Modeling Crown Biomass for Three North Idaho Conifers

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Objectives

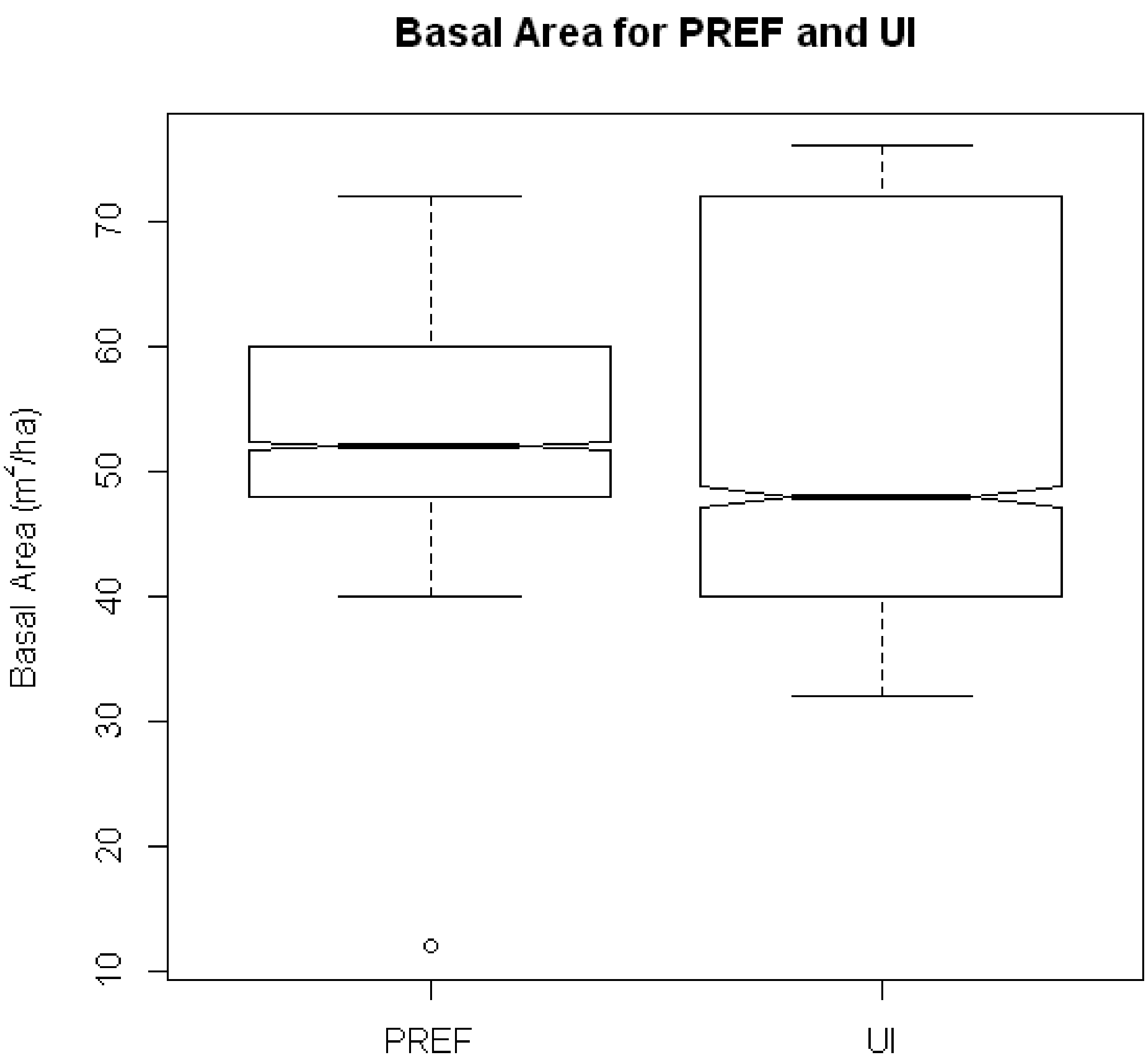
- Develop allometric models to predict individual branch biomass and leaf area.
- Scale the branch level models up to the tree and predict whole tree branch biomass and leaf area.
- Use nonlinear mixed effects modeling to predict branch basal diameter from branch insertion height.

- Sample from mixed species stands at Priest River Experimental Forest and UI School Forest
- Destructive sampling study using Douglas-Fir, Grand Fir and Western Hemlock in two North Idaho locations
- Focus on branch biomass and leaf area

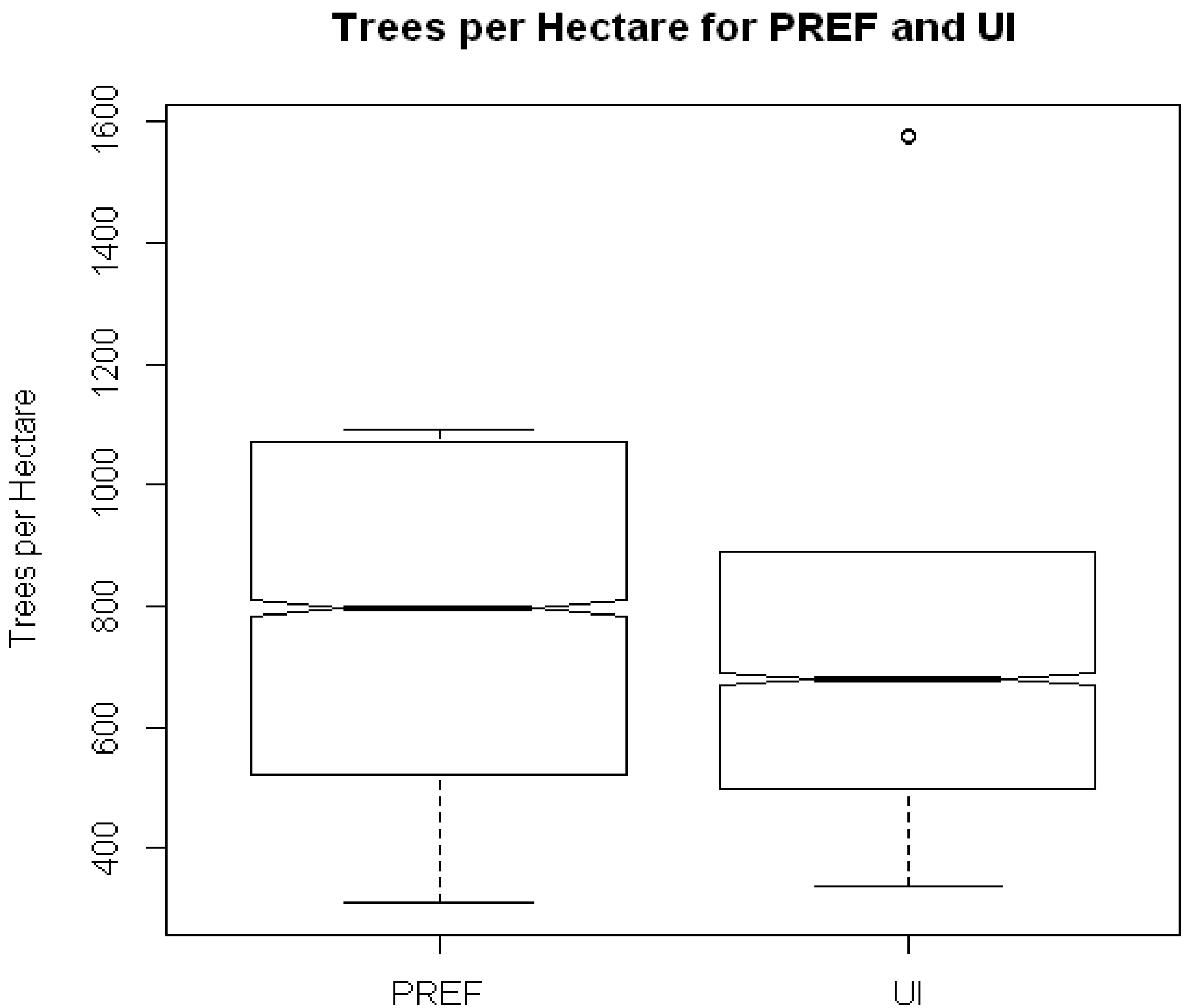
Potential Predictor Variables		
Plot	**Tree**	**Branch**
BA (m^2/ha)	Total height (m)	Insertion height (m)
Trees per hectare	Crown length (m)	Basal diameter (mm)
	Diameter at breast height (cm)	Green weight (g)
	Basal area (m^2)	Length of branch (cm)
	Diameter inside bark at breast height (cm)	Foliated length (cm)
	Diameter inside bark at crown base (cm)	Branch weight (g)
	Age (years)	Branch wood weight (g)
	Height to Diameter ratio	Needle weight, green (g)
	Crown ratio	Needle weight, dry (g)
		Needle area (cm^2)

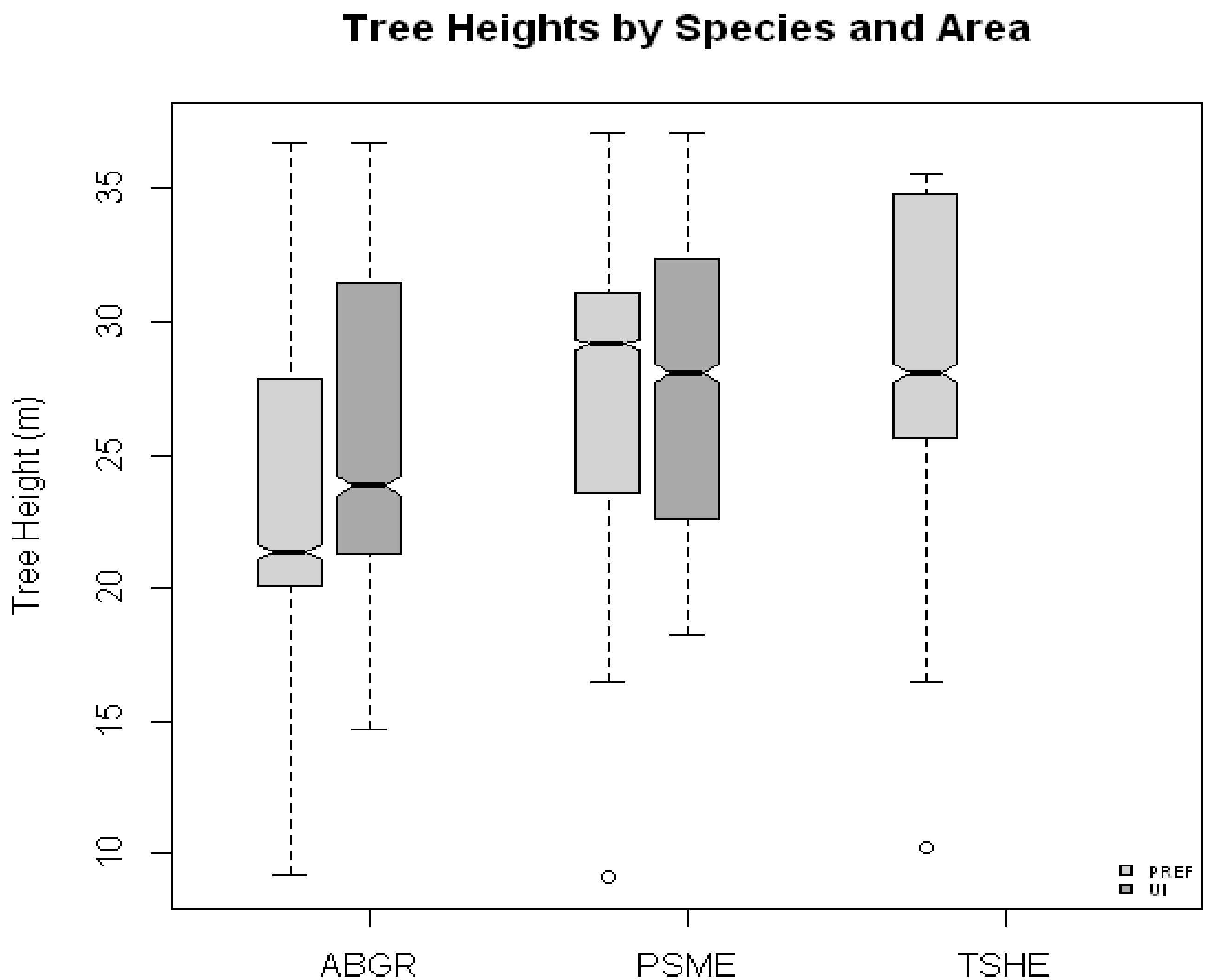
Part 1: Allometric Equations predicting individual branch biomass from predictors

- Goal: Obtain allometric equations for branch biomass components and leaf area
  - Total biomass in branch (wood + needles)
  - Needle biomass
  - Branch wood biomass
  - Needle Area
- Generate initial equations at individual branch level, then scale up for tree level equations

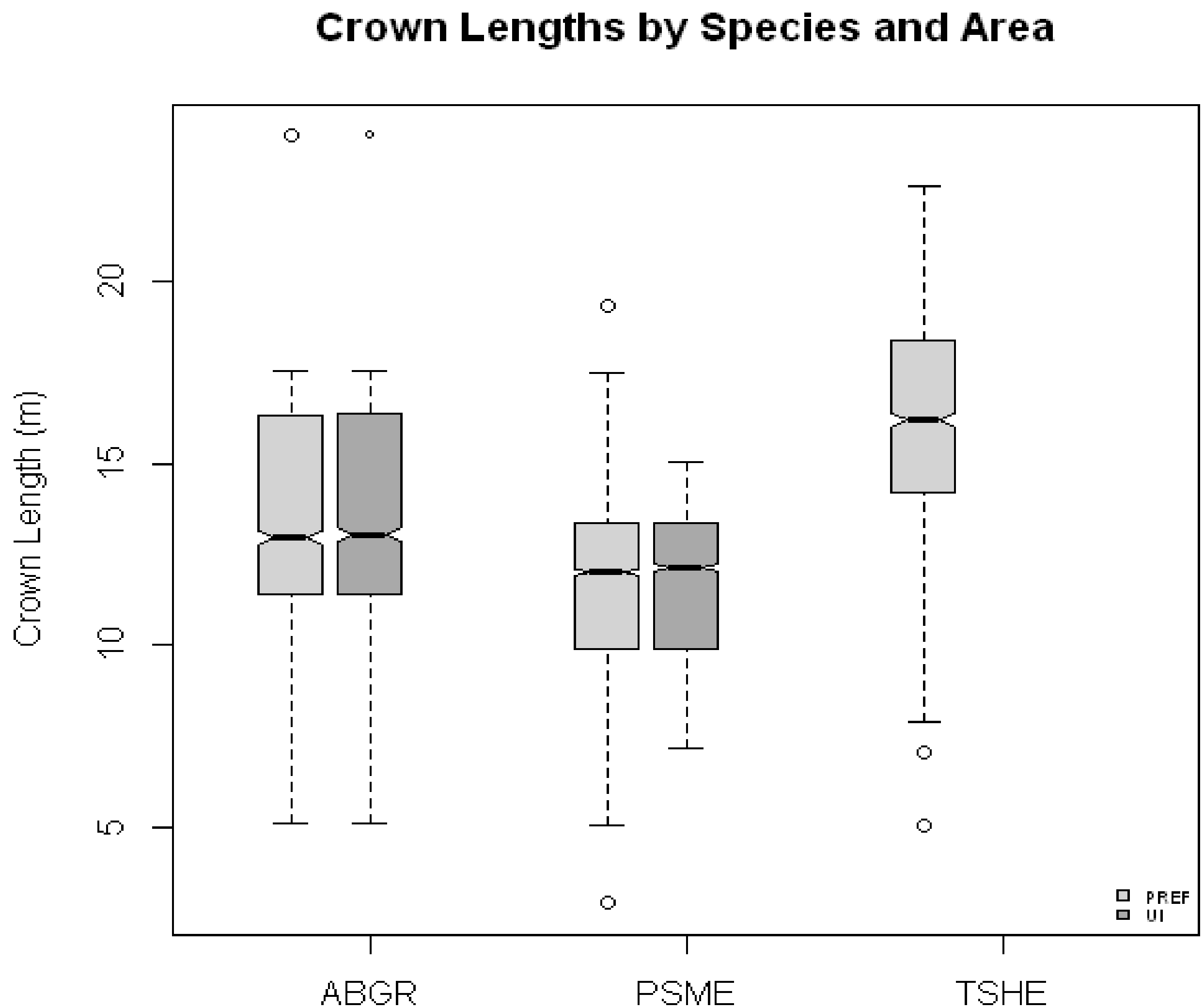


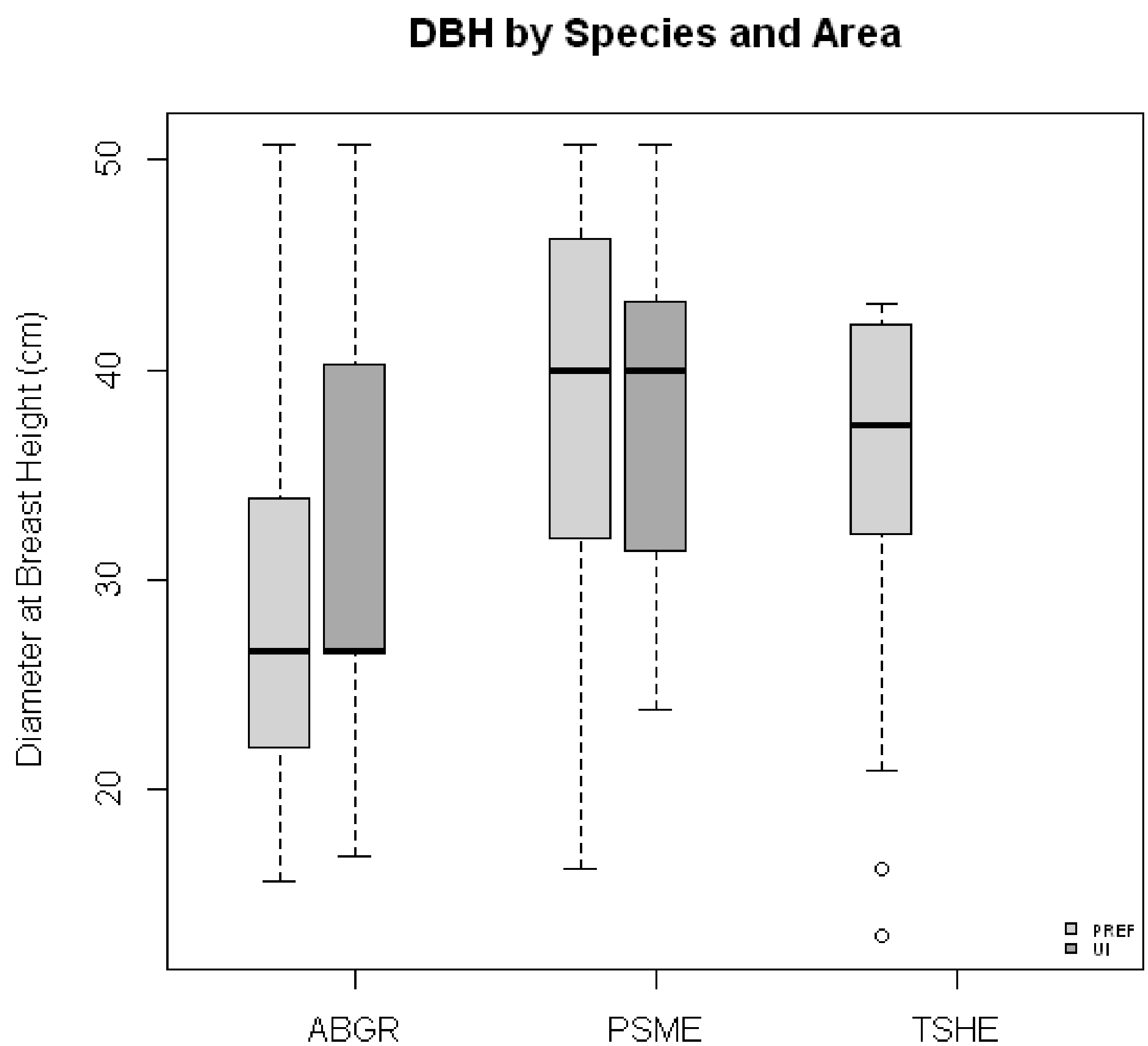
Basal Area for PREF and UI
Basal Area (m²/ha)
10
20
30
40
50
60
70
PREF
UI


Trees per Hectare for PREF and UI
Trees per Hectare
1600
1400
1200
1000
800
600
400
PREF
UI



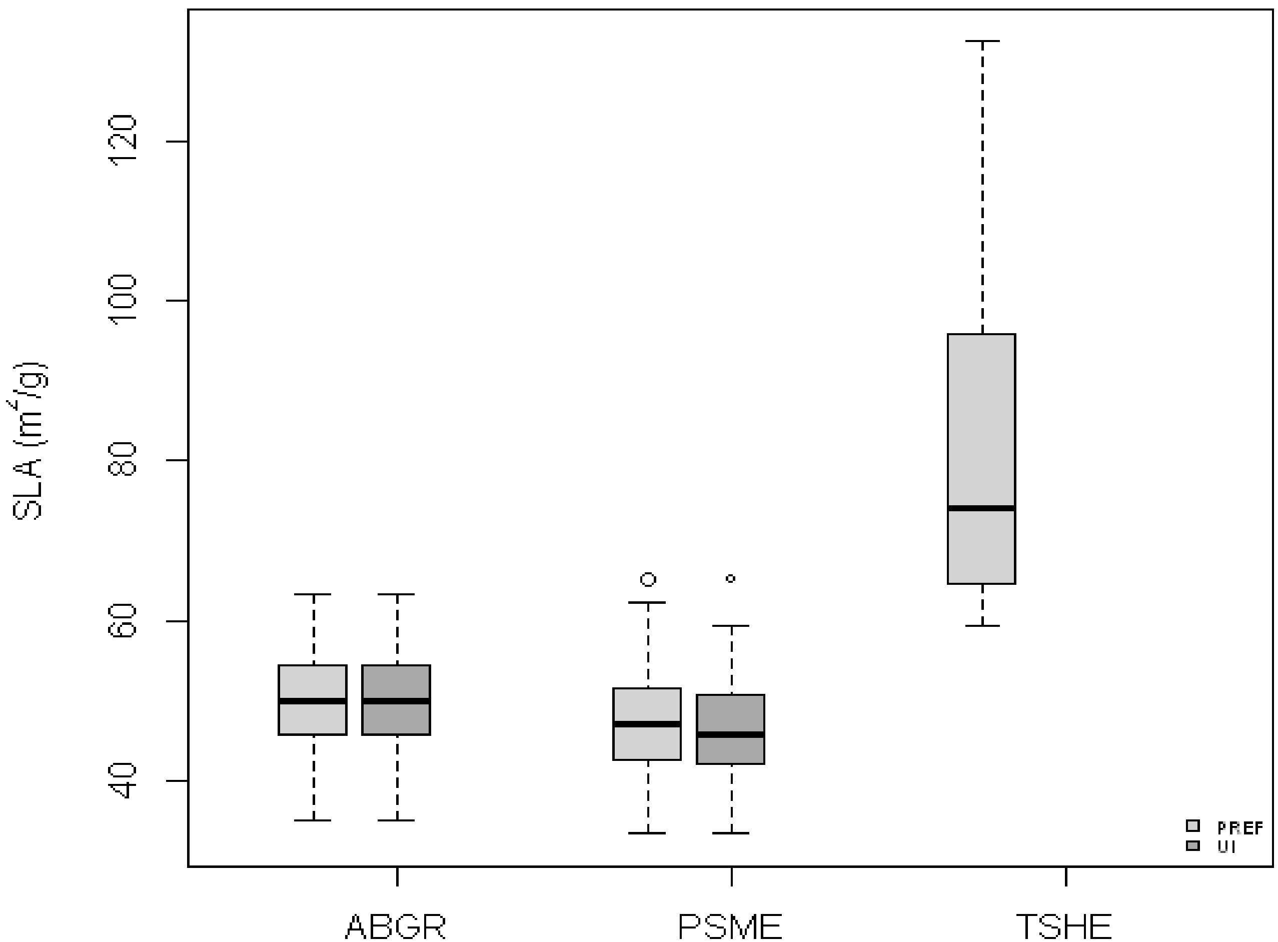
Tree Heights by Species and Area
Tree Height (m)
10
15
20
25
30
35
ABGR
PSME
TSHE
PREF
UI


Crown Lengths by Species and Area
Crown Length (m)
5
10
15
20
ABGR
PSME
TSHE
PREF
UI



DBH by Species and Area
Diameter at Breast Height (cm)
20
30
40
50
ABGR
PSME
TSHE
PREF
UI

SLA by Species and Area



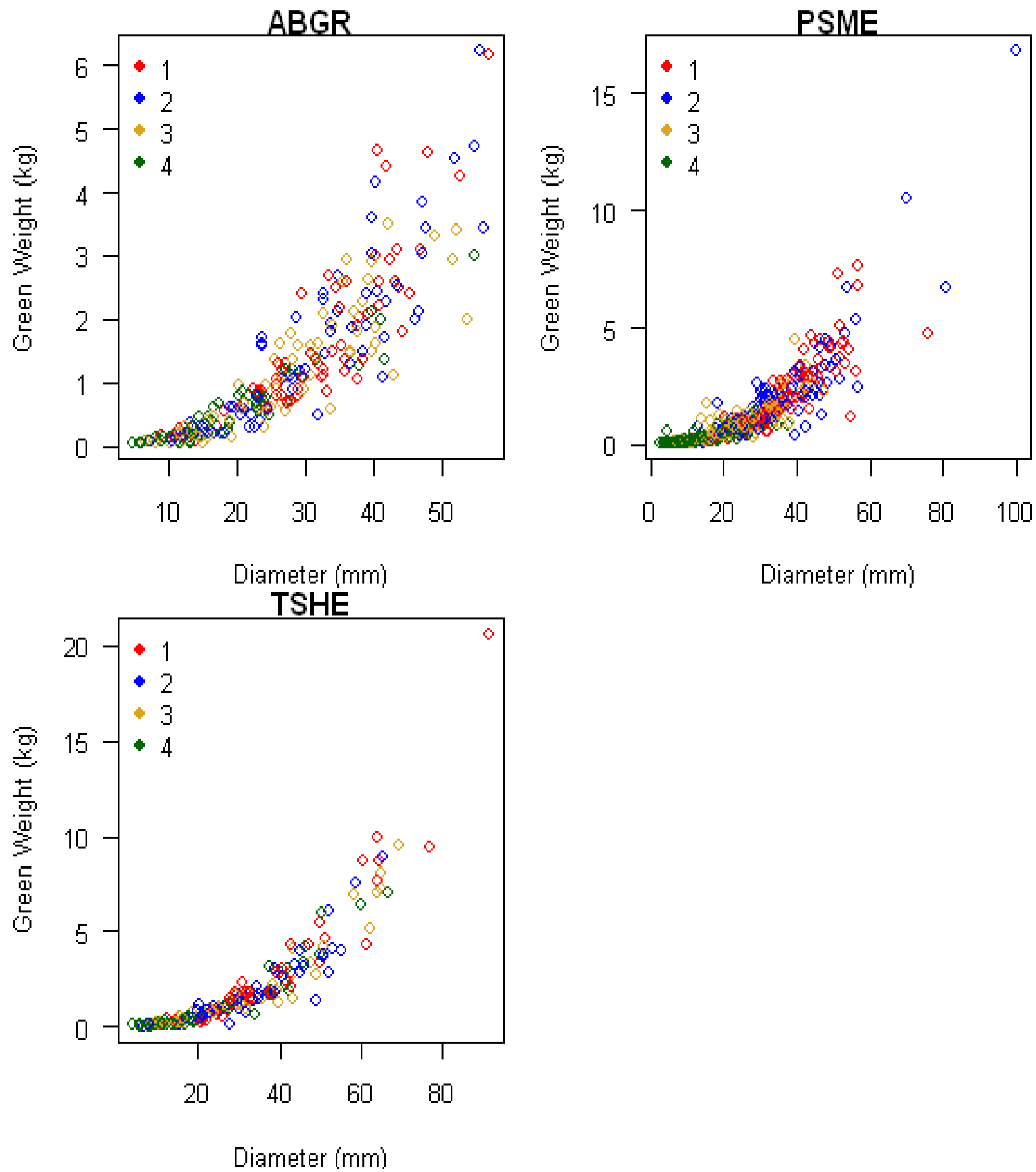
Individual Branch Allometric Equations

Branch Level: Full Models

- Wood biomass
  - R^2 = 0.89, 0.74, 0.89
- Needle biomass
  - R^2 =0.65, 0.62, 0.82
- Total branch biomass
  - R^2 = 0.93, 0.90, 0.95
- Needle area
  - R^2 = 0.69, 0.62, 0.90

Branch Level: Reduced Models

- Wood biomass
  - R^2 = 0.86, 0.71., 0.86
- Needle biomass
  - R^2 = 0.65, 0.54., 0.77
- Total branch biomass
  - R^2 = 0.90, 0.84., 0.91
- Needle area
  - R^2 = 0.69, 0.60, 0.89


ABGR
PSME
TSHE
1
2
3
4
Green Weight (kg)
Diameter (mm)
0
1
2
3
4
5
6
10
15
20
30
40
50
60
80
100

Tree Level Allometric Equations

Tree Level: Full Models

- Wood biomass
  - R^2 = 0.64, 0.67, 0.69
- Needle biomass
  - R^2 = 0.68, 0.63, 0.60
- Total branch biomass
  - R^2 = 0.93, 0.59, 0.56
- Needle area
  - R^2 = 0.37, 0.40, 0.50

Tree Level: Reduced Models

- Wood biomass
  - R^2 = 0.64, 0.47, 0.56
- Needle biomass
  - R^2 = 0.56, 0.39, 0.46
- Total branch biomass
  - R^2 = 0.81, 0.46., 0.56
- Needle area
  - R^2 = 0.37, 0.40, 0.50

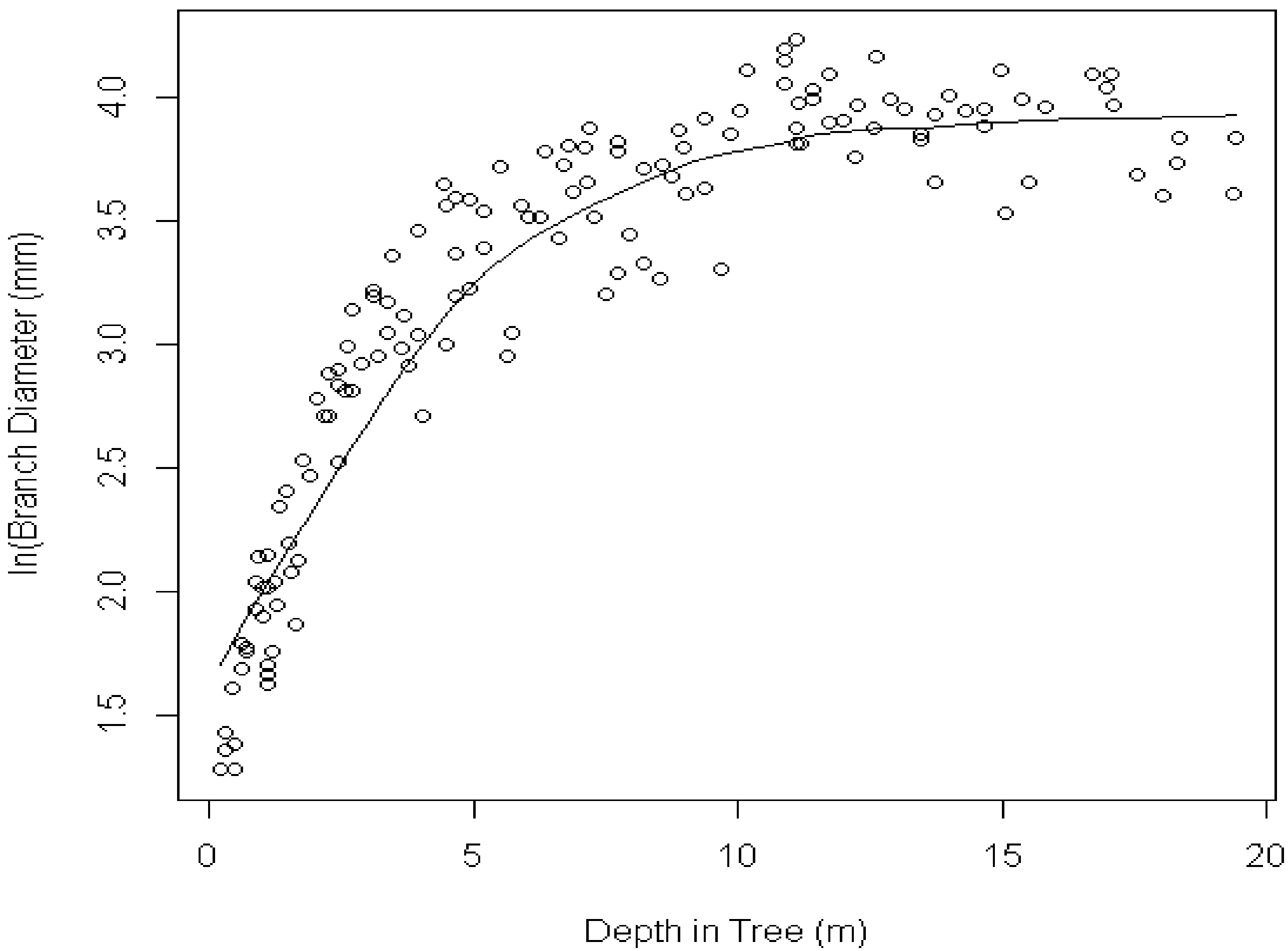
Part 1 Conclusion

- Branch level equations provided good allometric fit for biomass components and needle area
  - Full models generally only needed branch length to improve fit
- Tree level (scaled) equations explain less variability in biomass components and needle area

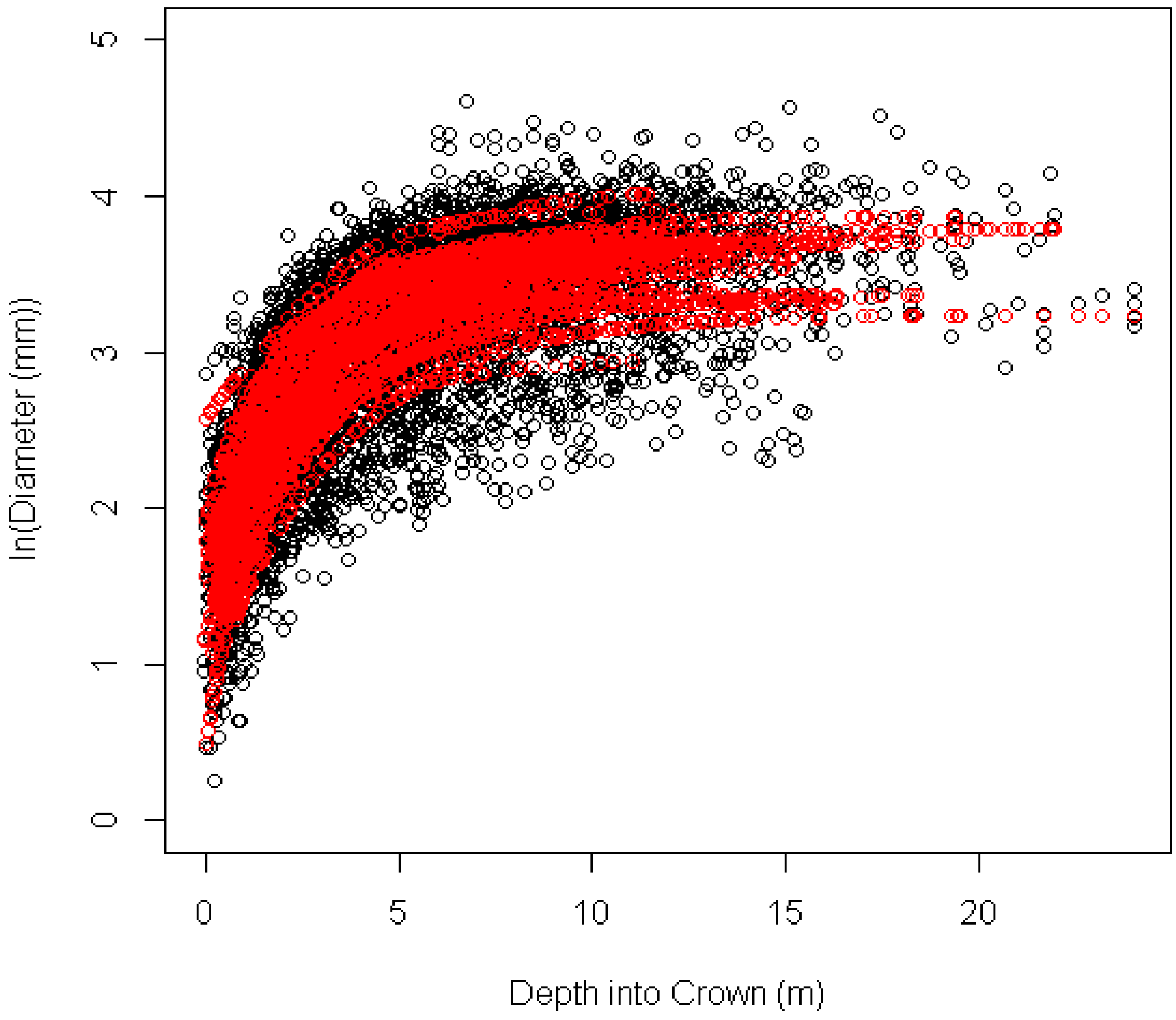
Part 2: Predict Branch Basal Diameter from Insertion Height

- Goal: predict branch basal diameter from insertion height
- Feed predicted branch diameters into the allometric equations to predict branch biomass quantities from bole characteristics

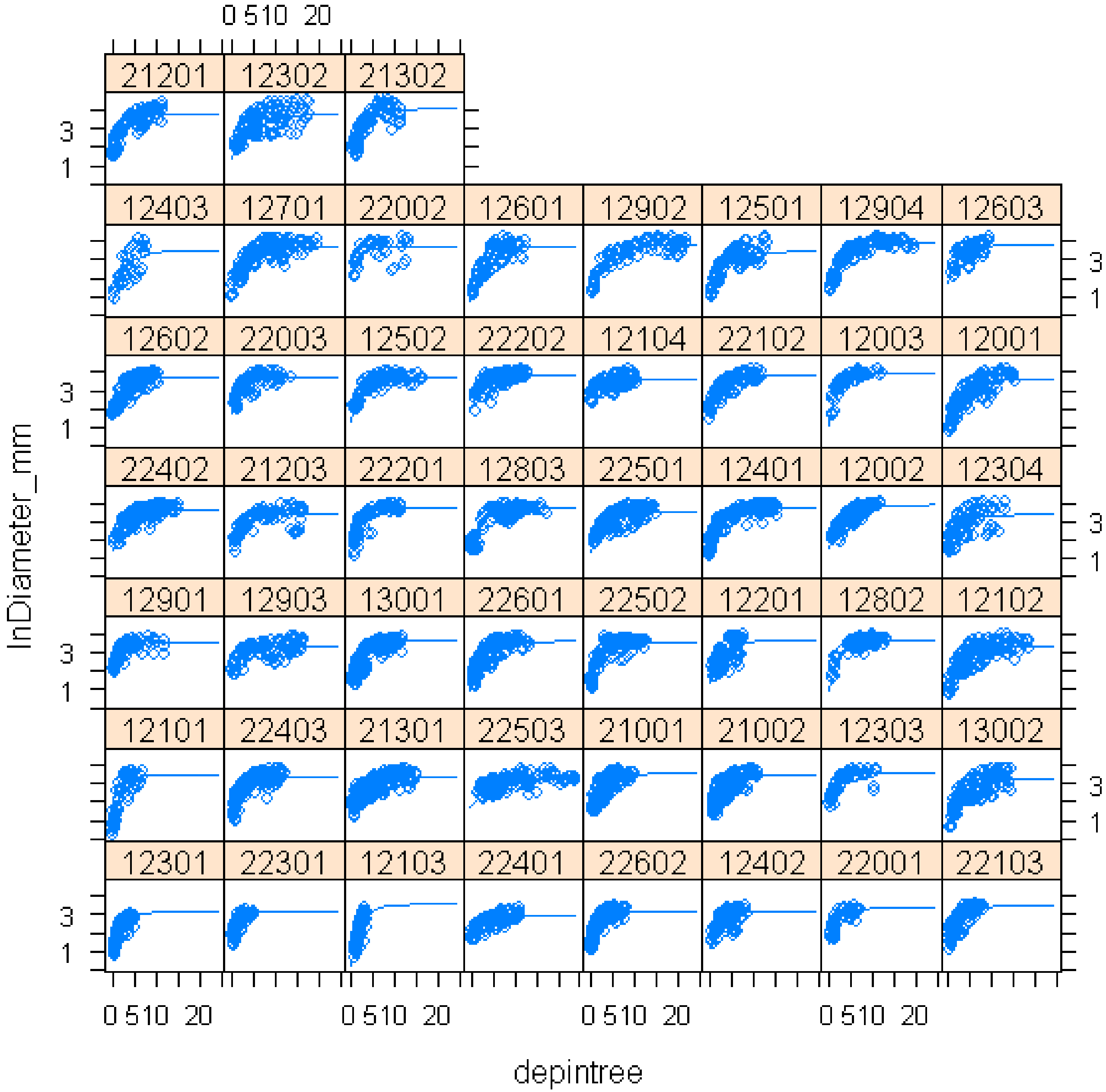
Smoothed Scatterplot



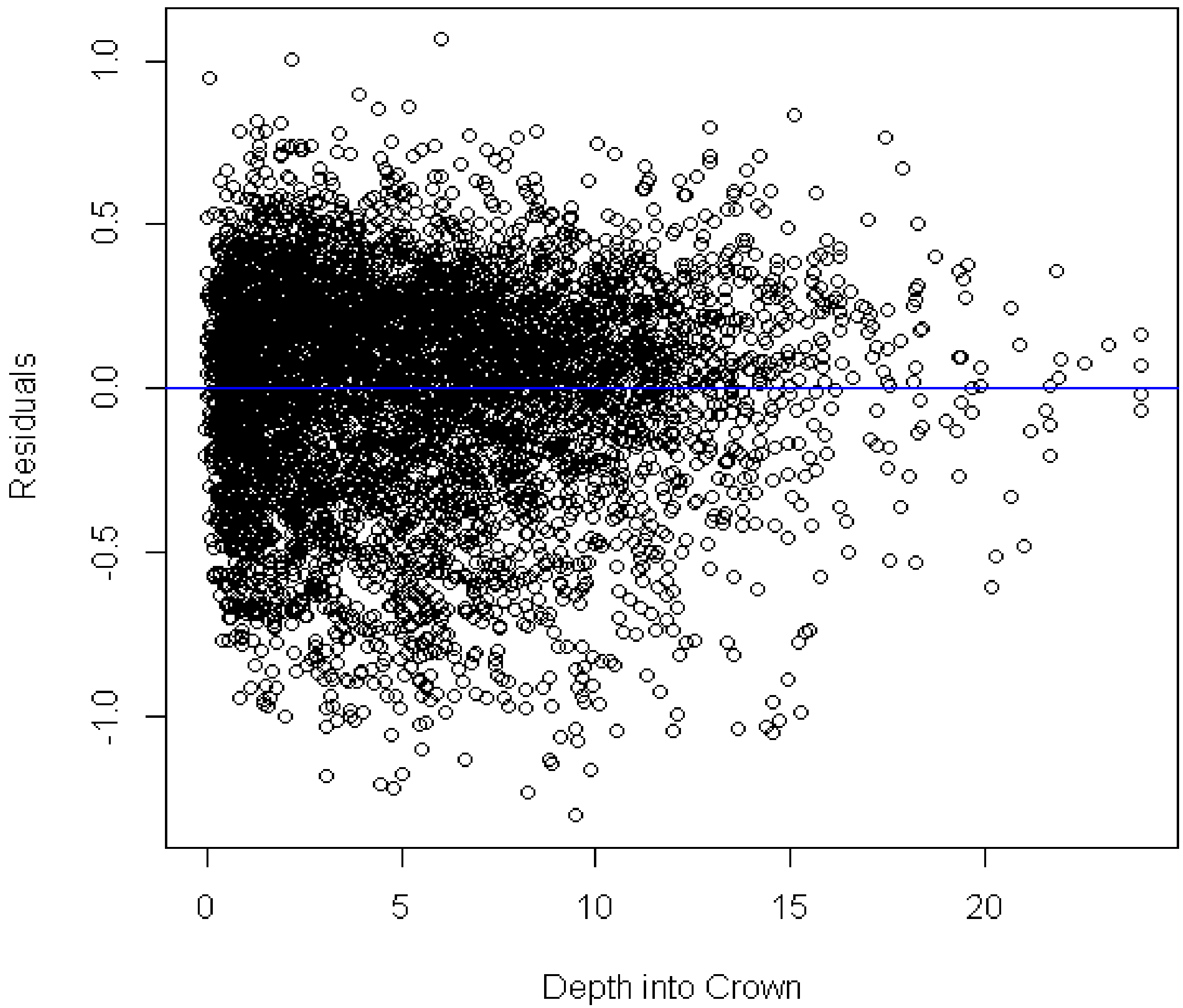
- Nonlinear asymptotic model
- Include autocorrelation function to account for lack of independence of branches
- Include variance model to account for increasing variance in branch diameter as they occur deeper into the crown



ln(Diameter (mm))
0
1
2
3
4
5
0
5
10
15
20
Depth into Crown (m)



21201
12302
21302
12403
12701
22002
12601
12902
12501
12904
12603
12602
22003
12502
22202
12104
22102
12003
12001
22402
21203
22201
12803
22501
12401
12002
12304
12901
12903
13001
22601
22502
12201
12802
12102
12101
22403
21301
22503
21001
21002
12303
13002
12301
22301
12103
22401
22602
12402
22001
22103
lnDiameter_mm
depintree
0 5 10 20
1
3



Residuals
1.0
0.5
0.0
-0.5
-1.0
0
5
10
15
20
Depth into Crown

Part 2 Conclusion

- Nonlinear asymptotic model with autocorrelation and a power function variance model provides a good fit between branch basal diameter and insertion height on bole

- Combining both models will allow branch biomass and leaf area predictions from branch insertion height on bole
- Next step is to add stem biomass model from the study trees for crown biomass prediction