University of Idaho
College of Natural Resources

Intermountain Forestry Cooperative

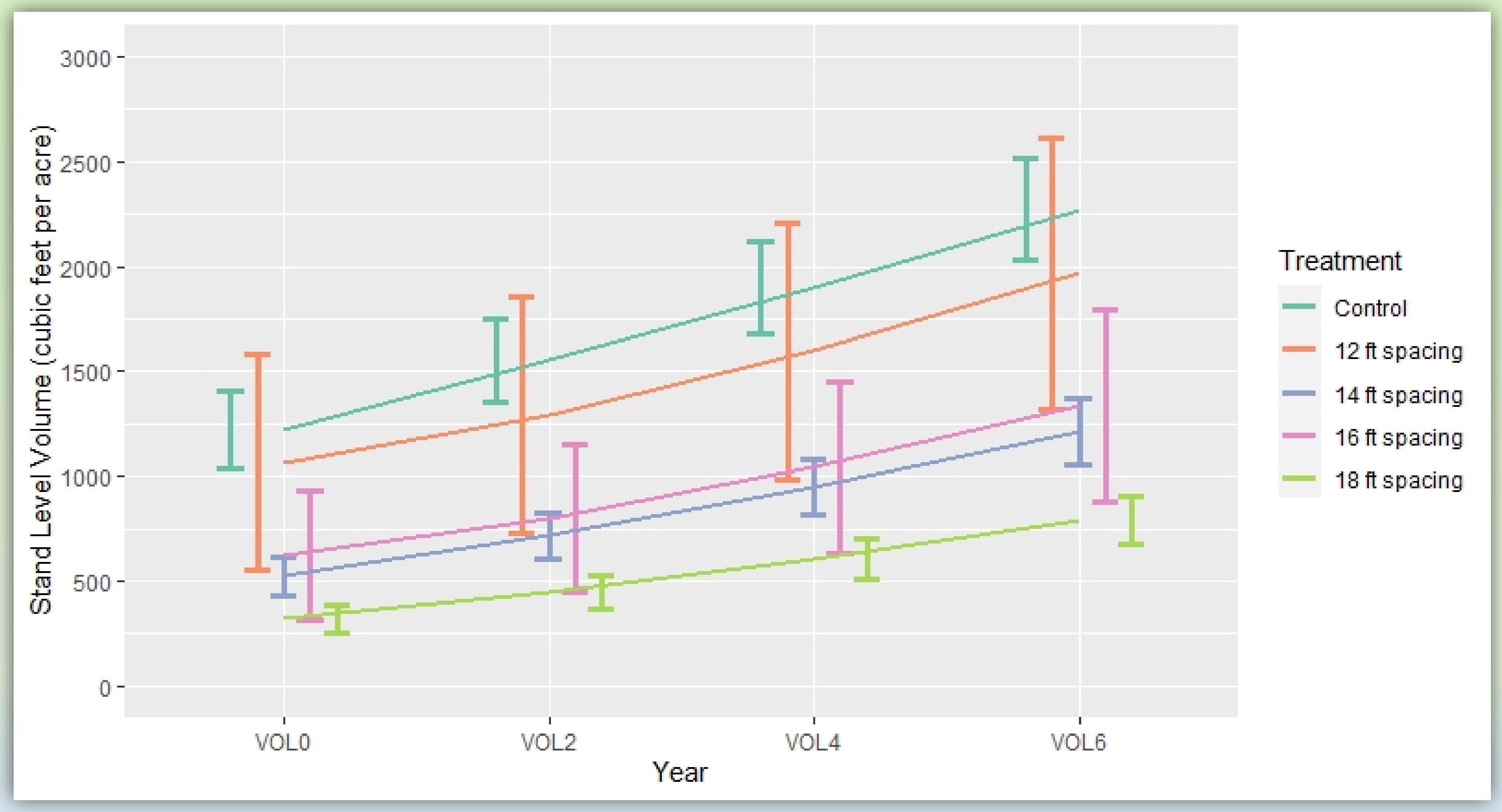
# Physiographic Influence of Douglas-fir Thinning Response

SIXTH YEAR MEASUREMENTS

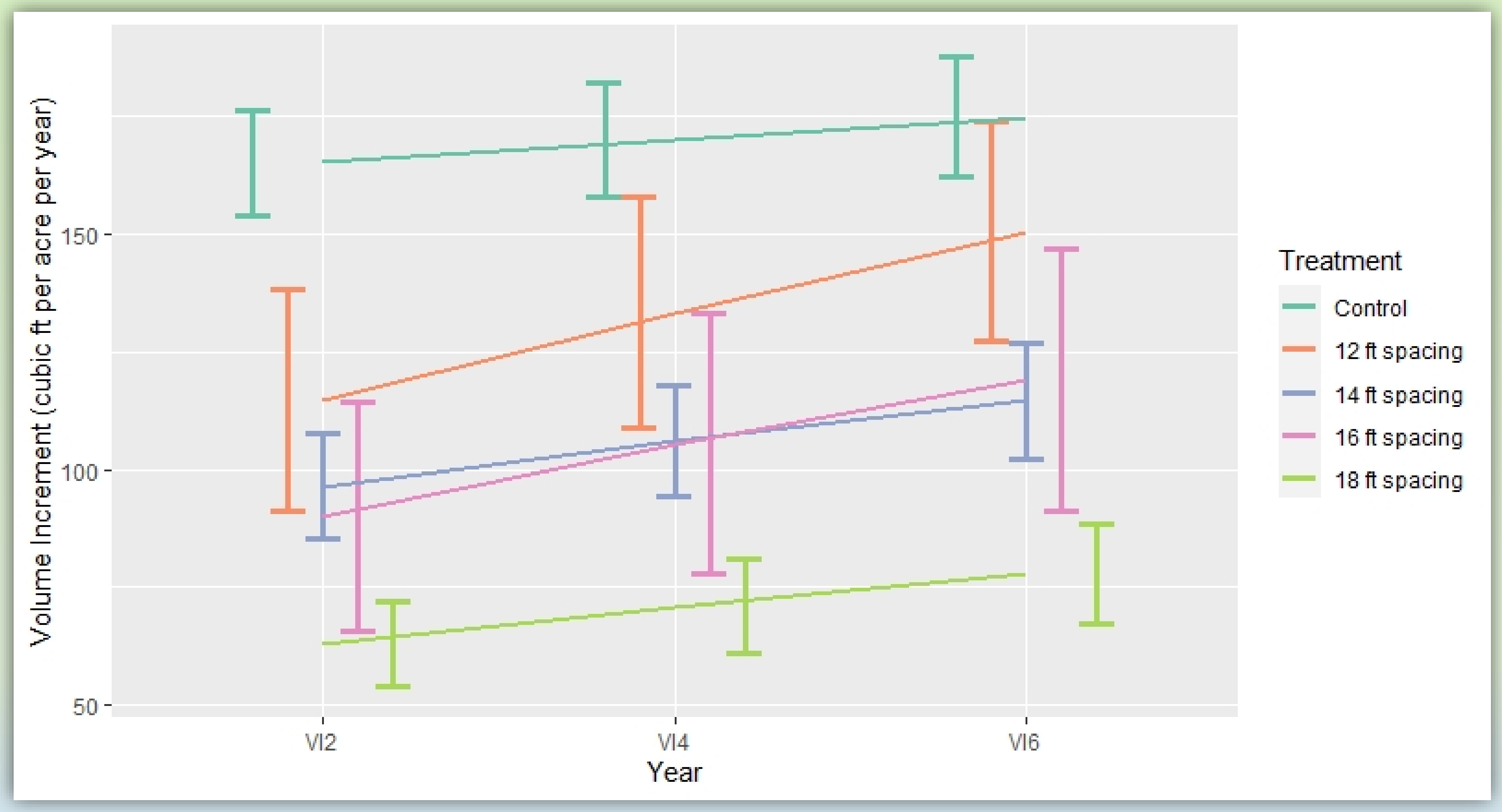
PPDM Update

Ryan Heiderman

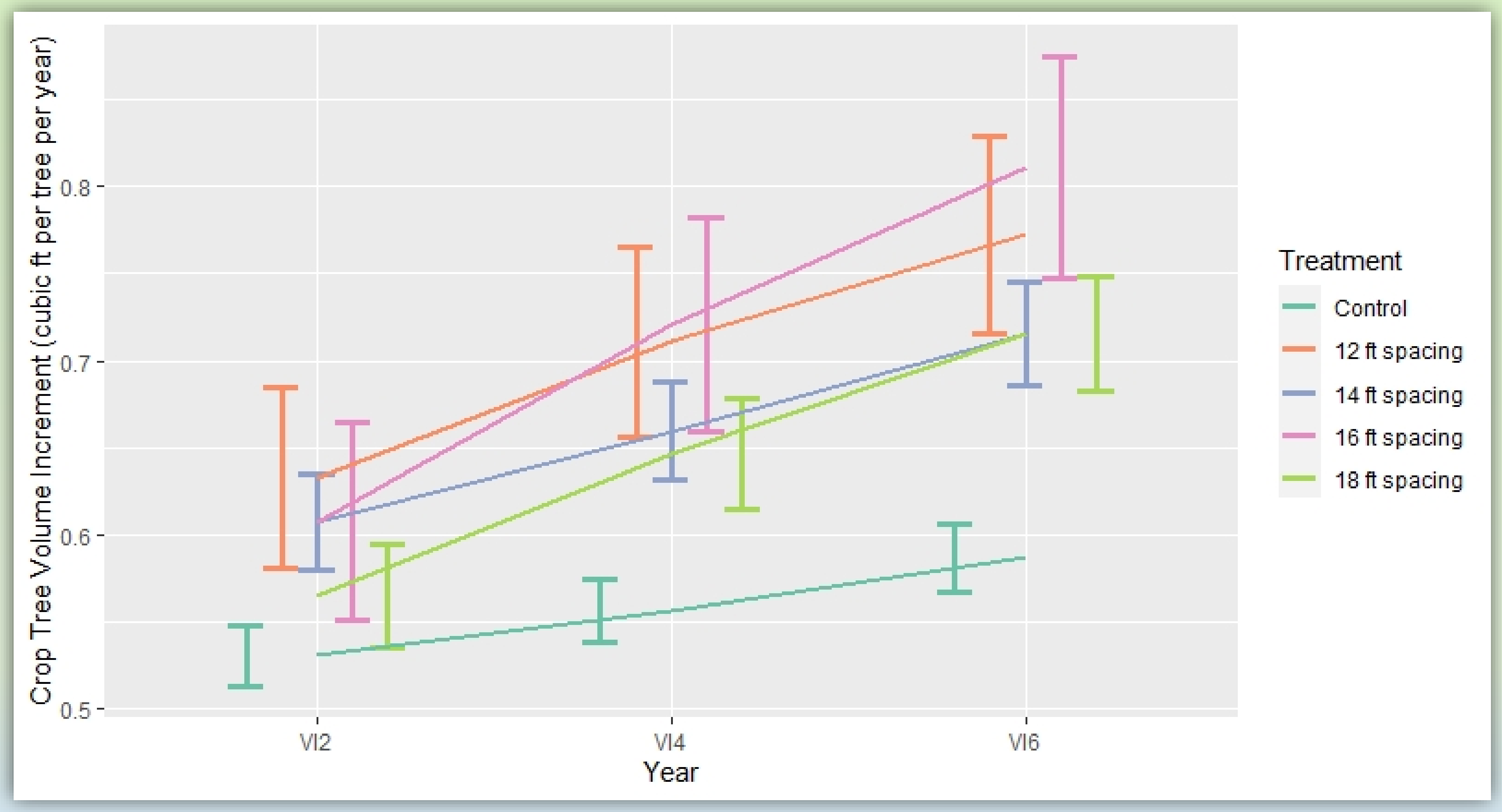
# Treatments: Stand Level Response



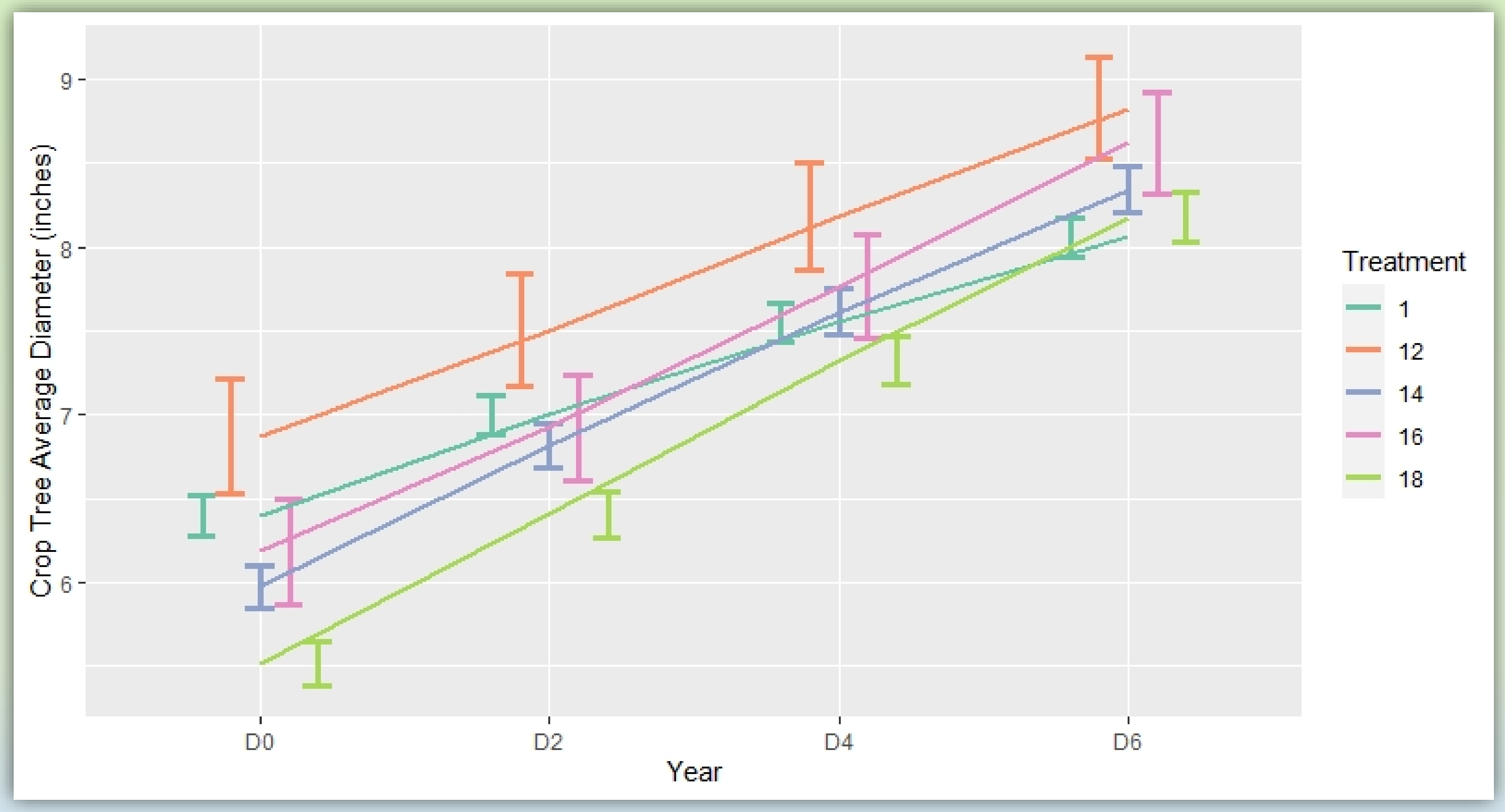
# Treatments: Stand Level Response



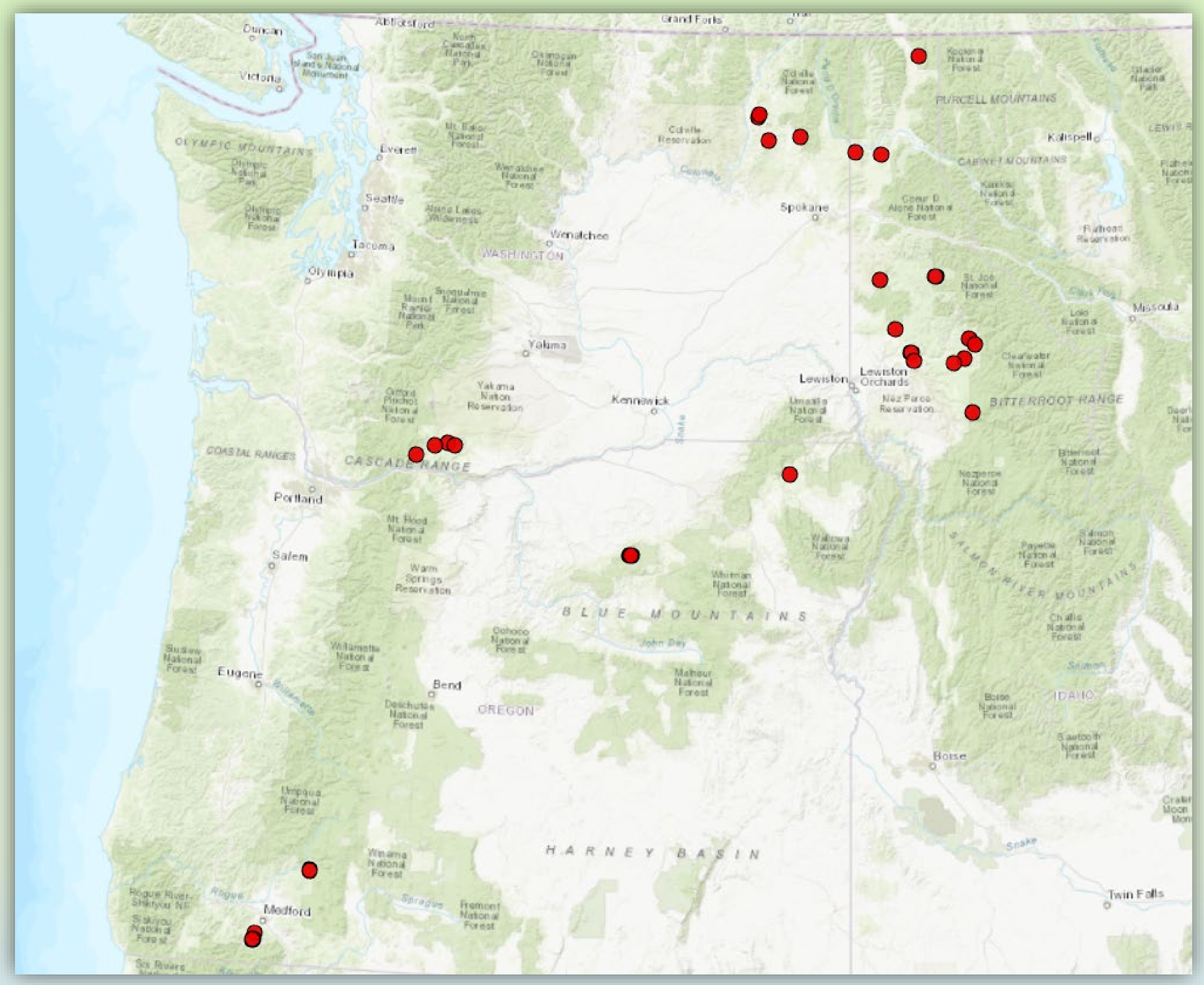
# Treatments: Individual Crop Tree Response



# Treatments: Individual Crop Tree Response



# Treatments: Locations




sixty-seven plots at twenty-two sites with six year measurements

# Treatments: Stand Level Metrics

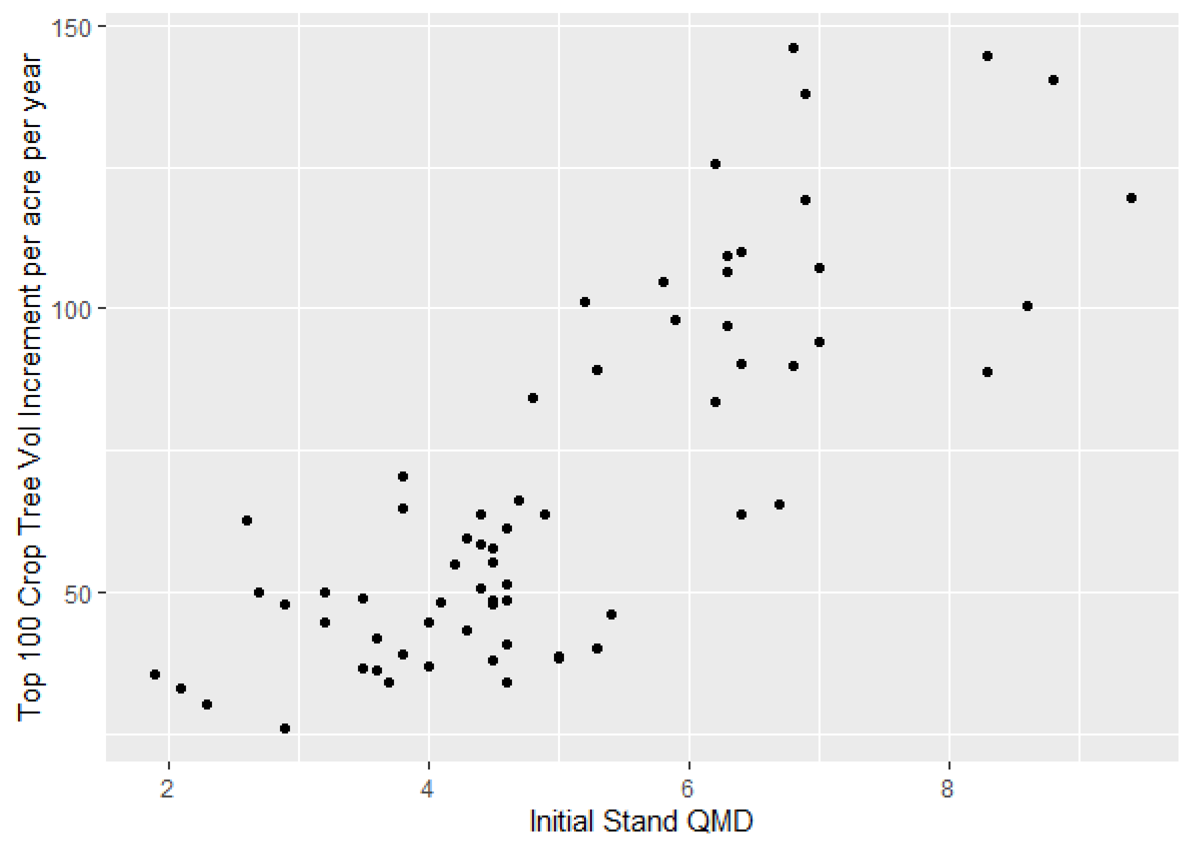
| | Min | Mean | Max | SD |
|---|---|---|---|---|
| SDI0 | 31 | 140 | 476 | 110 |
| QMD0 | 1.9 | 5 | 9.4 | 1.7 |
| TPA0 | 120 | 550 | 3810 | 815 |
| VOL0 | 111 | 745 | 3457 | 720 |
| VOL6 | 336 | 1512 | 5167 | 1045 |

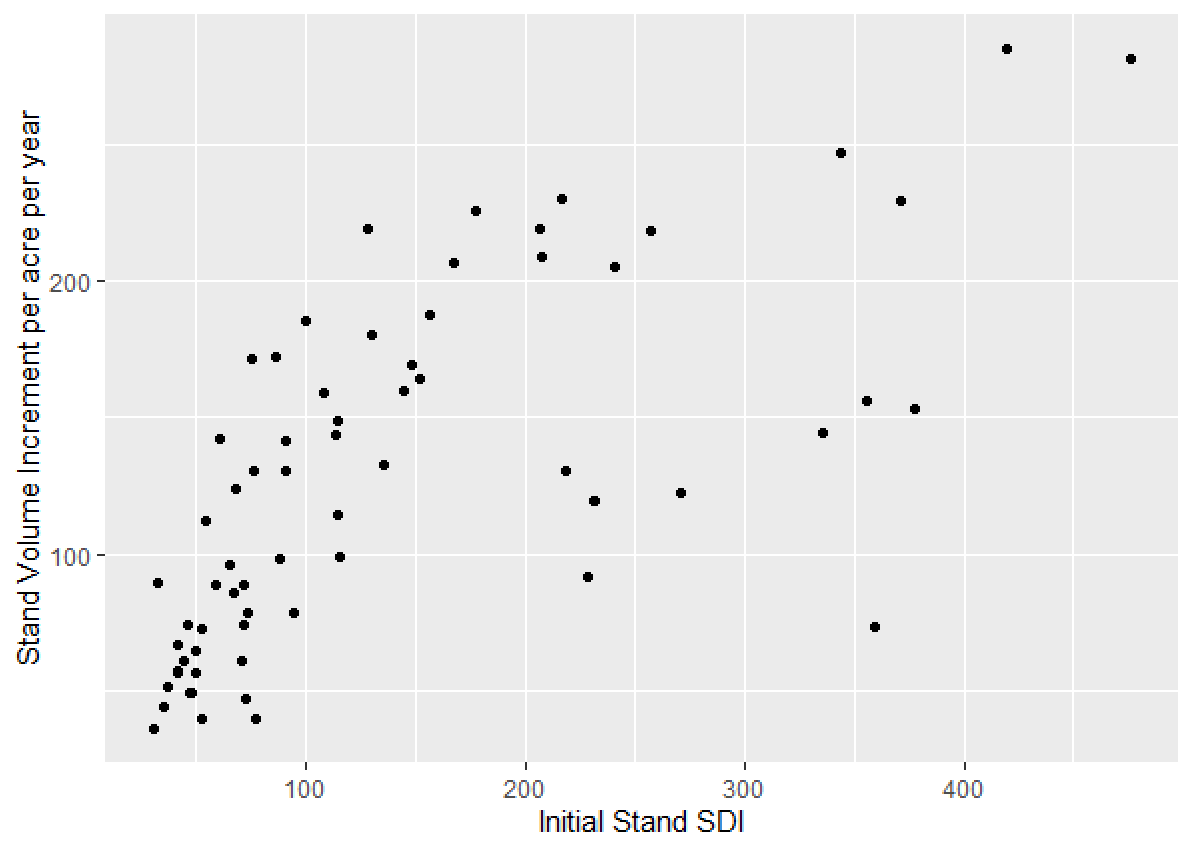
sixty-seven plots at twenty-two sites with six year measurements

# Research Questions at 6 years

- What factors influence growth?
  - Stand/Tree Factors
  - Physiographic Factors
  - Interactions
- Prediction of Net Volume Increment
- Control for stand conditions
  - Pre-treatment, Post-treatment and current
- Mortality will become more important as study progresses
  - Currently 0.7% mortality (TPA) in treated stands

# Stand and Tree Characteristics determine Volume



# Treatments: Physiographic Influence

| | Min | Mean | Max | SD |
|---|---|---|---|---|
| Elevation (ft) | 2165 | 3474 | 5180 | 751 |
| HeatLoad (DD1040 x SolarRad) | 471 | 901 | 1255 | 185 |
| PRATIO (GSP:MAP) | 0.12 | 0.24 | 0.32 | 0.07 |
| Avail Water Supply | 12.5 | 17 | 30 | 4 |

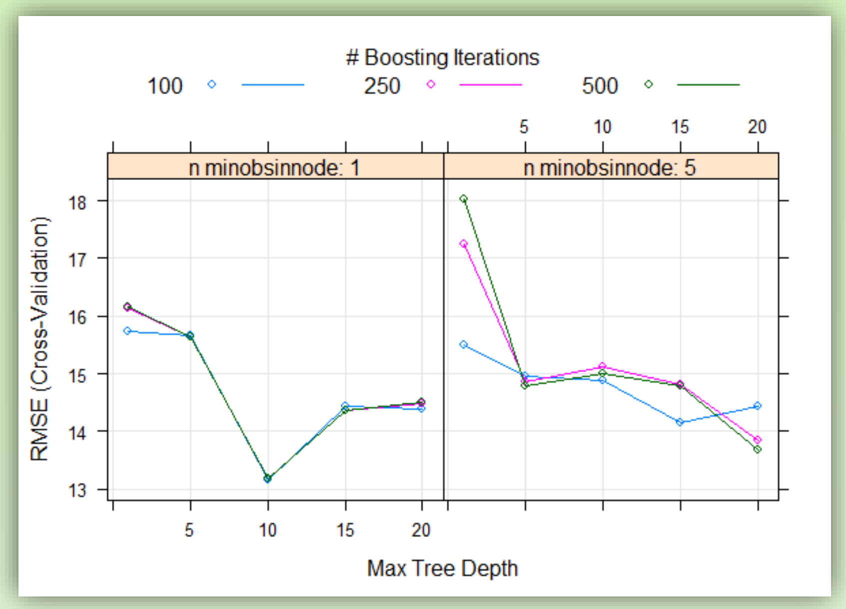
sixty-seven plots at twenty-two sites with six year measurements

# Crop Tree Analysis

- Top 100 trees per acre by initial volume
- Net Volume Increment (Time 6–Time 0)/6
- Stand Characteristics
  - Initial Stand QMD, TPA and BA
  - Treatment metrics BA removed, Pre-treatment SDI and SDI removed
- Environmental Characteristics
  - Location specific climate normals (1981–2010)
  - Incoming Solar Radiation
    - Adjusted for Elevation/Latitude/Topographic Position
  - Soils – Available Water Supply
- Analysis via Ensemble Learning (ie Random Forest, Boosted Reg Trees)

*"If the goal of an analysis is prediction rather than formal explanation of hypotheses, machine learning provides a set of tools that can dramatically improve results"*

*Evans et al., 2011*




# Modeling Approach

- Gradient Boosting Methodology
  - 'Boosted' Regression Trees
  - Cross-Validation (multiple random splits of test/train while building model)
  - Prediction on 'unseen' validation data (sites held out of the analysis)
  - RMSE and Mean Absolute Percent Error
- Three Scenarios to Predict Net Volume Increment (YR6)
  - Tree/Stand data only
  - Environmental data only
  - Both

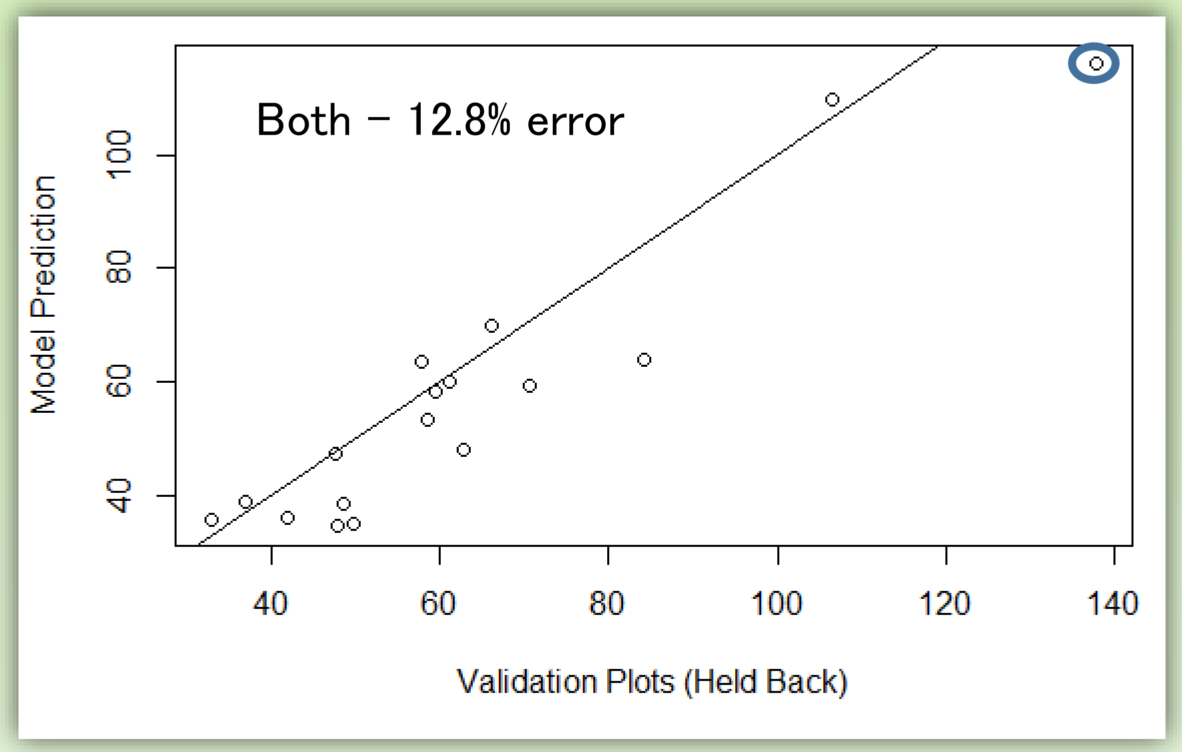
# Results

| | | Stand/Tree Data Only | Environmental Data Only | Both |
|---|---|---|---|---|
| 5-Fold CV | RMSE | 13.9 | 16.3 | 13.1 |
| | Pseudo R2 | 0.84 | 0.77 | 0.86 |
| **Validation** | RMSE | **21.7** | **20.5** | **10.4** |
| | MAPE | **23.7%** | **25.6%** | **12.8%** |

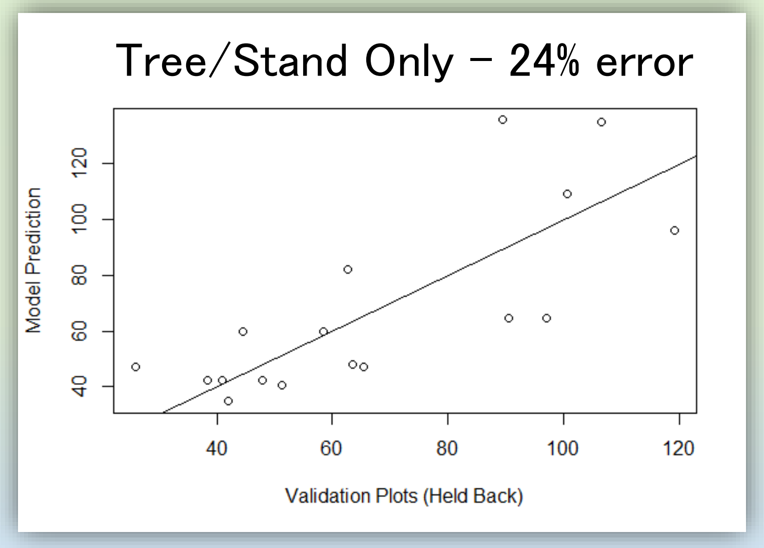
*Validation on held back data, unseen by the original model

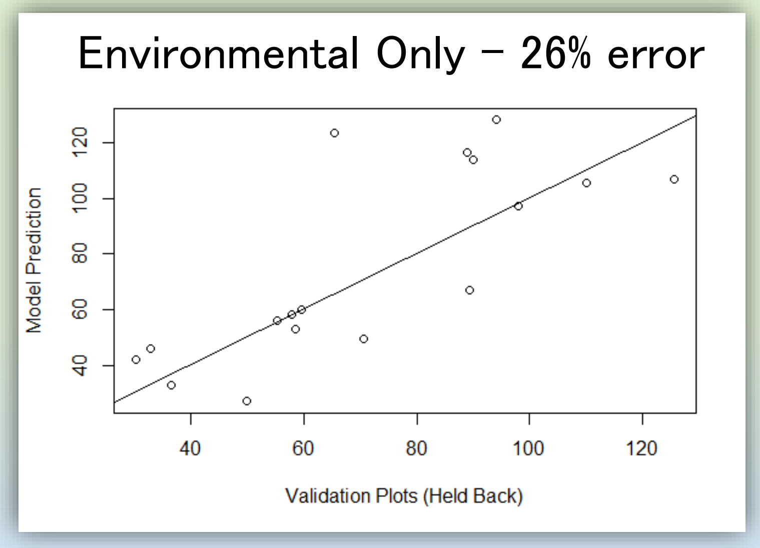
# Results – Validation

```
> varImp(gbm_model)
gbm variable importance

  only 20 most important variables shown (out of 86)

             Overall
QMD0_stand   100.000
DD5_wt        23.369
BA_Removed0    8.528
SDIpre         4.434
AHM            3.871
PPT_at         3.691
HeatLoad       3.649
RH_wt          3.513
SDI0           3.480
Tmin_sp        3.387
pratio         3.331
PPT_sm         3.283
PPT_wt         3.079
EXT            2.987
AWS100         2.759
DD_0_wt        2.723
DD_18_sm       2.652
Tmax_wt        2.576
CMD_sp         1.937
Tave_sm        1.610
```




n = 17



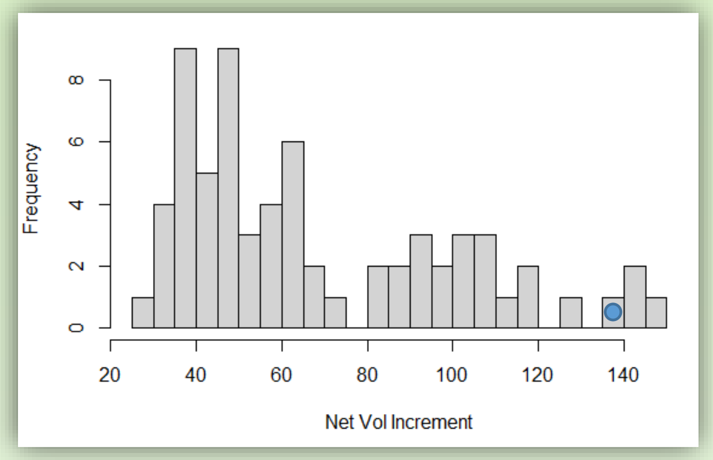



# Results

- Tree and Stand level data strongly correlated with volume increment, as expected
- Prediction of held back data
  - Model with both environmental and tree/stand data best results
- Application
  - Volume increment for a site with unknown current measurements may be predicted with decent accuracy given some initial characteristics of the stand and treatment applied, along with site specific environmental factors

# Application – Scenario with Held Back Sites

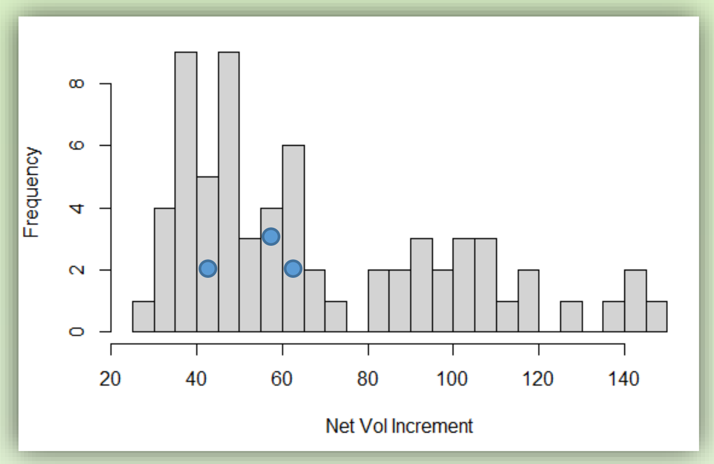
- Consider a management scenario where we want to explore volume response under various thinning levels
- Install 617
  - At random, site had two plots held back in validation data
  - Included plot with the 4th highest Net Vol Increment
    - model showed under prediction at high end > less data points
  - Made up scenarios of different thinning intensities
  - RMSE 12.9 cuft per acre per year




| SDI Pre-Trt | SDI Post-Trt | TPA Post_Trt | BA Post_Trt | BA Removed | QMD Post-Trt | NETVI6 | Prediction |
|---|---|---|---|---|---|---|---|
| 207.7 | 207.7 | 520 | 80 | 0 | 5.3 | 89.32 | 88.03 |
| 207.7 | 181.7 | 400 | 73 | 6 | 5.8 | * | 96.27 |
| 207.7 | 153.6 | 300 | 65 | 15 | 6.3 | 106.52 | 109.51 |
| 207.7 | 99.3 | 170 | 44 | 36 | 6.9 | 137.87 | 115.85 |
| 207.7 | 60.9 | 100 | 27 | 52 | 7.1 | * | 117.84 |
| 207.7 | 32.3 | 50 | 15 | 65 | 7.4 | * | 118.35 |

# Application – Scenario with Held Back Sites

- Install 635
  - Randomly had 2 of 3 plots held back in validation data
  - Synthetic thinning scenarios
  - RMSE of 3.1 cuft per acre per year




| SDI Pre-Trt | SDI Post-Trt | TPA Post_Trt | BA Post_Trt | BA Removed | QMD Post-Trt | NETVI6 | Prediction |
|---|---|---|---|---|---|---|---|
| 144.27 | 144.27 | 550 | 47.3 | 0 | 4 | 44.51 | 45.68 |
| 144.27 | 113.8 | 400 | 38 | 9 | 4.2 | * | 47.78 |
| 144.27 | 90.41 | 300 | 31.3 | 16 | 4.4 | 58.46 | 53.39 |
| 144.27 | 69.2 | 220 | 24 | 23 | 4.5 | * | 61.57 |
| 144.27 | 58.6 | 180 | 20.9 | 26 | 4.6 | 61.14 | 60.16 |
| 144.27 | 34.5 | 100 | 13 | 35 | 4.8 | * | 61.74 |

# Conclusions

- Tree measurements the most important component
- Stand dynamics controls volume/growth trajectory
- However, growth trajectory is modified by site conditions
- Predictions using environmental covariates and ensemble learning methodology may be useful for projecting volume increments in unmeasured or under-measured areas
- Validation is important for any modelling effort
- As more data collected, over longer periods these models can be tuned and revalidated