Evaluating FVS calibration options for predicting biomass accumulation across diverse Oregon landscapes

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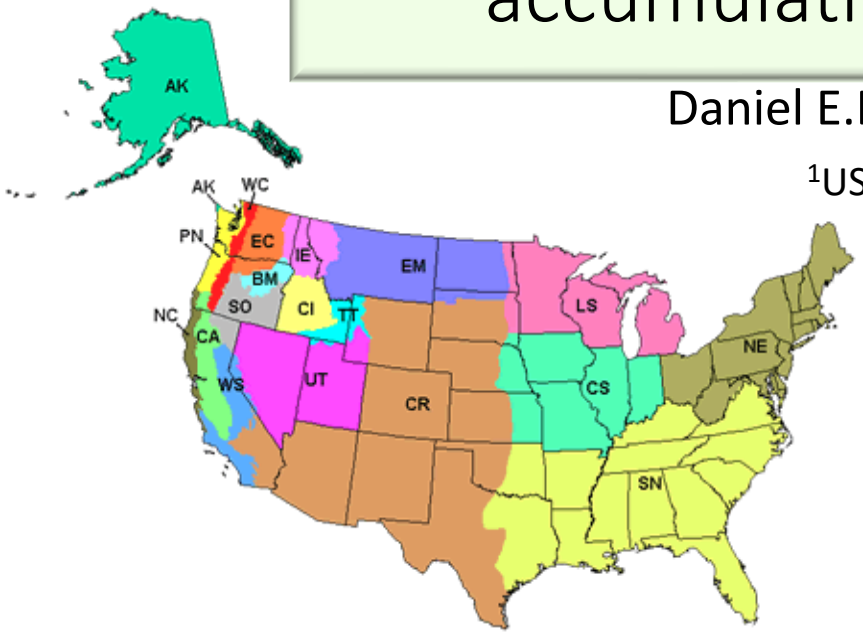
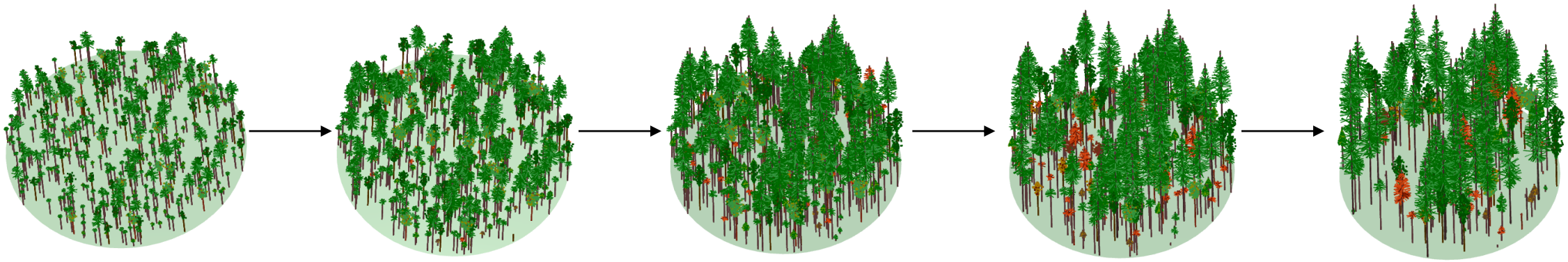
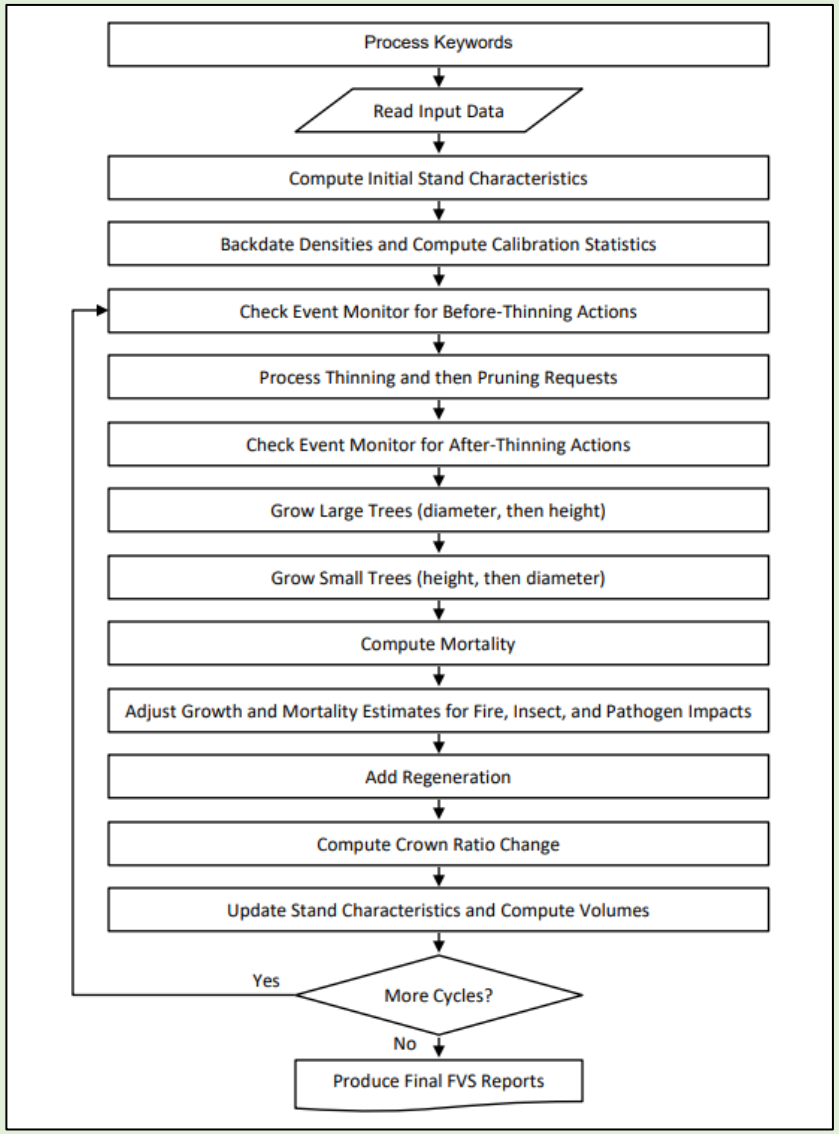




What is the Forest Vegetation Simulator (FVS)?

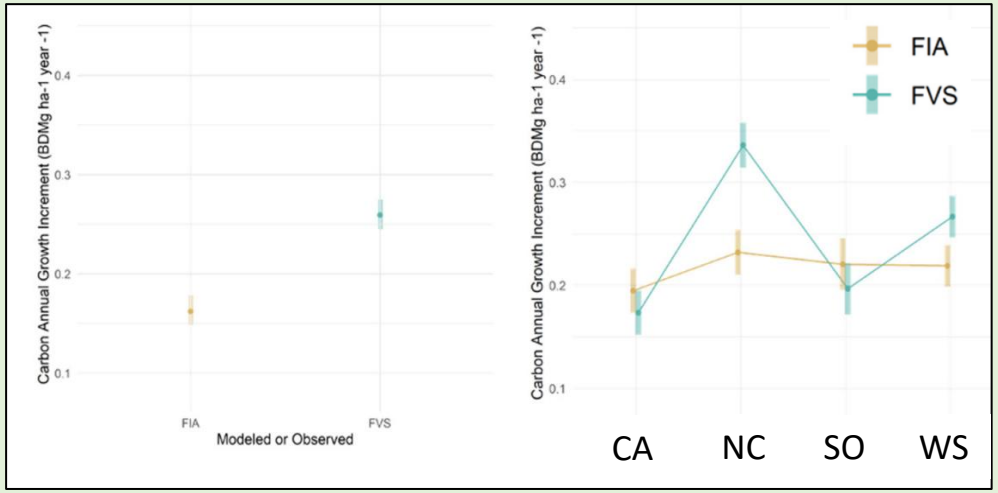
- Individual tree, empirical growth and yield model
- Statistical relationships based on remeasured field data
- Accessible
- Data inputs for FVS “out of the box” (OOB)
    1. Tree list
    2. Site attributes (e.g., site index)



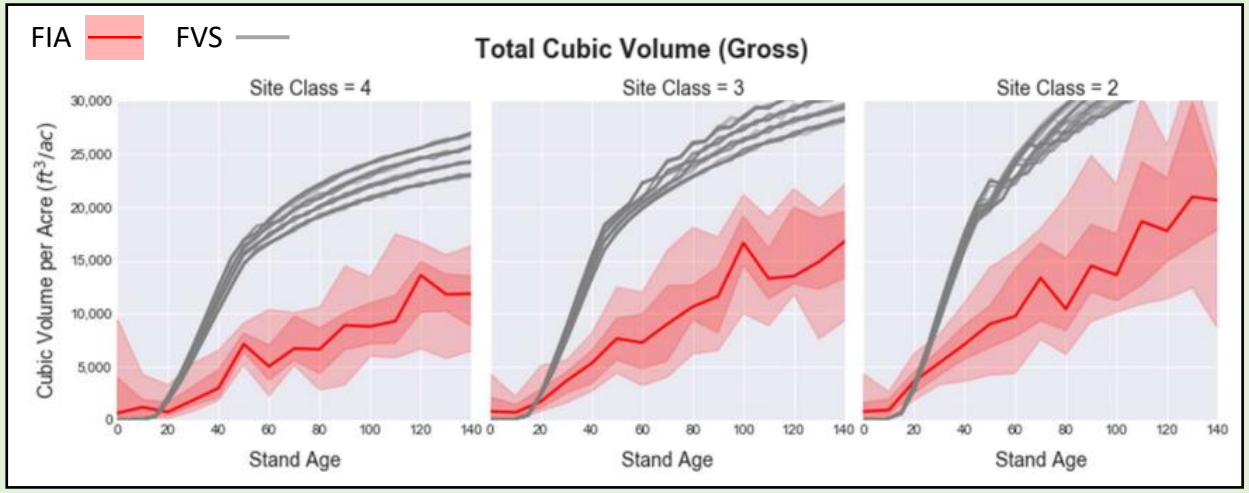
Dixon (2002) – Essential FVS

FVS OOB tends to overpredict stand growth

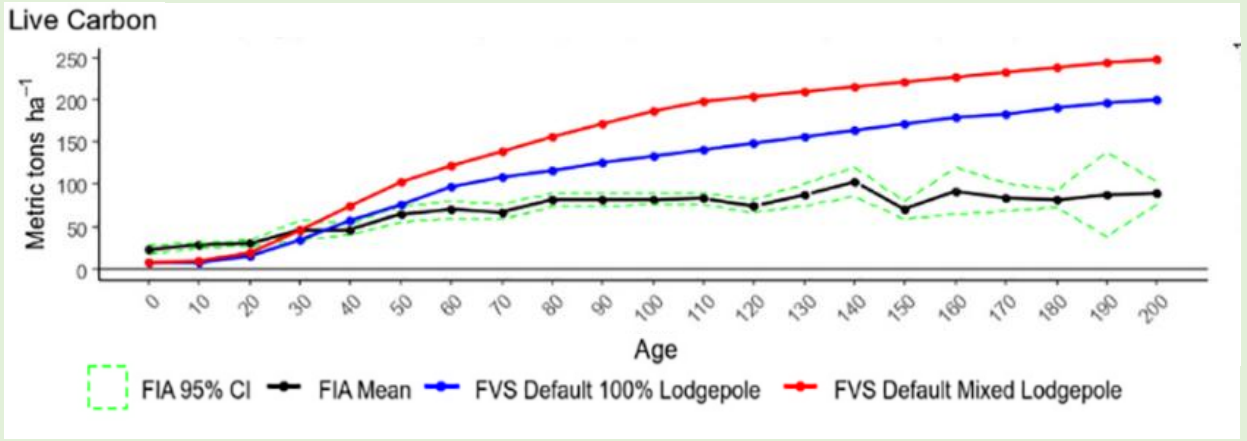
Herbert et al. (2023) – multiple variants

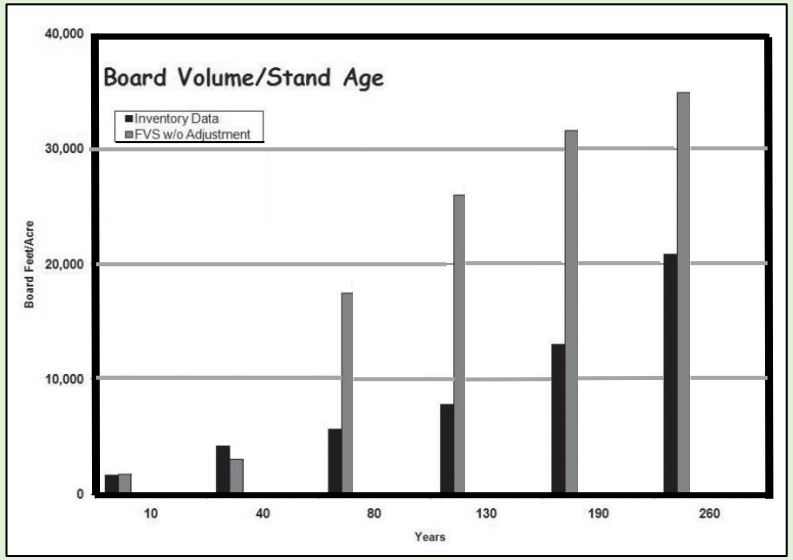


Diaz et al. (2018) – PN variant



Bagdon et al. (2021) – CR variant





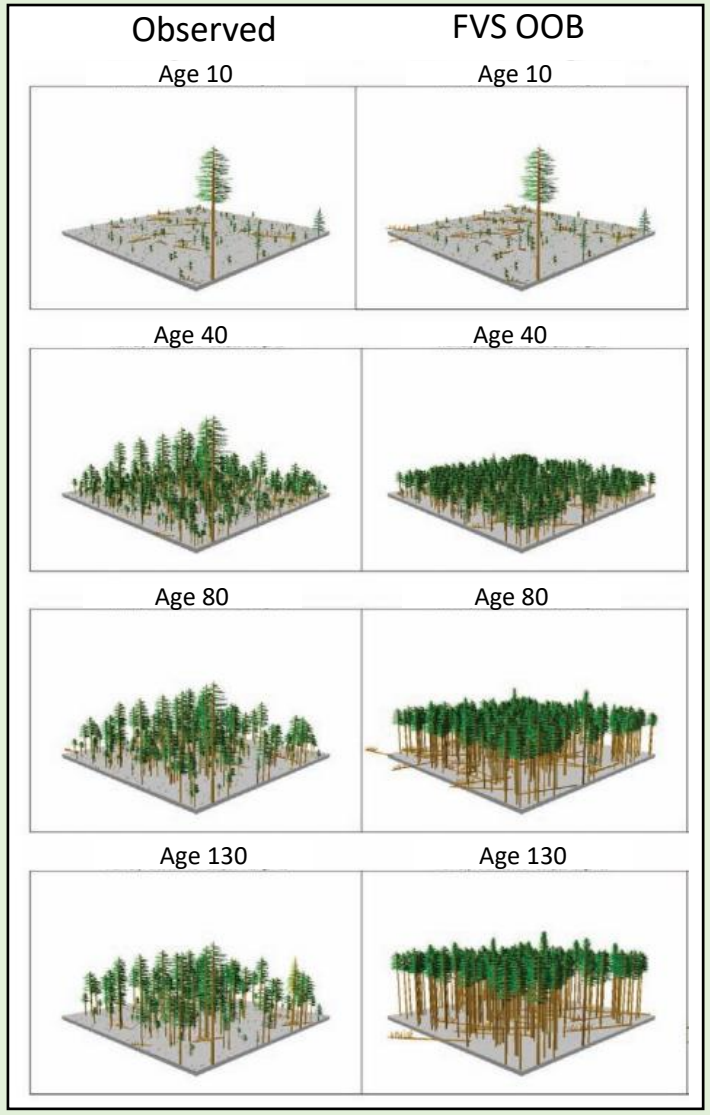
Vandendriesche (2010) – BM variant

FVS variant key:

BM: Blue Mountains
CA: Inland California
CR: Central Rockies
NC: Klamath Mountains
PN: Pacific Northwest Coast
SO: Southern OR
WS: Western Sierra Nevada

Adjustments to FVS OOB

Vandendriesche (2010) – FVS Out of the Box: Assembly Required



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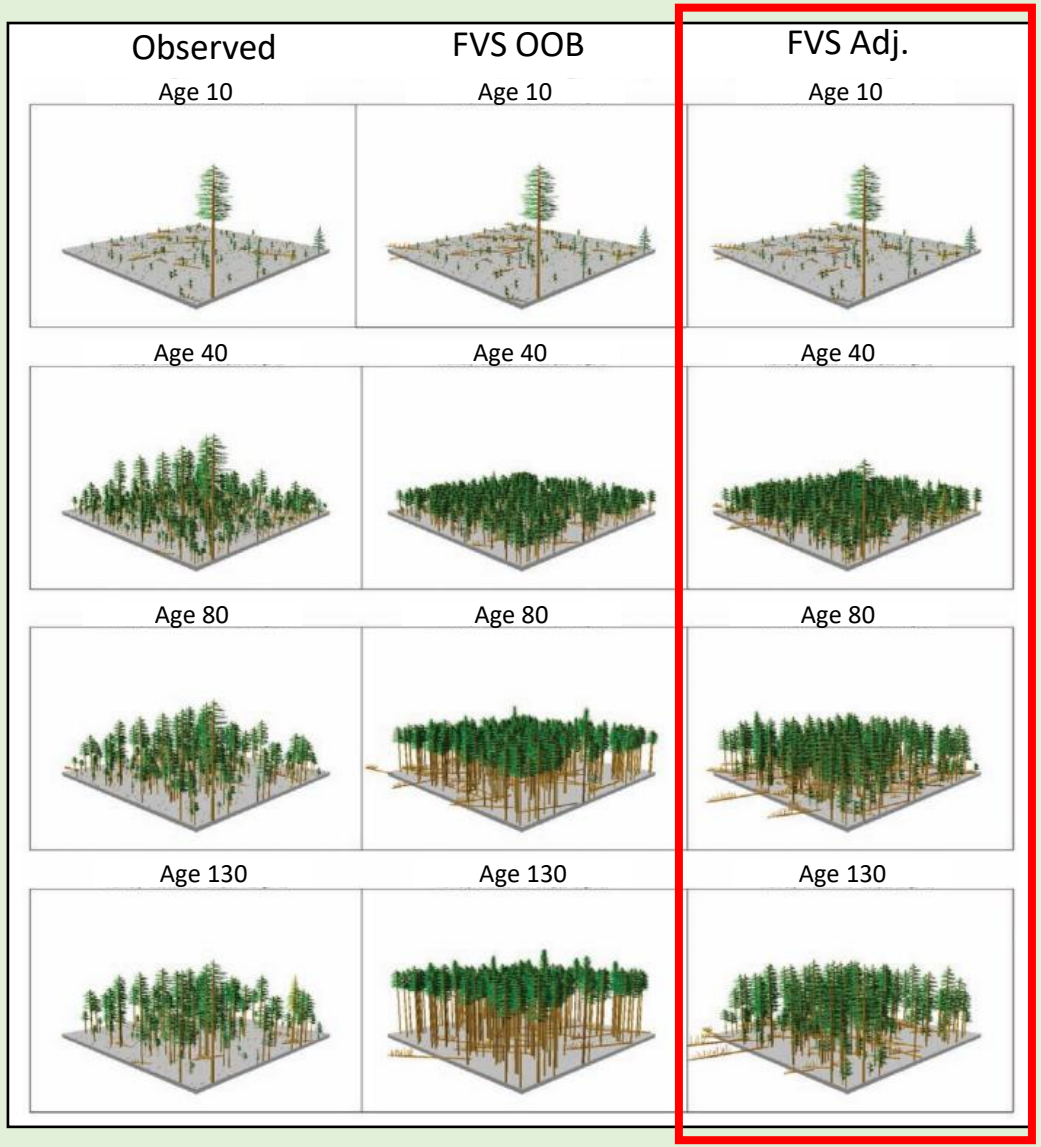

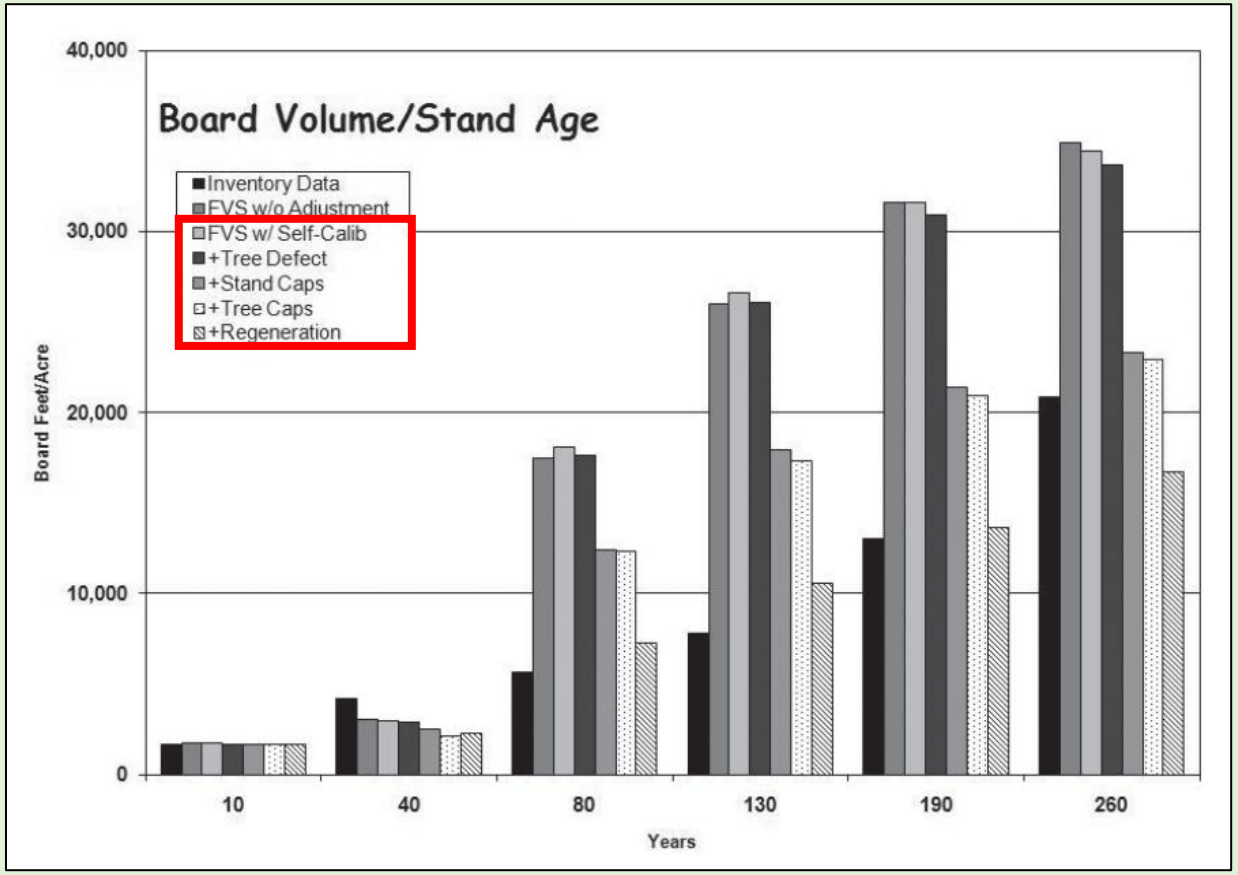

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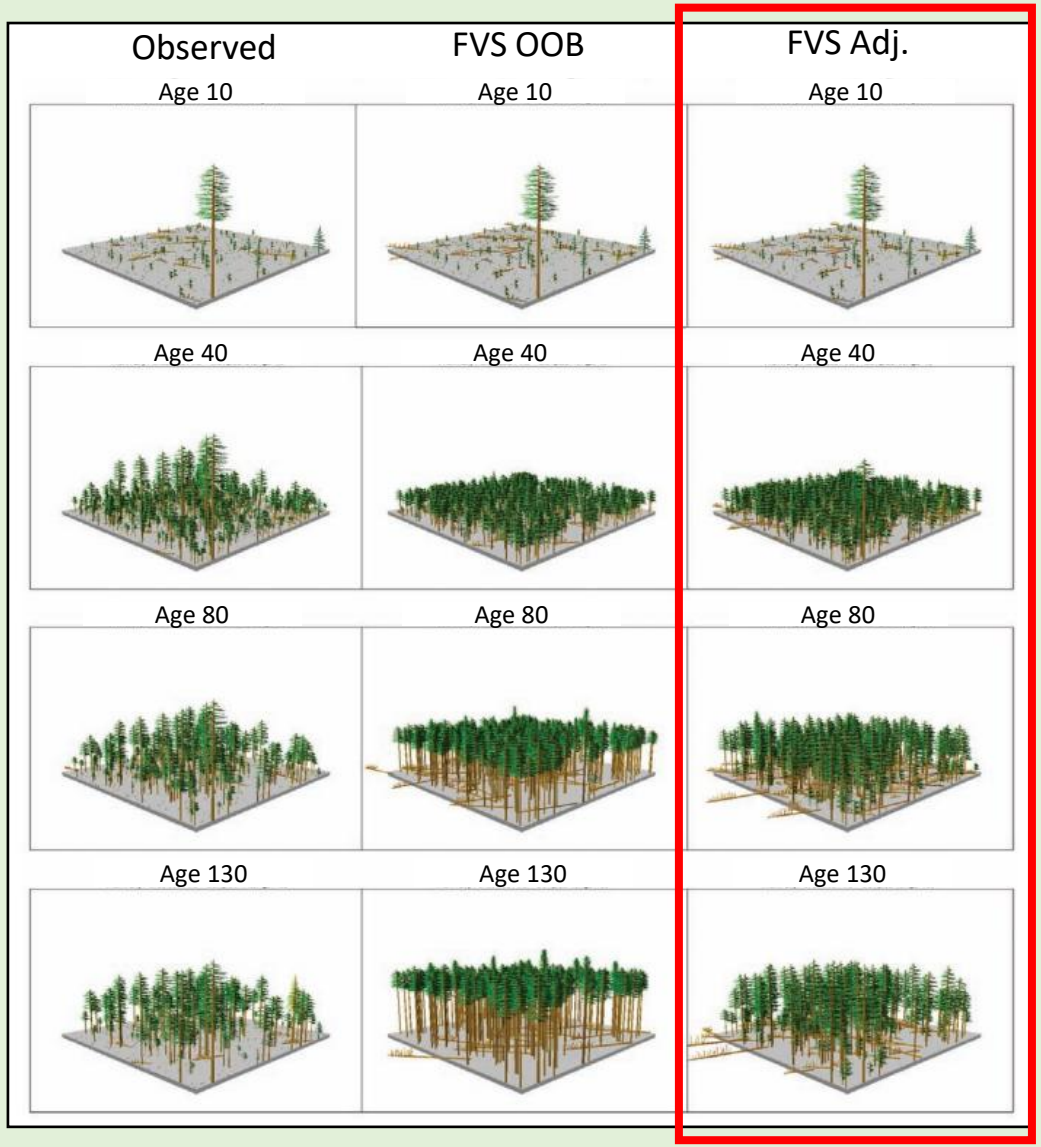
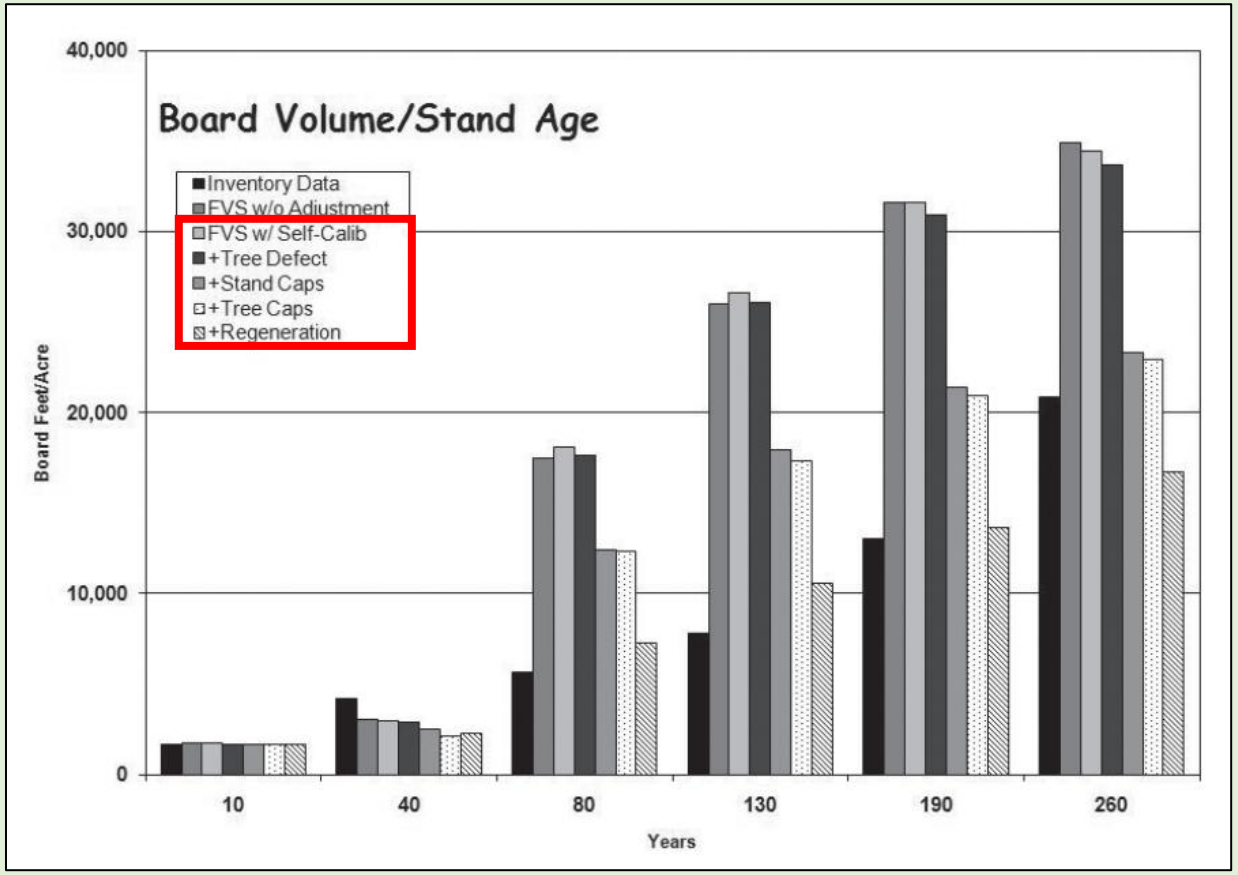




Just for bare ground simulations of ponderosa pine in Blue Mountains

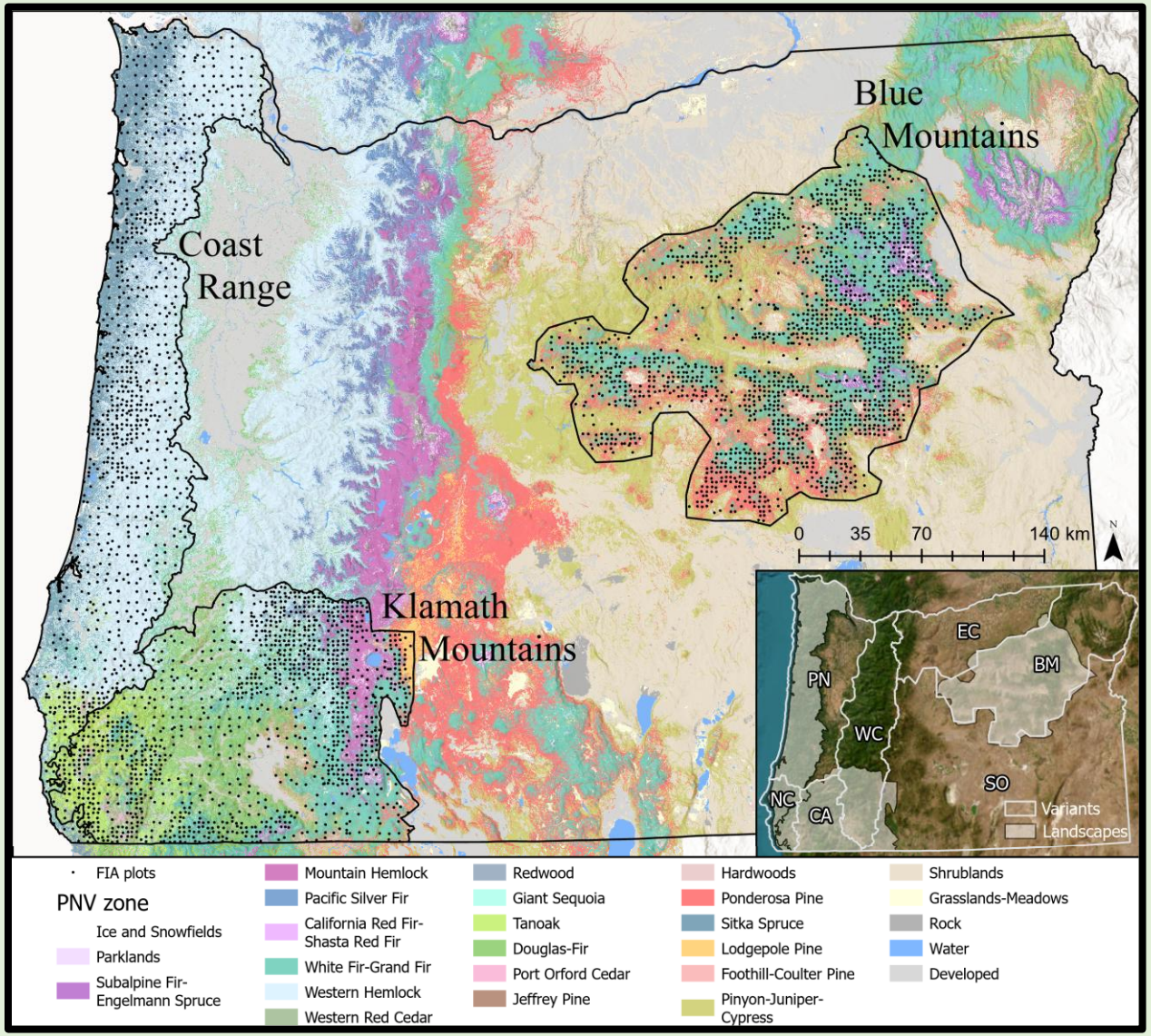
Objectives and hypotheses

1. Evaluate FVS OOB predictions across climate and forest type gradients
   i. We expect overprediction of stand growth
   ii. In particular, stand types generally considered more susceptible to changing climate and other forest health issues (e.g., grand & white fir)

2. Assess the effect of commonly deployed adjustments to FVS on stand growth

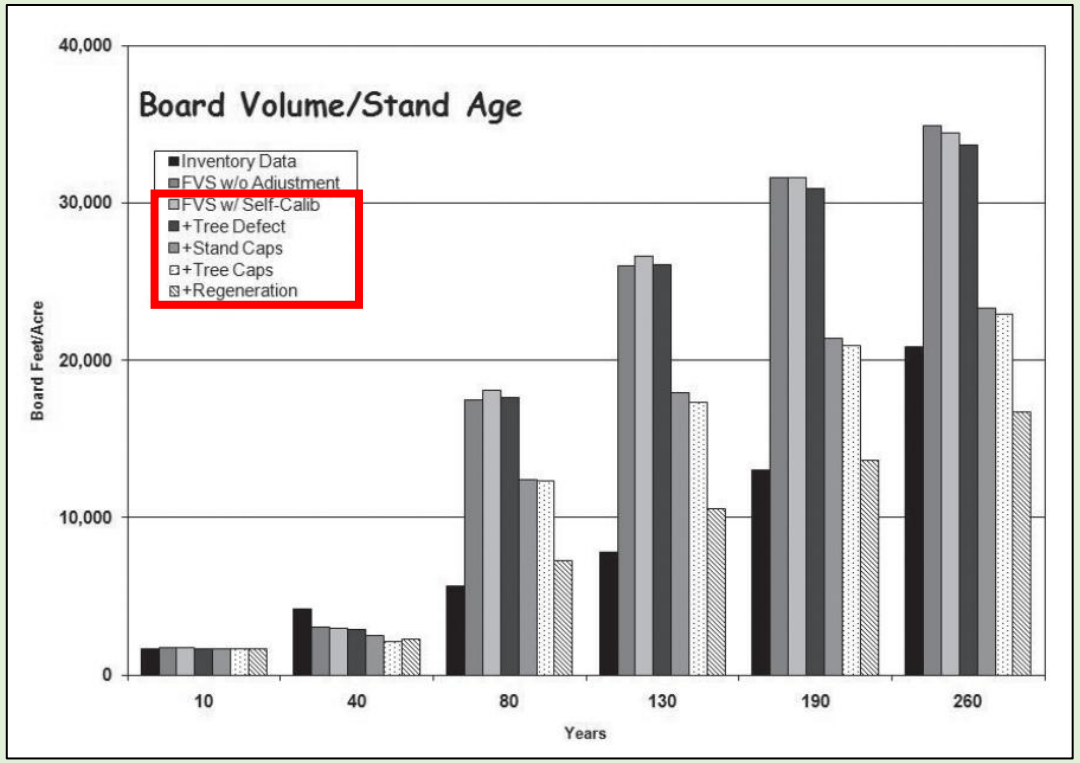
Evaluation landscapes

- Coast Range:
  - Median site class - 3
  - Median stand age - 47 years
  - 16% USFS, 30% other public, 54% private
- Klamath Mountains:
  - Median site class - 4
  - Median stand age - 95 years
  - 44% USFS, 27% other public, 29% private
- Blue Mountains:
  - Median site class - 5
  - Median stand age - 95 years
  - 68% USFS, 6% other public, 27% private



Adjustments

1. FVS w/ Self-Calib:
   - Growth multipliers based on past growth (+READCORD)
2. ~~Tree Defect~~
3. Stand Caps
   - New SDImax values (+SDIMAX)
   - From Chivhenge et al. (2025)
4. Tree Caps
   - Tree size constraints (+TREESZCP)
5. Regeneration
   - REGIMPUTE (based on REPUTE)



Vandendriesche (2010) – FVS Out of the Box: Assembly Required

Chivhenge, E., Weiskittel, A.R., Woodall, C.W., D'Amato, A.W. and Daigneault, A., 2025. Geospatial Estimation of Forest Relative Density for Carbon Stewardship Decision Support across the Continental US. *Scientific Data*, *12*(1), p.1728.

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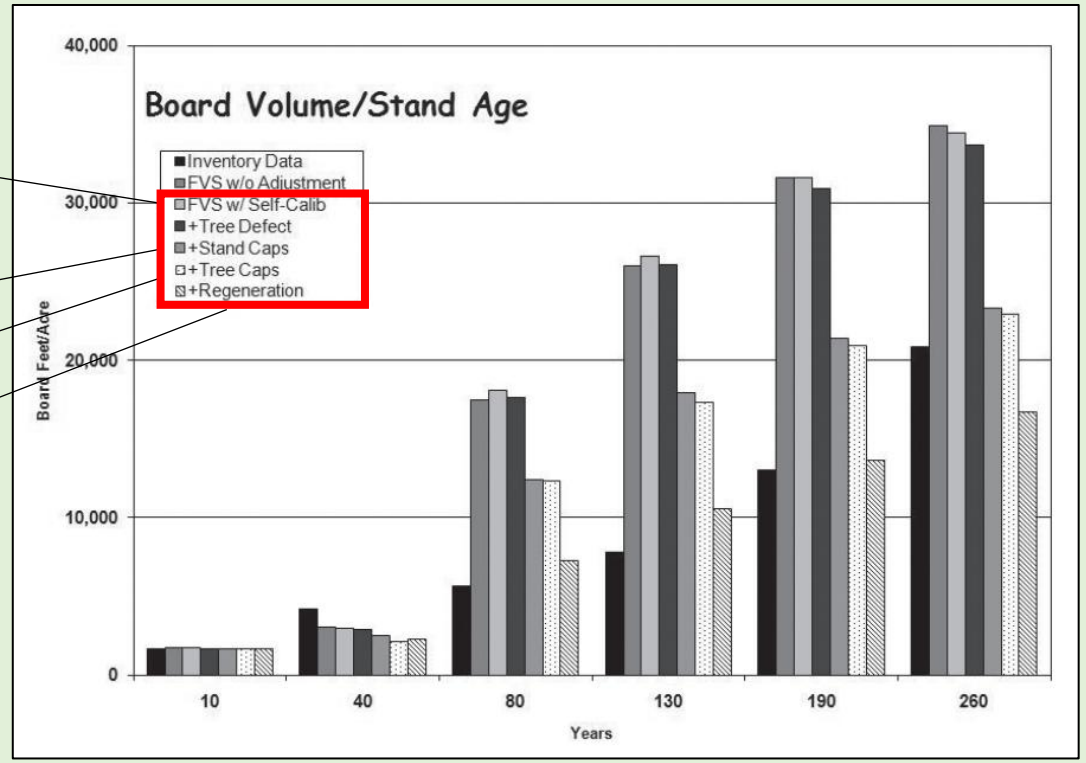

Vandendriesche (2010) – FVS Out of the Box: Assembly Required

Evaluation dataset	Time interval	Sample size
FIA remeasurements Time 1 (2000s) to Time 2 (2010s)	8 to 12 years	3290

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Evaluating FVS vs. *remeasured FIA data*

Model performance overall by landscape

Evaluation dataset	Time interval	Sample size
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Net change = G - M

Landscape	Calibration step	Net change					Growth		Mortality	
		FIA	FVS	Bias	RMSE	% error	FIA	FVS	FIA	FVS
Blue Mountains	FVS OOB	1.22	1.36	0.14	1.32	11.6%	1.63	1.74	0.41	0.38
	+READCORD	1.22	1.19	-0.03	1.25	-2.3%	1.63	1.51	0.41	0.32
	+SDIMAX	1.22	1.29	0.07	1.19	5.6%	1.63	1.53	0.41	0.24
	+TREESZCP	1.22	1.16	-0.06	1.17	-4.7%	1.63	1.39	0.41	0.23
Coast Range	FVS OOB	6.84	9.25	2.41	5.17	35.3%	7.99	10.23	1.15	0.98
	+READCORD	6.84	8.02	1.18	4.33	17.2%	7.99	8.93	1.15	0.92
	+SDIMAX	6.84	7.79	0.95	4.31	13.9%	7.99	8.80	1.15	1.01
	+TREESZCP	6.84	7.45	0.61	4.33	8.9%	7.99	8.45	1.15	1.00
Klamath Mountains	FVS OOB	3.03	3.82	0.80	3.73	26.3%	4.22	4.50	1.20	0.68
	+READCORD	3.03	3.76	0.74	3.62	24.3%	4.22	4.41	1.20	0.65
	+SDIMAX	3.03	3.47	0.44	3.76	14.6%	4.22	4.33	1.20	0.86
	+TREESZCP	3.03	3.08	0.06	3.82	1.9%	4.22	3.90	1.20	0.82

Evaluating FVS vs. *remeasured FIA data*

Model performance overall by landscape

- FVS OOB overpredicted net change

Pos. = overprediction
Neg. = underprediction

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Evaluating FVS vs. *remeasured FIA data*

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- FVS OOB overpredicted net change
- Calibrations reduce overprediction biases

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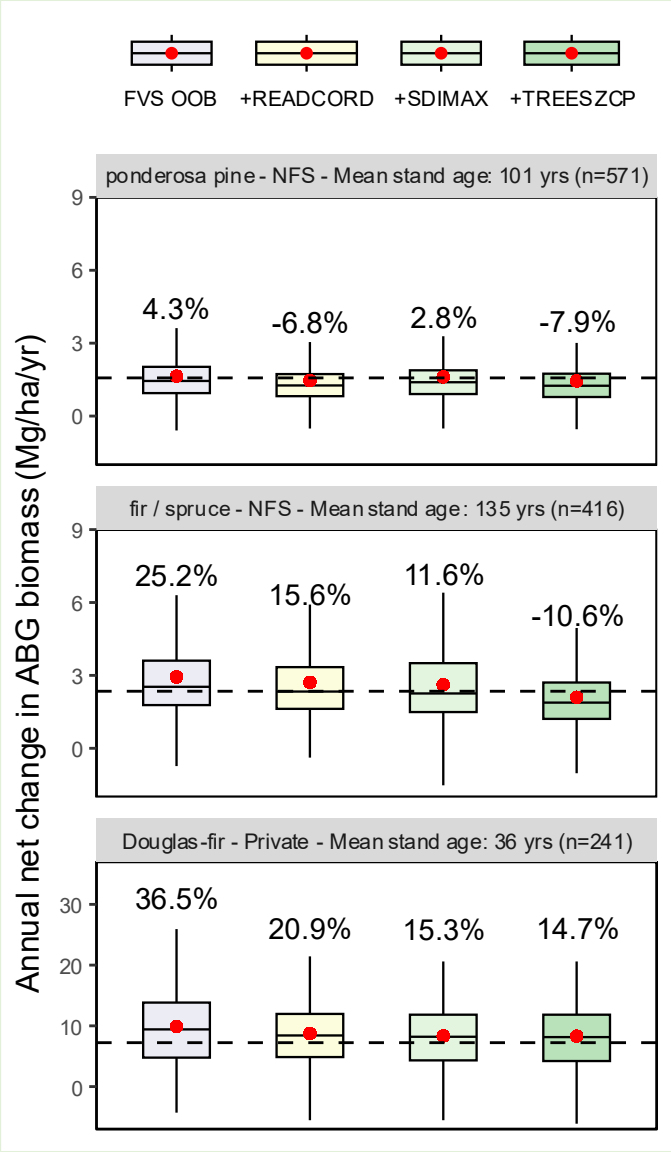
Evaluating FVS vs. *remeasured FIA data*

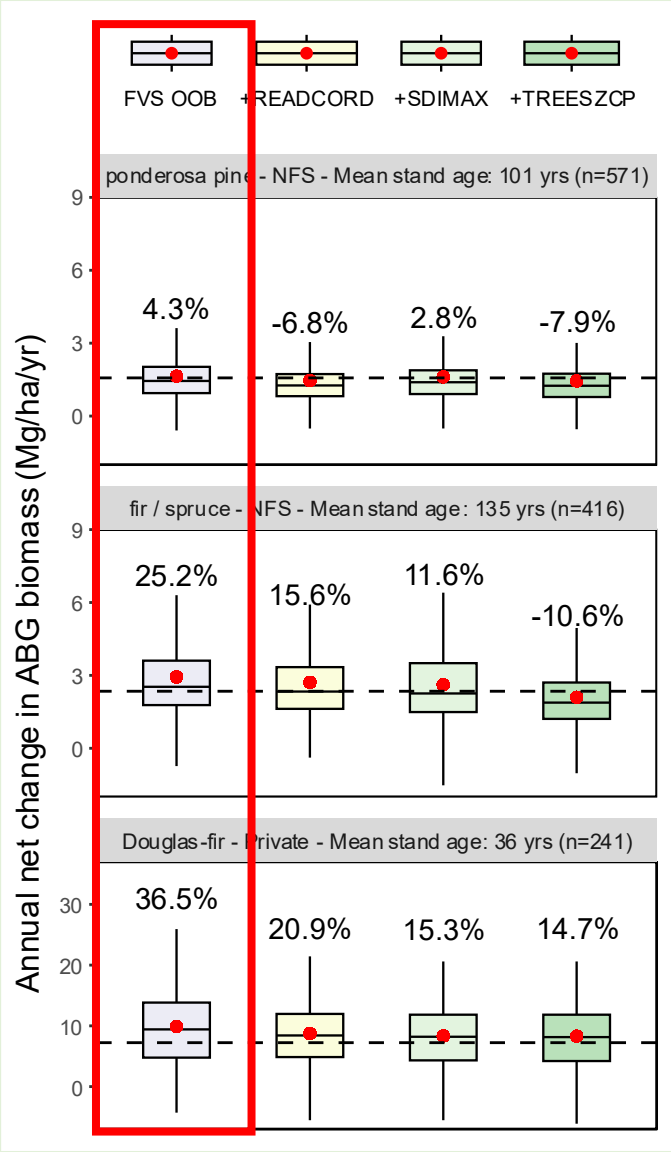
Model performance by stand/site attributes



Evaluating FVS vs. *remeasured FIA data*

Model performance by stand/site attributes

- FVS OOB:
  - Ponderosa pine stands well-modeled
  - Performance for fir/spruce stands poor
  - Younger Douglas-fir stands on private lands have very high net change % error initially



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- ❑ FVS OOB:
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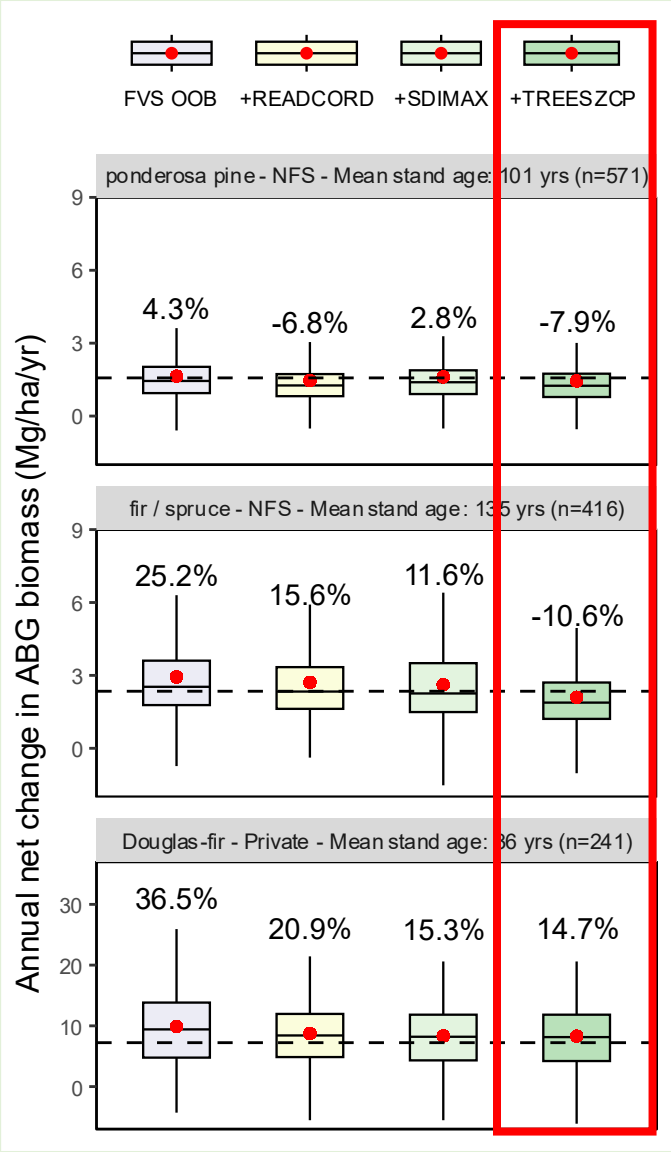
  - Performance for fir/spruce stands poor
  - Douglas-fir stands on private lands have very high net change % error initially
- ❑ Adjustments:
  - Collectively, % error *is* shifted closer to 0
  - Applying all of the calibrations can overcompensate, in certain cases



Evaluating FVS vs. *remeasured FIA data* (climate context)

Model performance by remeasurement interval

- Quantified average Drought Severity and Coverage Index (DSCI) for each 10-year FIA remeasurement period
- For each interval, compared DSCI to FVS model performance

Landscape	Remeasurement interval	Avg. DSCI	Net change		
			FIA	FVS	% error
Blue Mountains	2001 to 2011	130	0.96	1.33	37.8%
	2002 to 2012	105	1.33	1.52	14.0%
	2003 to 2013	92	1.26	1.38	9.9%
	2004 to 2014	81	1.34	1.24	-7.6%
	2005 to 2015	97	1.31	1.46	10.8%
	2006 to 2016	107	1.12	1.30	16.1%
	2007 to 2017	124	1.22	1.43	17.1%
	2008 to 2018	115	1.25	1.37	9.5%
	2009 to 2019	128	1.17	1.23	5.5%
	2011 to 2021	146	1.00	1.55	54.6%
Coast Range	2001 to 2011	43	7.17	8.06	12.4%
	2002 to 2012	21	8.02	10.26	27.9%
	2003 to 2013	20	7.11	8.83	24.3%
	2004 to 2014	19	7.33	9.12	24.6%
	2005 to 2015	36	8.21	10.40	26.7%
	2006 to 2016	50	5.76	8.95	55.2%
	2007 to 2017	56	5.84	9.05	54.9%
	2008 to 2018	56	6.05	8.56	41.4%
	2009 to 2019	71	6.17	9.83	59.2%
	2011 to 2021	92	6.64	10.32	55.5%
Klamath Mountains	2001 to 2011	67	3.05	4.25	39.3%
	2002 to 2012	37	2.89	3.94	36.1%
	2003 to 2013	35	3.55	4.03	13.5%
	2004 to 2014	42	2.97	3.29	10.8%
	2005 to 2015	71	2.95	3.57	21.1%
	2006 to 2016	94	2.94	4.17	42.0%
	2007 to 2017	101	2.85	3.09	8.4%
	2008 to 2018	99	3.24	4.63	42.8%
	2009 to 2019	115	2.87	3.65	27.3%
	2011 to 2021	136	1.68	2.75	63.9%

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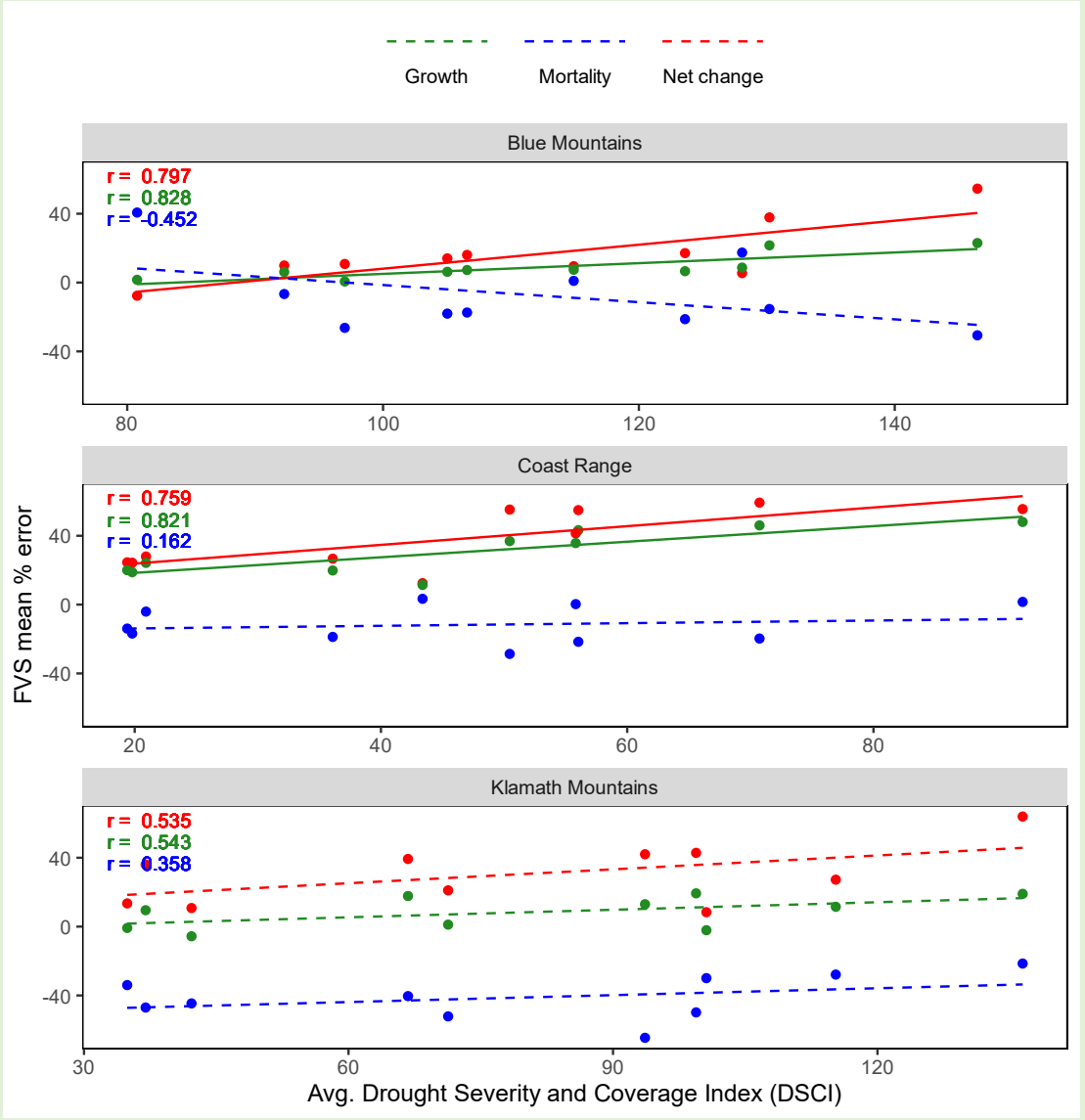
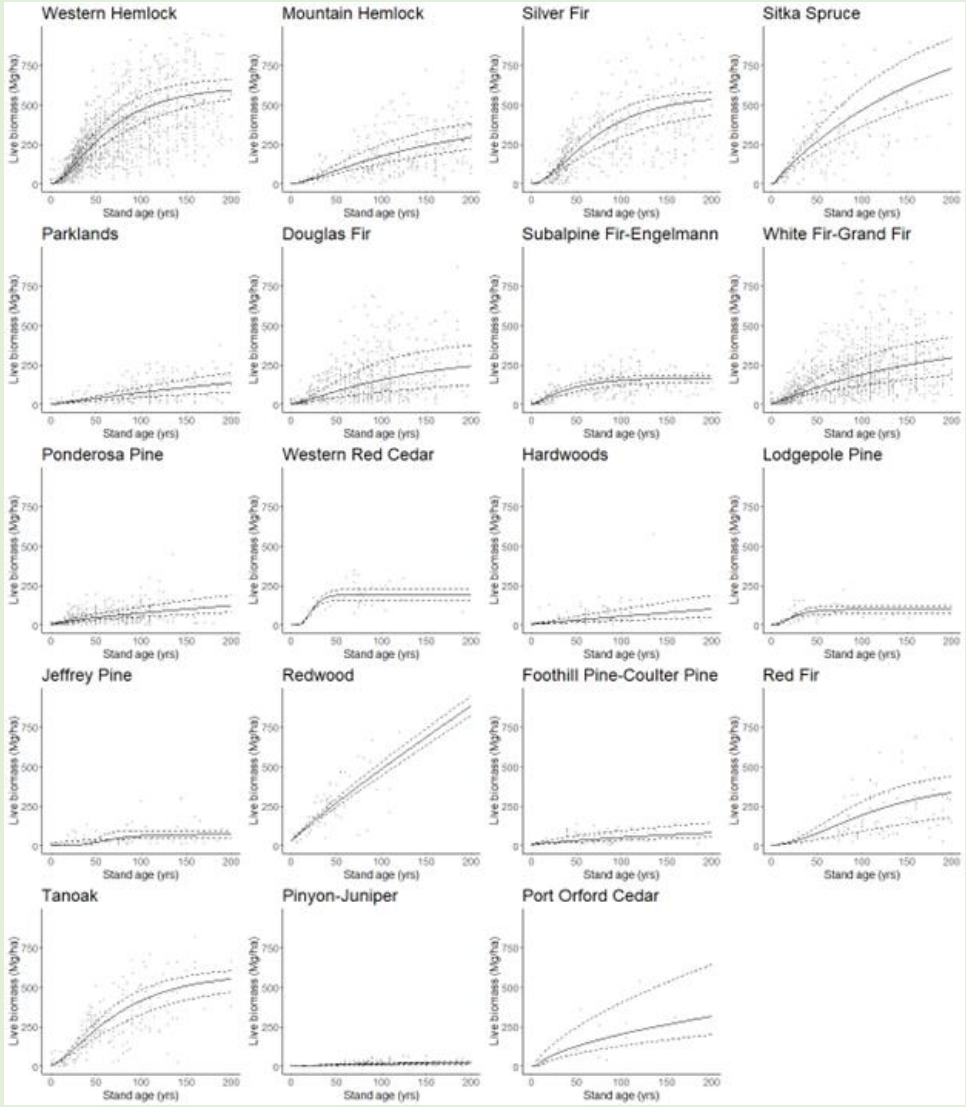
- For each interval, compared DSCI to FVS model performance
- For 2 of the 3 landscapes, we found significant ($p < 0.05$) correlation between mean DSCI and FVS mean % error



Evaluating FVS vs. *yield curves*

- Curves are from Chisholm & Gray (2024)
- Curves were fit to FIA data that had no fire or harvest since stand origin
- Curves estimate total live biomass (roots, wood, bark, and foliage)
- Curves for potential vegetation zone are based on 2 parameters:
  - Productivity (Mean annual increment at culmination, MAI)
  - Stockability (Maximum canopy cover, MCC)

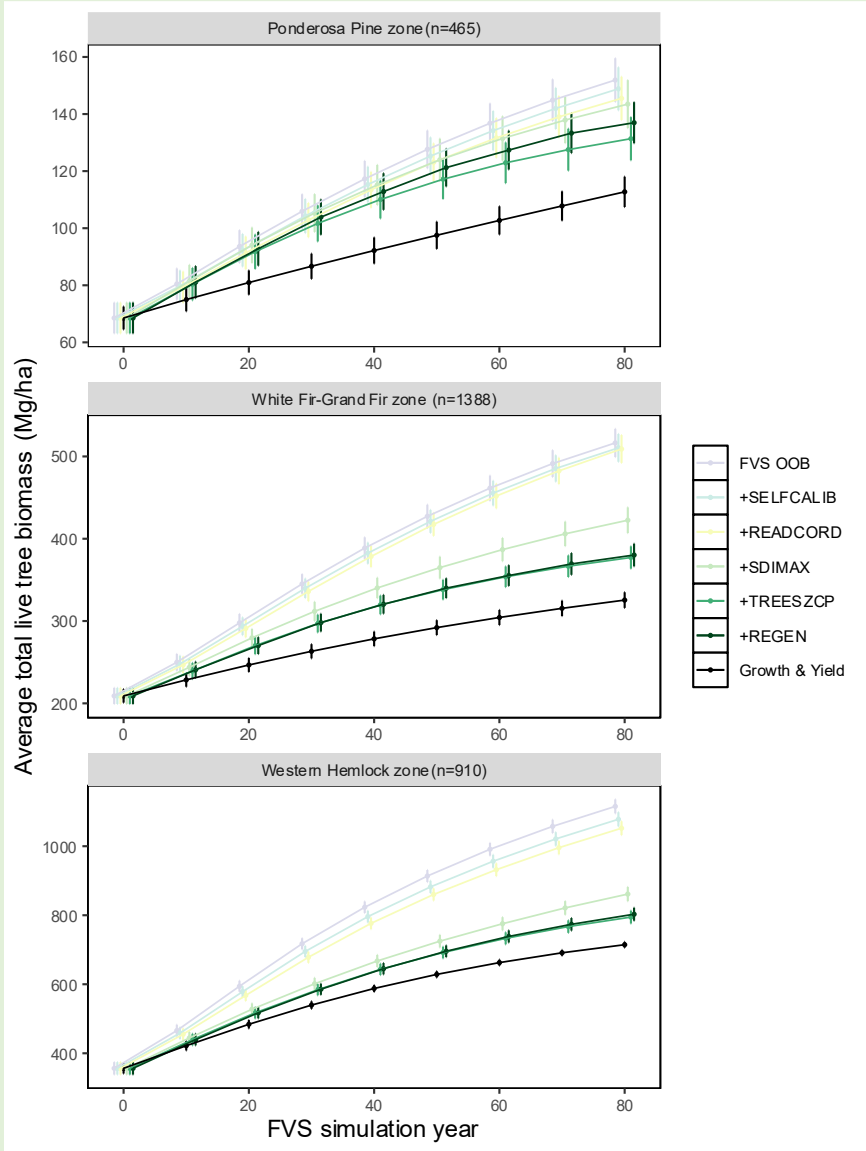
$$y(t) = a_1 MCC^{b1}\left(1 - e^{-a_2 MAI^{b2} t}\right)^{a_3 MAI^{b3}}$$



Chisholm, P.J. and Gray, A.N., 2024. Forest carbon sequestration on the west coast, USA: Role of species, productivity, and stockability. *Plos one*, *19*(5), p.e0302823.

Evaluating FVS vs. *yield curves*

Model agreement by vegetation zone



Evaluating FVS vs. *yield curves*

Model agreement by vegetation zone

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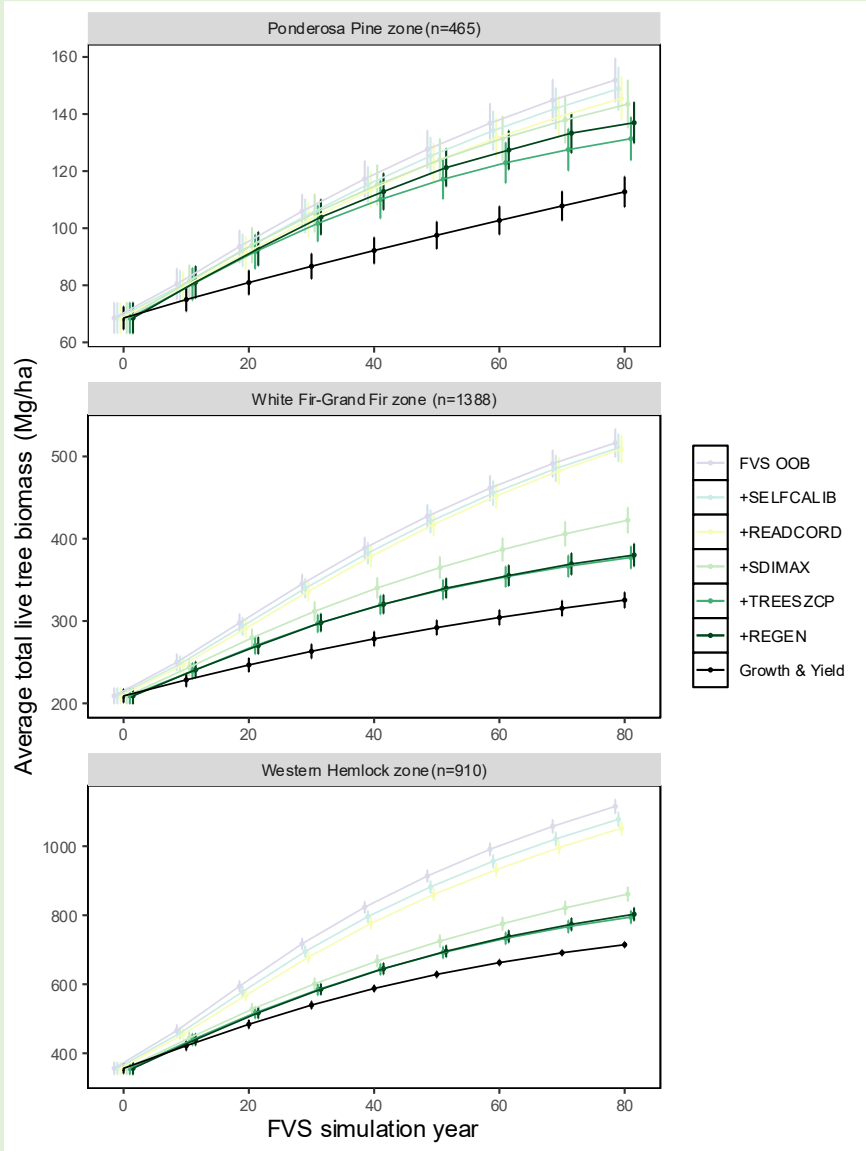
  - Ponderosa pine zones exhibited most agreement
  - Western hemlock zones exhibited most disagreement



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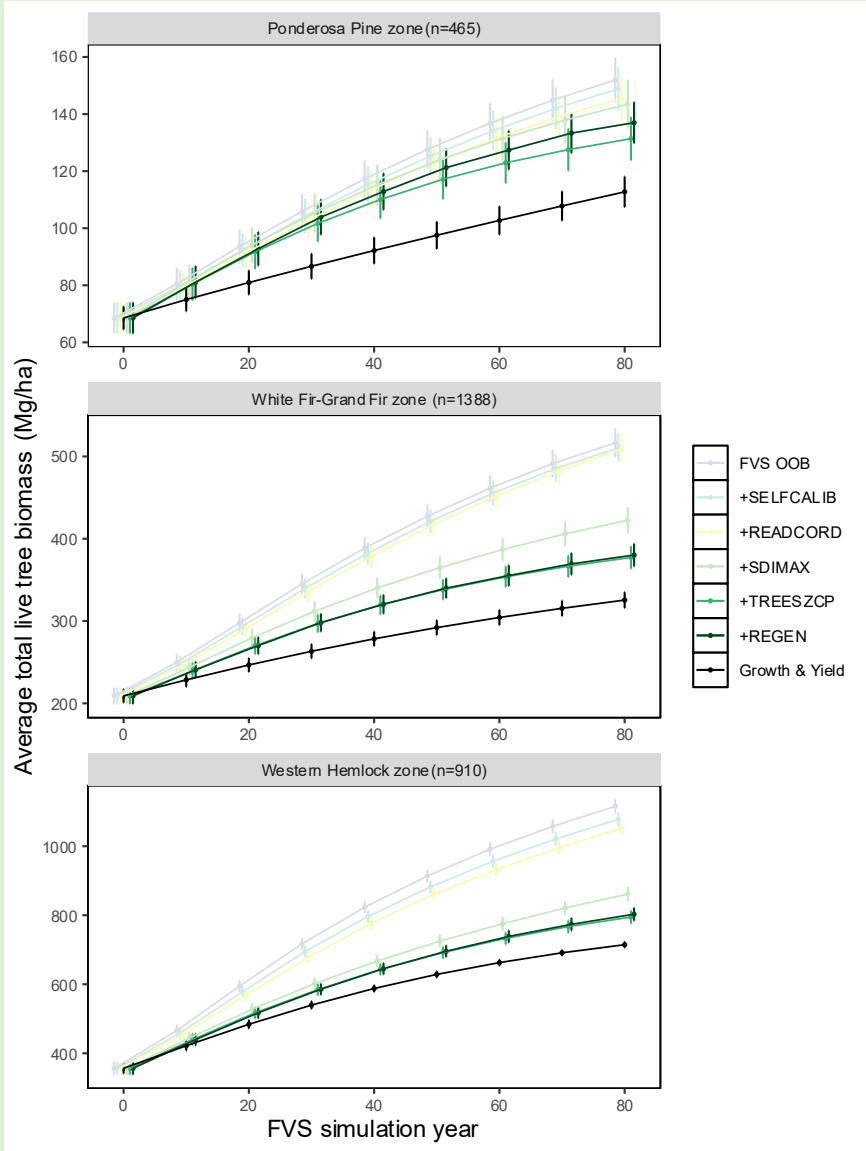
- Adjustments:
  - Long-term predictions are much more impacted by SDIMAX and TREESZCP (but not in PIPO zone)
  - Regeneration had barely any impact
  - Overall, much higher agreement between models after calibration adjustments



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- ❑ Limitations of model evaluation
  - We only evaluated net change in live tree biomass
  - Calibrations were applied in the spirit of the Vandendriesche paper and so were applied at the species-level, but consistently across the entire landscape
  - Long-term evaluation was really a model comparison, not field data evaluation