University of Idaho
College of Natural Resources

PAIRED PLOT DENSITY TRIALS:
PONDEROSA PINE – 4YR RESULTS

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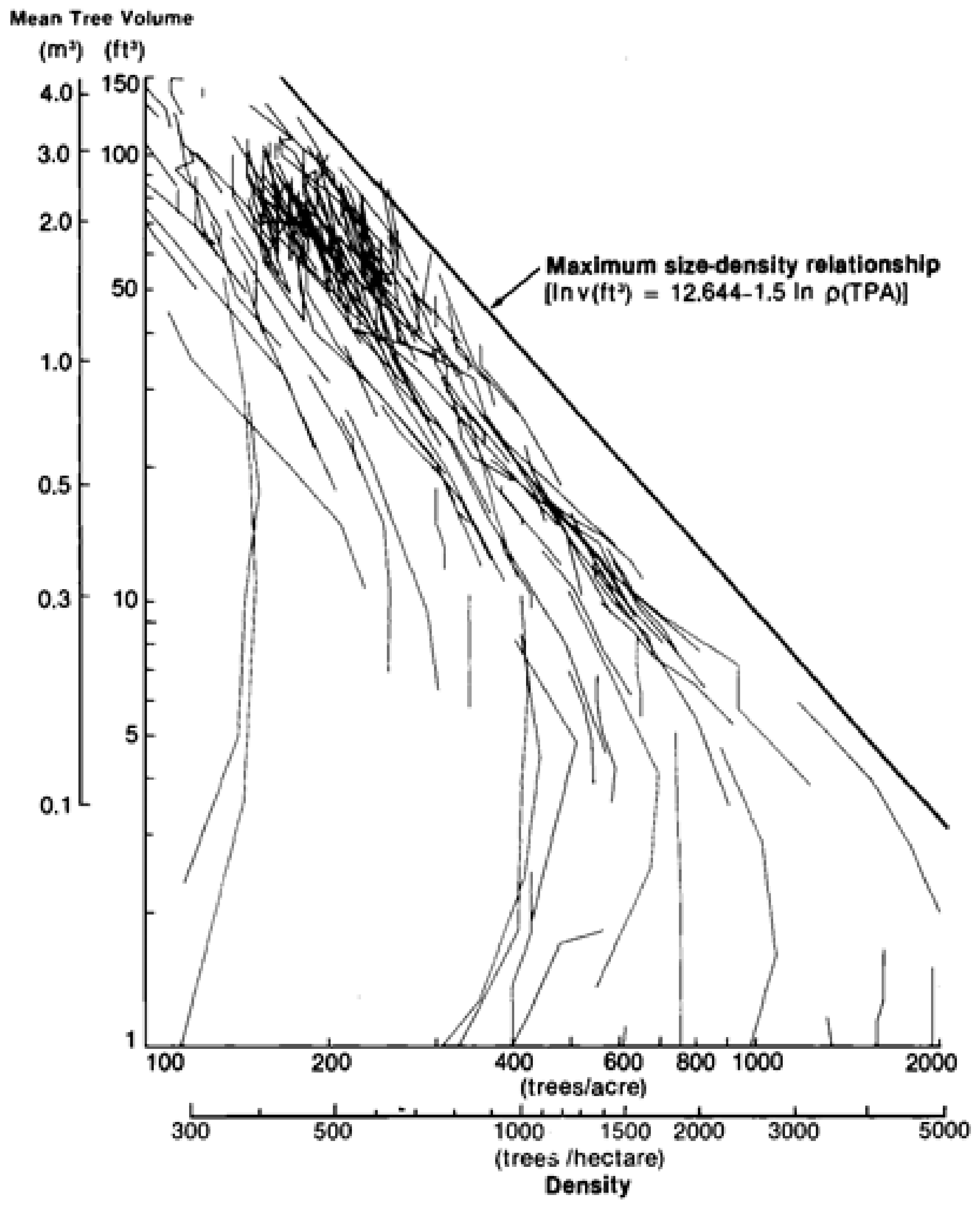
Intermountain Forestry Cooperative

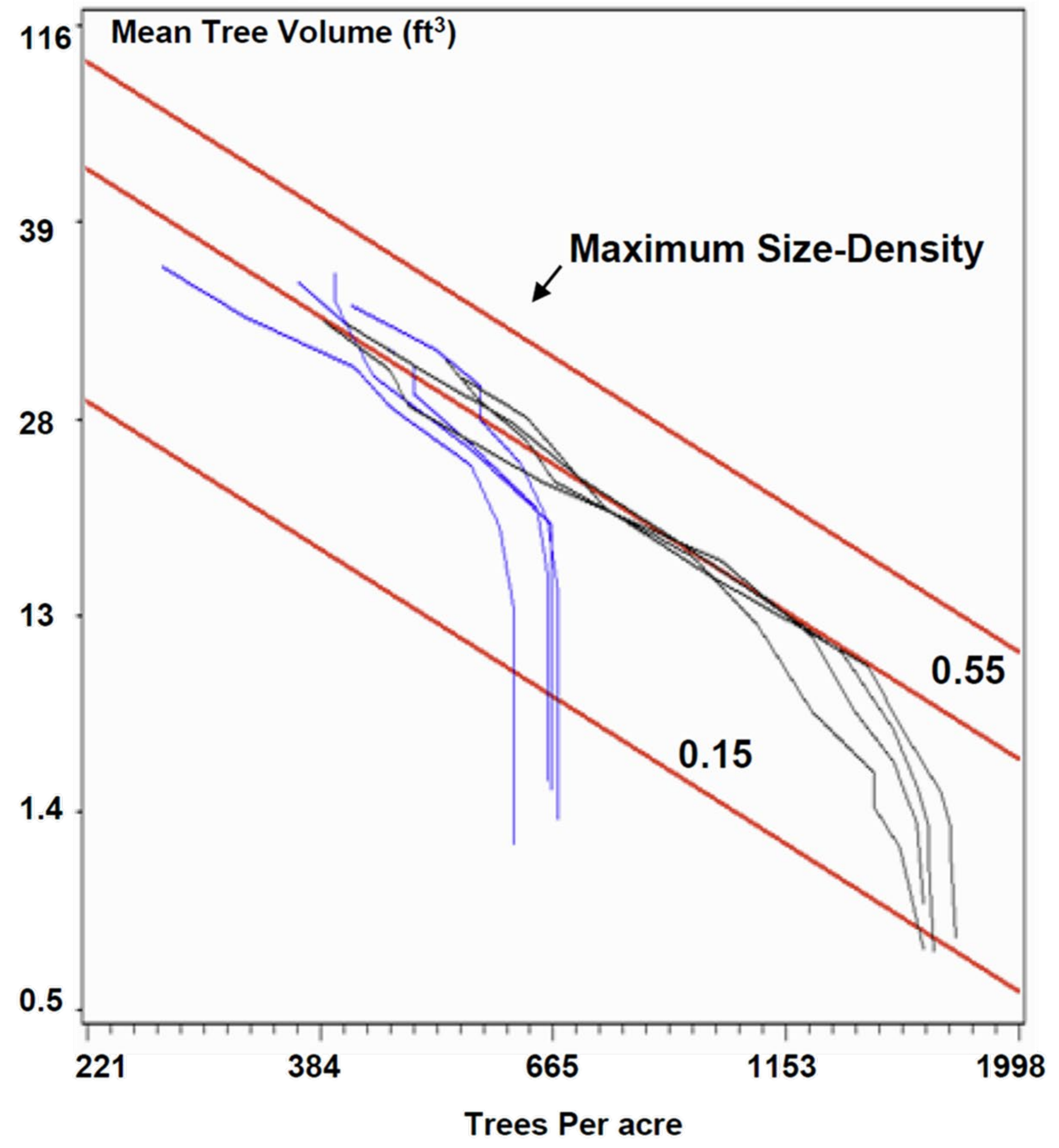
PRESENTATION OVERVIEW

- Principles of Stand Density and Thinning Response
- Site Type Initiative (STI) Introduction
  - Phase 1 – Big Data: SDImax
  - Phase 2 – Paired Plot Trials
- Outcomes and Products
- Future Outputs

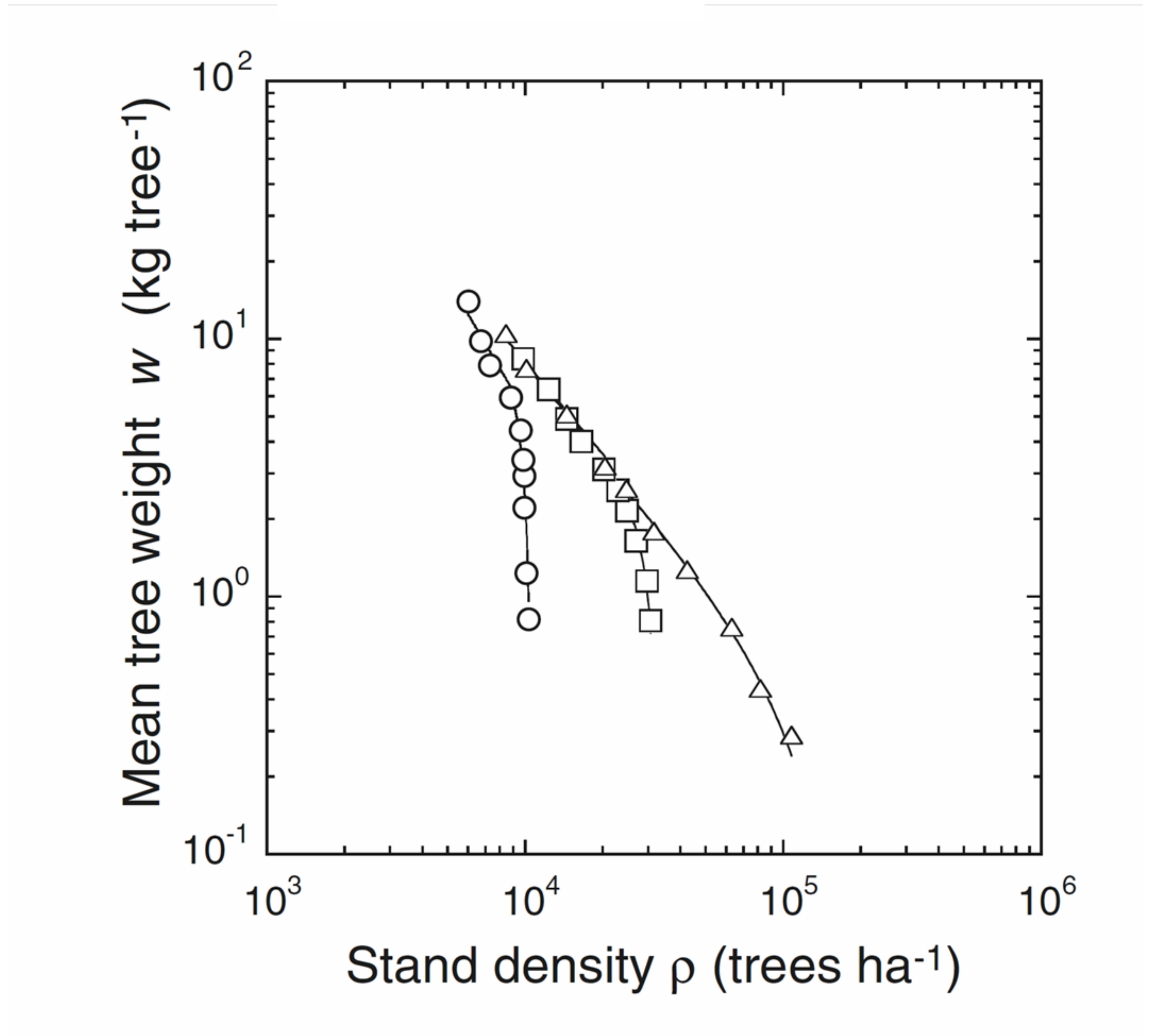
Drew & Flewelling 1977



Hyink 2005



Xue et al 2010



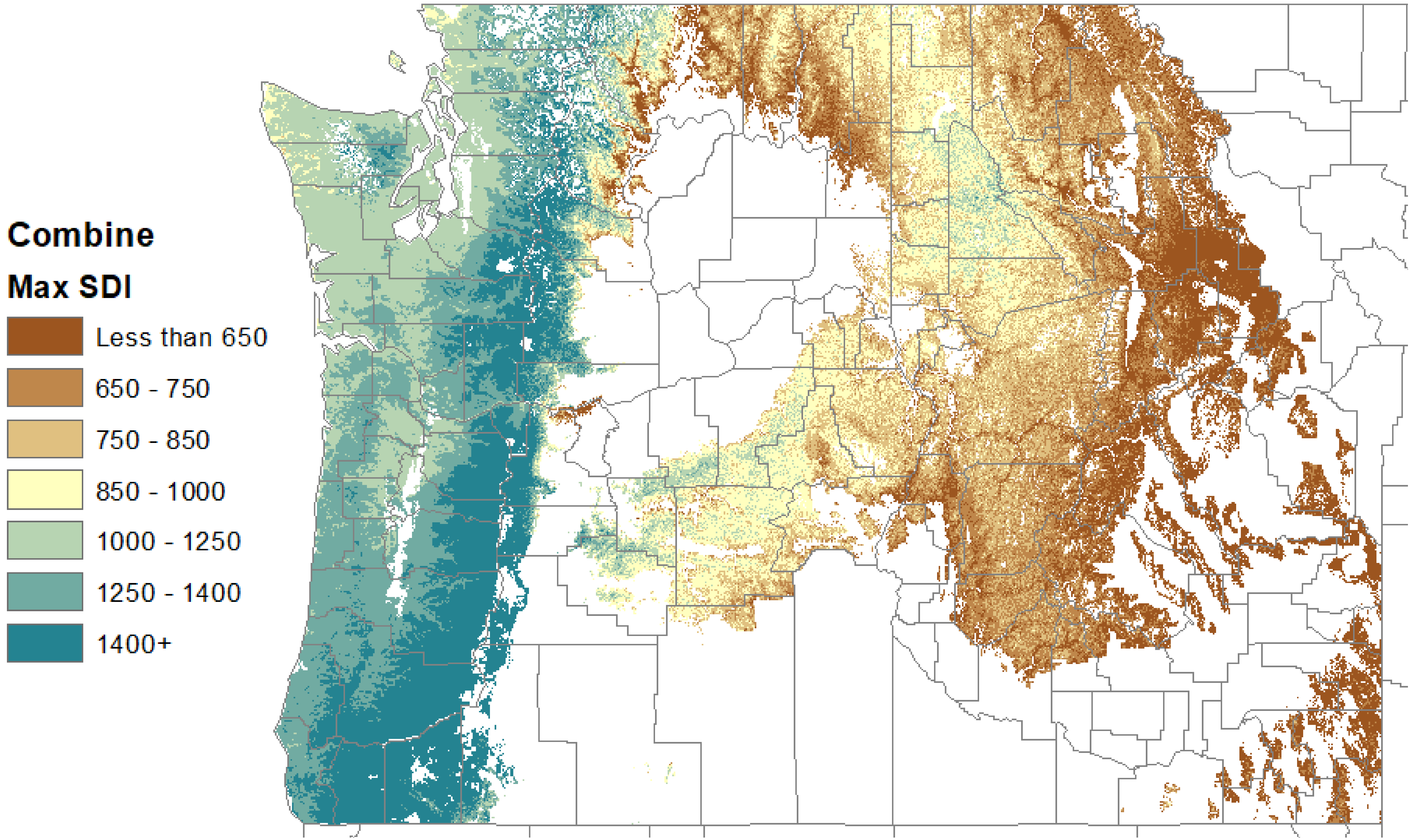
TREE AND STAND RESPONSES TO THINNING

… *ARE CONTROLLED BY COMPETITIVE INTERACTIONS*

Tree- and stand-density principles [laws]

- Crowded stands will self-thin (biological carrying capacity)
- Crown/needle architecture/mass determines rate and degree of self-thinning
- Competition decreases average tree size
- Two-phase growth trajectory – 1) non-competitive (limited by site), 2) competitive (track along normal or SDImax boundary)
- Consistent patterns are useful for understanding how competition limits the size of individuals
- Most studies cannot tell us about timing or site effects
  - The length in each phase is not described
  - The effects of site are uncertain

SPATIAL SDI$_{MAX}$ MODELING



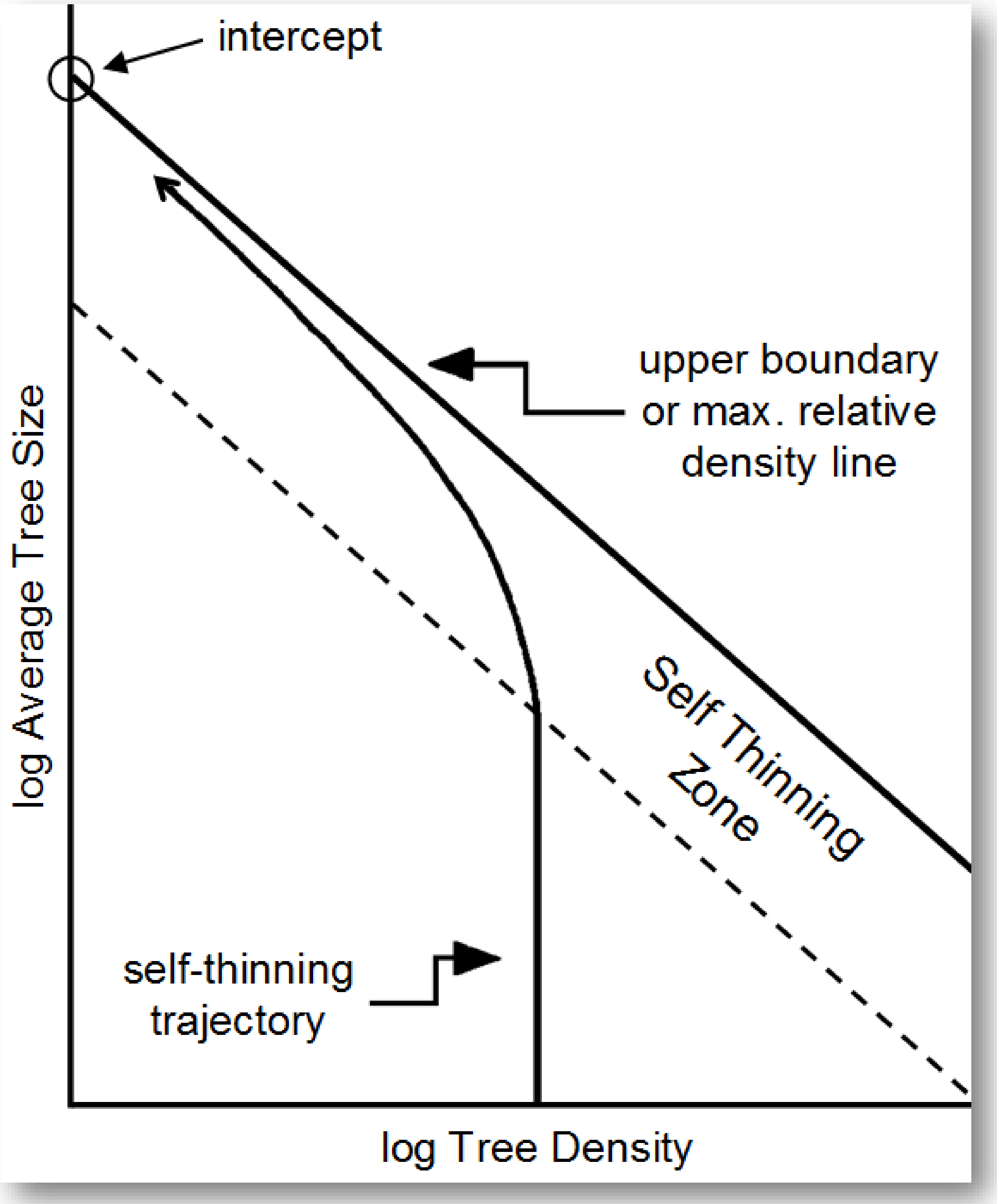
Regional SDI$_{MAX}$ geospatial model

- Site-species sensitive model
- Scalable to assessment needs
- Can be modified to reflect climate change
- Current models:
  - DF, GF, WL, PP, LP, WH

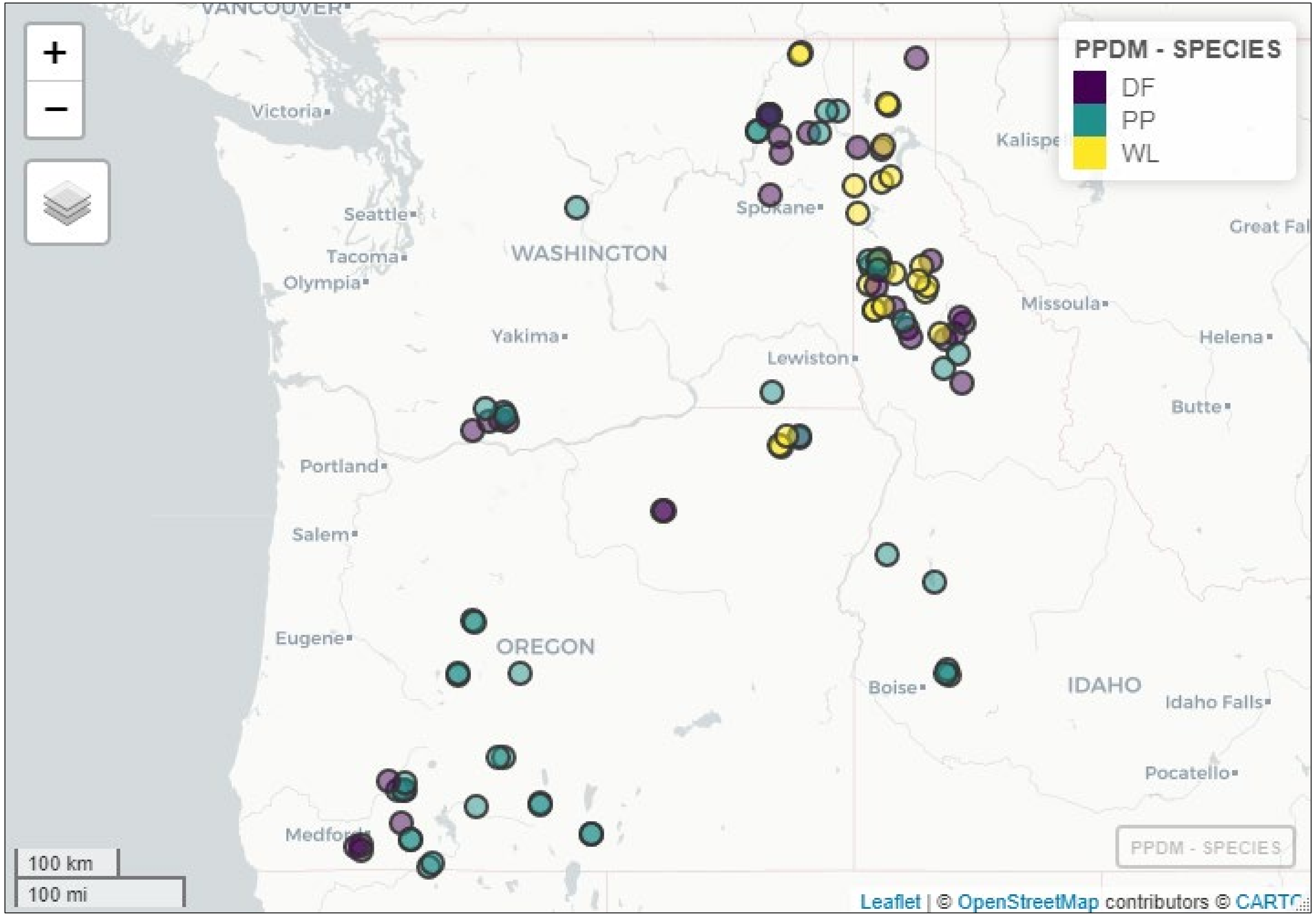
STI-PHASE 2: PAIRED PLOT FIELD TRIALS

UNDERSTANDING RATE OF APPROACH TO SDIMAX

- Questions:
  - What density optimizes forest health and/or productivity relative to species composition and site type?
  - When is the optimal time to thin given a suite of site and stand characteristics?
  - How can silvicultural treatments be effectively prescribed to utilize limiting site resources relative to ecological/economic objectives?
  - Are species-site type SDIMAX models accurate?

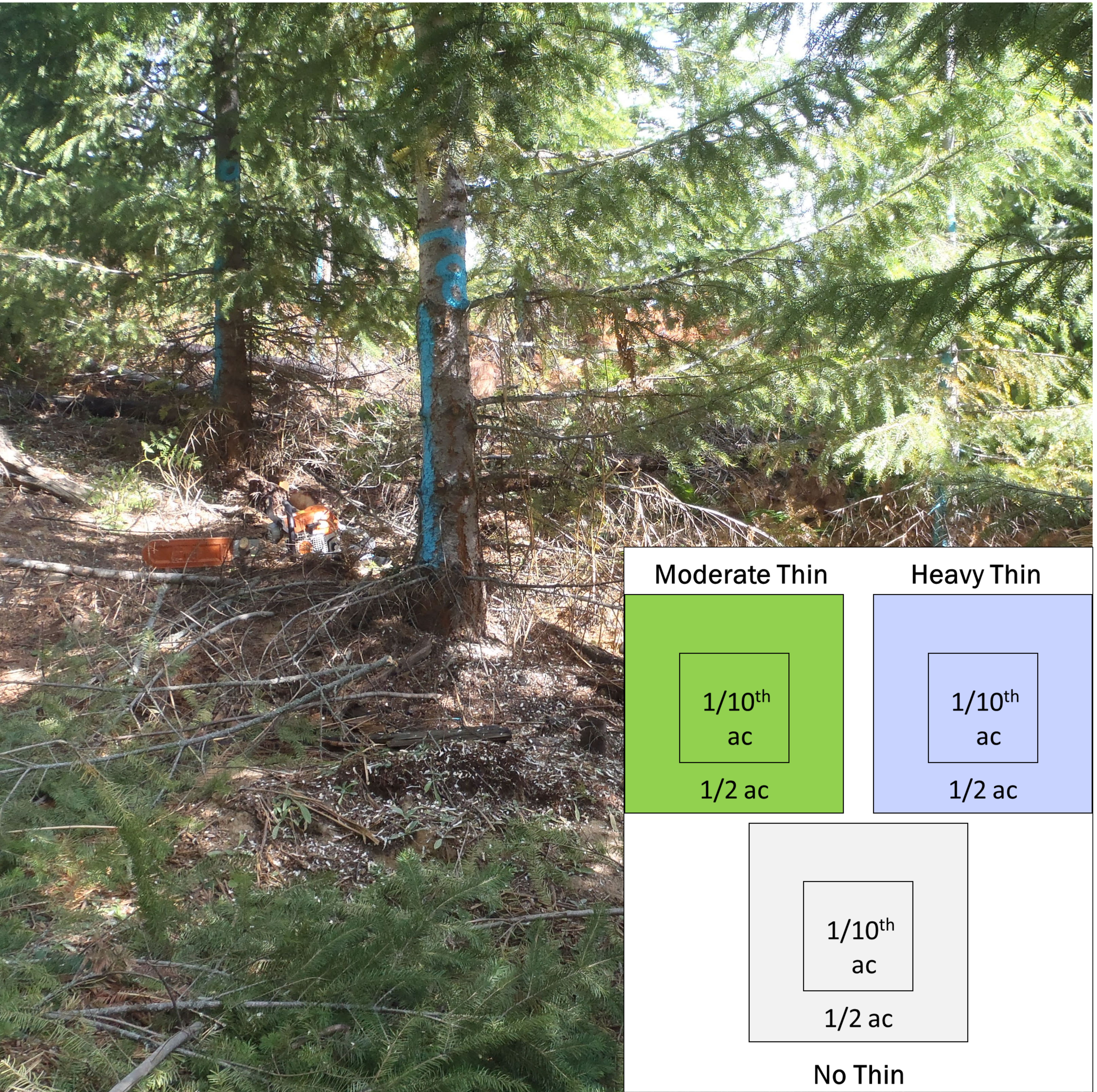


IFC PPDM NETWORK



101 INSTALLATIONS ACROSS THE INLAND NORTHWEST

- 34 DF installations
  - 6Yr measurements (n=23)
  - 4Yr measurements (n=28)
  - 2Yr measurements (n=34)
- 44 PP installations
  - 6Yr measurements (n=15)
  - 4Yr measurements (n=33)
  - 2Yr measurements (n=44)
- 23 WL installations
  - 6Yr measurements (n=0)
  - 4Yr measurements (n=11)
  - 2Yr measurements (n=23)



IFC PPDM NETWORK

EXPERIMENTAL DESIGN REFRESHER

PPDM OBJECTIVE: IDENTIFY OPTIMAL THINNING GUIDELINES BY SPECIES AND SITE TYPE TO PROMOTE FOREST HEALTH AND PRODUCTIVITY

	Class I 10YR ≤ 18'	Class II 19' ≥ 10YR ≤ 22'	Class III 23' ≥ 10YR ≤ 26'	Class IV 10YR ≥ 27'
Index I RD ≤ 35	1 SEWA[3] (1)	4 NID (2); NEO (1); SCOR (1)	3 NID (1); SCOR (2)	3 NID (1); SCWA (2)
Index II 36 ≥ RD < 60	3 NEWA (3)	6 NEO (2); NID (1); NEWA (2); SCOR (1)	3 SCWA (1) NID (2)	1 SCWA (1)
Index III RD ≥ 60	1 NEWA (1)	3 NID (1); NEWA (1); SCOR (1)	4 NID (4)	2 NID (1); SCOR (1)

Curtis, 1982: $RD = BA/QMD^{0.5}$
Ziede 1978, 1993, 1999: 2-point method
Arney and Miller 2000, Arney 2015: 10m SI

IFC PPDM NETWORK

THINNING PROTOCOL (UNTREATED + 2 THIN TREATMENTS ~ 134 – 435 TPA)

Control

10 x 10 ~ 435 TPA

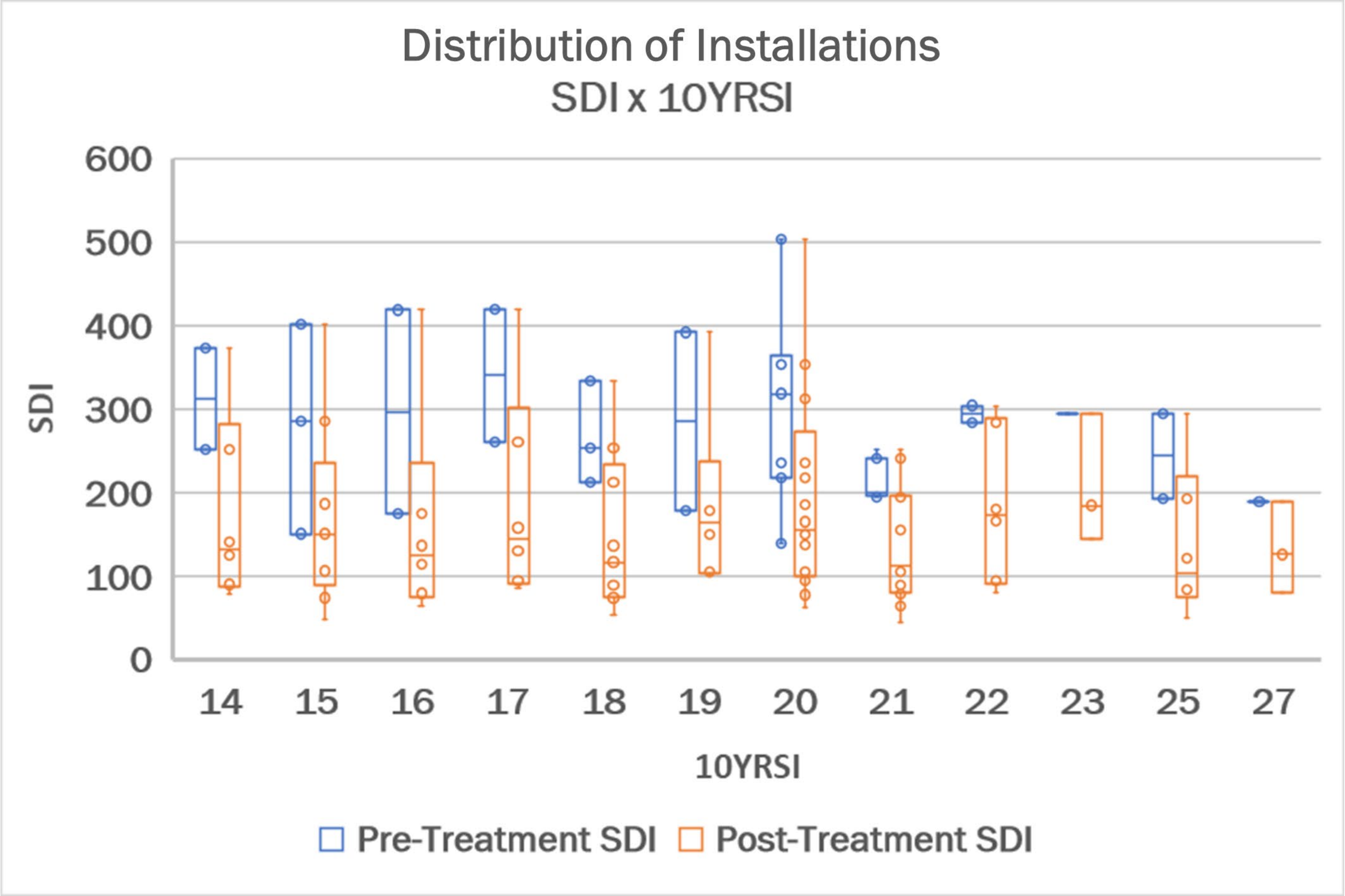
14 x 14 ~ 222 TPA

IFC PPDM NETWORK

CURRENT MEASUREMENT PROTOCOL

- Every 2 yrs from 0-10, every 4 yrs thereafter
  - DBH
  - Height growth increment (all trees)
  - Defect
  - Mortality
- Measured at year 8 and subsequent periodic measurements
  - Base of live crown
  - Ingrowth
- Future:
  - Stem map w/high resolution GPS for remote sensing analysis

PP SITE DISTRIBUTION: SDI x SI



4-YEAR RESULTS

PONDEROSA PINE THINNING RESPONSE BY:

INDIVIDUAL/CROP TREE – DBH/HT

CROP TREE/STAND – VOLUME

FULL PP REGRESSION MODELS*

TREE & STAND LEVEL

Individual/Crop Tree Growth – DIA and Height

$$DIA/HT_{annual} = \beta_0 + (\beta_1 \text{ x SI10YR}) + (\beta_2 \text{ x } SDI_{Pre\text{-}Trt}) + (\beta_3 \text{ x SI10YR x } SDI_{Pre\text{-}Trt}) + (\beta_4 \text{ x } DIA_{Post\text{-}Trt**}) + (\beta_5 \text{ x } SDI_{Post\text{-}Trt}) + (\beta_6 \text{ x } SDI_{Post\text{-}Trt} \text{ x } SDI_{Post\text{-}Trt})$$

Whole Stand/Crop Tree Stand Growth – Volume (cu ft)

$$NetVOL_{annual} = \exp(\beta_0 + (\beta_1 \text{ x SI10YR}) + (\beta_2 \text{ x } SDI_{Pre\text{-}Trt}) + (\beta_3 \text{ x SI10YR x } SDI_{Pre\text{-}Trt}) + (\beta_4 \text{ x } QMD_{Post\text{-}Trt}) + (\beta_5 \text{ x } SDI_{Post\text{-}Trt}) + (\beta_6 \text{ x } SDI_{Post\text{-}Trt} \text{ x } SDI_{Post\text{-}Trt}))$$

* *All models fit using SAS 9.4 PROC GLM*

***Post-treatment implies Yr0 baseline measurements*

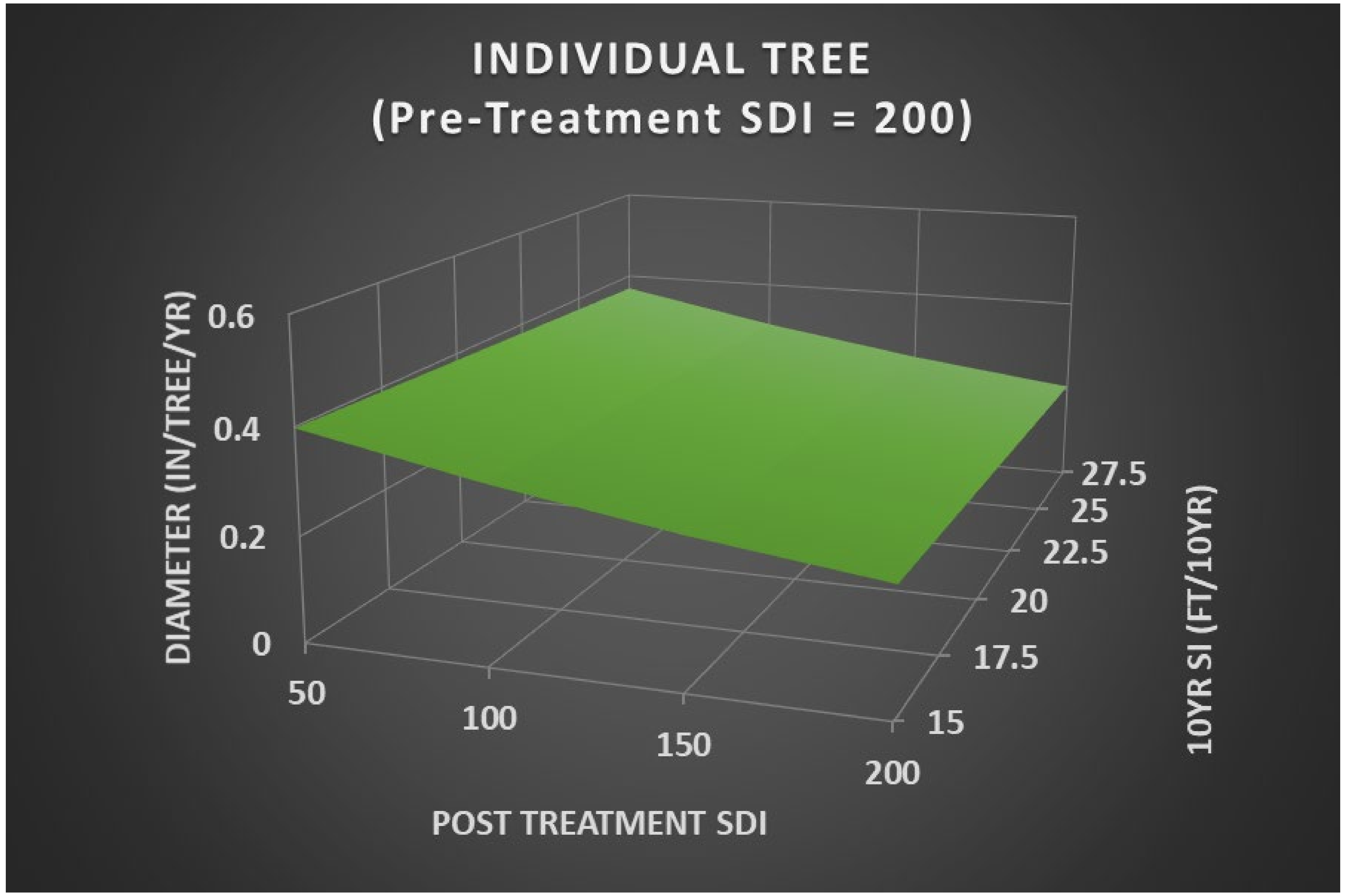
PP RESPONSE MODEL STATISTICS

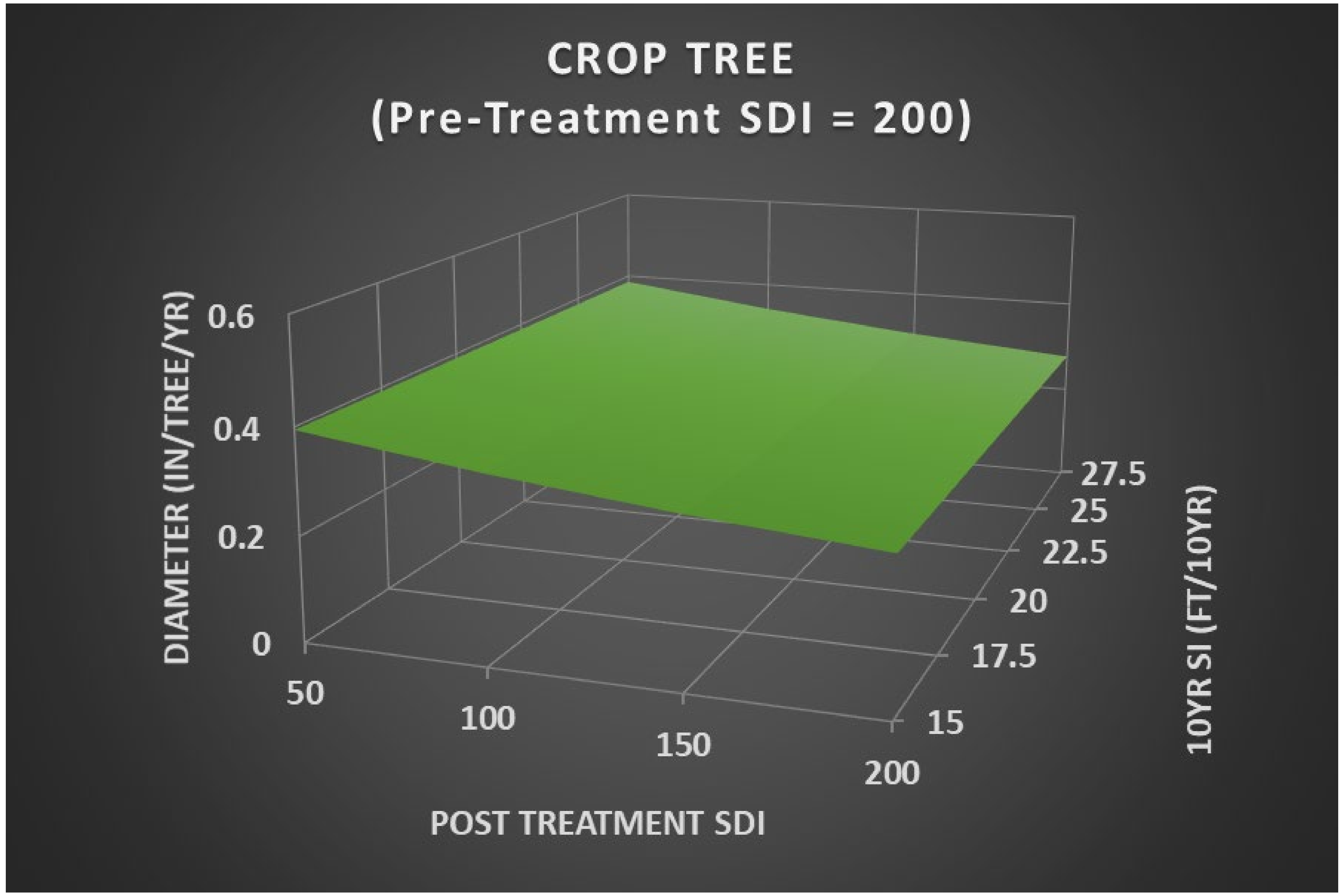
Model	R^2	RMSE	F-Value	Pr>F
Ind Tree – DIA (in)	0.57	0.08	23.6	<0.0001
Ind Tree – HT (ft)	0.50	0.25	15.0	<0.0001
Crop Tree – DIA	0.47	0.08	16.1	<0.0001
Crop Tree – HT	0.53	0.25	16.4	<0.0001
Crop Tree Stand – NetVol (cu ft)	0.62	0.24*	24.1	<0.0001
Whole Stand – NetVol	0.75	0.26*	44.6	<0.0001

* *Not back transformed, values roughly equivalent to 30 cu ft/ac/yr*

DBH RESPONSE SURFACE

INDIVIDUAL VS CROP TREE – INITIAL LOW-DENSITY STAND

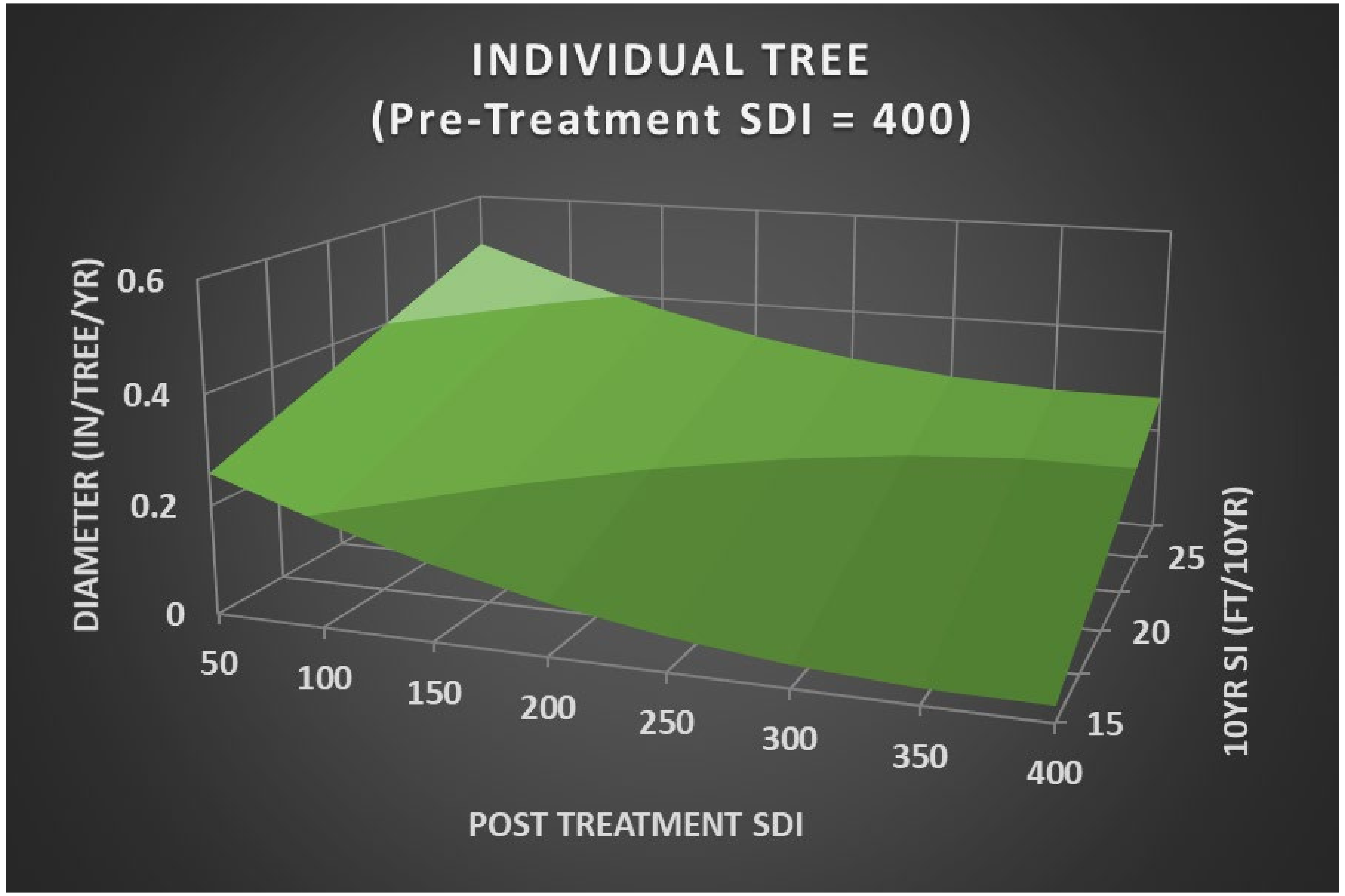


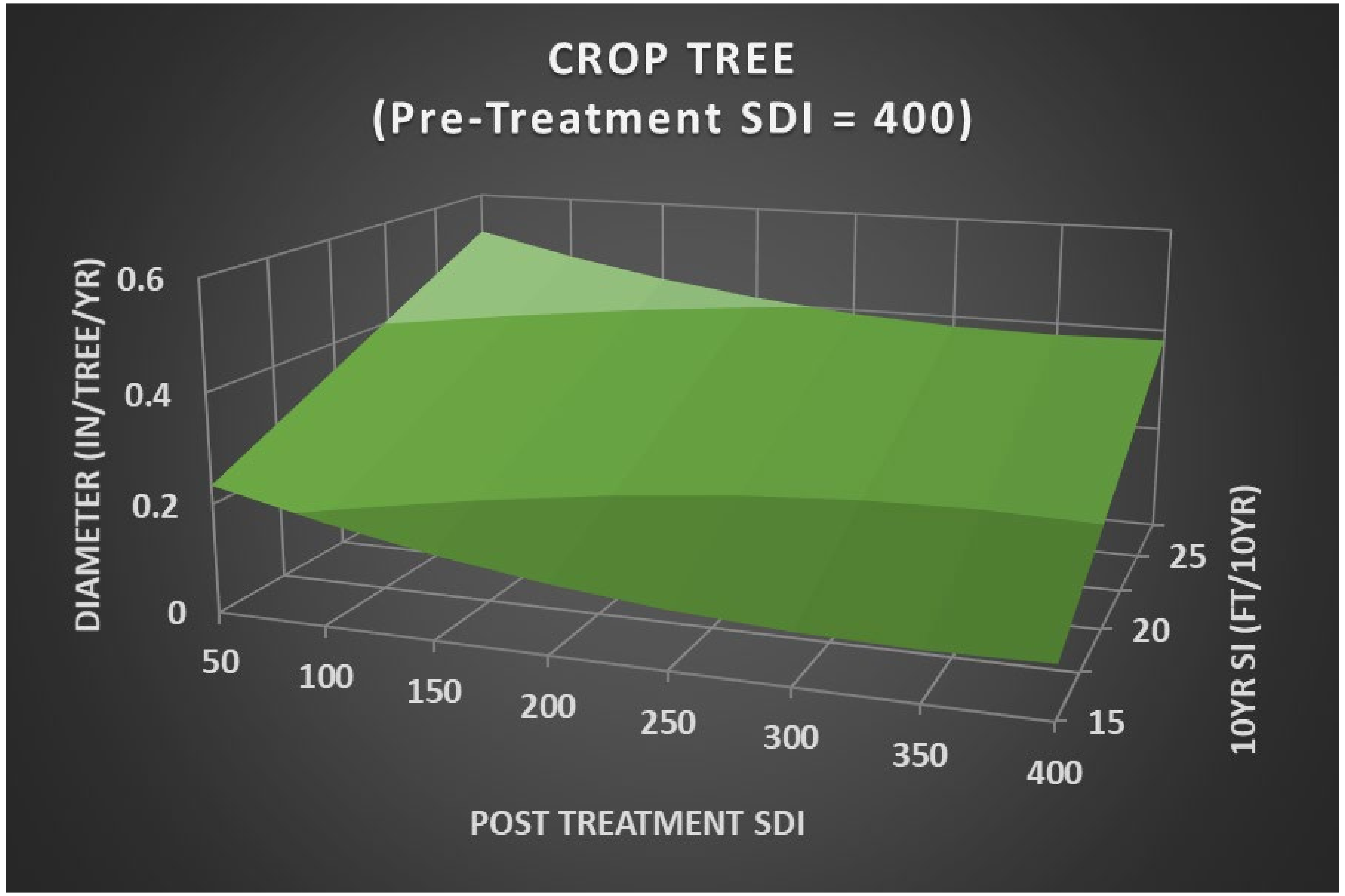


NOTE: To convert SDI to BA, multiply by 0.5454

DBH RESPONSE SURFACE

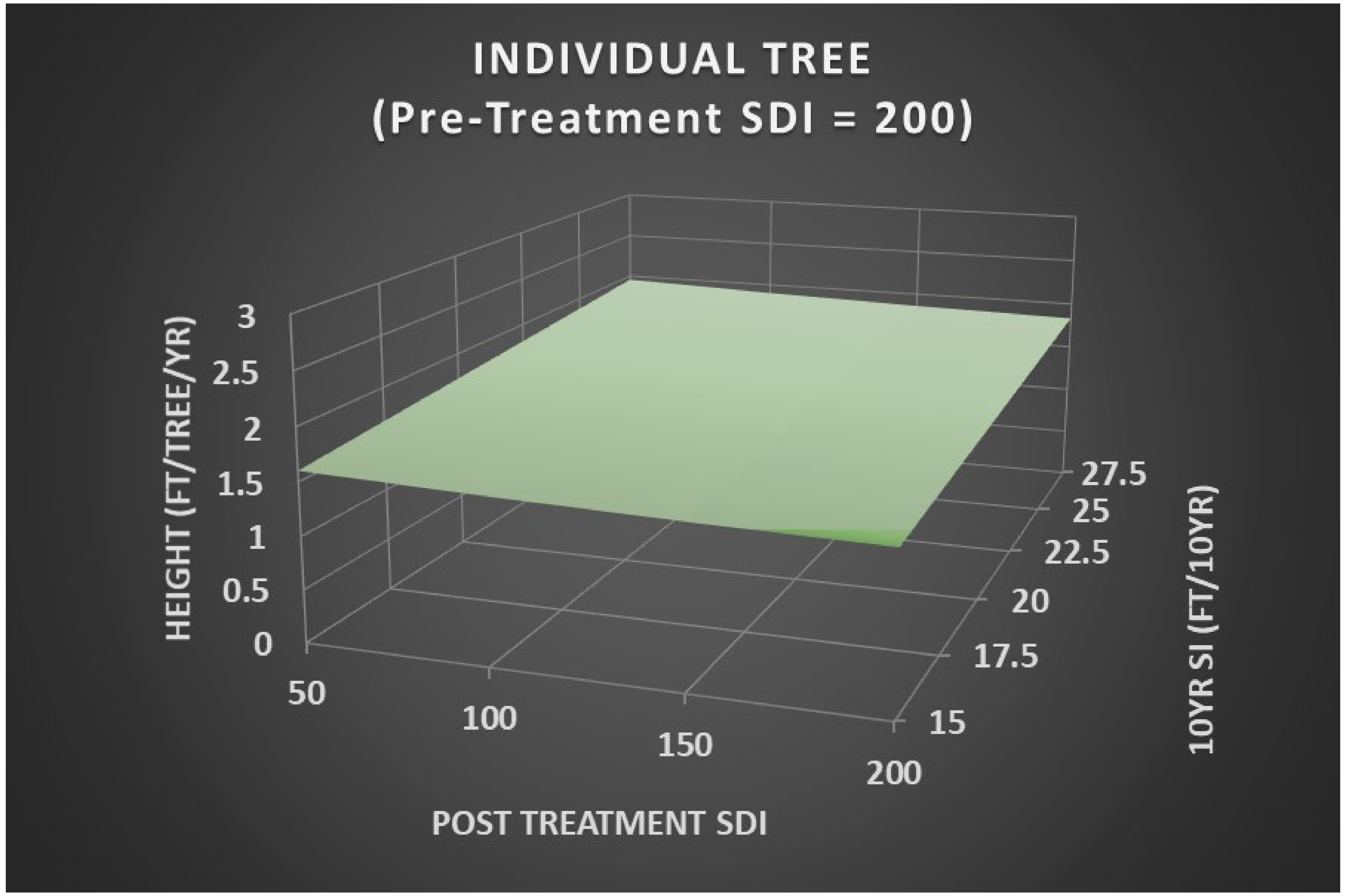
INDIVIDUAL VS CROP TREE – INITIAL HIGH-DENSITY STAND

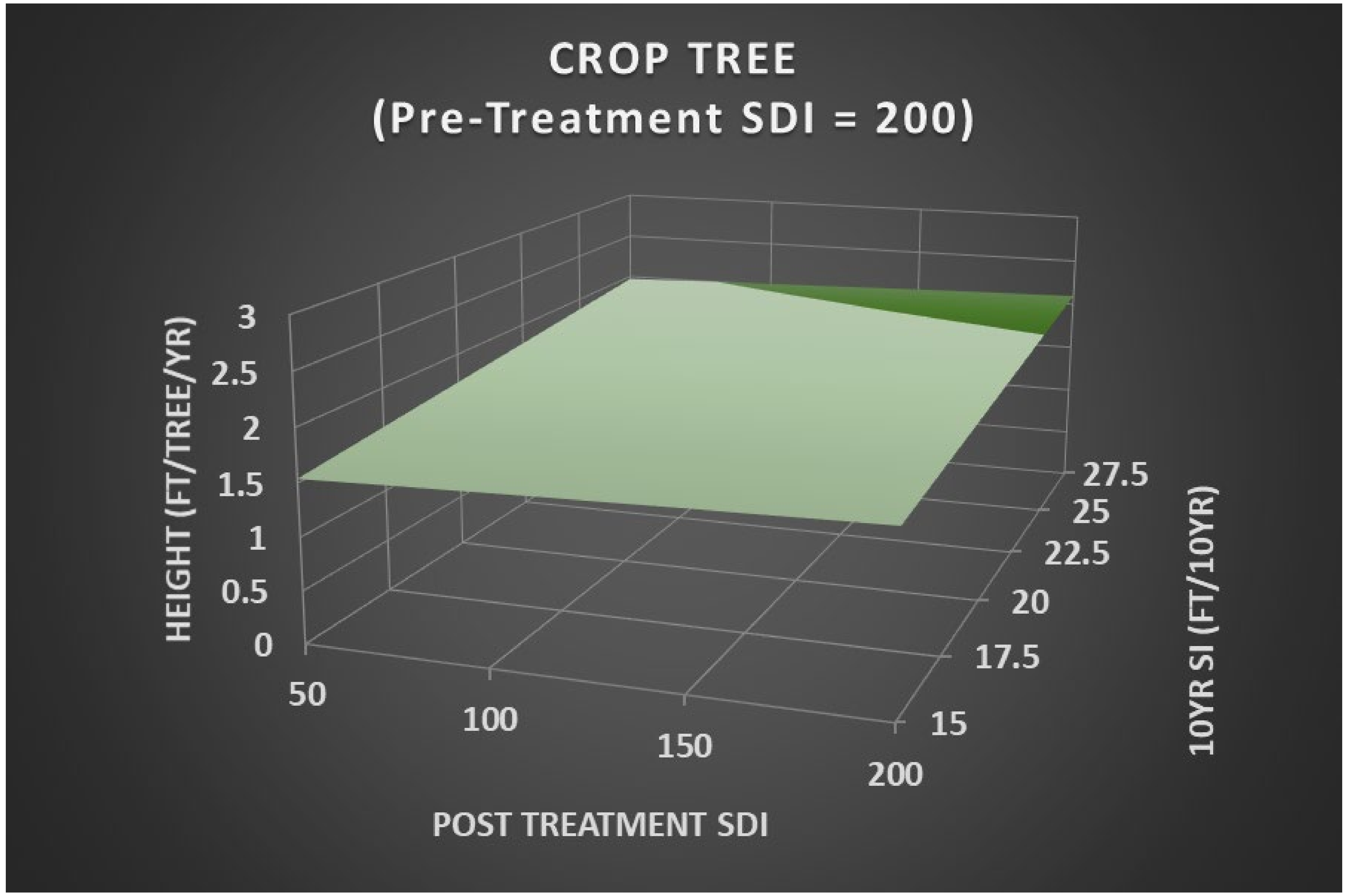




HEIGHT RESPONSE SURFACE

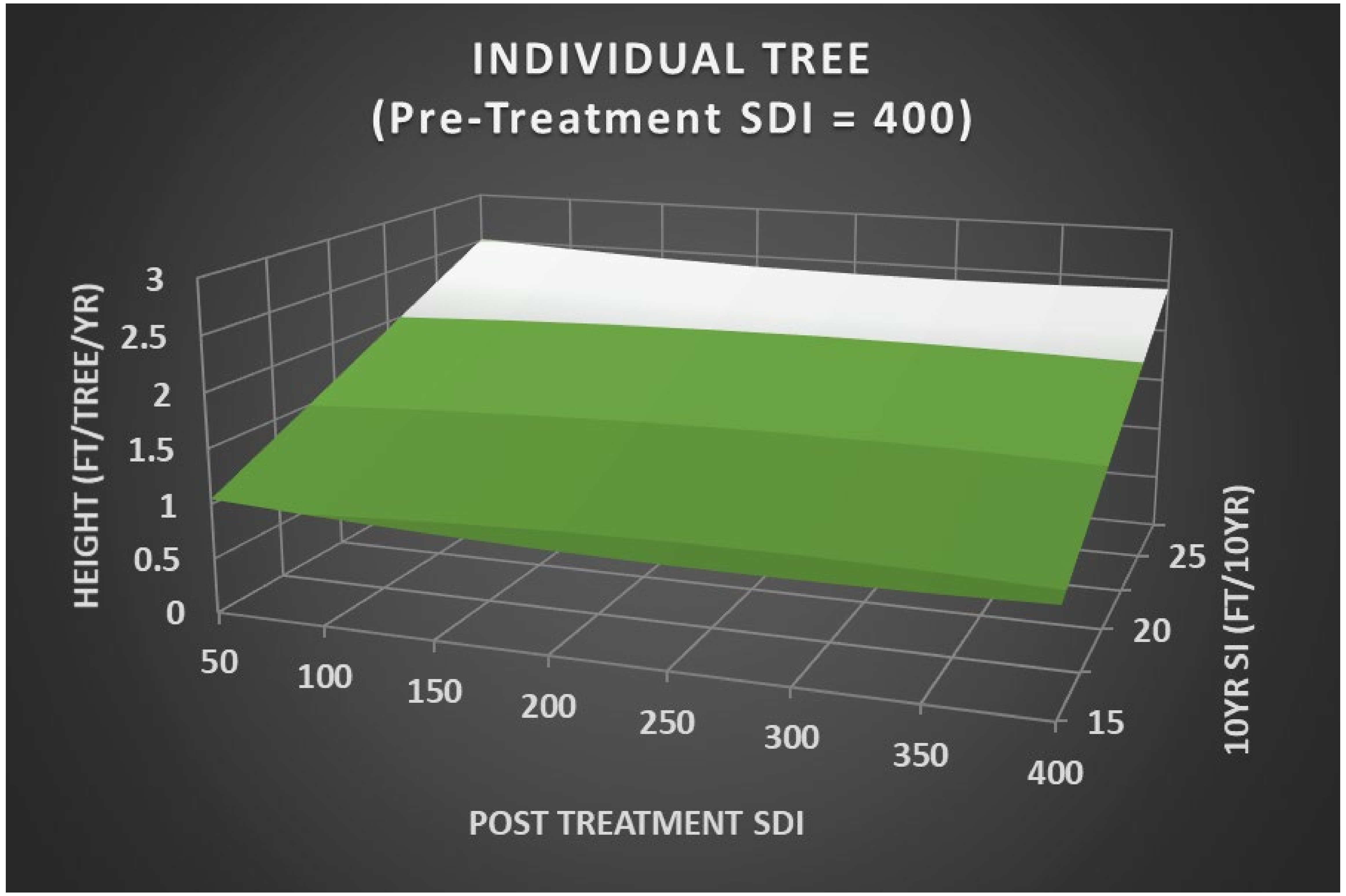
INDIVIDUAL VS CROP TREE – INITIAL LOW-DENSITY STAND

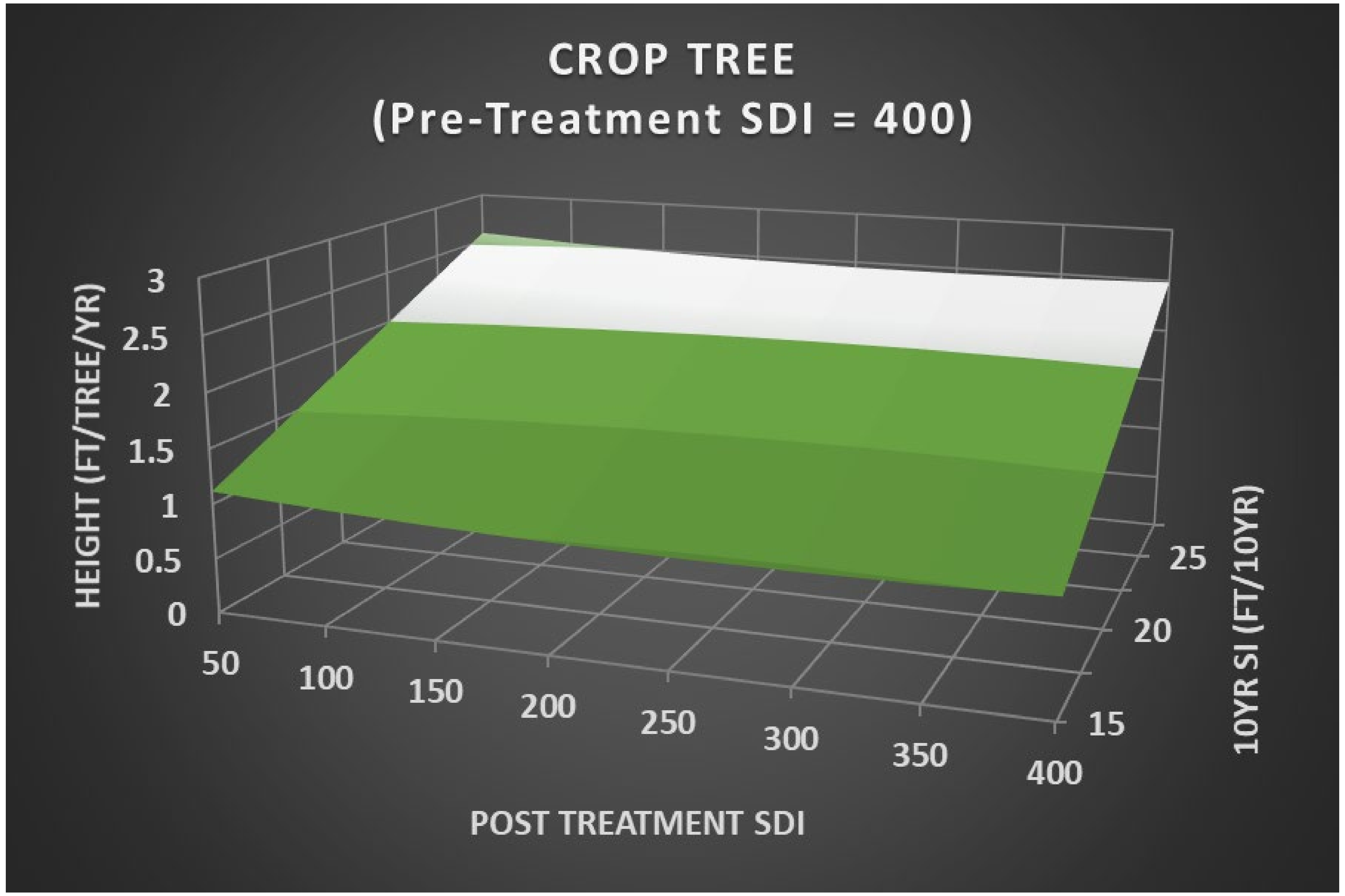




HEIGHT RESPONSE SURFACE

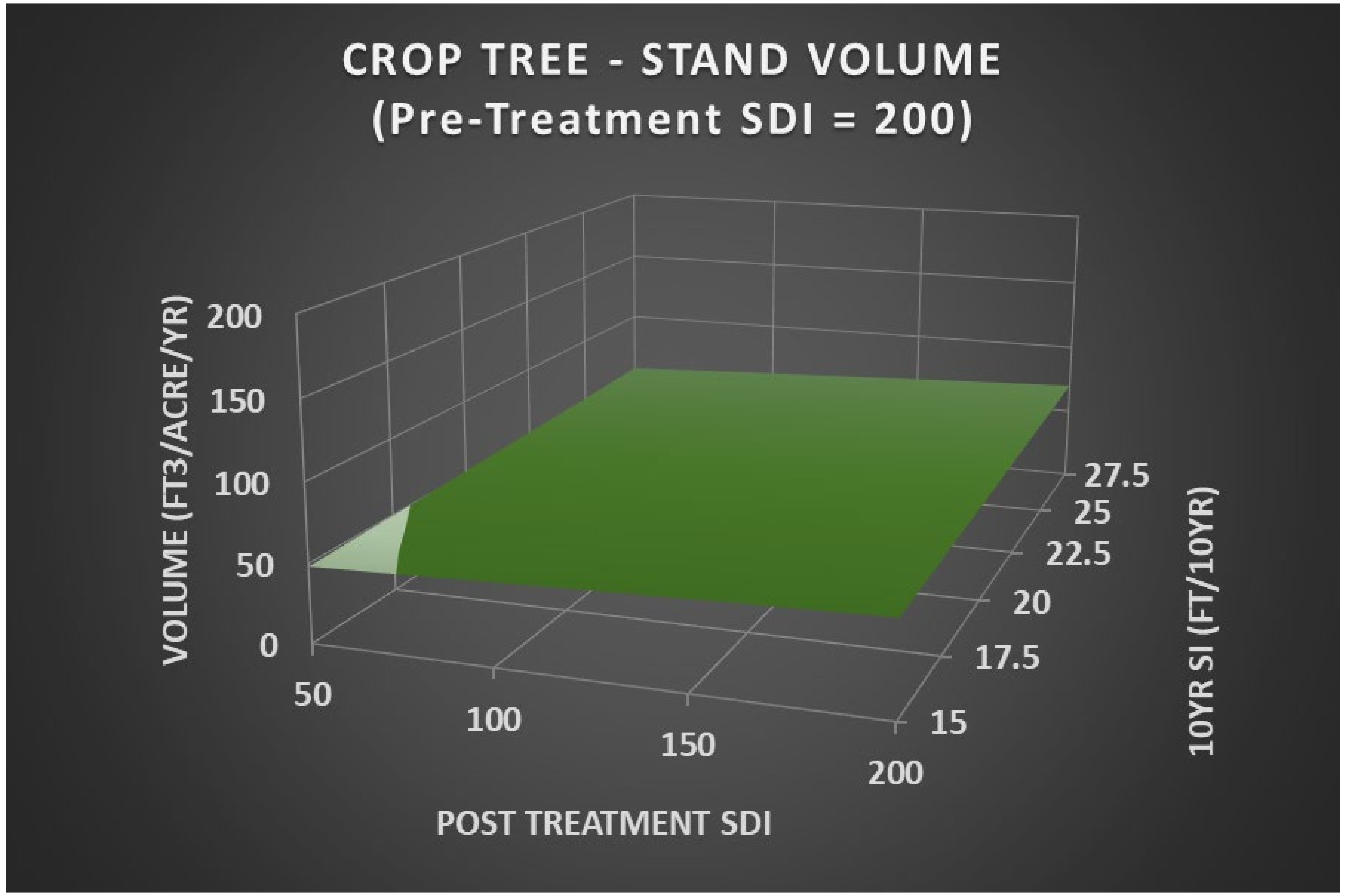
INDIVIDUAL VS CROP TREE – INITIAL HIGH-DENSITY STAND

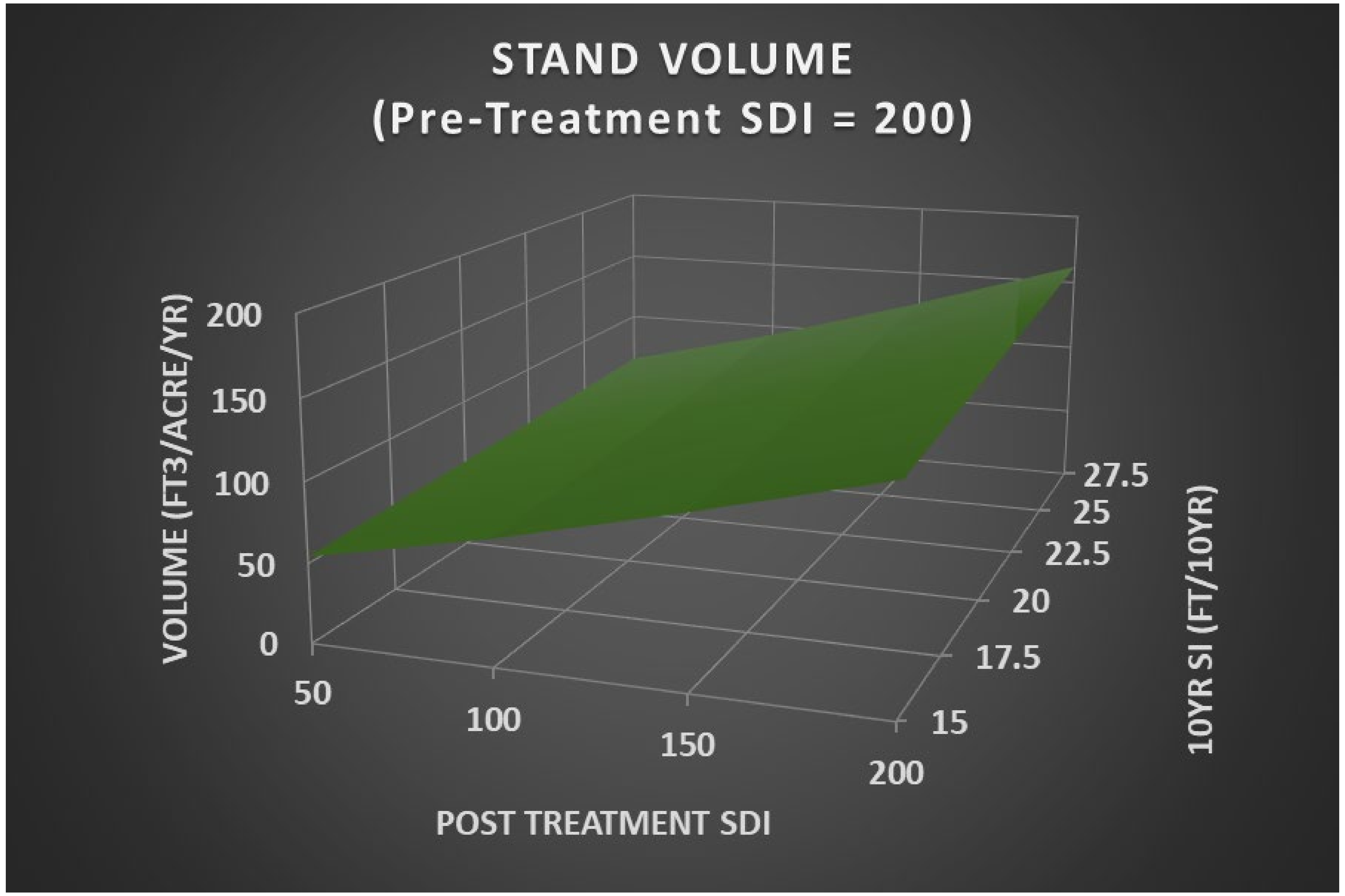




STAND VOLUME RESPONSE SURFACE

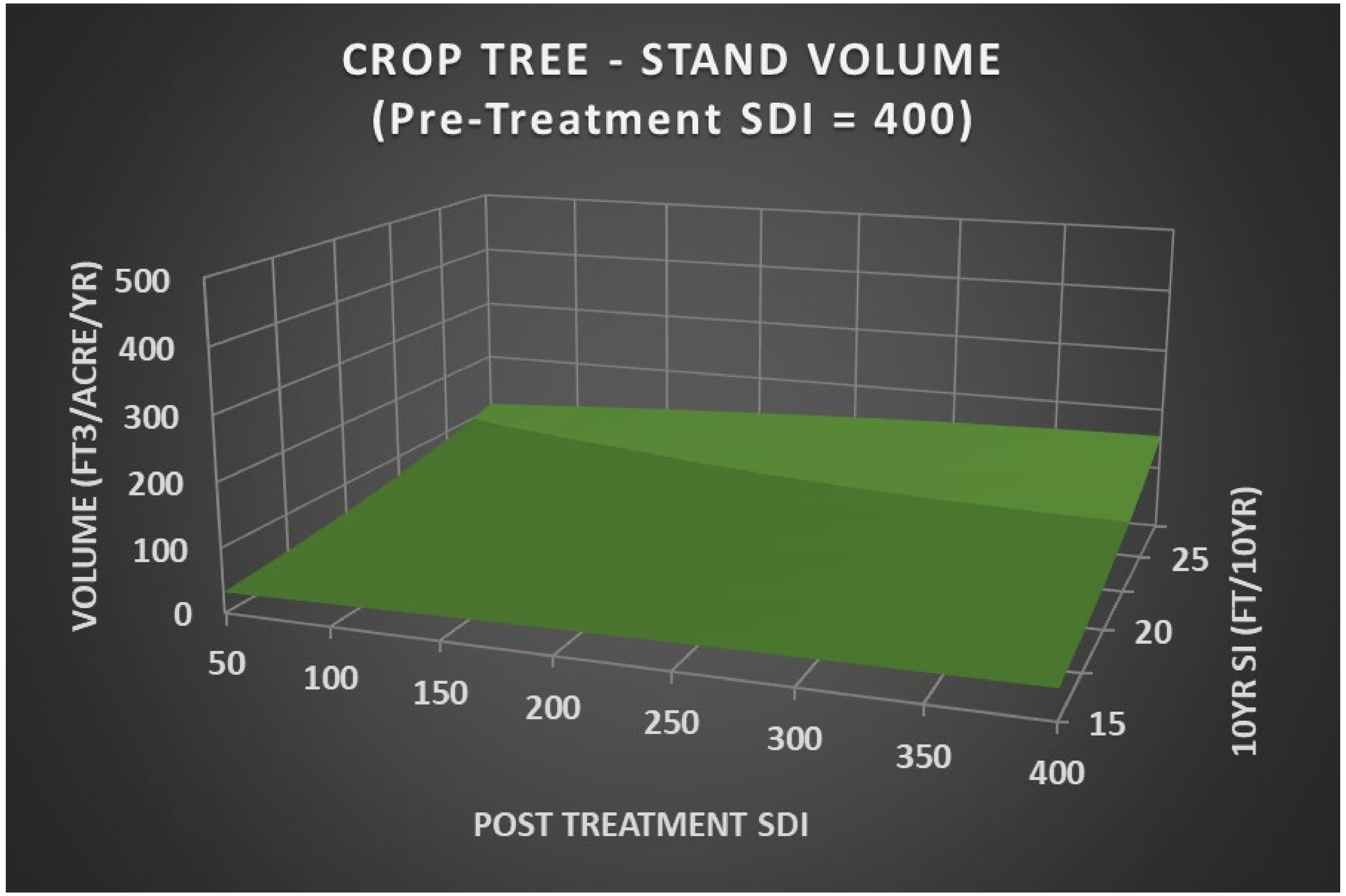
CROP TREE VS WHOLE STAND – INITIAL LOW-DENSITY STAND

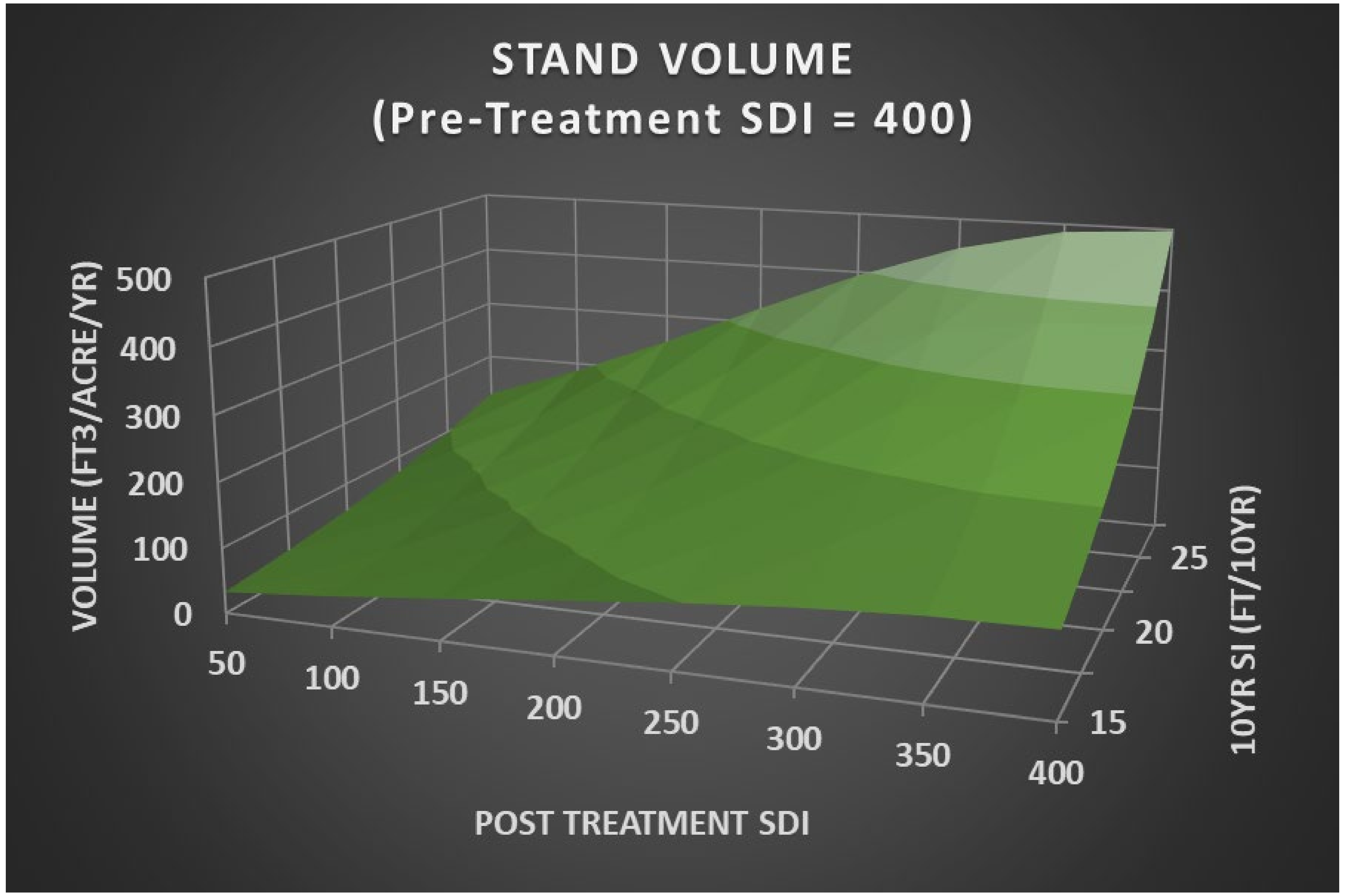




STAND VOLUME RESPONSE SURFACE

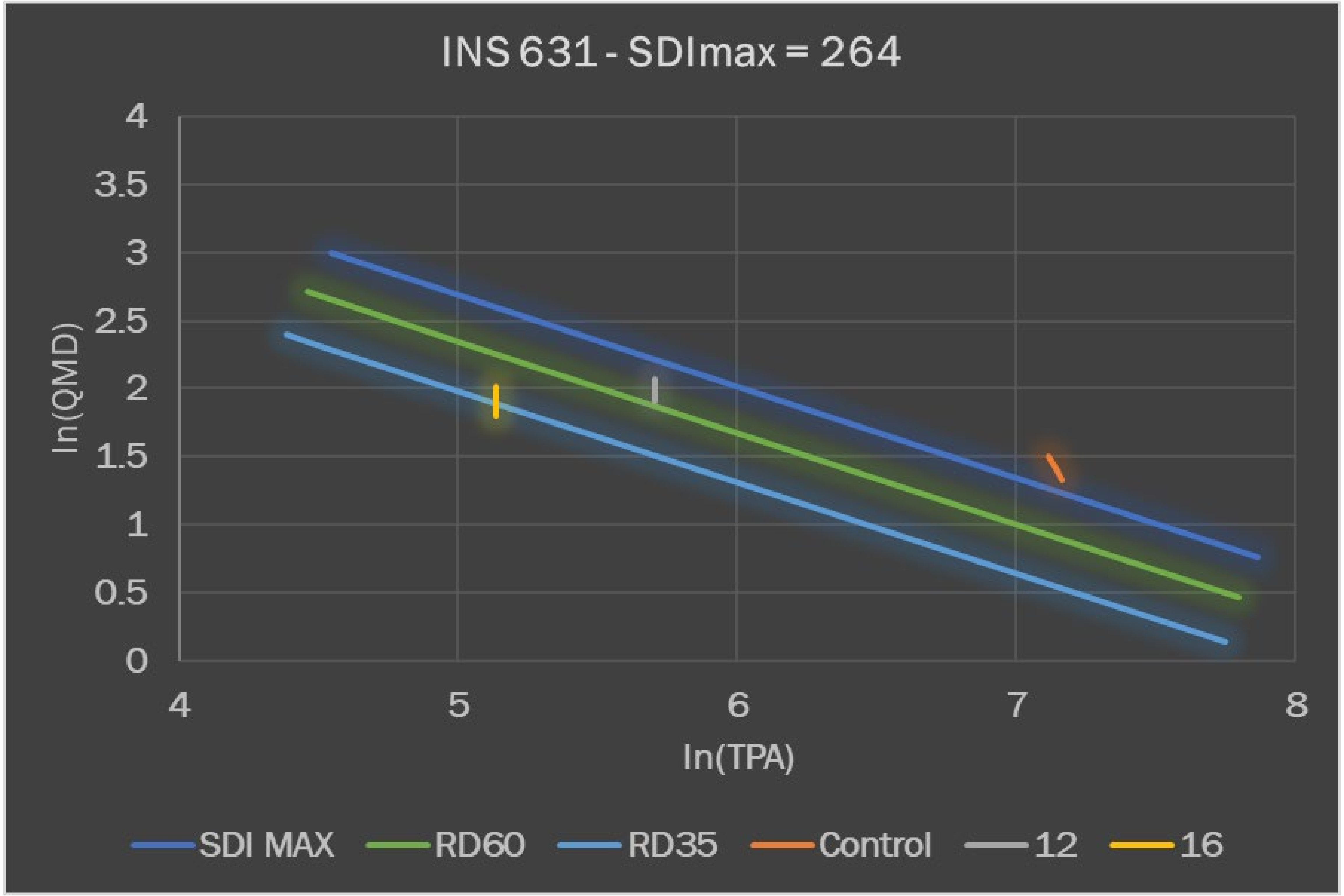
CROP TREE VS WHOLE STAND – INITIAL HIGH-DENSITY STAND





VALIDATING SDIMAX MODELS

"DENSITY MANAGEMENT DIAGRAM"



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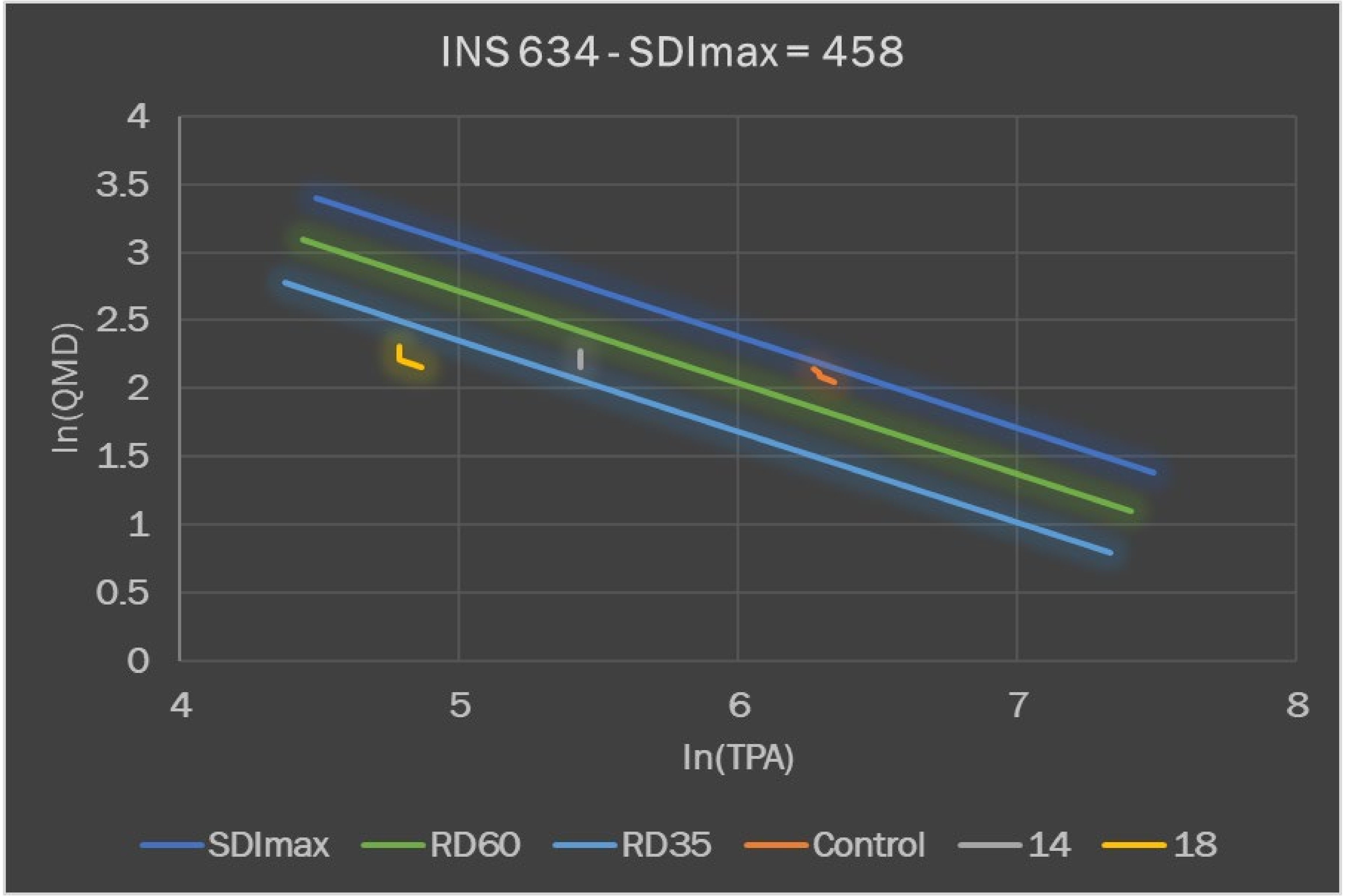

Trout Lake, WA

SUMMARY

BROAD OUTCOMES TO DATE

- DIA growth increment response in initial low-density stands (<200 SDI) was driven primarily by thinning intensity, not by site type
- DIA growth increment in initial high-density stands (>200 SDI) was affected both by thinning intensity and by site type – average tree and crop tree response patterns were similar at higher thinning intensities; however, crop trees outperformed the average tree at higher post-treatment densities
- Height growth increment was not affected by thinning across site types; however, there was a strong interaction between initial stand density and site type
  - Lower density stands (<200 SDI) showed no differentiation in height regardless of thinning regime, site type, or whether the tree was considered a crop tree
  - Dense stands (>200 SDI) on drier, less productive site types exhibited height suppression; whereas moist, productive site types saw greater height growth increments

SUMMARY

BROAD OUTCOMES TO DATE

- Site type did not express itself in volume response across low density stands
- As pre-treatment SDI exceeded 200-250 SDI, site type became an important driver of volume response
- Crop tree volume response in initial high-density stands dominated stand response across low productivity site types and/or in aggressive thinning regimes
- Highly productive site types showed a greater capacity to carry more crop and non-crop tree volume than low-productivity sites
- IFC SDI_{MAX} models overall are predicting relevant maximums, however, some sites are exceeding predictions
  - Tracking under-predictions for future model refinement

CONCLUDING STATEMENTS

THE FUTURE OF PPDM

- Validate SDImax models
- Validate G&Y models
- Develop growth and mortality multipliers by site quality, stand density, and species composition
- Calibrate G&Y software packages for thinning response by site/species
- Develop silvicultural guidelines for targeting optimal timing window and thinning to maximize growth response on crop trees while minimizing mortality