



**University of Idaho**

College of Natural Resources

# **INLAND NORTHWEST SEEDLING GROWTH & SURVIVAL MODEL**

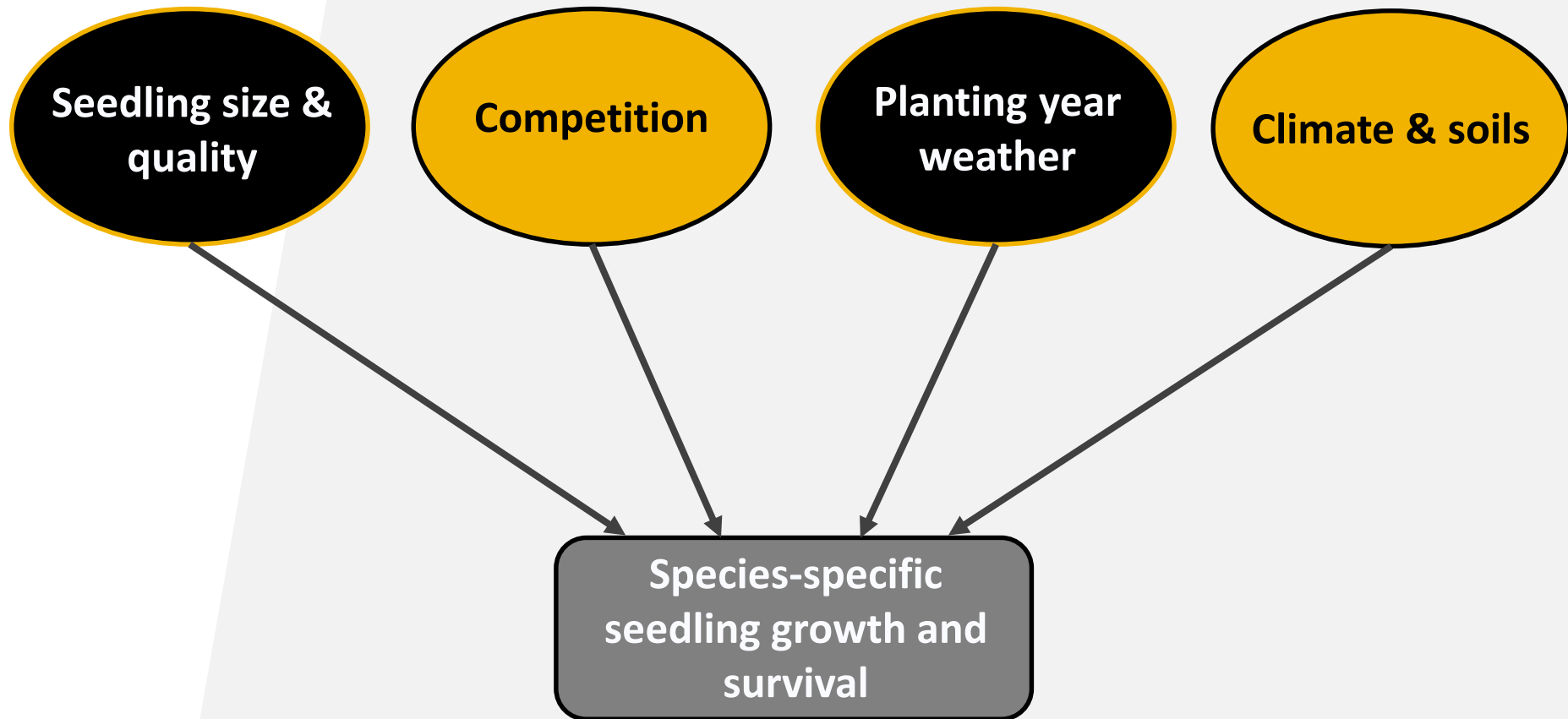
**ANDREW S. NELSON**

**CENTER FOR FOREST NURSERY &  
SEEDLING RESEARCH**

# WHY DO WE NEED A SEEDLING MODEL?

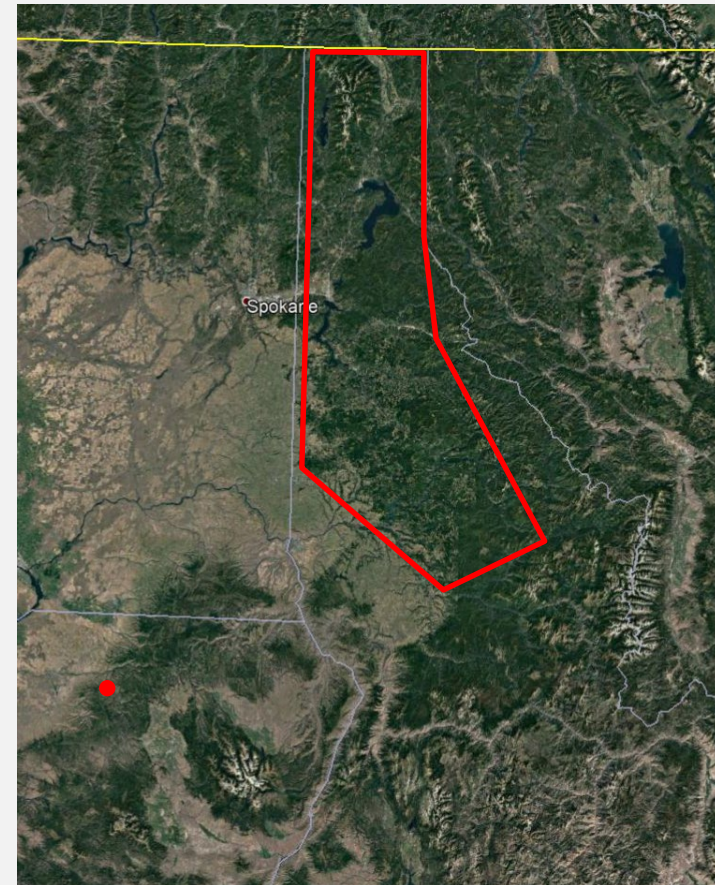
- I Available G&Y models do not account for modern reforestation practices:
  - Lack ability to predict individual seedling growth & survival
  - Poorly account for competition from non-tree vegetation
  - Do not account for seedling variability from the nursery
  - Variable weather, soils, and climate of the INW influences seedling success
- I Assist in developing precision silvicultural prescriptions

# MODEL STRUCTURE



# STUDY SITES PRIMARILY NORTHERN IDAHO

	Western Larch	Douglas-fir
Study Sites	31	25
Seedlots	58	39
Elevation Range	2,822-4,355 ft	2,822-4,276 ft
Habitat Types	Moist Grand fir- Western hemlock	Moist Grand fir- Western hemlock
Land Ownership	PotlatchDeltic, Hancock, Molpus, Stimson, Uldaho	PotlatchDeltic, Hancock, Uldaho, USFS
1 year observations	6,752	3,402
2 year observations	1,129	1,014



# SEEDLING VARIABLES

Seedling Variable	Western Larch	Douglas-fir
	Mean (Range)	
Initial height (cm)	30.1 (8.5 – 56.0)	29.2 (8.8 – 57.8)
Initial caliper (mm)	3.9 (0.3 – 6.9)	4.0 (1.2 – 6.7)
Root growth potential (# new white roots)	13.2 (1.4 – 56.5)	30.6 (7.4 – 68.0)





# SEEDLING QUALITY: ROOT GROWTH POTENTIAL

- “...defined as a seedling’s ability to grow roots when placed into an environment which is highly favorable for root growth (ie. Warm, moist, well-lit)” (Ritchie & Tanaka 1990)
- Assesses seedling vitality (free of disease, injury, or stress)



# COMPETITION VARIABLES

Competition Variable	Western Larch	Douglas-fir
	Mean (Range)	
Forb (%)	12.2 (0 – 100)	18.0 (0 – 100)
Shrub (%)	3.4 (0 – 100)	7.5 (0 – 90)
Grass (%)	1.9 (0 – 100)	3.4 (0 – 90)
Slash (%)	27.4 (0 – 100)	22.7 (0 – 100)



# PLANTING YEAR WEATHER VARIABLES



Weather Variable	Western Larch	Douglas-fir
	Mean (Range)	
March precipitation (mm)	82.8 (46.9 – 252.3)	110.2 (61.0 - 308.5)
March minimum temperature (°C)	-1.8 (-3.3 - -0.2)	-1.8 (-3.4 - -0.2)
March maximum temperature (°C)	7.7 (6.6 – 9.2)	8.2 (4.7 – 9.2)
March average temperature (°C)	2.9 (2.0 – 4.5)	3.2 (1.7 – 4.5)
June precipitation (mm)	45.8 (27.8 – 82.4)	42.9 (27.8 – 82.4)
June minimum temperature (°C)	6.9 (5.7 – 8.0)	7.0 (5.6 – 8.0)
June maximum temperature (°C)	20.5 (18.1 – 22.6)	21.3 (18.3 – 22.6)
June average temperature (°C)	13.7 (12.2 – 15.3)	14.1 (12.8 – 15.3)
August maximum temperature (°C)	27.0 (24.0 – 29.8)	27.6 (24.7 – 29.8)
August max vapor pressure deficit (kPa) ( <i>Difference between amount of moisture in the air and how much moisture the air can hold when saturated</i> )	3.0 (2.5 – 3.4)	3.1 (2.6 – 3.4)
Heating degree days March-May 18.3 °C (°C) ( <i>Number of degrees that a day's average temp is <b>below</b> 18.3 °C</i> )	290.4 (256.8 – 348.6)	286.5 (256.8 – 354.9)
Cooling degree days June-Aug. 18.3 °C (°C) ( <i>Number of degrees that a day's average temp is <b>above</b> 18.3 °C</i> )	11.2 (0.0 – 26.8)	9.5 (0.4 – 26.8)





# WEATHER FROM CLIMATE TRACKER

Climate Tracker Track historical climate variability for a location in the contiguous USA.

Documentation Cite Tool Take Tour

Location: 45.80° N, 115.67° W

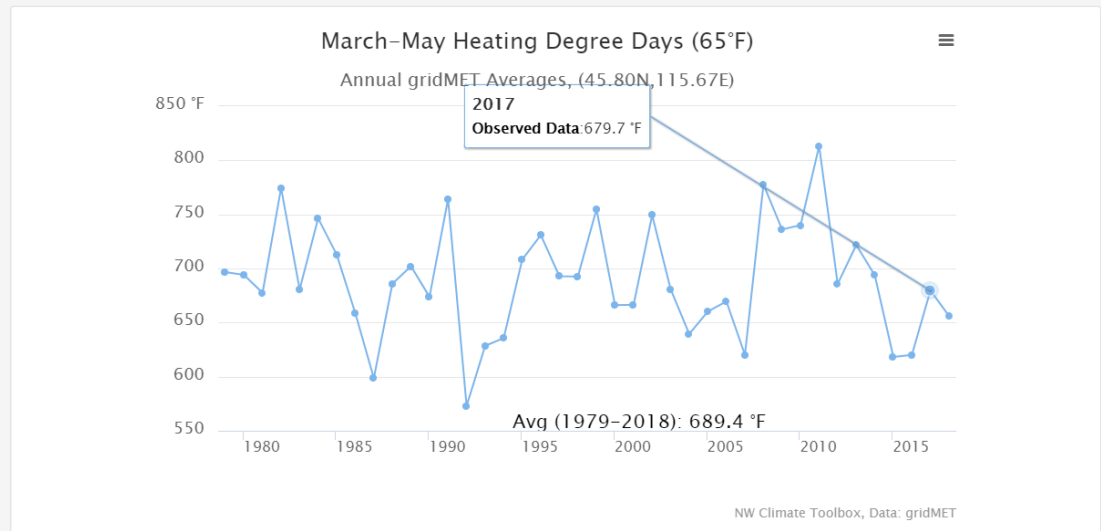
### Data

March-May  
Heating Degree Days (65°F)

### Customization

Plot Type:  
Scatter Plot

Add Best-Fit Line



Created by University of Idaho

Powered by NNI

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<https://climatetoolbox.org/tool/historical-climate-tracker>

# CLIMATE TRACKER BASED ON GRIDMET

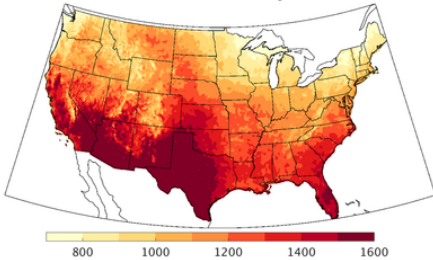
## Climatology Lab

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### GRIDMET

1 Jan-9 Nov 2017  $ET_0$  (mm)



800 1000 1200 1400 1600

#### WHAT IS GRIDMET?

gridMET is a dataset of daily high-spatial resolution (~4-km, 1/24th degree) surface meteorological data covering the contiguous US from 1979-yesterday. We have also extended these data to cover southern British Columbia in our real time products. These data can provide important inputs for ecological, agricultural, and hydrological models. These data are updated daily. gridMET is the preferred naming convention for these data; however, the data are also known as cited as METDATA.

<http://www.climatologylab.org/gridmet.html>



# SITE VARIABLES

Site Variable	Western Larch	Douglas-fir
	Mean (Range)	
Available water supply 0-50 cm (cm)	11.2 (4.6-15.5)	11.9 (8.9-15.5)
Bulk density top 50 cm (g/cm <sup>3</sup> )	0.64 (0.20 – 1.16)	0.47 (0.20 – 1.52)
Soil organic matter (%)	4.8 (1.8 – 11.3)	3.5 (2.0 – 8.0)
Sand 0-50 cm (%)	37.4 (15.7 – 50.6)	30.9 (19.7 – 50.6)
Precipitation (mm) May-September. 30-year norm (1980-2010)	246.0 (204.5 – 318.3)	262.7 (219.5 – 328.2)
Max temperature (°C) May-September. 30-year norm (1980-2010)	22.2 (18.9 – 24.1)	22.5 (20.4 – 24.1)
Min temperature (°C) May-September. 30-year norm (1980-2010)	6.2 (5.2 – 7.5)	6.1 (4.9 – 7.5)



# SOILS DATA FROM WEB SOIL SURVEY

**Warning: Soil Ratings Map may not be valid at this scale.**  
You have zoomed in beyond the scale at which the soil map for this area is intended to be used. Mapping of soils is done at a particular scale. The soil surveys that comprise your AOI were mapped at 1:24,000. The design of map units and the level of detail shown in the resulting soil map are dependent on that map scale. Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Summary by Map Unit — Latah County, Idaho (ID057)				
Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
Ae3	Aquandic Endoaquepts-Manning-Spacecreek complex, 0 to 12 percent slopes	35.5	0.0	0.1%
Hm1j	Norwidge-Threebear complex, 5 to 30 percent slopes	35.7	0.0	0.2%
Ps4	Regoer ashy silt loam, 5 to 25 percent slopes	15.7	17.3	99.8%

UI Experimental Forest

<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>





# LONG-TERM CLIMATE DATA FROM PRISM

**PRISM CLIMATE GROUP**  
Northwest Alliance for Computational Science and Engineering

Home Normals Comparisons This Month Prior 6 Months Recent Years Historical Past Projects Explorer **FAQ**

Download data [from multiple locations](#) [Hide text](#)

Location  
 State & County: Idaho Latah  
 Coordinates: Latitude: 46.9176 Longitude: -116.5823 Elevation: 4209ft (1283m)

Data Settings  
 Precipitation  Mean dewpoint temp  
 Minimum temp  Minimum VPD  
 Mean temp  Maximum VPD  
 Maximum temp

30-year normals, 1981-2010 (monthly and annual)  
Resolution:  4km  800m

Annual values  
start: 2017 end: 2017

Single month values  
start: 2017 end: 2017  
January

Monthly values  
start: January 2017  
end: January 2017

Daily values  
start: 01 January 2017  
end: 01 January 2017

Data Stability: **stable (unlikely to change)**

Units:  English  SI (metric)  
 Interpolate grid cell values (see text)

Controls  
**Retrieve Time Series** Download Time Series Restore Previous Settings

Once settings are complete, **retrieve** the results

Click to select. Click & drag to pan. Use mouse wheel to zoom.

<http://www.prism.oregonstate.edu/>

# SURVIVAL MODEL FORM

$$Survival = \frac{e^{a+b \times SEEDLING + c \times COMP + d \times WEATHER + e \times SITE}}{1 + e^{a+b \times SEEDLING + c \times COMP + d \times WEATHER + e \times SITE}}$$


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$$b \times SEEDLING = b_1 ht_0 + b_2 cal_0 + b_3 RGP_{count}$$

$$c \times COMP = c_1 Forb + c_2 Shrub + c_3 Grass + c_4 Slash$$

$$d \times WEATHER = d_1 Precip_{June} + d_2 HDD_{March-May} + d_3 VPDmax_{Aug}$$

$$e \times SITE = e_1 Sand_{50} + e_2 MaxTemp_{May-Sept}$$

Logistic regression with binary response (1=alive, 0=dead)

Removed damaged or browsed seedlings

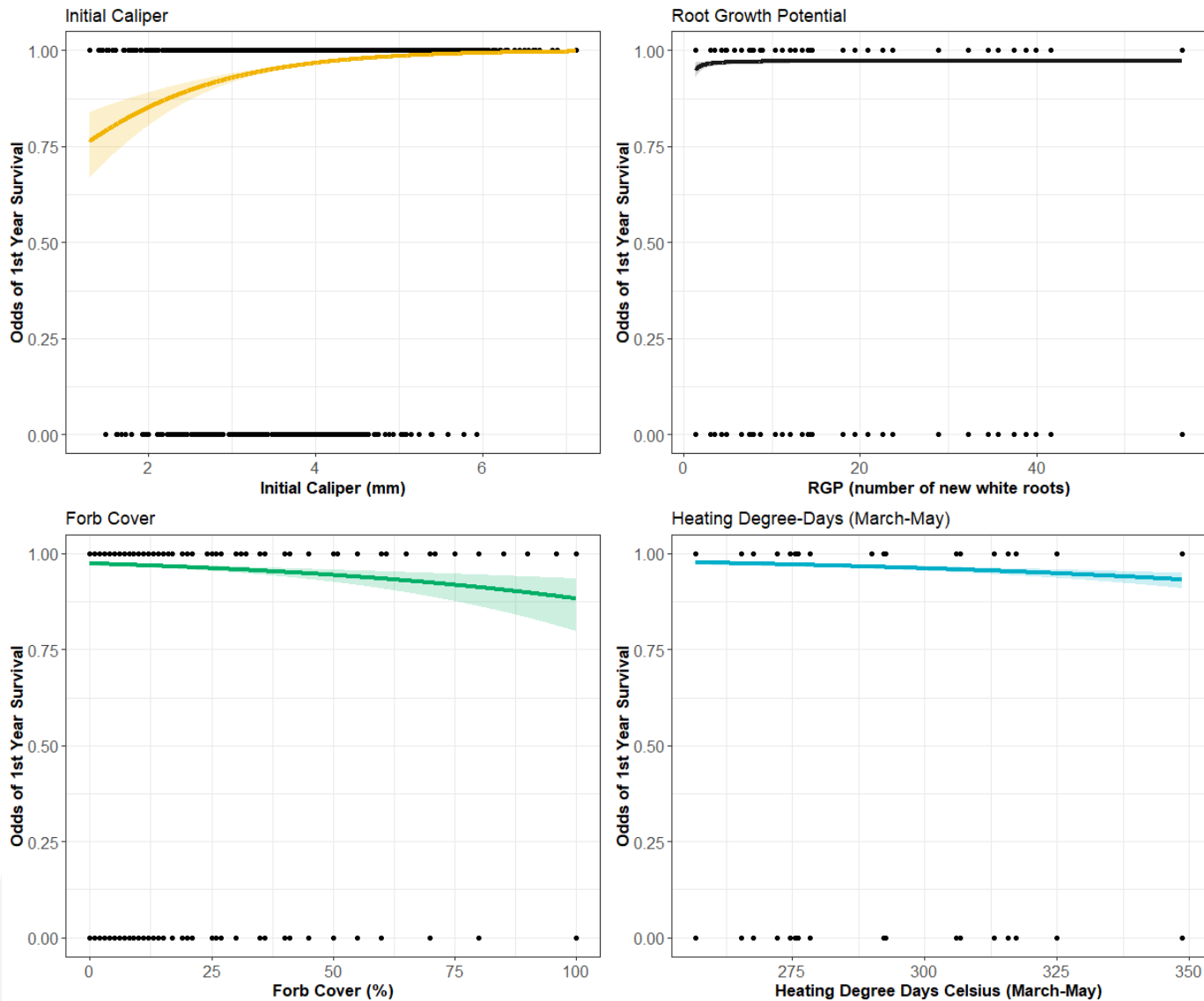


# 1-YEAR SURVIVAL MODEL PARAMETERS

Parameter	Western Larch	Douglas-fir
Intercept	4.353815	27.769755
Ht <sub>0</sub> (initial height)	- -0.035715	-
Cal <sub>0</sub> (initial diameter)	+ 0.819334	-
$RGP_{count}^{-1}$	+ -0.859206	- 17.054616
Forb (%)	- -0.016115	-
Shrub (%)	-	-
Grass (%)	-	-
Slash (%)	-	-
June precipitation	+ 0.014390	+ 0.044786
Spring heating degree-days	- -0.012270	- -0.059624
August max VPD (kPa)	-	- -1.584204
Sand upper 50 cm (%)	-	- -0.101531
May-Sept max temperature	-	-



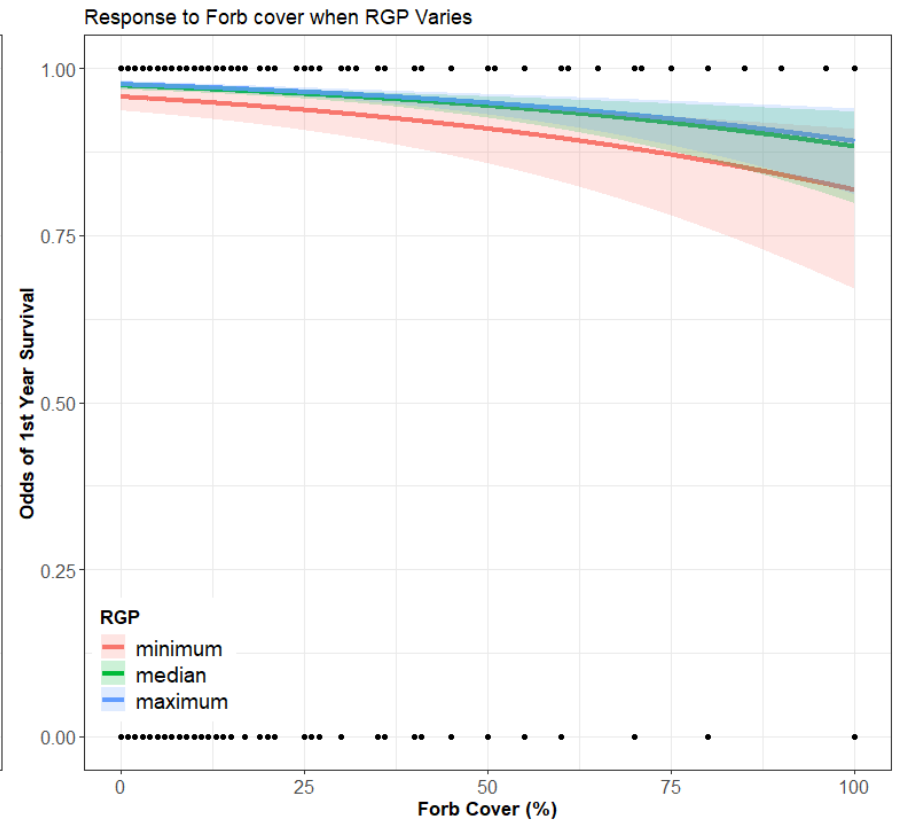
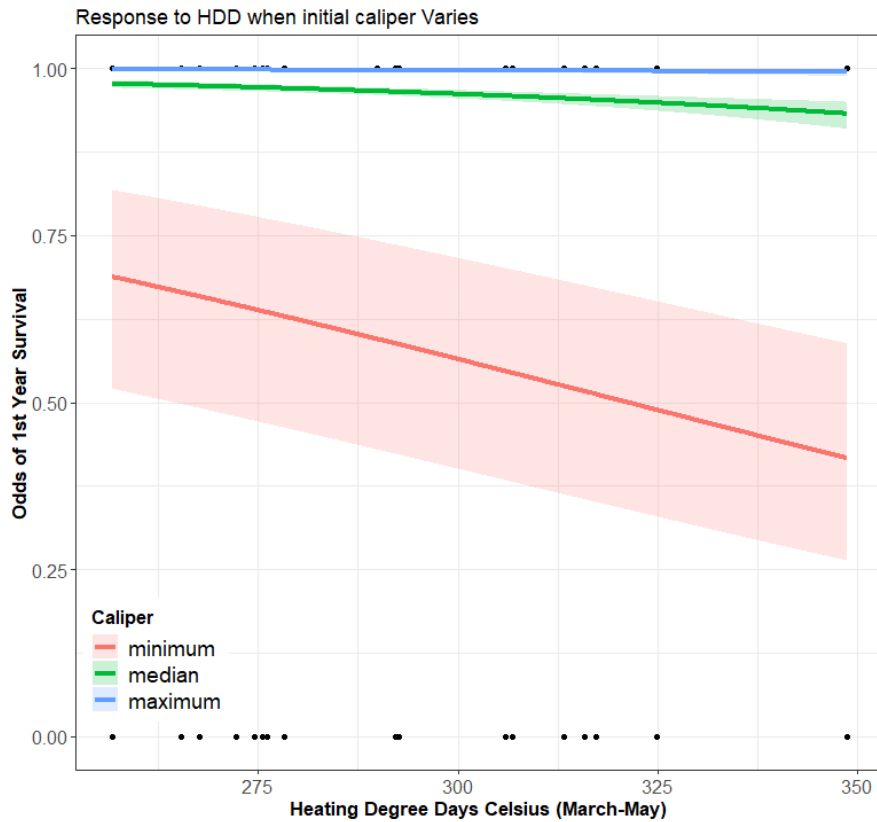
# WESTERN LARCH 1<sup>ST</sup> YEAR SURVIVAL





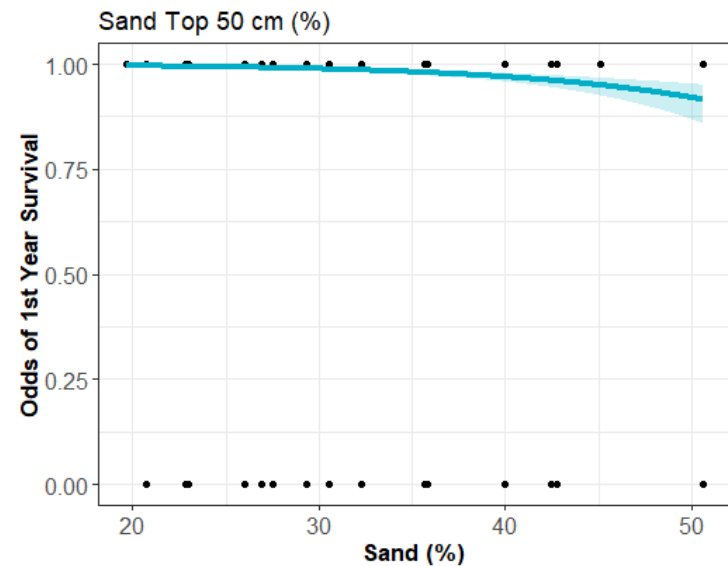
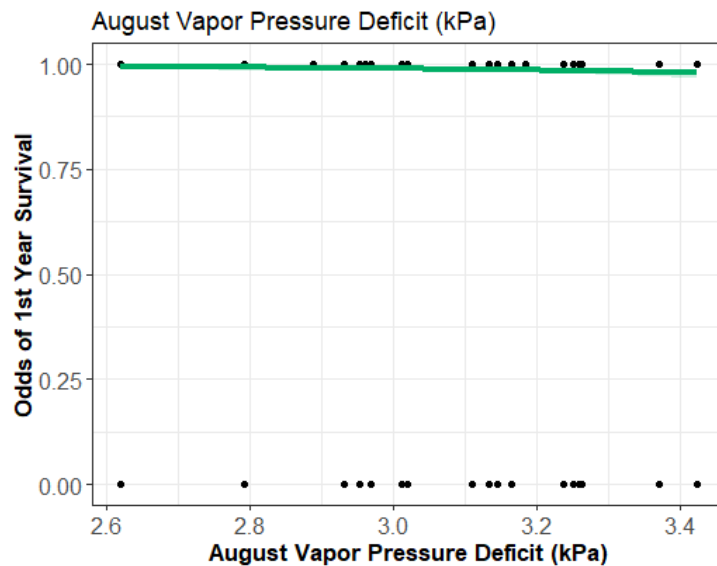
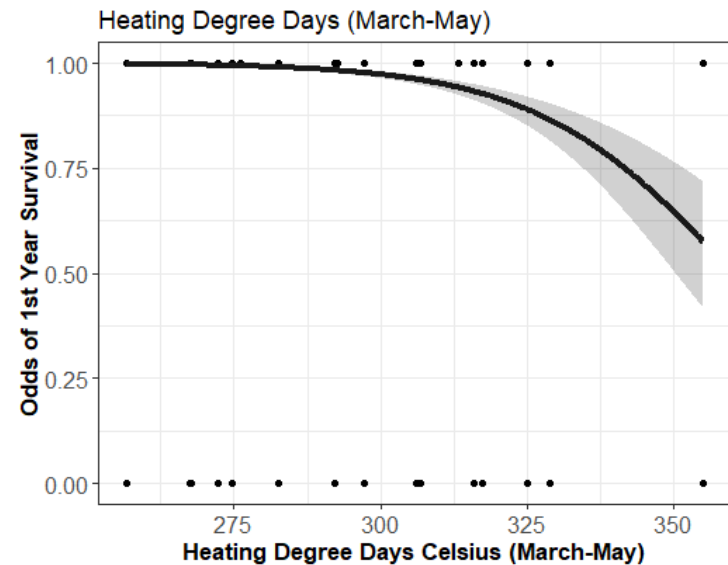
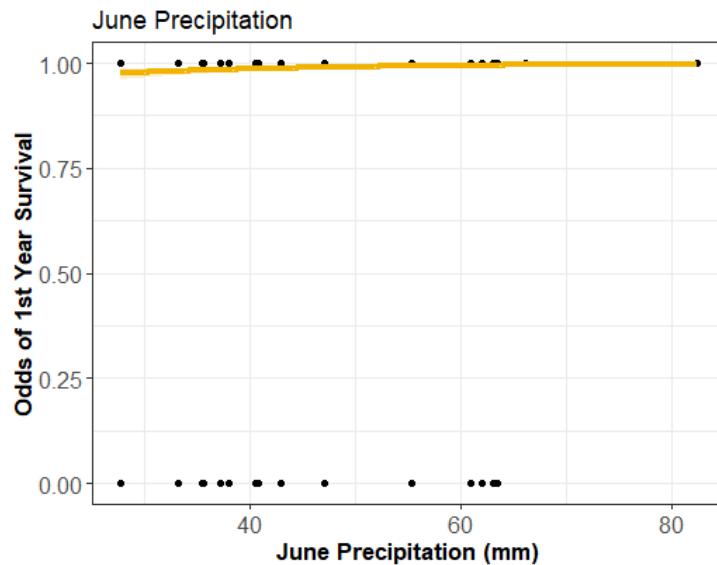


# WL SURVIVAL – INTERACTING FACTORS





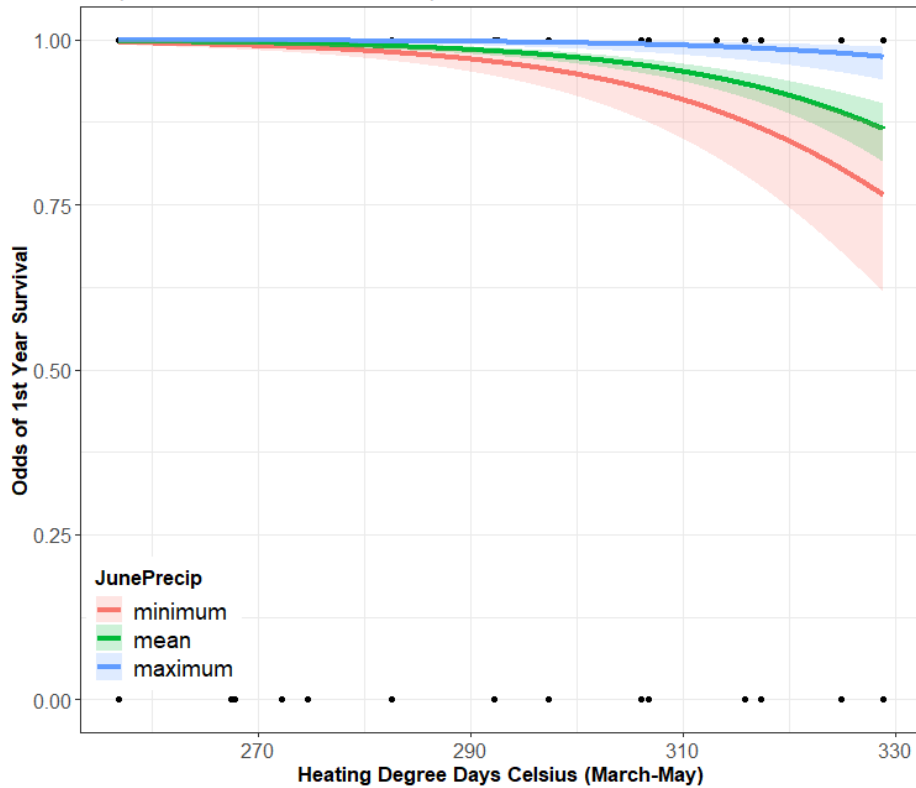
# DOUGLAS-FIR 1<sup>ST</sup> YEAR SURVIVAL



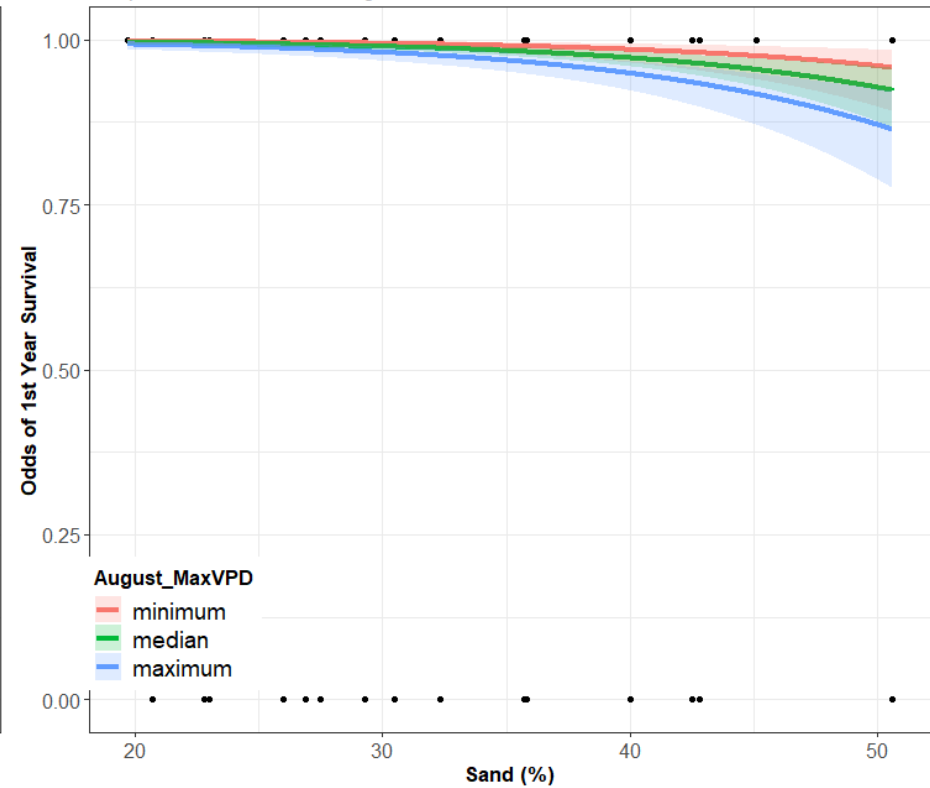


# DF SURVIVAL – INTERACTING FACTORS

Response to HDD when June Precipitation varies



Response to Sand when August VPD Varies



# CALIPER GROWTH MODEL FORM

$$\ln(cal_1 - cal_0) = a + b \times \mathbf{SEEDLING} + c \times \mathbf{COMP} + d \times \mathbf{WEATHER} + e \times \mathbf{SITE}$$

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$$b \times \mathbf{SEEDLING} = b_1 ht_0 + b_2 cal_0 + b_3 RGP_{count}$$

$$c \times \mathbf{COMP} = c_1 Forb + c_2 Shrub + c_3 Grass + c_4 Slash$$

$$d \times \mathbf{WEATHER} = d_1 Precip_{March} + d_2 HDD_{Mar-May}$$

$$e \times \mathbf{SITE} = e_1 Sand_{50} + e_2 ASW_{0-50}$$

Fit with quantile regression (15<sup>th</sup>, 30<sup>th</sup>, 45<sup>th</sup>, 60<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup> quantiles [percentiles])



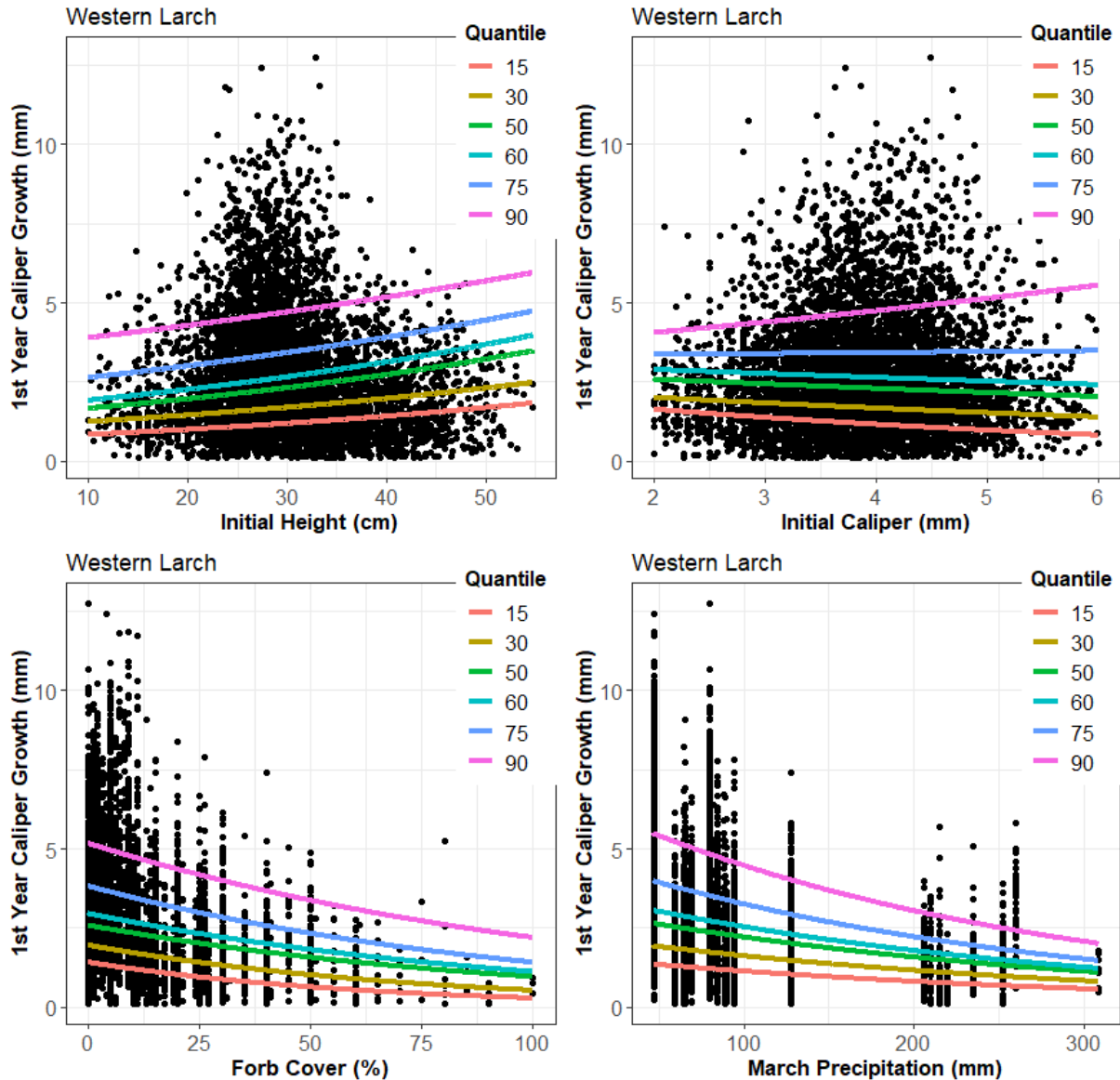


# MEDIAN 1-YEAR CALIPER MODEL PARAMETERS

Parameter	Western Larch	Douglas-fir
Intercept	-	1.62162
Ht <sub>0</sub> (cm)	+ 0.01646	+ 0.01649
Cal <sub>0</sub> (mm)	- -0.05984	- -0.21839
RGP <sub>count</sub> (count of new roots)	- -0.01048	- -0.00855
Forb (%)	- -0.00994	- -0.00855
Shrub (%)	- -0.01368	- -0.01232
Grass (%)	- -0.00550	-
Slash (%)	-	+ 0.00711
March precipitation (mm)	- -0.00337	+ 0.00434
Spring heating degree-days (°C)	+ 0.00400	- -0.00799
Sand upper 50 cm (%)	-	-
Available soil water 0-50 cm (cm)	-	+ 0.07084

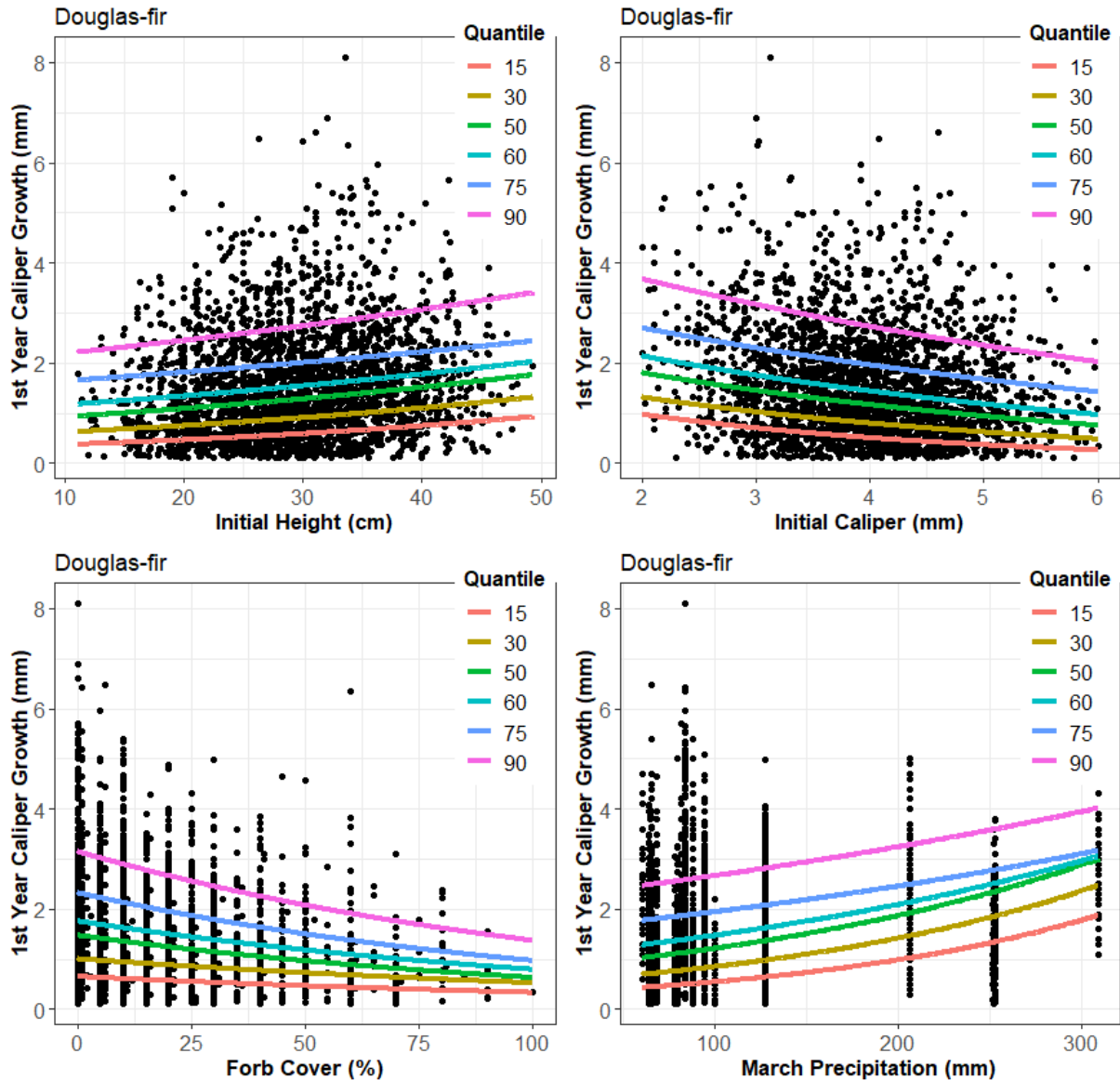


# WESTERN LARCH 1 YEAR CALIPER GROWTH





# DOUGLAS-FIR 1 YEAR CALIPER GROWTH





# WESTERN LARCH EXAMPLE (50<sup>TH</sup> PERCENTILE)

HT <sub>0</sub>	Cal <sub>0</sub>	RGP	Forb	Shrub	Grass	March precip	June precip	HDD
31.8	2.0	15	10	0	5	90	40	290
22.0	1.9	15	40	5	15	90	40	290
30.2	3.4	15	10	0	0	90	40	290
27.1	1.8	15	20	10	5	90	40	290
32.4	4.1	15	60	0	5	90	40	290
28.7	3.8	15	20	0	0	90	40	290





# WESTERN LARCH EXAMPLE (50<sup>TH</sup> PERCENTILE)

HT <sub>0</sub>	Cal <sub>0</sub>	RGP	Forb	Shrub	Grass	March precip	June precip	HDD	Surv
31.8	2.0	15	10	0	5	90	40	290	0.84
22.0	1.9	15	40	5	15	90	40	290	0.81
30.2	3.4	15	10	0	0	90	40	290	0.95
27.1	1.8	15	20	10	5	90	40	290	0.82
32.4	4.1	15	60	0	5	90	40	290	0.93
28.7	3.8	15	20	0	0	90	40	290	0.96



# WESTERN LARCH EXAMPLE (50<sup>TH</sup> PERCENTILE)

HT <sub>0</sub>	Cal <sub>0</sub>	RGP	Forb	Shrub	Grass	March precip	June precip	HDD	Surv	Calg (mm)
31.8	2.0	15	10	0	5	90	40	290	0.84	0.92
22.0	1.9	15	40	5	15	90	40	290	0.81	0.30
30.2	3.4	15	10	0	0	90	40	290	0.95	0.84
27.1	1.8	15	20	10	5	90	40	290	0.82	0.62
32.4	4.1	15	60	0	5	90	40	290	0.93	0.19
28.7	3.8	15	20	0	0	90	40	290	0.96	0.67



# WESTERN LARCH EXAMPLE (50<sup>TH</sup> PERCENTILE)

HT <sub>0</sub>	Cal <sub>0</sub>	RGP	Forb	Shrub	Grass	March precip	June precip	HDD	Surv	Calg (mm)
31.8	2.0	15	10	0	5	90	40	290	0.84	0.92
22.0	1.9	15	40	5	15	90	40	290	0.81	0.30
30.2	3.4	15	10	0	0	90	40	290	0.95	0.84
27.1	1.8	15	20	10	5	90	40	290	0.82	0.62
32.4	4.1	15	60	0	5	90	40	290	0.93	0.19
28.7	3.8	15	20	0	0	90	40	290	0.96	0.67
<b>AVERAGE:</b>									<b>0.84</b>	<b>0.92</b>

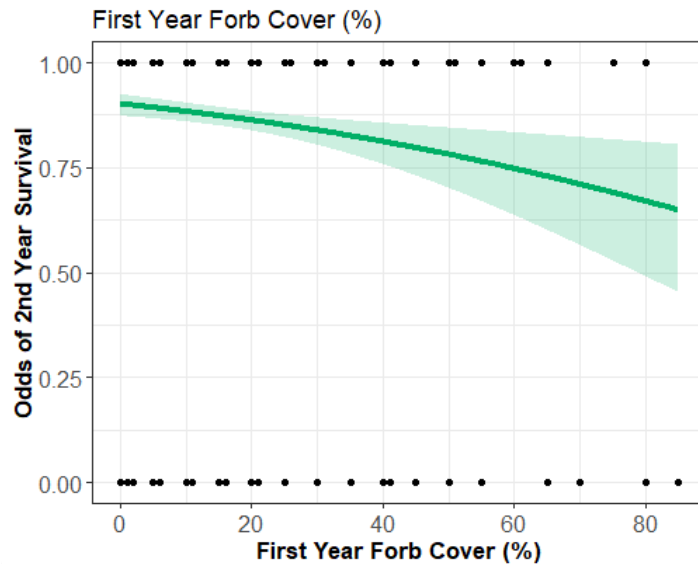
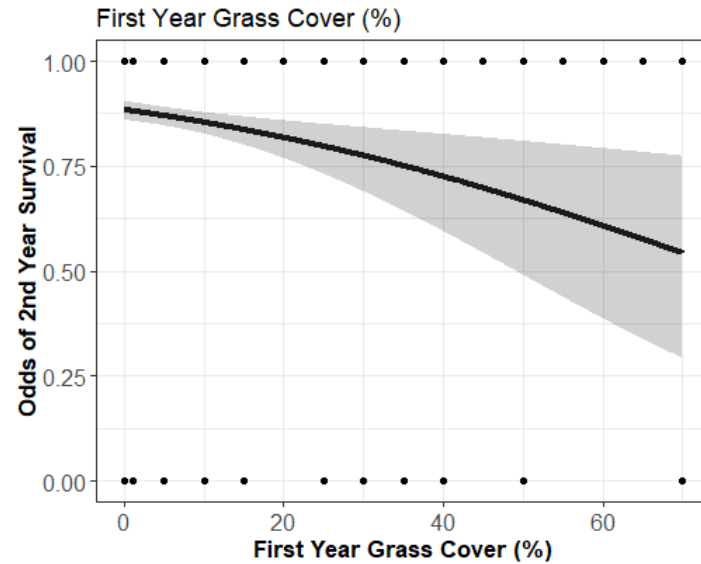
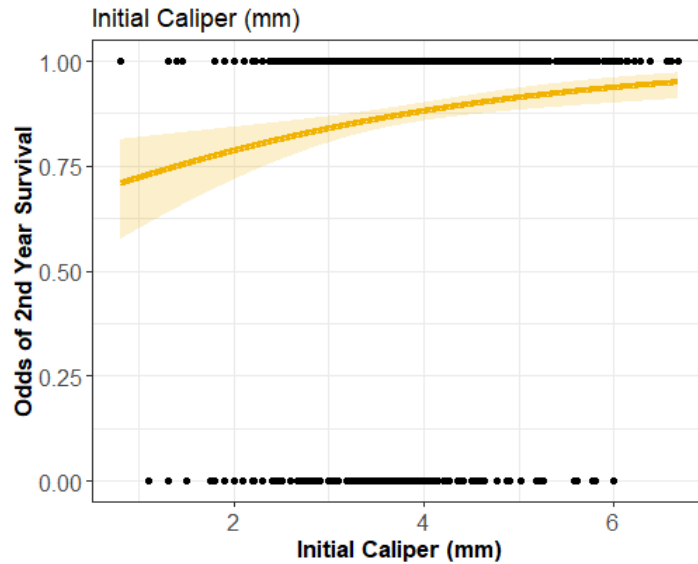


# 2-YEAR SURVIVAL MODEL PARAMETERS

Parameter	Western Larch	Douglas-fir
Intercept	-	12.139152
Ht <sub>0</sub> (initial height)	-	-0.050704
Cal <sub>0</sub> (initial diameter)	+ 0.348039	-
<i>RGP<sub>count</sub></i>	-	
Forb (%)	- -0.018821	
Shrub (%)	-	-0.017286
Grass (%)	- -0.026557	-
Slash (%)	-	-
June precipitation	+ 0.221188	-
Spring heating degree-days	- -0.033953	- -0.017681
Sand upper 50 cm (%)	- -0.307795	- -0.119052

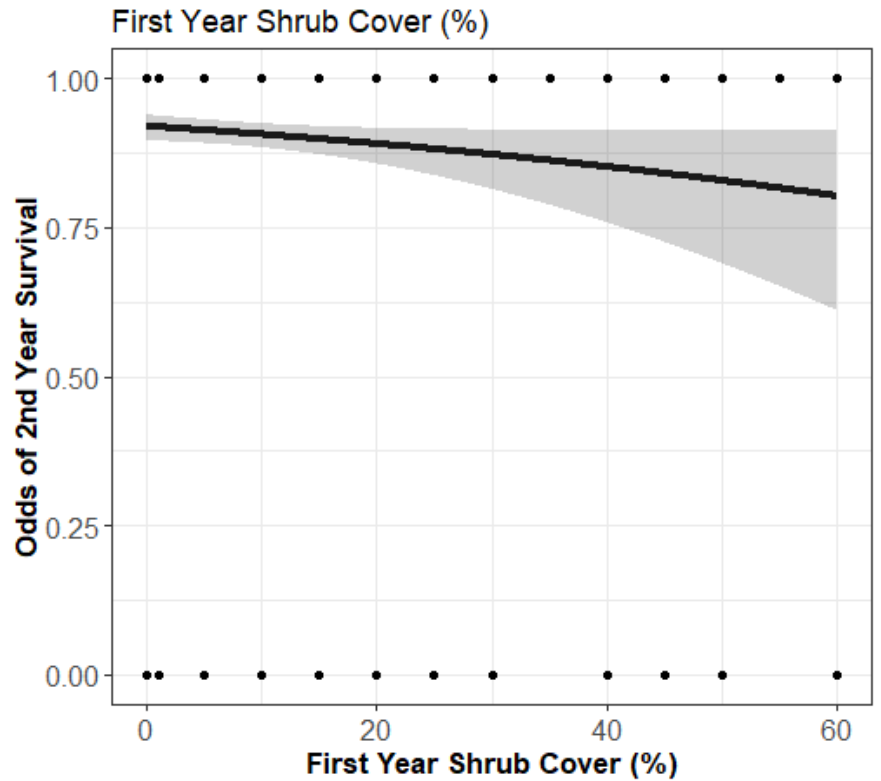
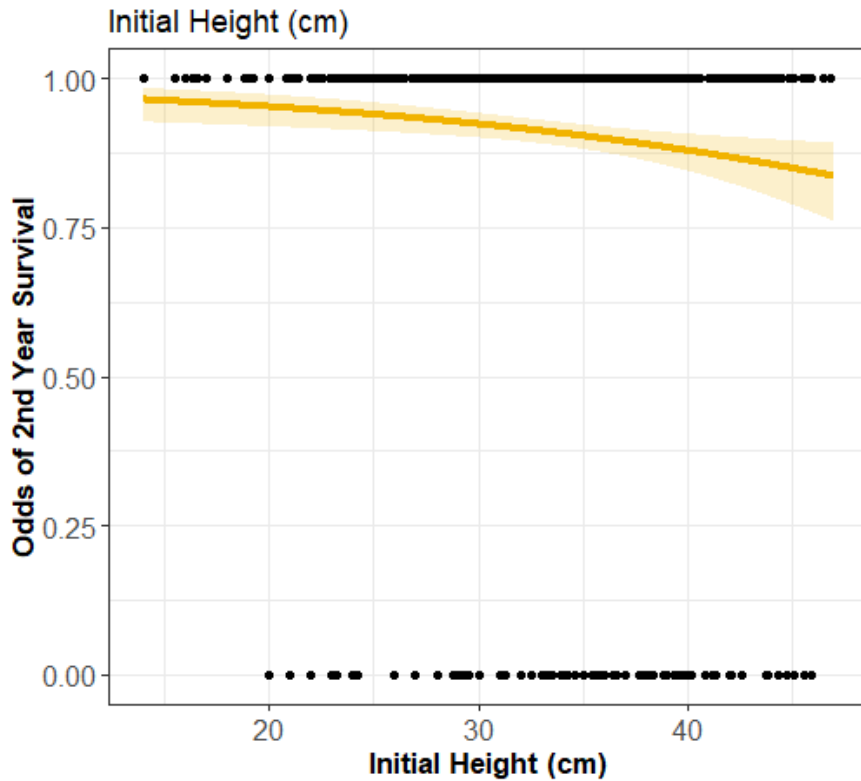


# WESTERN LARCH 2-YEAR SURVIVAL





# DOUGLAS-FIR 2-YEAR SURVIVAL







# SUMMARY

- I First year growth and survival is a start to better understand drivers of DF and WL seedling performance in the INW.
- I Model is unique: includes initial seedling size, seedling quality, competition, planting-year weather, and site characteristics all easily measured or obtained from public sources.
- I More precipitation in June and cooler spring temps (lower heating degree days) resulted in greater survival for both WL and DF.
- I Larger caliper seedlings and greater competition from forbs, shrubs, and grasses led to lower caliper growth during the first season.
- I Greater March precipitation led to less WL caliper growth but greater DF caliper growth demonstrating different species sensitivity to weather.



# NEXT STEPS

- I Work with cooperators to measure additional seedlings planted in 2019
- I Remeasure first year seedlings to increase number of observations for 2<sup>nd</sup> year modeling
- I Track growth and survival through age 5
- I Obtain individual seedling data from broad range of site productivity and geography
- I Expand model to additional species: Ponderosa pine, lodgepole pine, and western white pine



# ACKNOWLEDGEMENTS

- I PotlatchDeltic Corporation
- I Hancock Forest Management
- I Stimson Lumber Company
- I Molpus Timberland Investment
- I USDA Forest Service RMRS
- I Uldaho Experimental Forest
- I Lori Mackey (CFNSR)
- I Numerous field crew members