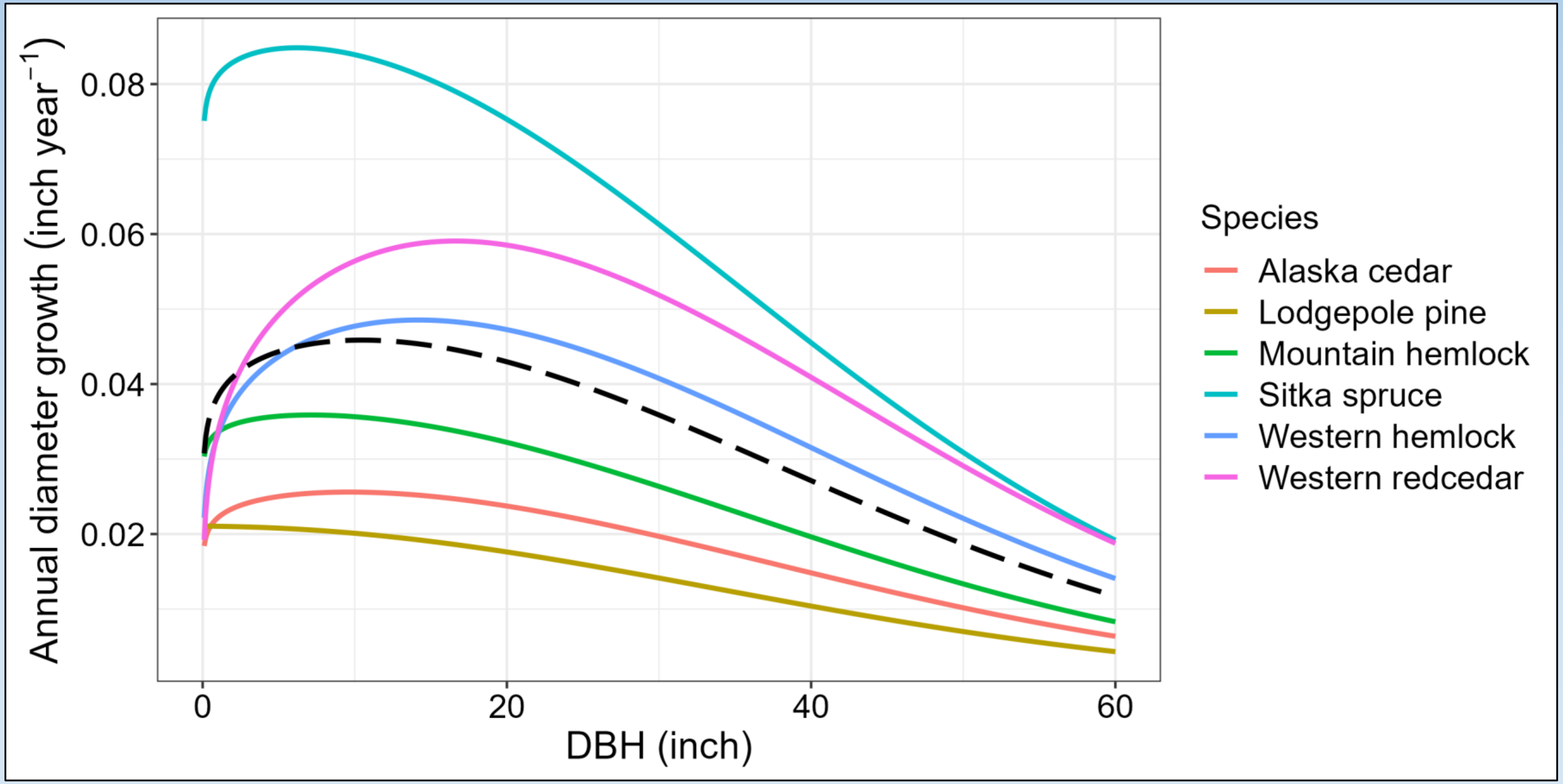
- Modeled annualized diameter growth (Cao 2000, Weiskittel et al. 2007, Kuehne et al. 2020 and 2022)
- Bring growth predictions to a consistent timestep
- Leverages more of the available data and avoids manipulation of response variable

Challenge 2: sample size limitations across species and diameter ranges

- Mixed effects modelling with species treated as random effects

Mixed Effects Modeling

- Fit global equation and add species random effects to a subset of parameters
- Use partial pooling to borrow information from other species to derive more realistic growth curves when data is limited



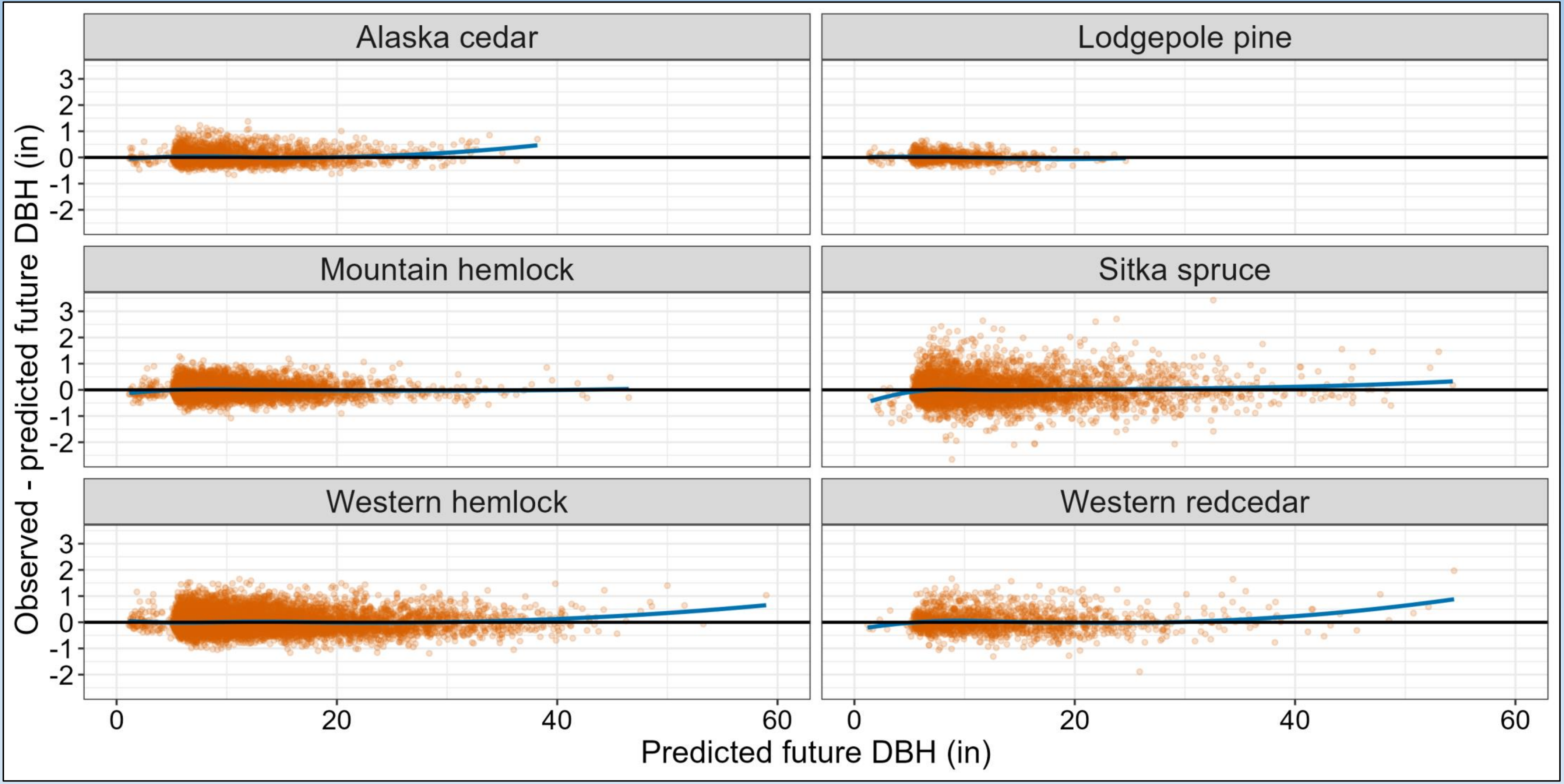
Diameter Growth Model

ADI = exp(X)

X = (b_1 + **sp**) + (b_2 + **sp**) * ln(DBH) + b_3 * DBH^2 + (b_4 + **sp**) * BAL + b_5 * ln(CR) + b_6 * Slope + b_7 * Slope * cos(Aspect) + b_8 * ln(SI)

- ADI = annualized diameter growth
- DBH = diameter at breast height
- BAL = basal area in trees larger than subject tree
- CR = crown ratio
- Slope = percent slope
- Aspect = aspect in radians
- SI = site index
- sp = species random effect

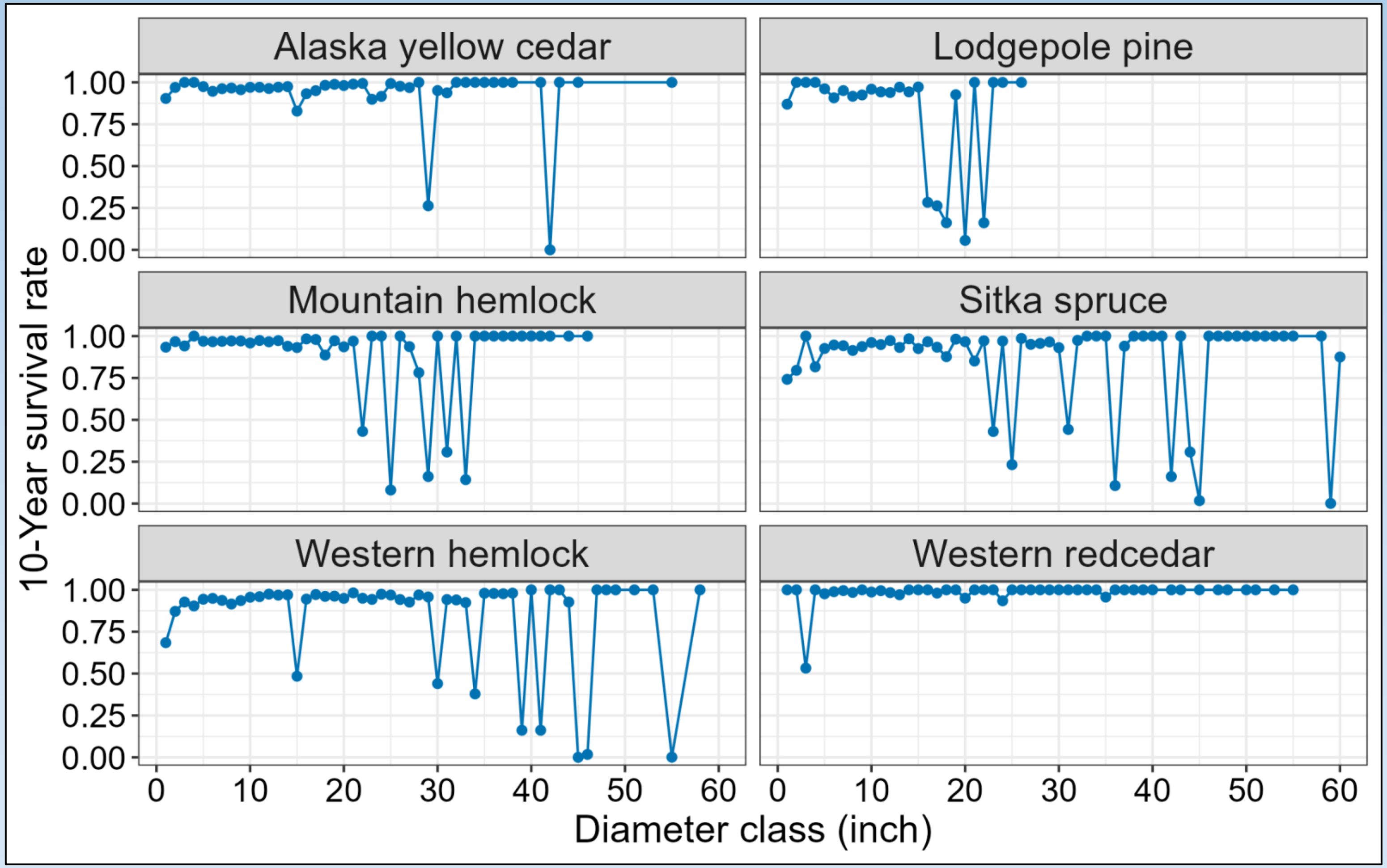
Diameter Growth Results



RMSE	MB	MB%	MAB	MAB%
0.3622	-0.0065	0.1097	0.2660	2.7440

Survival

- Inconsistent measurement intervals (mean 11, min 4, max = 18)
- Limited sample size in larger diameter classes (2160 trees above 24” DBH)



Species	Live	Dead
YC	5517	276
LP	1392	105
MH	8814	374
SS	6646	379
WH	14046	908
RC	2186	34
All	38601	2076

Survival Modeling Approach

Challenge 1: Inconsistent measurement intervals

- Modeled annual tree survival using compound interest rate approach (Monserud 1976, Yang and Huang 2013, Cortini et al. 2017)
- Brings survival predictions to a consistent time step
- Leverages more of the available data

Challenge 2: sample size limitations across species and diameter ranges

- Mixed effects modelling with species treated as random effects

Survival Model

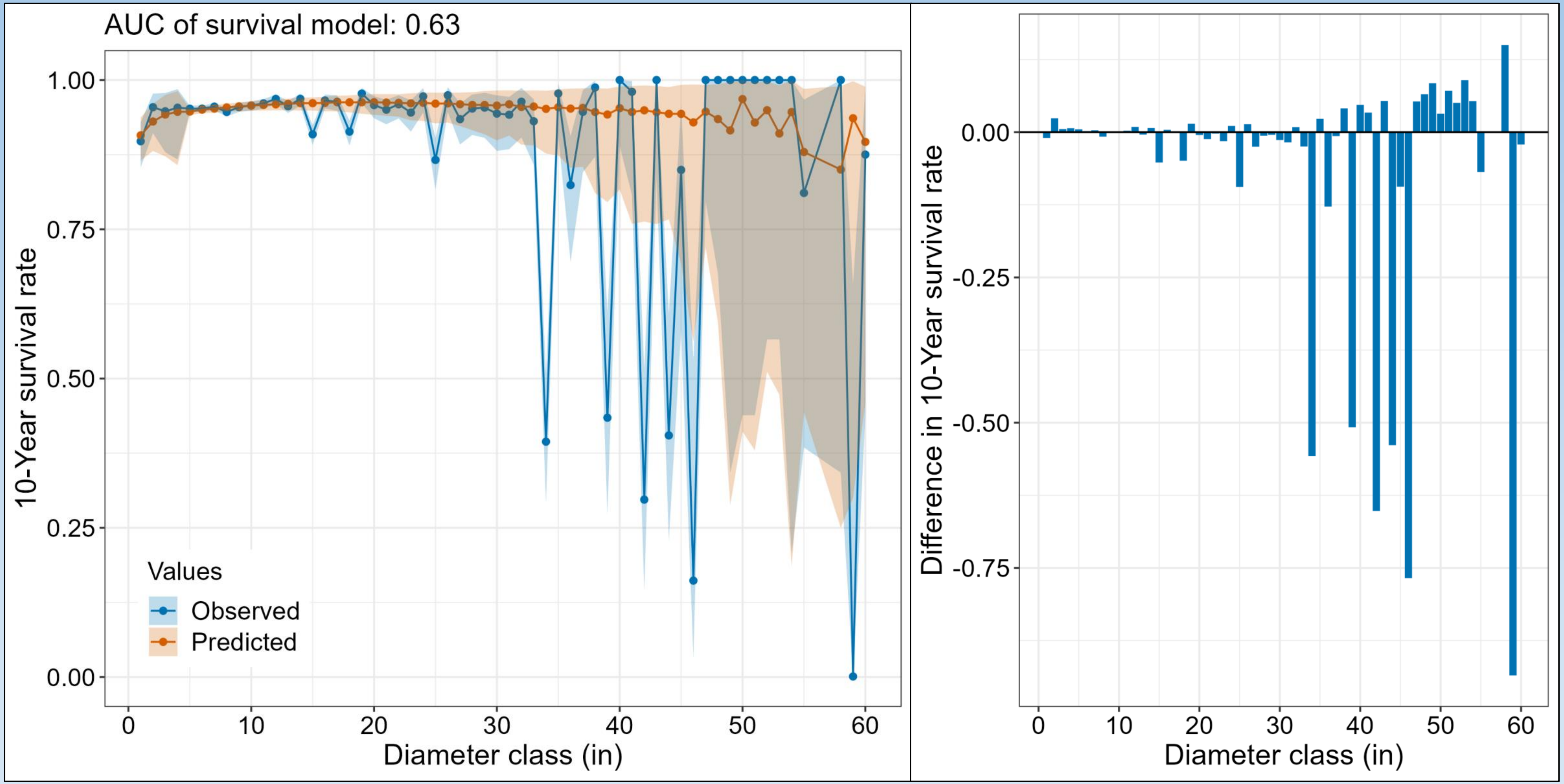
$$\text{Prob(Survival)} = (\exp(X) / (1 + \exp(X))^{L}$$

$$X = (b_1 + \mathbf{sp}) + b_2 * \text{DBH} + (b_3 + \mathbf{sp}) * \text{DBH}^2 + (b_4 + \mathbf{sp}) * \text{BAL/DBH}$$

- DBH = diameter at breast height
- BAL = basal area in trees larger than subject tree
- L = length of measurement interval
- Sp = species random effects

- Mortality rate is applied to all tree records during growth cycle
- Calculated mortality rates are reapplied to tree records if stand is predicted to exceed maximum SDI or BA

Survival Results



Future Work

- Update and further refine current equations
  - ~15,000 more diameter increment observations
  - ~21,500 more mortality observations (19712 live, 1781 dead)

- Consider alternative modeling frameworks (multistage mortality modeling?)

- Identify other key drivers in growth and mortality
  - Climate sensitivity?
  - How to get these into FVS?

Questions or Comments?