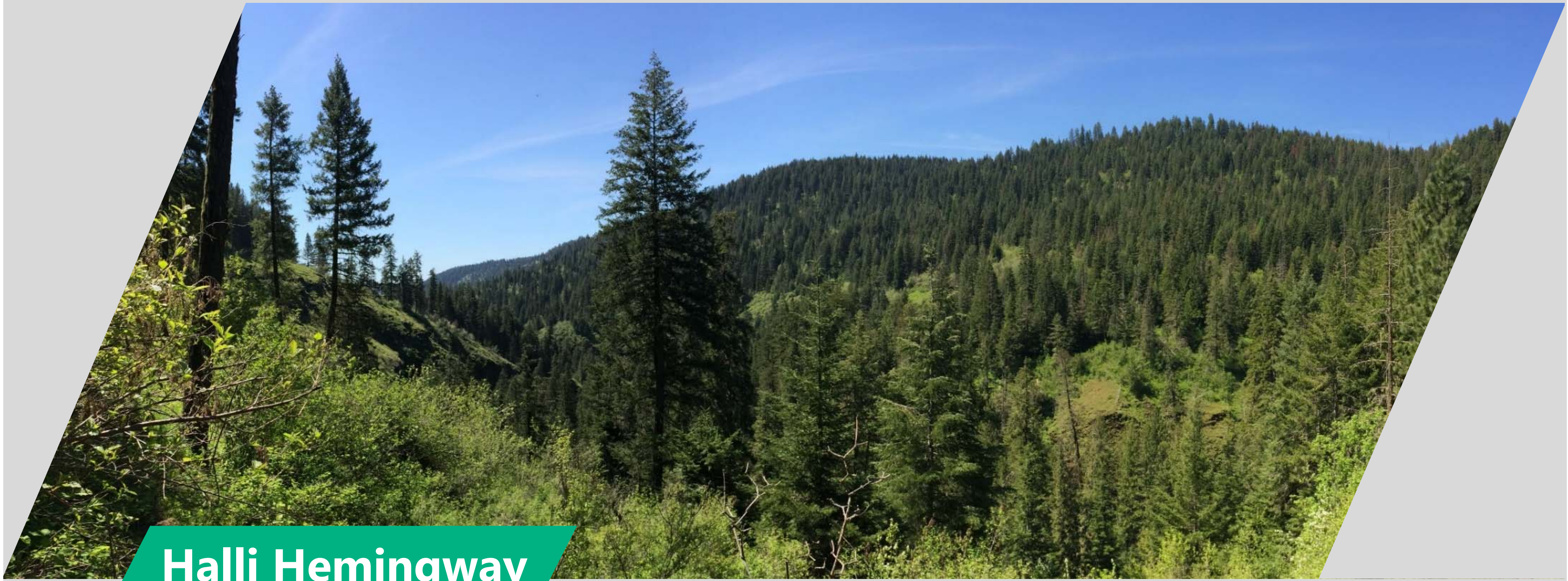


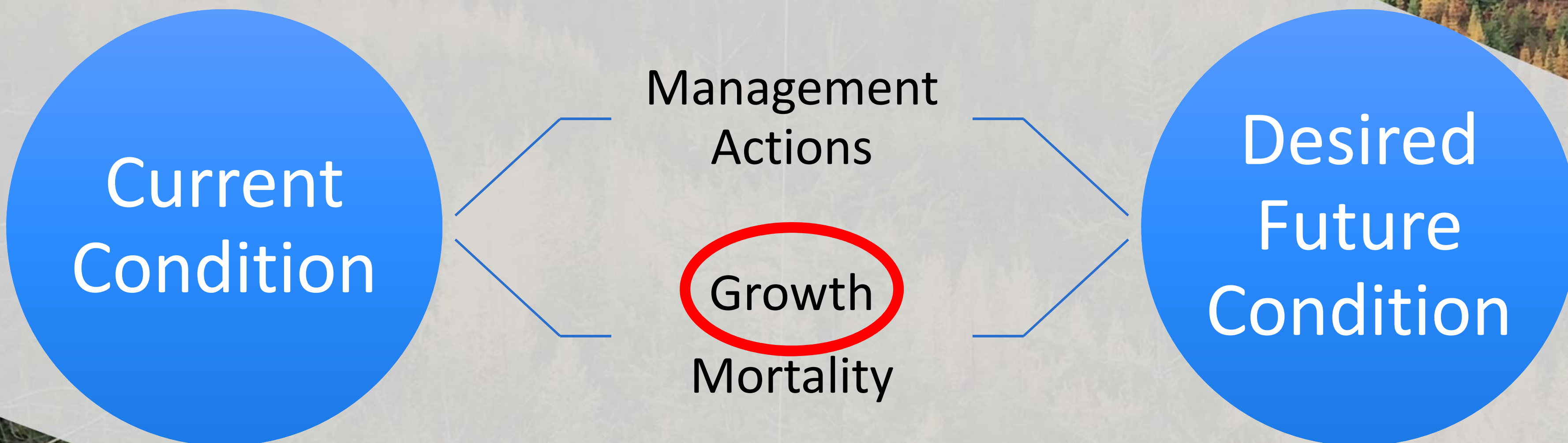
Halli Hemingway

Defining and Estimating Forest Productivity Using Multi-Point Measures and a Nonparametric Approach

University of Idaho, MS Natural Resources
Advisor: Mark Kimsey, PhD

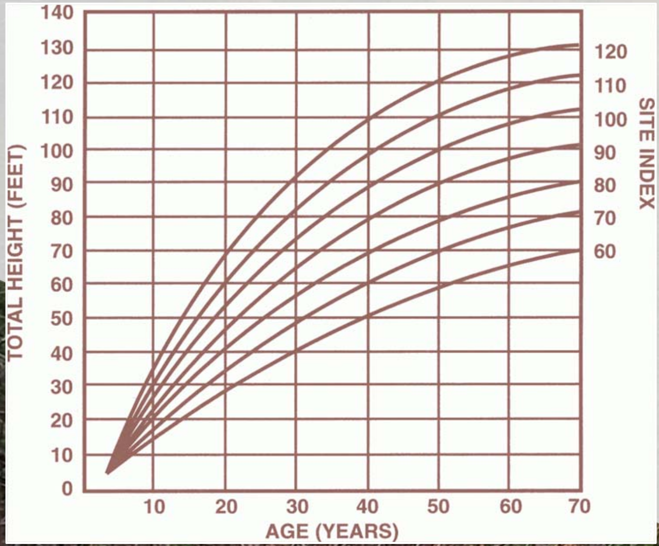
Bennett Lumber Products, Inc.

INTRODUCTION



INTRODUCTION

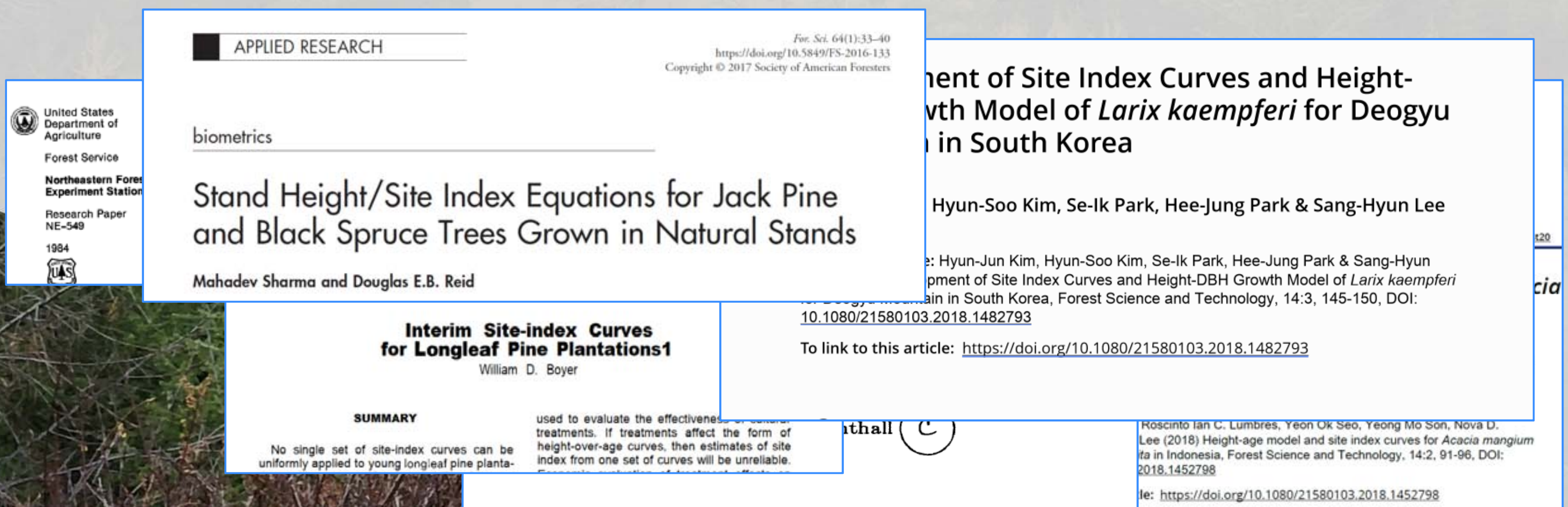
Understanding productivity of forestland is essential in sustainable management and preservation of forest ecosystems (Skovsgaard and Vanclay, 2013; Weiskittel et al., 2011).



The most common measure of forest site productivity is breast height age site index (BHASI) – the expected height at a reference breast height (1.4 m) age. BHASI has been used for over a century to quantify forest productivity (Batho and Garcia, 2006).

INTRODUCTION

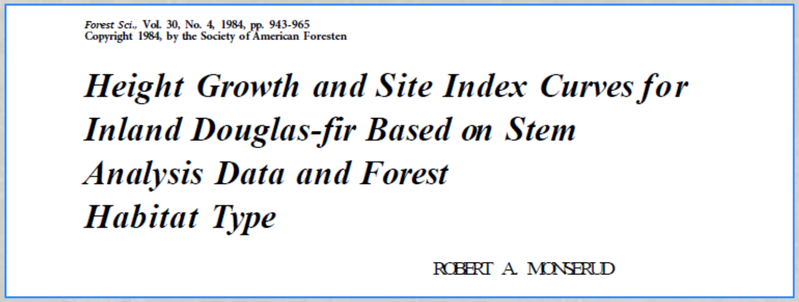
- Breast Height Site Index (BHASI)
  - Many equations developed for differing forest conditions, species, and locations



INTRODUCTION

The first stem-analysis based site index equations and growth curves for Rocky Mountain Douglas-fir (Pseudotsuga menziesii var. glauca) in the Inland Northwest, USA were developed by Monserud (1984).

- ❖ Applicable for even-aged, uneven-aged, and mix-species stands
- ❖ No geospatial stratification
  - ❖ Sample equally in 5 habitat types



Forest Sci., Vol. 30, No. 4, 1984, pp. 943-965
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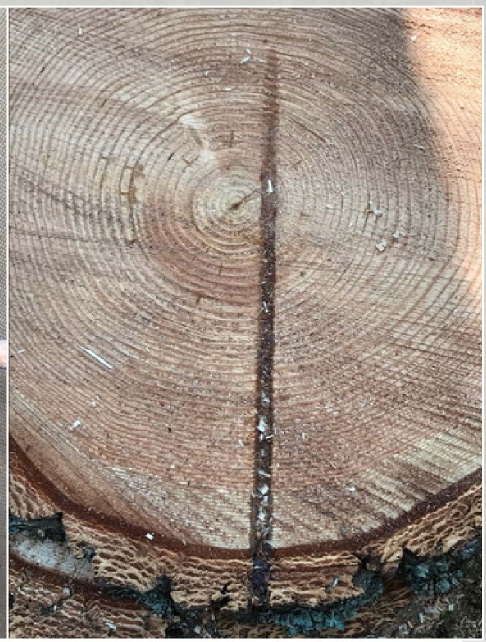
Height Growth and Site Index Curves for Inland Douglas-fir Based on Stem Analysis Data and Forest Habitat Type

ROBERT A. MONSERUD

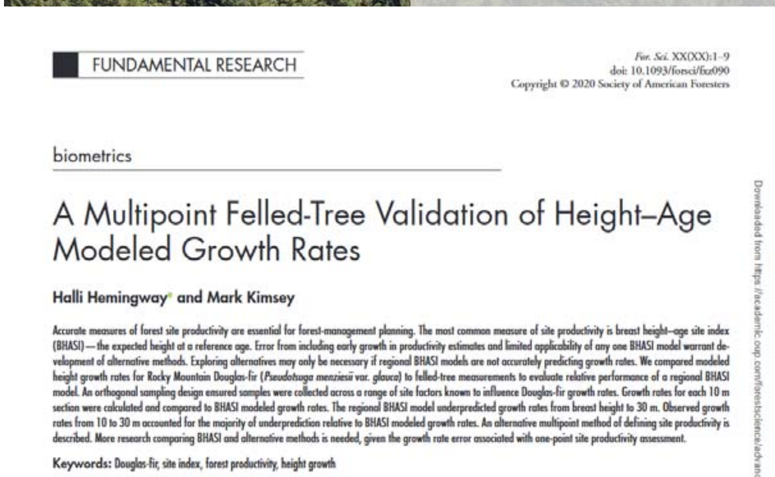
INTRODUCTION

BHASI SHORTCOMINGS



- One height/age measurement
- Disturbance, uneven-aged stands, afforestation, and conversions
- Measurement error
- No systematic landscape scale stratification

INTRODUCTION: BHASI SHORTCOMINGS


FUNDAMENTAL RESEARCH

For. Sci. XX(XX):1–9
doi: 10.1093/forsci/fxz090

biometrics

A Multipoint Felled-Tree Validation of Height–Age Modeled Growth Rates

Halli Hemingway* and Mark Kimsey

Accurate measures of forest site productivity are essential for forest-management planning. The most common measure of site productivity is breast height–age site index (BHASI)—the expected height at a reference age. Error from including early growth in productivity estimates and limited applicability of any one BHASI model warrant development of alternative methods. Exploring alternatives may only be necessary if regional BHASI models are not accurately predicting growth rates. We compared modeled height growth rates for Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) to felled-tree measurements to evaluate relative performance of a regional BHASI model. An orthogonal sampling design ensured samples were collected across a range of site factors known to influence Douglas-fir growth rates. Growth rates for each 10 m section were calculated and compared to BHASI modeled growth rates. The regional BHASI model underpredicted growth rates from breast height to 30 m. Observed growth rates from 10 to 30 m accounted for the majority of underprediction relative to BHASI modeled growth rates. An alternative multipoint method of defining site productivity is described. More research comparing BHASI and alternative methods is needed, given the growth rate error associated with one-point site productivity assessment.

Keywords: Douglas-fir, site index, forest productivity, height growth

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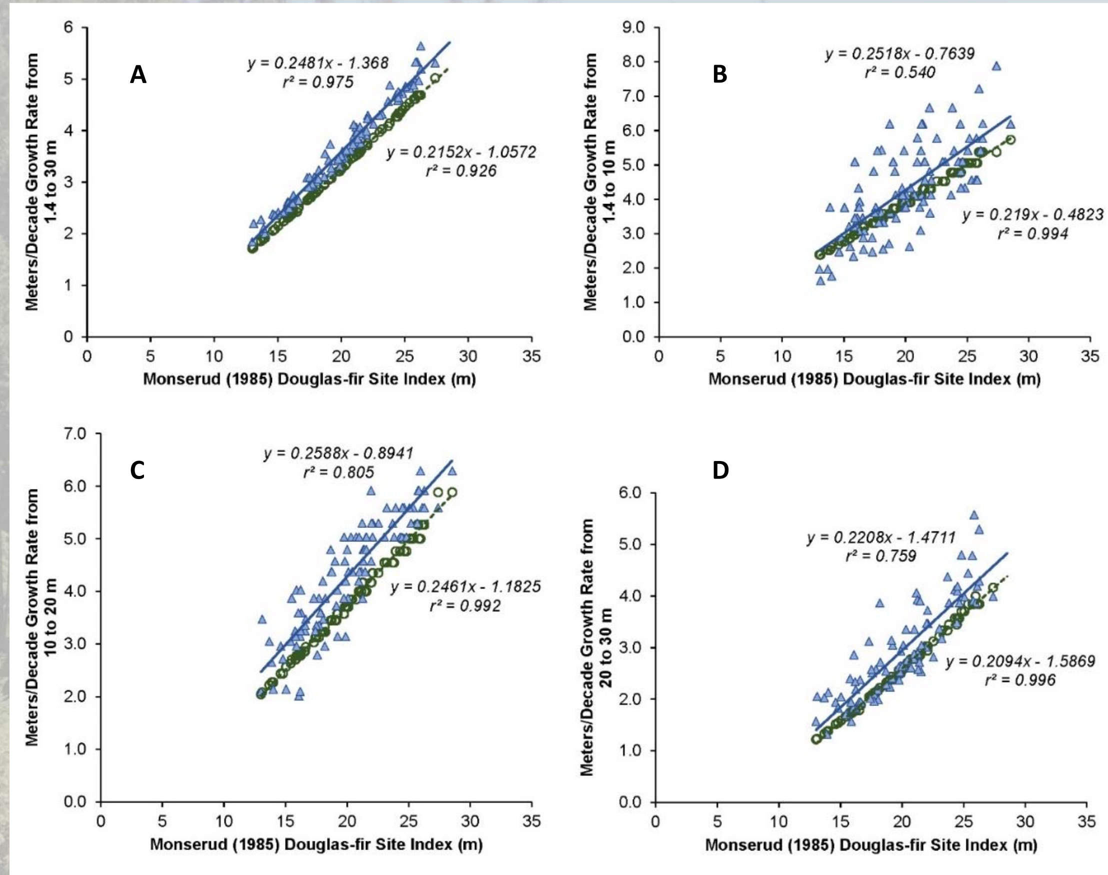
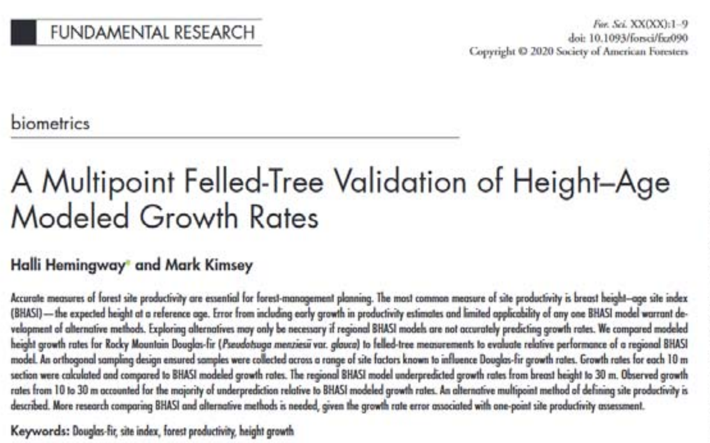


INTRODUCTION: BHASI SHORTCOMINGS



FUNDAMENTAL RESEARCH

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biometrics

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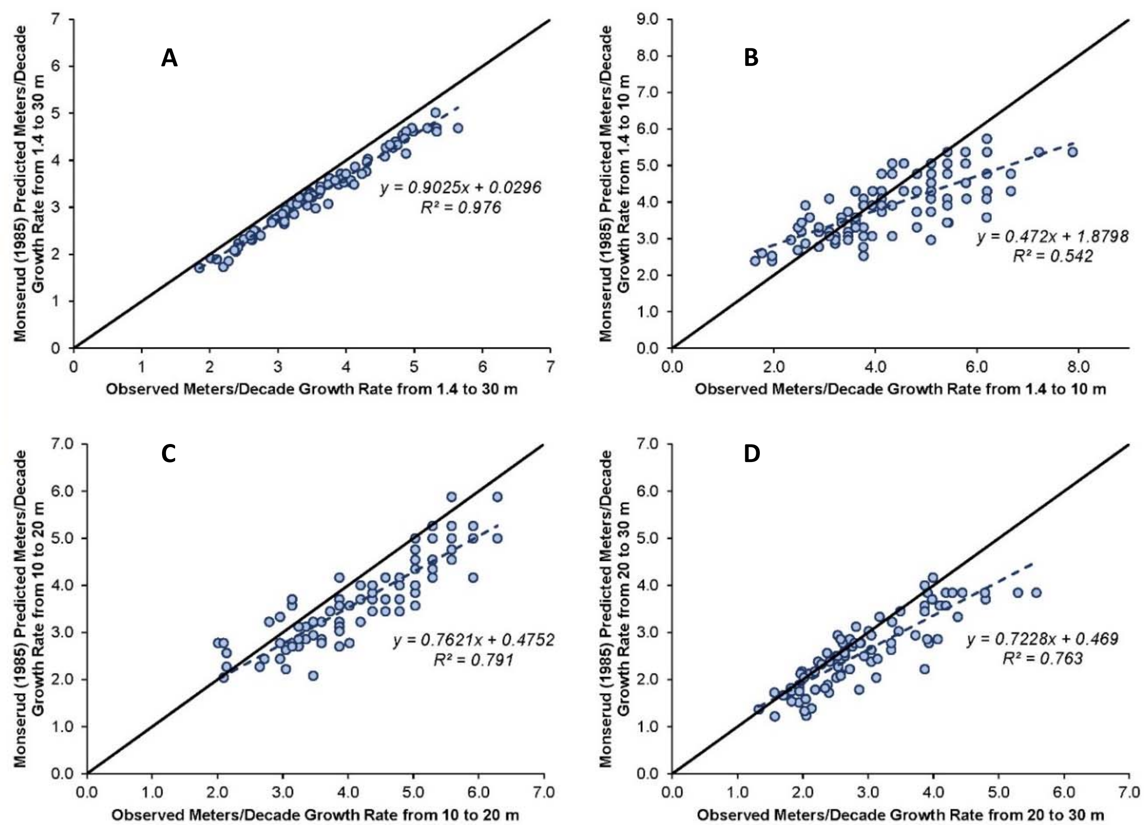

INTRODUCTION

Estimating forest productivity across large landscapes indirectly using environmental variables.

- ❖ Direct productivity measures
- ❖ Geocentric approach
- ❖ Balanced sampling across factors influencing tree growth
- ❖ Attention to problem of correlations of predictors
- ❖ Problems with multiple interacting predictors
- ❖ Nonparametric multiplicative regression
- ❖ Abandon simplistic assumptions and embrace interaction

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Institute of Chartered Foresters

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Predictive approaches to forest site productivity: recent trends, challenges and future perspectives

Jean-Daniel Bontemps[1,2]* and Olivier Bouriaud[3]

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Non-parametric habitat models with automatic interactions

McCune, Bruce

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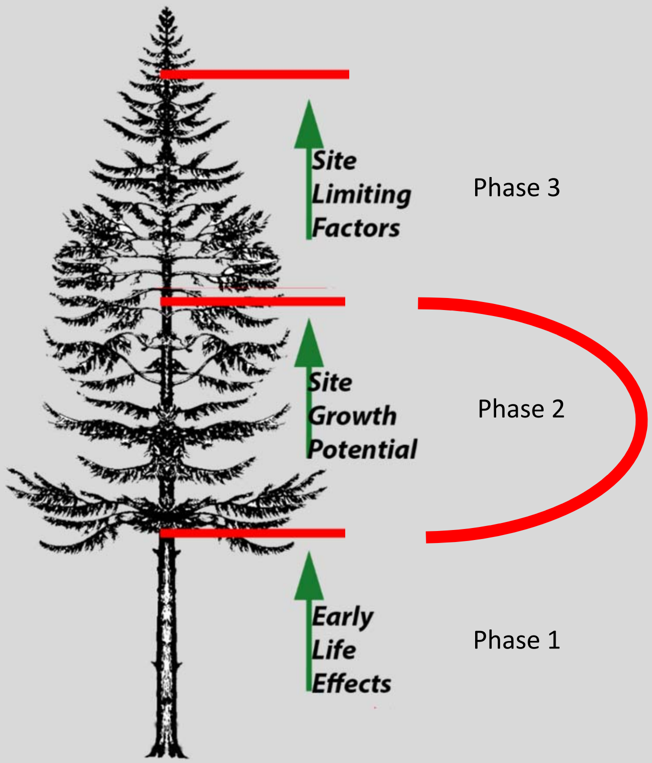
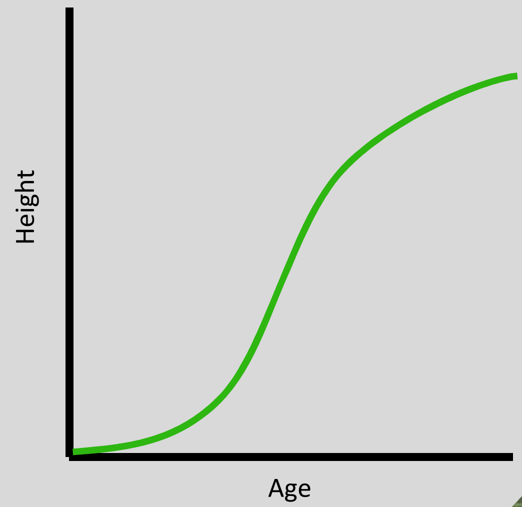
INTRODUCTION





10-Meter Site Index (Arney, 2017)

INTRODUCTION

- The Forest Projection and Planning Software (FPS)
  ->Forest Biometrics Research Institute
- FPS used by 82 forestry organizations managing over 4.8 million hectares
- Accuracy of FPS 10-meter site index predictions?
- FPS modeling strategies and parameters?

RESEARCH OBJECTIVES

Determine if the Monserud regional BHASI model is accurately predicting tree height growth rates

Yes

- Explore nonparametric approaches of modeling BHASI
- Produce and evaluate GIS maps of BHASI for the study area

No

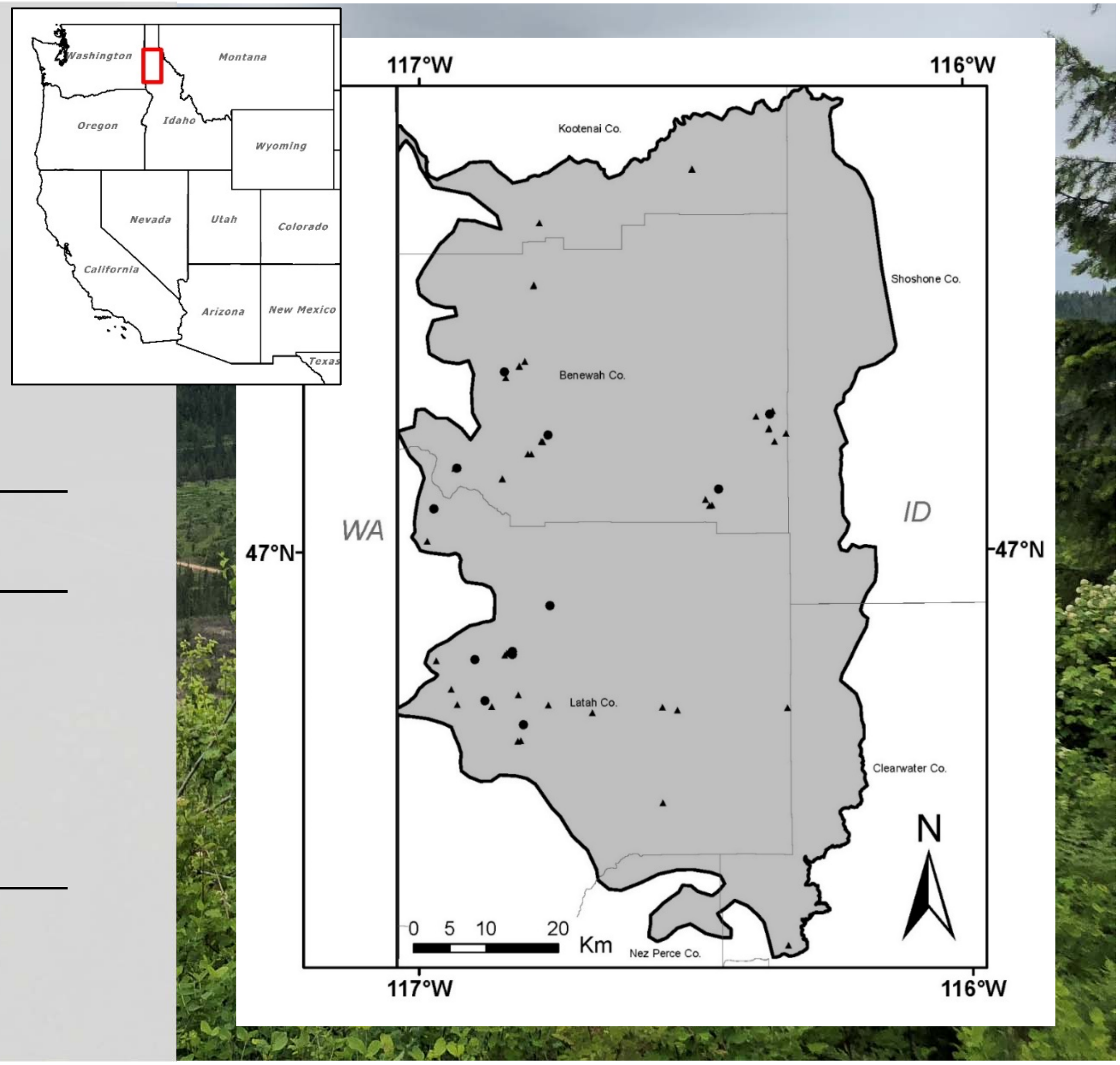
- Determine relative accuracy of FPS predicted 10-Meter Site Index
- Explore alternative, non-parametric modeling parameters and approaches
- Produce and evaluate GIS maps of 10-Meter Site Index for the study area

METHODS:
STUDY AREA

1.3 million acres

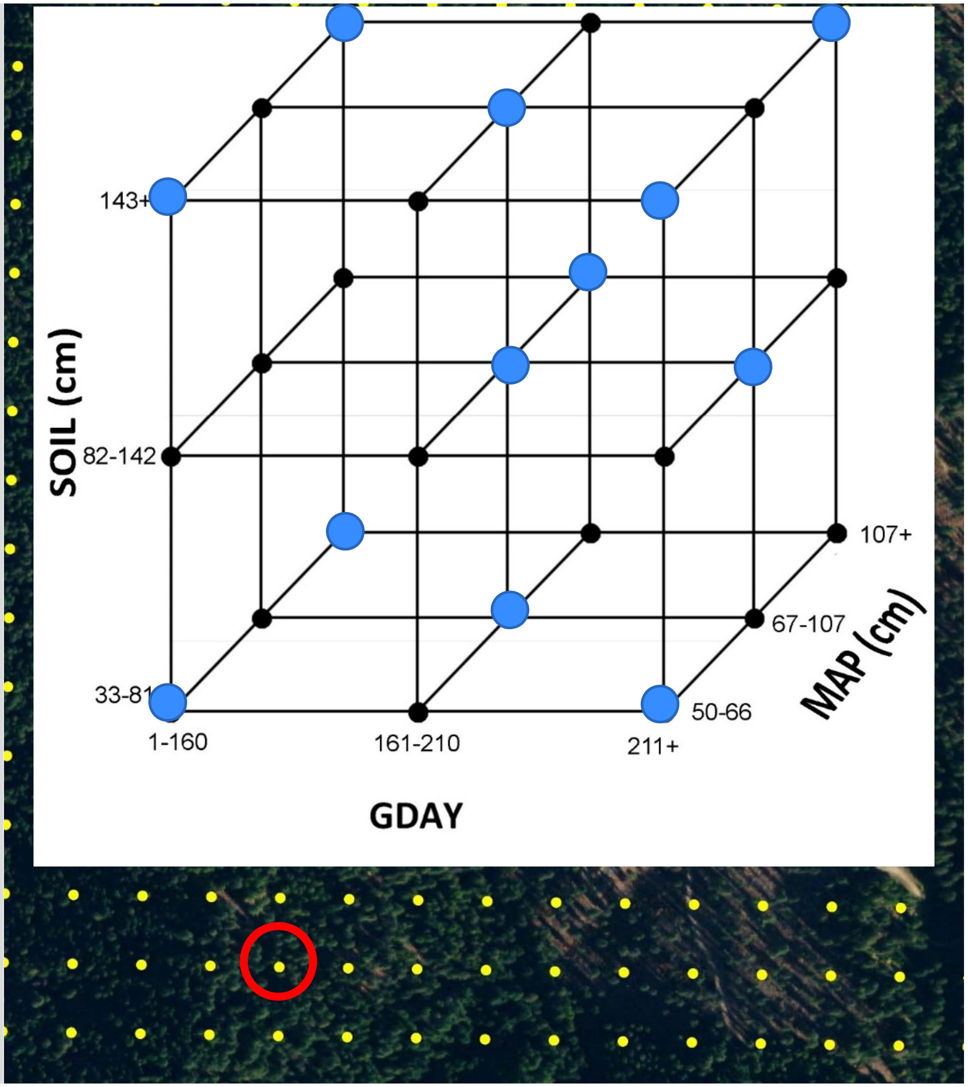
	Range
Elevation	965 – 6,358 ft
Mean Annual Precipitation	19 – 63 in
Soil Depth	13 - >80 in

Douglas-fir chosen as the test species



METHODS:
STUDY AREA STRATIFICATION

- One-acre point grid applied to study area
- Balanced orthogonal sample
- Sample sites randomly selected from 27 strata
- 44 sample sites
  12 validation sites



METHODS:
SAMPLING

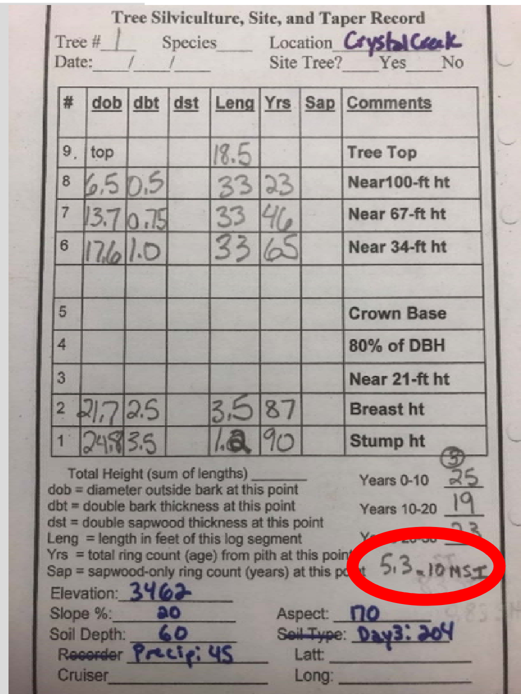
- 2-5 dominant or codominant Douglas-fir selected and felled
- Sectioned at stump, breast height, 10, 20, and 30 meters
- Ring counts at each section
- Total tree height measured
- Soil depth verified

METHODS:
SAMPLING

- 10-20 m growth rate calculated on site

$$10\text{MSI} = \frac{10_{YRS} \text{ x } 10\text{m}}{RC_{10} - RC_{20}}$$

- Sample trees growth rates within 1 m/d



Tree Silviculture, Site, and Taper Record

Tree # 1 Species___ Location Crystal Creek
Date:___/___/___ Site Tree?___Yes___No

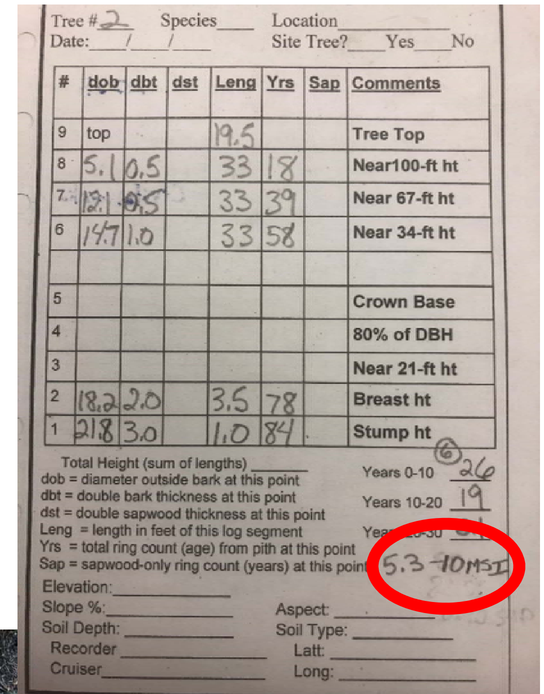
#	dob	dbt	dst	Leng	Yrs	Sap	Comments
9	top			18.5			Tree Top
8	6.5	0.5		33	23		Near100-ft ht
7	13.7	0.75		33	46		Near 67-ft ht
6	17.6	1.0		33	65		Near 34-ft ht
5							Crown Base
4							80% of DBH
3							Near 21-ft ht
2	21.7	2.5		3.5	87		Breast ht
1	24.8	3.5		1.8	90		Stump ht

Total Height (sum of lengths) ______
dob = diameter outside bark at this point
dbt = double bark thickness at this point
dst = double sapwood thickness at this point
Leng = length in feet of this log segment
Yrs = total ring count (age) from pith at this point
Sap = sapwood-only ring count (years) at this point

Years 0-10 25
Years 10-20 19
Years 20-30 23

5.3 10MSI

Elevation: 3462
Slope %: 20
Soil Depth: 60
~~Recorder~~ Precip: 45
Cruiser______
Aspect: 170
~~Soil Type~~: Day3: 204
Latt: ______
Long: ______



Tree # 2 Species___ Location______
Date:___/___/___ Site Tree?___Yes___No

#	dob	dbt	dst	Leng	Yrs	Sap	Comments
9	top			19.5			Tree Top
8	5.1	0.5		33	18		Near100-ft ht
7	12.1	0.5		33	39		Near 67-ft ht
6	14.7	1.0		33	58		Near 34-ft ht
5							Crown Base
4							80% of DBH
3							Near 21-ft ht
2	18.2	2.0		3.5	78		Breast ht
1	21.8	3.0		1.0	84		Stump ht

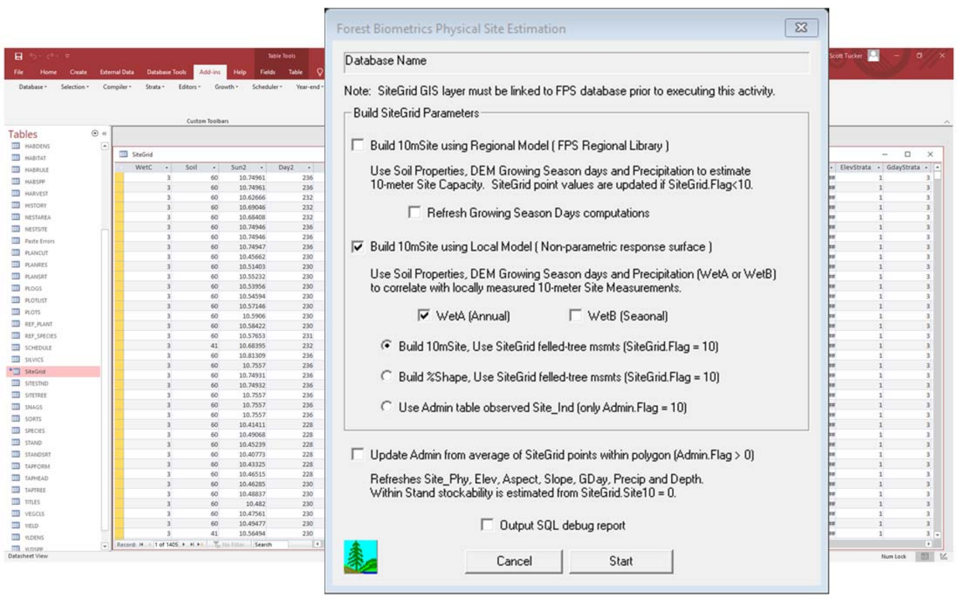
Total Height (sum of lengths) ______
dob = diameter outside bark at this point
dbt = double bark thickness at this point
dst = double sapwood thickness at this point
Leng = length in feet of this log segment
Yrs = total ring count (age) from pith at this point
Sap = sapwood-only ring count (years) at this point

Years 0-10 26
Years 10-20 19

5.3 10MSI

Elevation: ______
Slope %: ______
Soil Depth: ______
Recorder ______
Cruiser ______
Aspect: ______
Soil Type: ______
Latt: ______
Long: ______

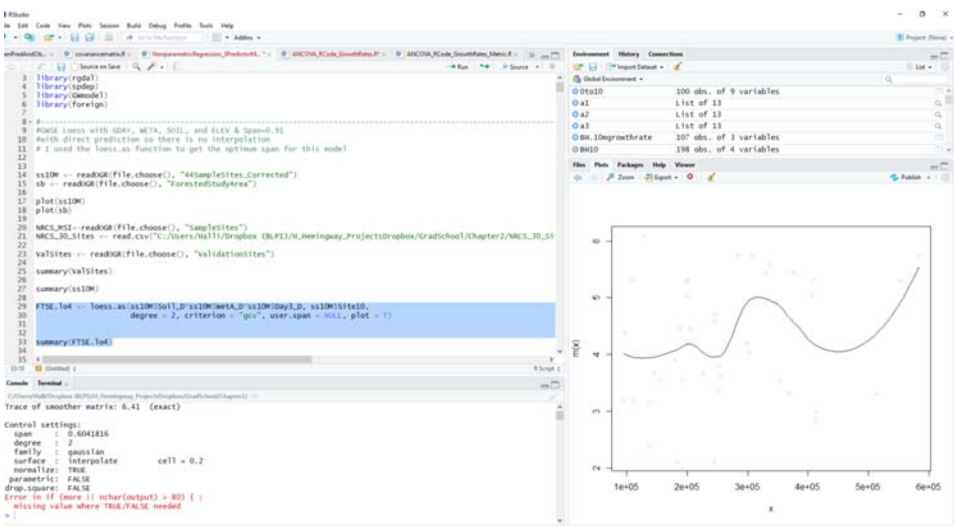
METHODS:
GENERATING FPS 10MSI PREDICTIONS



- Generate 10-Meter Site Index predictions across our study area using FPS and the process in Arney (2017).
- Input 44 sample location 10-Meter Site Index measurements, sample site MAP, SOIL, and GDAY.
- Input 1-acre point grid populated with MAP, SOIL, and GDAY.
- FPS uses nonparametric regression with a locally weighted smoothing parameter to estimate 10-meter site index for unsampled locations.
- SPAN = 1

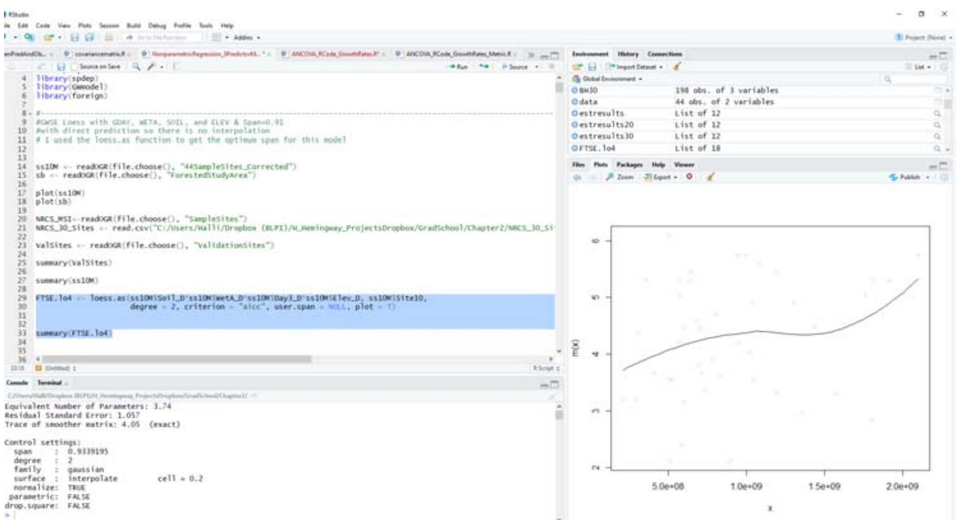
METHODS:

EVALUATING OPTIMUM SMOOTHING SPAN



- LOESS model 10MSI = f(MAP+GDAY+SOIL)
- LOESS.AS -> generate optimum smoothing span value (AICC & GCV)
- Compare Pearson correlation coefficients of 3FPS, 3AICC, and 3GCV models

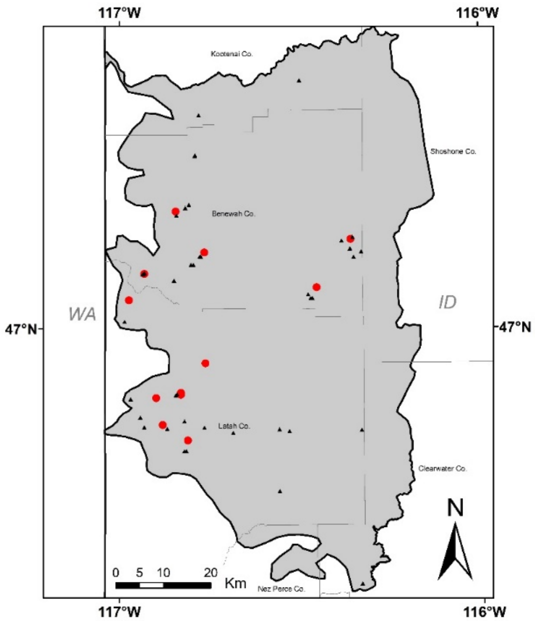
METHODS:
CREATING AN ALTERNATIVE 10MSI MODEL



- 10MSI = f(MAP+GDAY+SOIL+ELEV) Bontemps and Bouriaud (2014)
- LOESS.AS -> generate optimum smoothing span value (AICC & GCV)
- Compare Pearson correlation coefficients of 3FPS, 3AICC, 3GCV, 4AICC, and 4GCV models

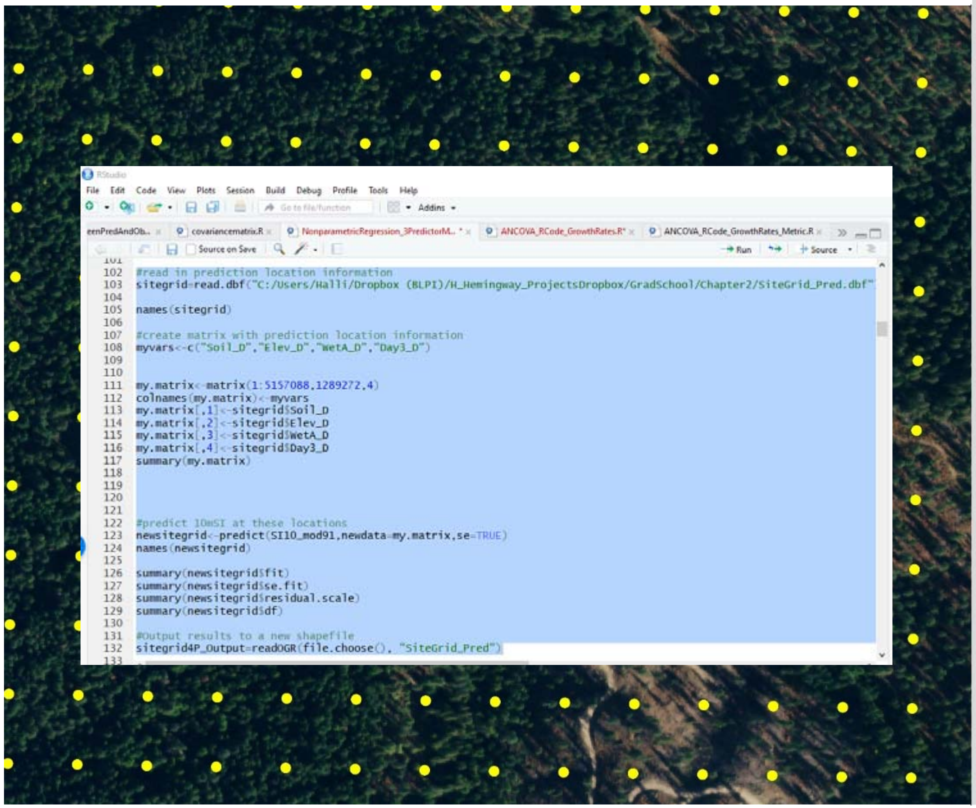
METHODS:

VALIDATING FPS AND ALTERNATIVE MODEL PREDICTIONS

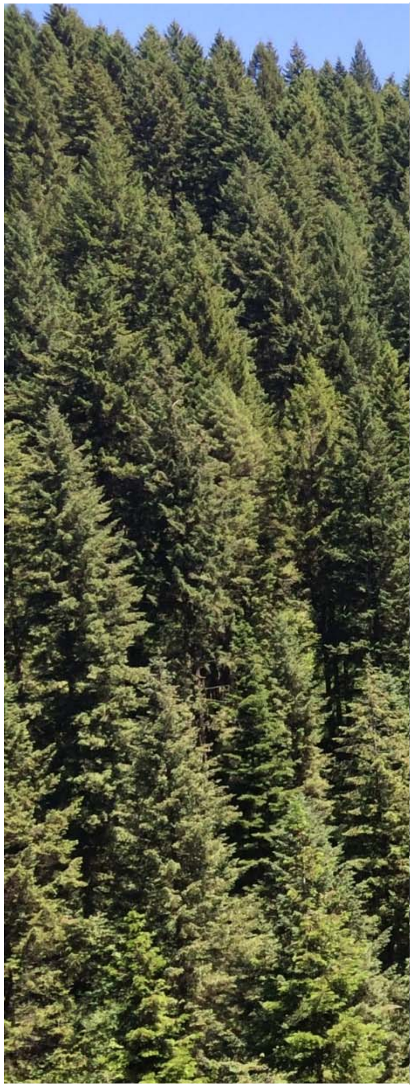


- Compare model predicted and observed 10MSI at each of the 12 validation sites. Models: 3FPS, 3AICC, 3GCV, 4AICC, and 4GCV
- Calculated 80% confidence interval for each model predicted 10MSI
- Determined if the observed 10MSI was within the 80% confidence interval of the models' predicted 10MSI

METHODS:
RASTER MAP PRODUCTION



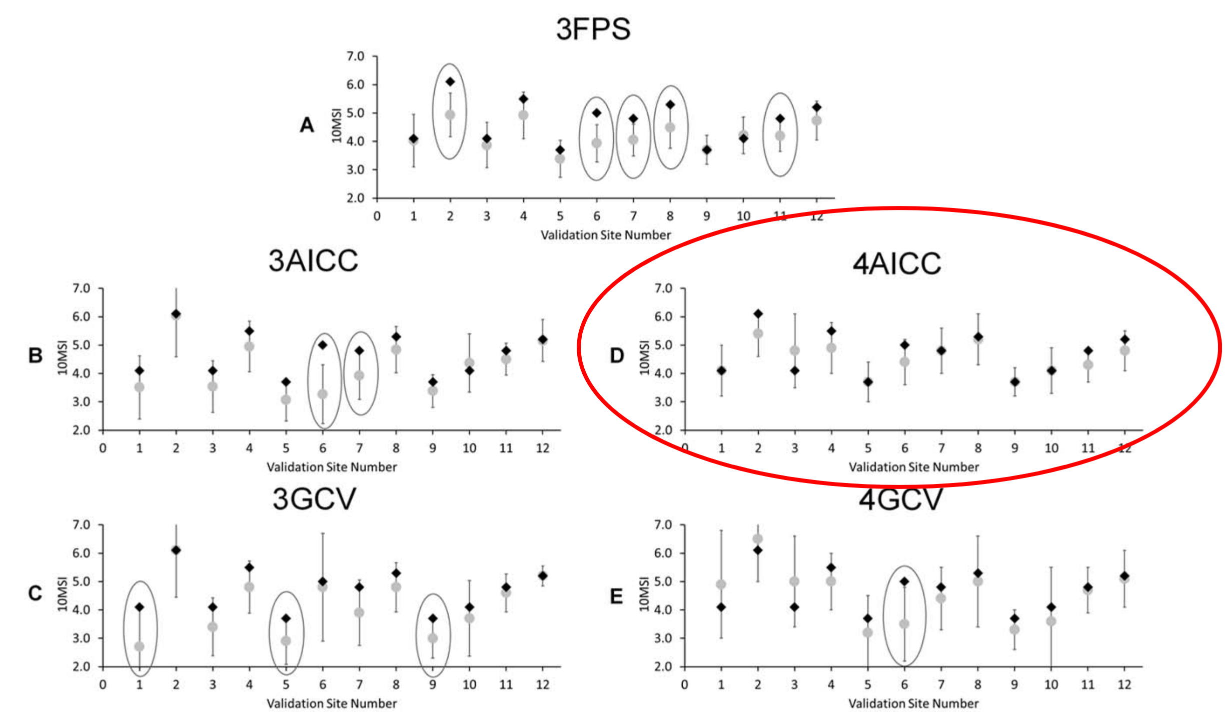
- Applied best model to 1-acre point grid of unsampled locations -> predict()
- Predicted 10-meter site index and standard error for each grid point
- Grid points with predictions outside the range of sampled 10-meter site index removed
- Point grids converted to raster datasets with a 1-acre grid size.



RESULTS

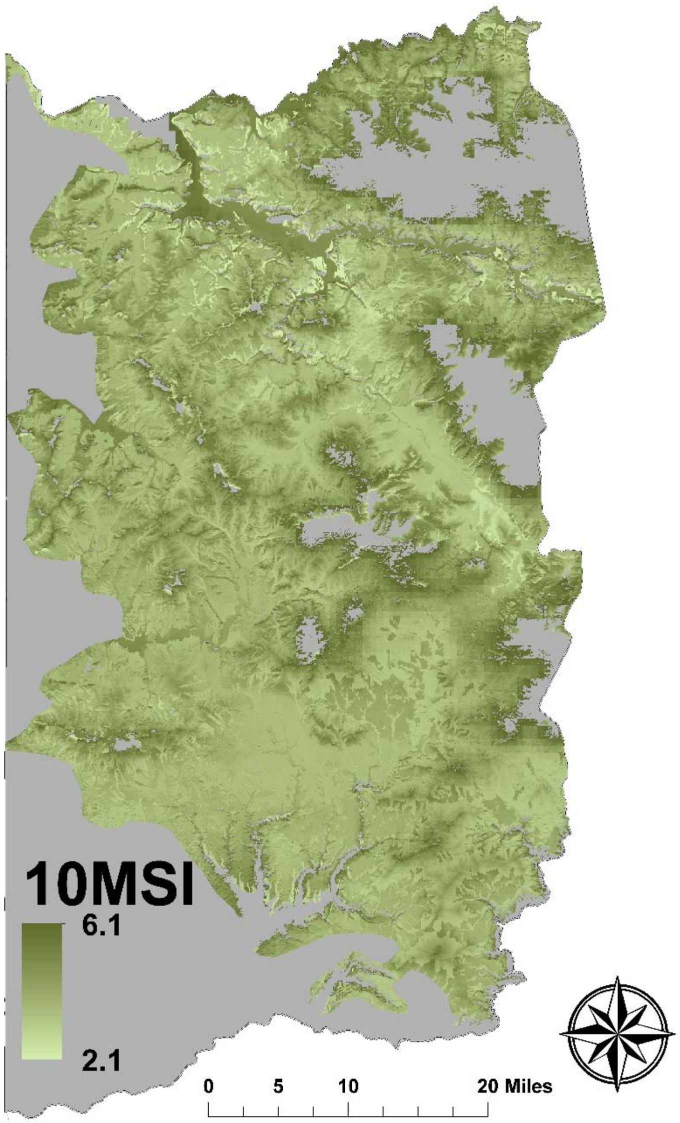
			Sample Sites		Validation Sites
Model	**SPAN**	**Predictors**	**r**	**p**	**% within 80% CI**
FPS7.54 3-Predictor Model (3FPS)	1	MAP GDAY SOIL	0.60	<0.001	58%
3-Predictor AICC Optimum Span (3AICC)	0.73	MAP GDAY SOIL	0.79	<0.001	83%
3-Predictor GCV Optimum Span (3GCV)	0.60	MAP GDAY SOIL	0.89	<0.001	75%
4-Predictor AICC Optimum Span (4AICC)	0.93	MAP GDAY SOIL ELEV	0.85	<0.001	100%
4-Predictor GCV Optimum Span (4GCV)	0.74	MAP GDAY SOIL ELEV	0.94	<0.001	92%

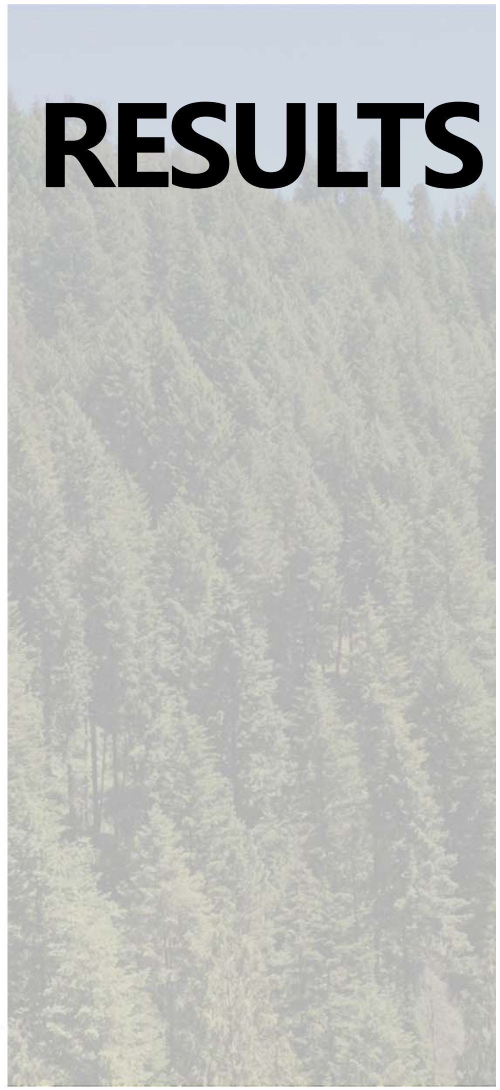
RESULTS

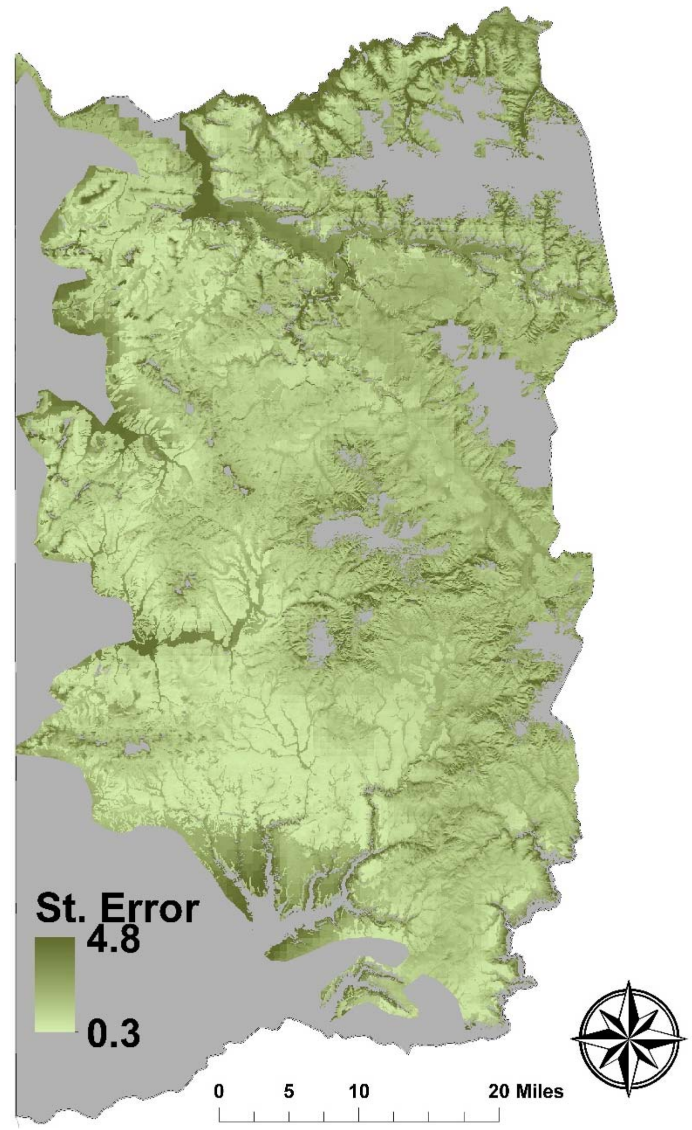


3FPS
A
10MSI
Validation Site Number
3AICC
B
3GCV
C
4AICC
D
4GCV
E

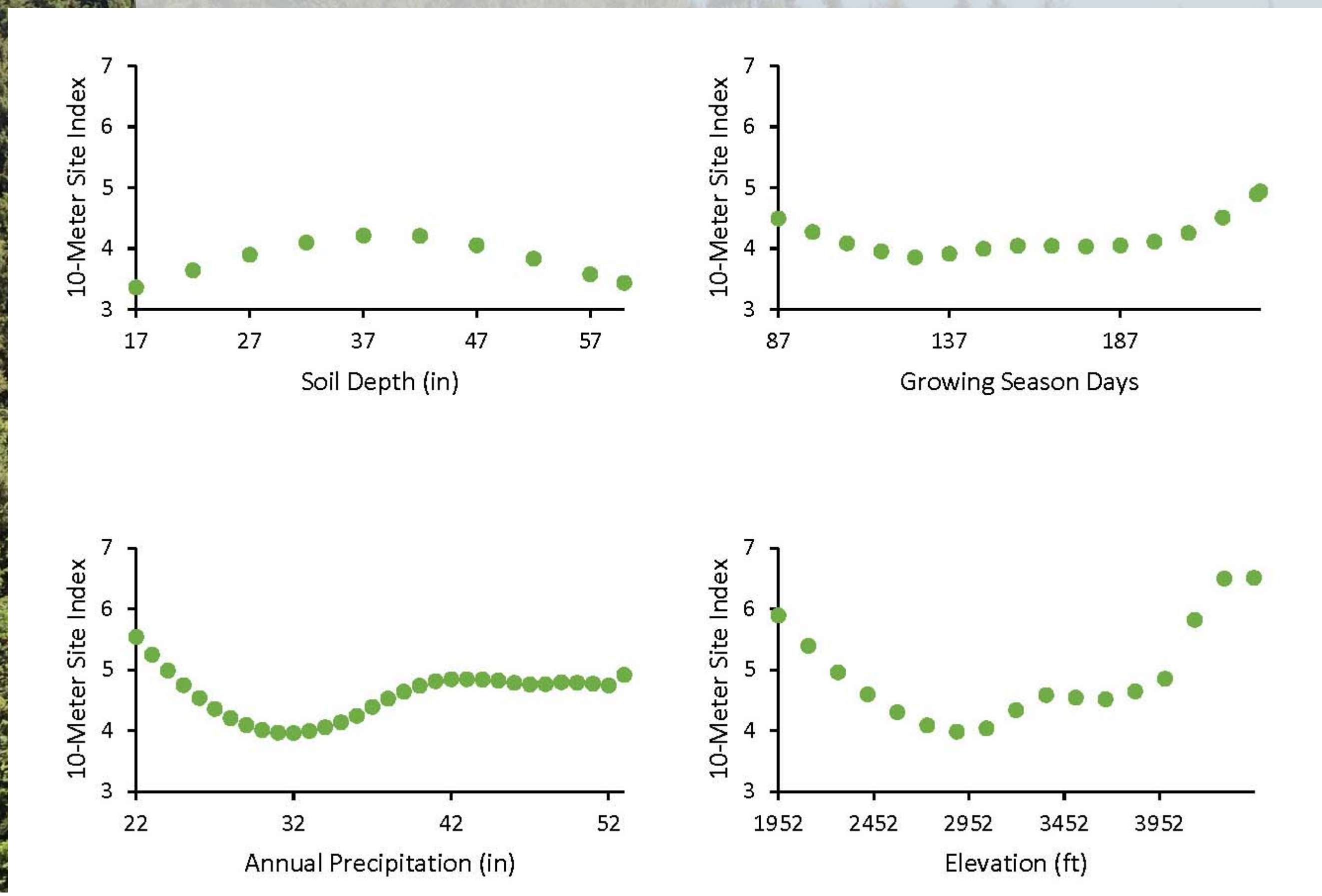
RESULTS



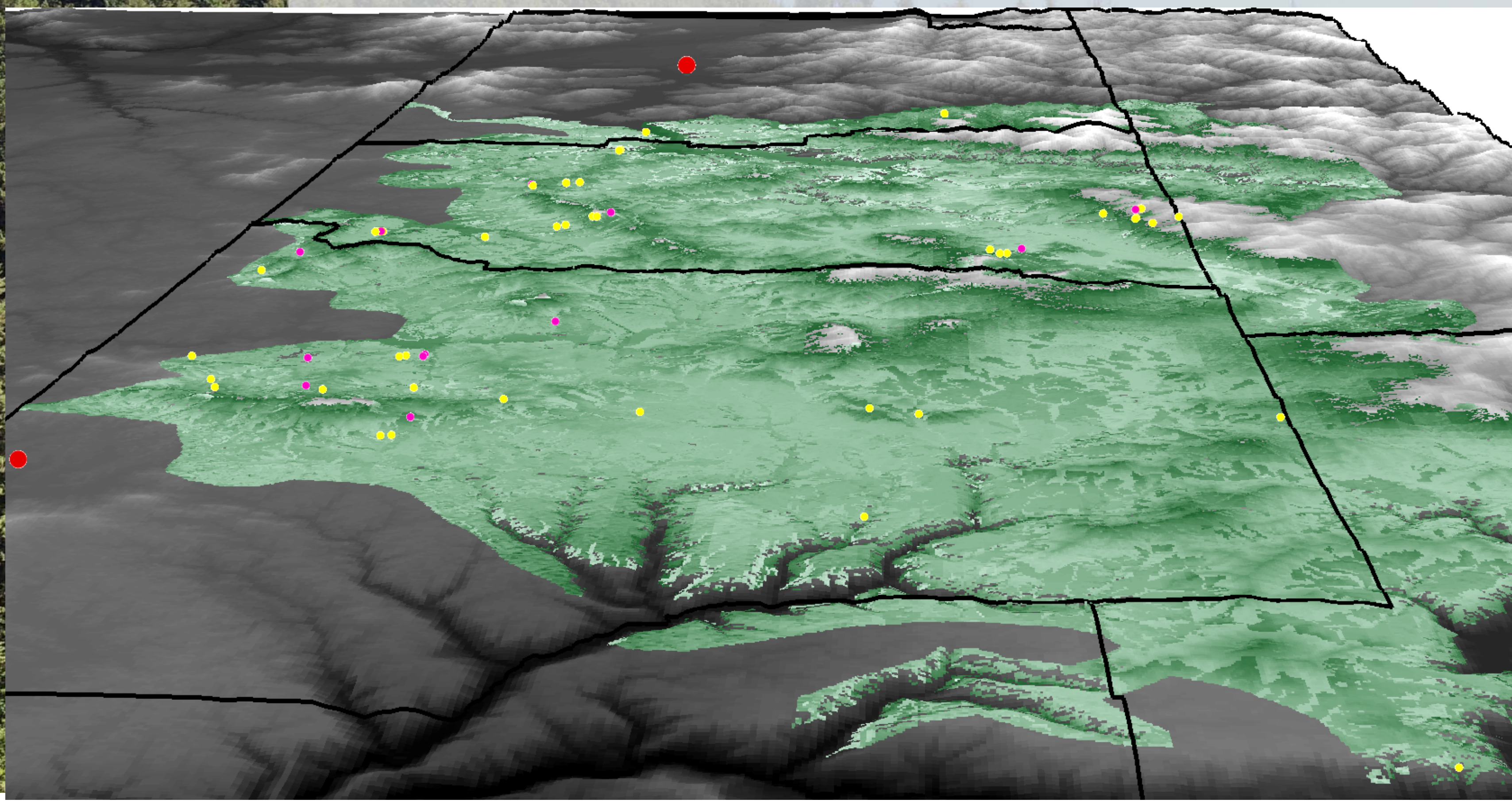




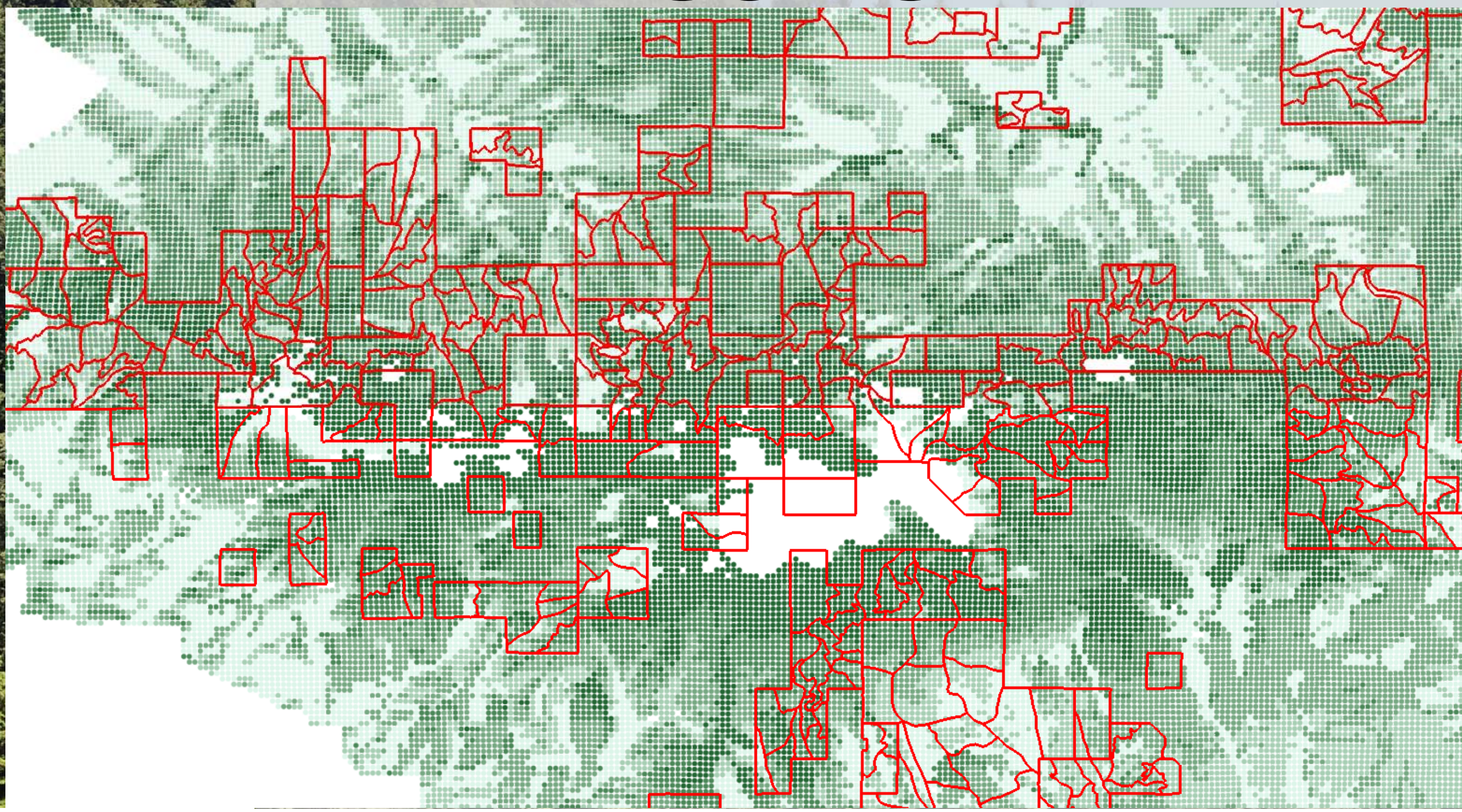
RESULTS


10-Meter Site Index
7
6
5
4
3
17
27
37
47
57
Soil Depth (in)
10-Meter Site Index
7
6
5
4
3
87
137
187
Growing Season Days
10-Meter Site Index
7
6
5
4
3
22
32
42
52
Annual Precipitation (in)
10-Meter Site Index
7
6
5
4
3
1952
2452
2952
3452
3952
Elevation (ft)

RESULTS



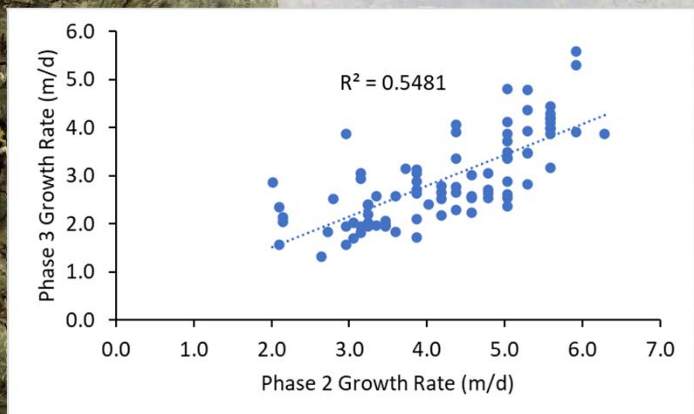
RESULTS

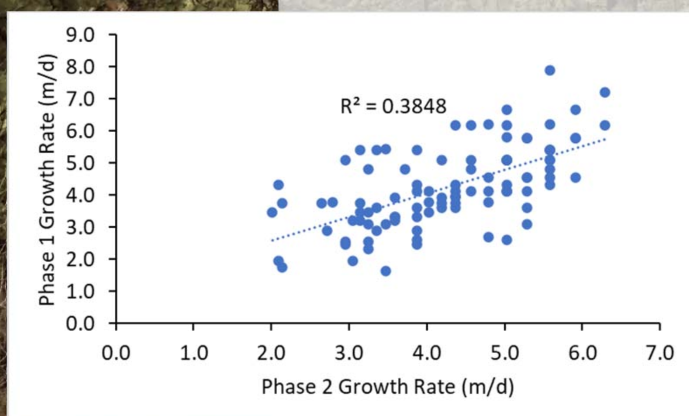


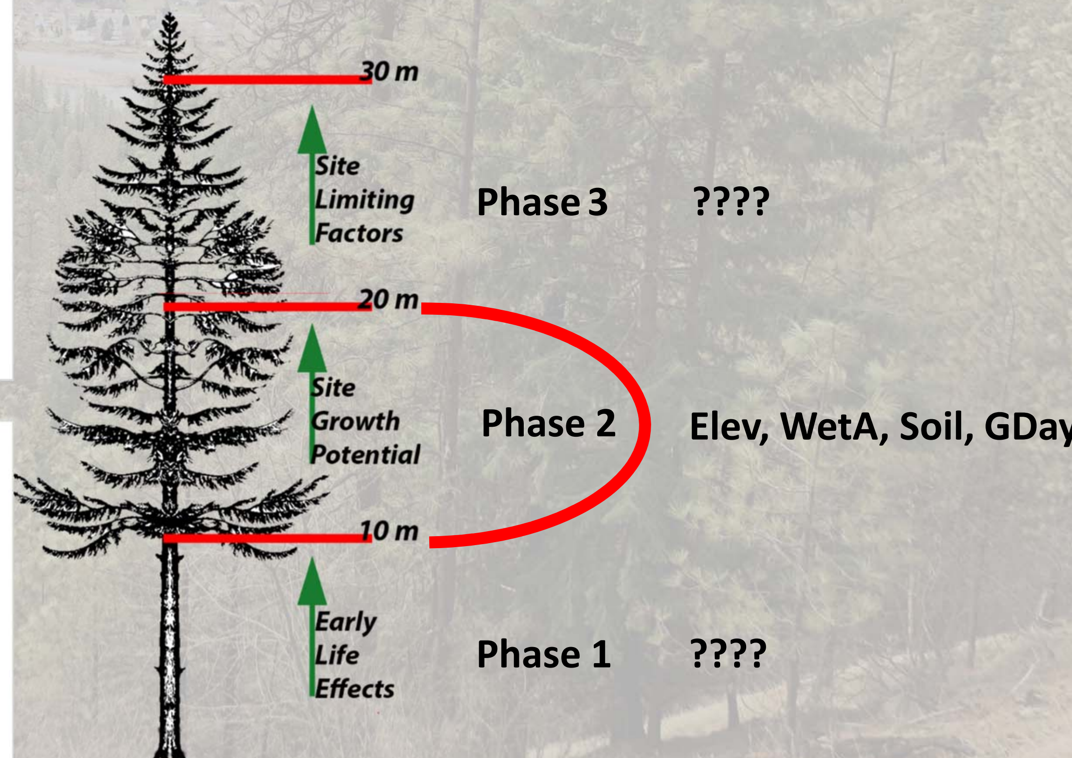
SUMMARY

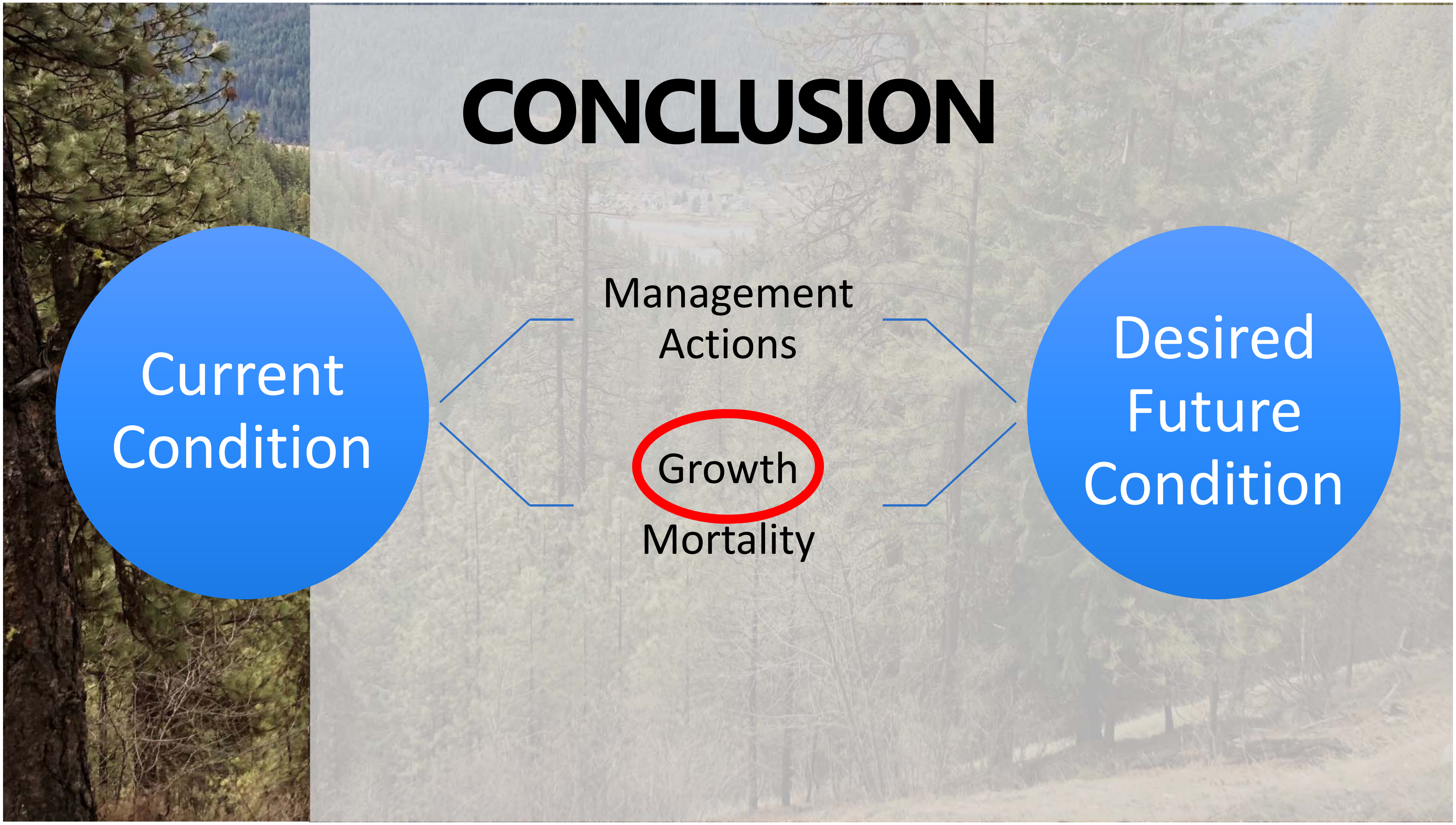
- Available regional site index curves and equations are not accurately predicting tree height growth in our area.
- A direct productivity measure: 10-meter site index
- FPS prediction accuracy less that expected
  - ❖ Revisions to FPS are in the works to allow for smoothing span optimization
- Fit and accuracy improved when elevation was added as a predictor and an optimum span value was chosen.

FUTURE RESEARCH



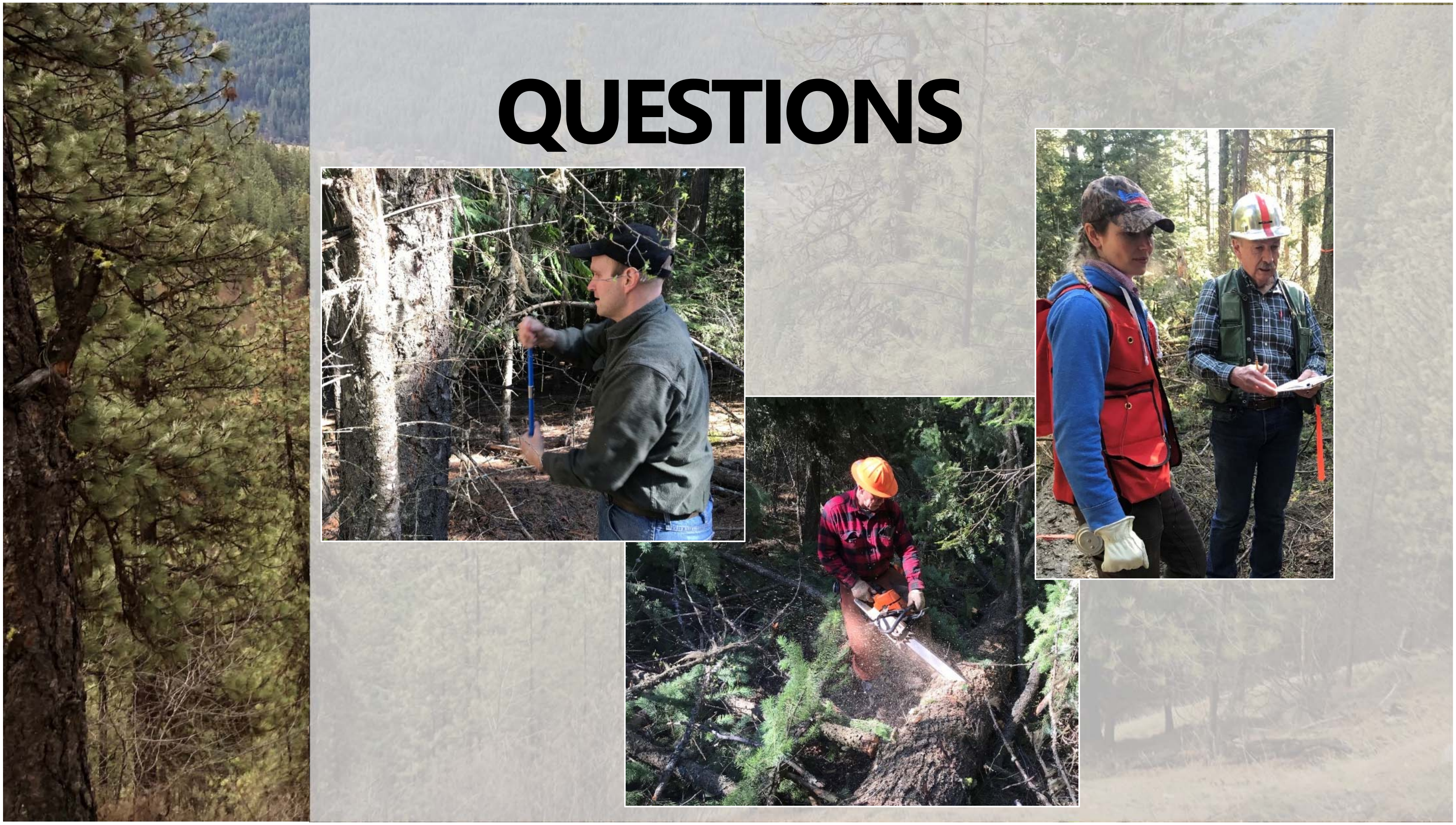





CONCLUSION
Current Condition
Management Actions
Growth
Mortality
Desired Future Condition

ACKNOWLEDGEMENTS

- Bennett Lumber Products, Inc.
- Forest Biometrics Research Institute
- University of Idaho
- Idaho Department of Lands
- Ben Koester Logging
- Mark Kimsey, Jim Arney, Ann Abbott, Andrew Nelson


QUESTIONS

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