Allometric Biomass Models and Applications for Chinese Tallow in a Mississippi Bottomland Forest

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Introduction

Chinese tallowtree (*Triadica sebifera*) is an unrelenting, non-native invader moving through the southeastern United States. The tallowtree can invade a multitude of habitats, from coastal prairies to closed canopy forests, forming mono-specific stands and driving out native flora and fauna.

An understanding of the ecology and biology of the tallowtree, along with its effects on forest alteration, is necessary for any attempt at control to be successful. In this time of climate change, it is critical to uncover and comprehend the relationships between invaders and carbon cycling dynamics. This becomes particularly important when those species out-compete their counterparts and drastically alter the habitat and, consequently, the carbon stores.

Objectives

This study aims to create functional biomass models at the individual branch level, which when used additively provide an understanding of the total crown biomass for the tallowtree. Modeling at this small scale allows us to gain an accurate measure of the biomass in different components of the tree.

These models, along with models created for the stem, can be used to show the relationship between crown biomass and stem biomass as an indication of competitive ability. These models are also important in understanding the total biomass of each tallowtree and how its spread may change carbon storage and cycling dynamics in its invasive range.

Methods

❖Location
Data was collected from a site near Poplarville, MS on September 25, 2012. The study site is in Pearl River County and borders the Louisiana State line.

❖Tree Sample Collection and Preparation
Data was collected for five trees (Table 1). Tree diameters were measured at breast height (DBH). Branches from each tree were cut along the bole and separated. The branches were then cut at any joint where the secondary branch was over 1cm in diameter. When all branches were separated, measurements were taken for the basal diameter and the length.

❖Subsample Measurements
200 subsamples from these branches and subsample disks taken at 3 foot intervals from each bole, were taken back to the laboratory and oven dried at 102° for 24 hours, until a constant weight was reached and recorded. We used dry weight as an indicator of biomass.
This information was used in to create our biomass models which we then used to calculate the total biomass for the crown and stem and plot them against each other to observe a trend in relationships.

❖Statistical Analysis and Modeling
Biomass, length (L) and basal diameter (D)for each branch were entered into SAS (SAS Institute 2008). We assumed that the biomass of an individual branch was a function of D and L. These models were fitted using SAS PROC REG.

Table 1. Calculated crown and stem biomass, ratios, and total biomass for Chinese tallowtree

Tree	Location	DBH (cm)	Calculated Crown Biomass (kg)	Calculated Stem Biomass (kg)	Stem:Crown	Total Biomass (kg)
1	Woods	19.23	1.67	76.75	46.07 : 1	78.42
11	Along Road	8.38	0.43	6.04	14.14 :1	6.46
10	Along Road	28.96	32.33	186.67	5.77 : 1	219.00
4	Forest Edge	16.56	2.66	40.05	15.04 : 1	42.71
8	Along Road	16.38	0.64	47.02	73.96 : 1	47.65

References

Bruce, K.A., Cameron, G.N., Harcombe, P.A., and Jubinsky, G. 1997. Introduction, Impact on Native Habitats, and Management of a Woody Invader, the Chinese Tallow Tree, Sapium sebiferum. Natural Areas Journal. 17: 255-260
Parresol, B.R. 1999. Assessing Tree and Stand Biomass: A Review with Examples and Critical Comparisons. Forest Science 45:573-593

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Results

❖We tested eight branch models using length, diameter and combination, and obtained AIC, R^2 and RMSE values and fit statistics for each. Based on these fit statistics, parameter estimations from the best fitting model were used to construct our final branch biomass model:

$$Biomass(g)=9.2813+exp(0.8342*Diameter)$$

❖Using previously calculated stem biomasses for each tree, we were able to graph a relationship between stem and crown biomass (Figure 2). We calculated crown to stem ratios for each tree and these can be found in Table 1.

❖We also constructed a relationship between the calculated total crown biomass and the tree DBH (Figure 3) which may be useful in future field work and models.
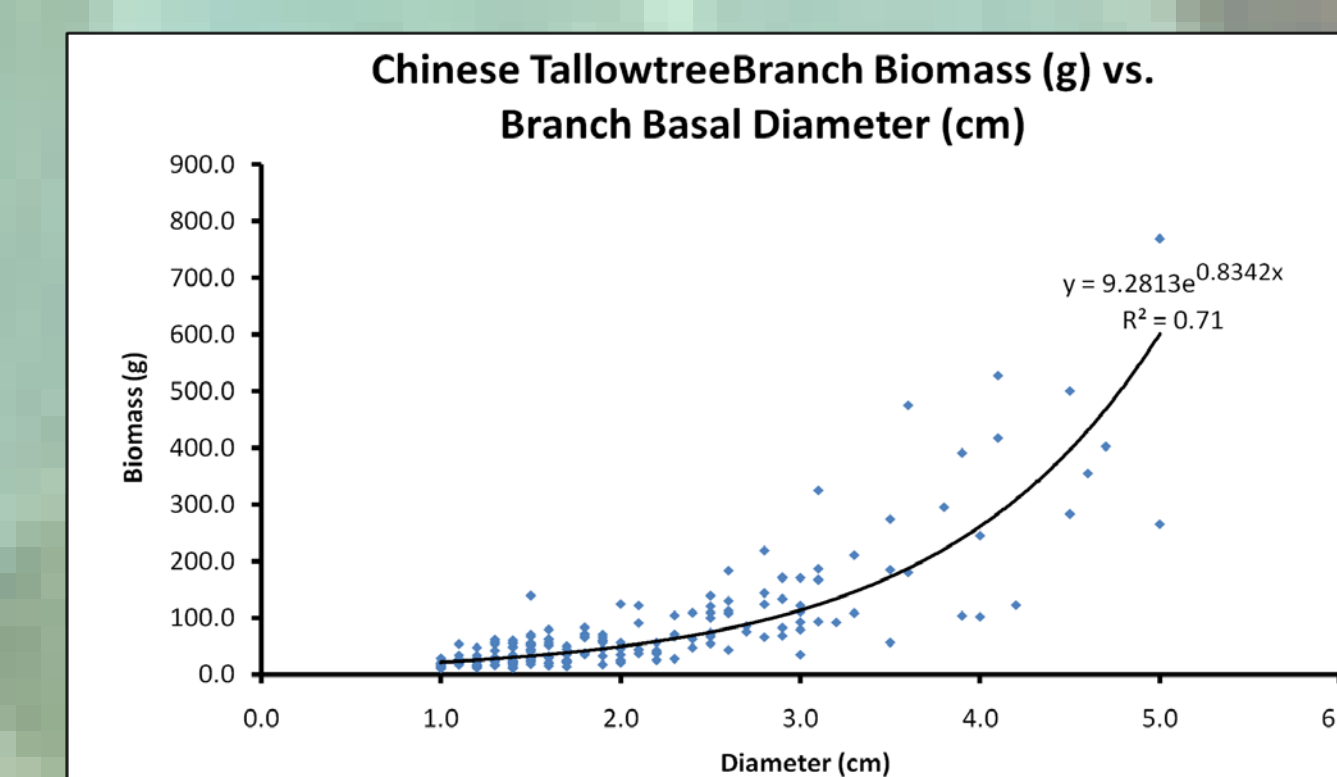

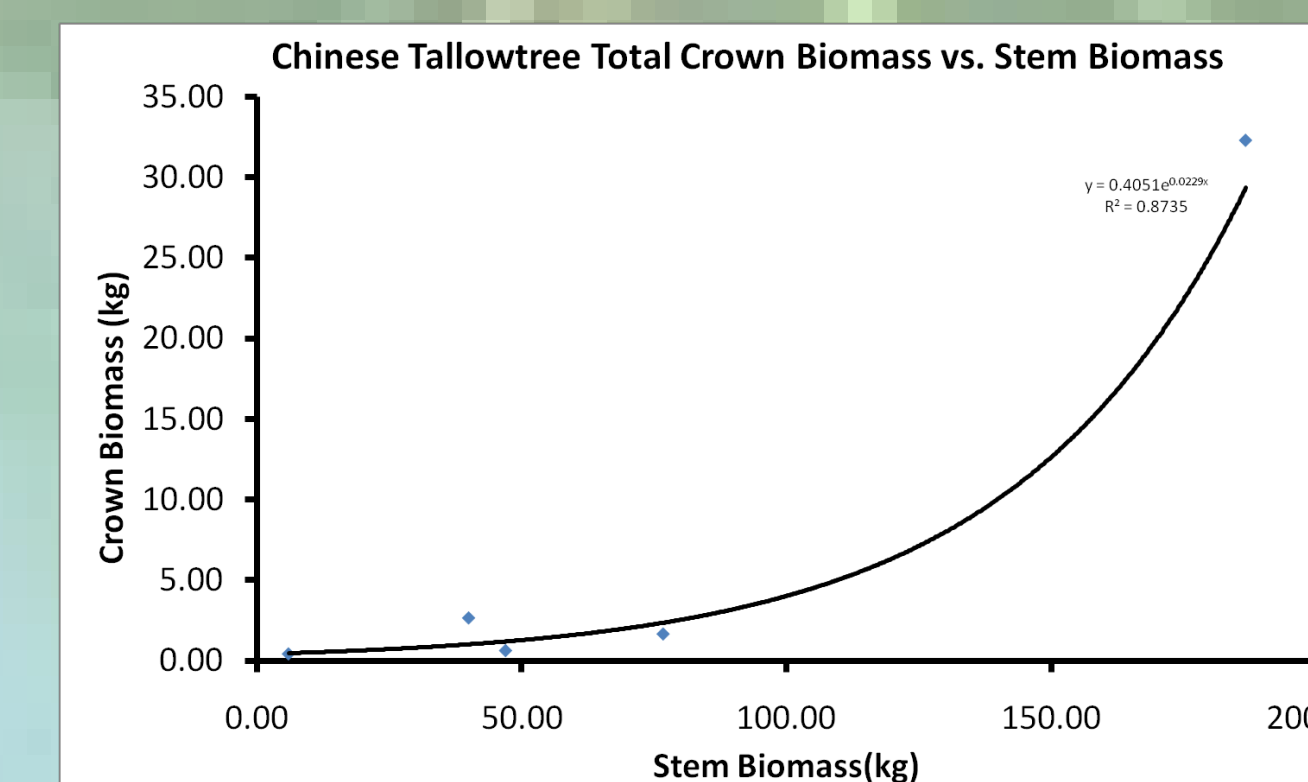**Figure 1.** Relationship between tallowtree branch biomass and branch diameter

Figure 2. Relationship between tallowtree stem biomass and crown biomass
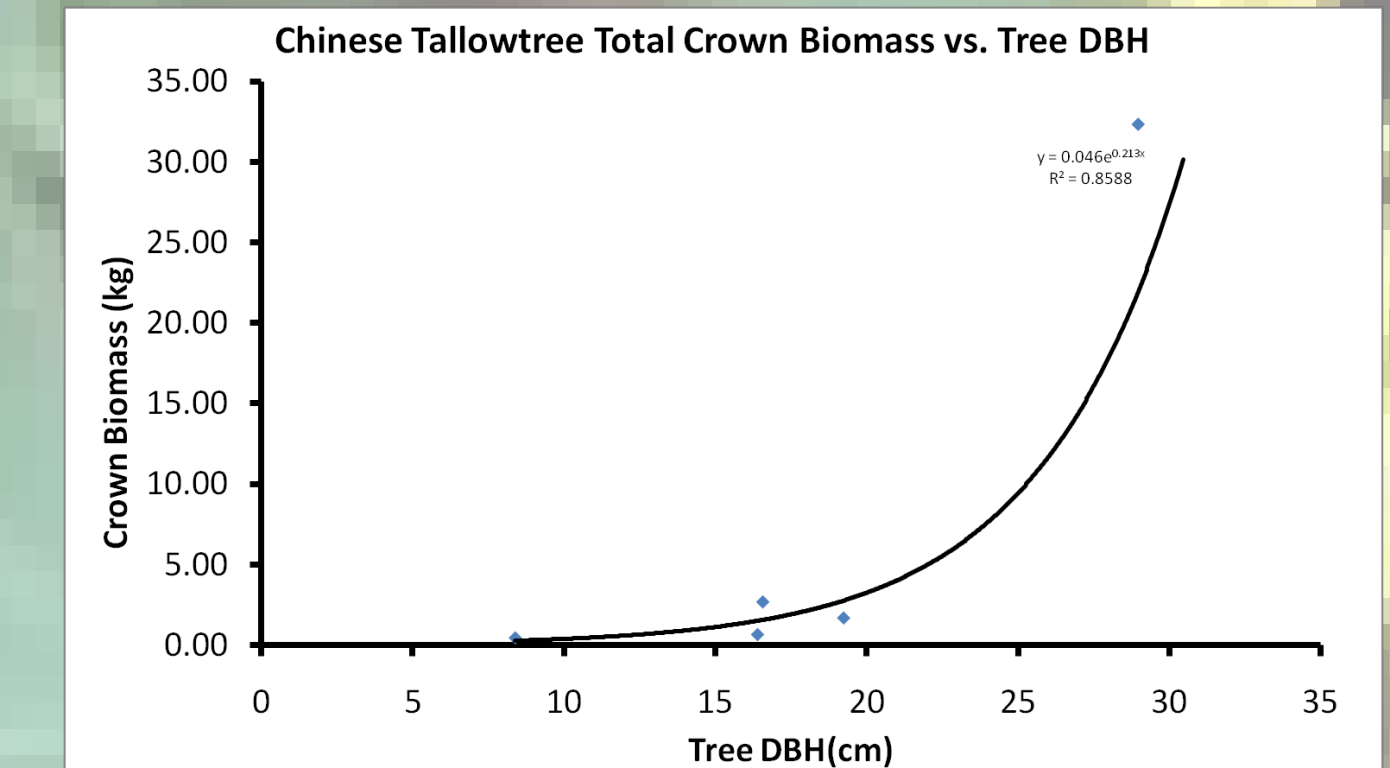

Figure 3. Relationship between tallowtree crown biomass and tree DBH

Conclusions

Biomass models can be accurately constructed through a thorough statistical analysis and prove to be a useful tool in estimating the biomass contained within a tree. This is especially useful when quantifying the impact that an invasive species may have on carbon pools as it invades and displaces native species. Through our analysis we have found that branch biomass is exponentially related to branch basal diameter and an accurate model to calculate biomass is: Biomass(g)=9.2813+exp(0.8342*Diameter).

This model can provide a very accurate calculation for the biomass in an individual branch or it can be used to compute the total crown biomass. We have additively calculated the total crown biomass for each tree sampled and compared them to our previously computed stem biomasses. In doing so, we have determined a stem to crown ratio for each tree which will prove useful in future research. A tree with a higher crown biomass to stem biomass will demonstrate a higher competitive ability and will be a successful invader. It is also important to note that the location in which a tree is found can have significant impact on this ratio. In future research, we aim to show a comparison of tallowtree crown to stem ratios with those of native species in an attempt to understand and predict the tallow's competitive ability in a quantifiable approach.

For field research, it will prove to be useful to have a model in place to easily and accurately evaluate crown biomass from tree DBH. In our study, we have graphed a relationship between our calculated crown biomass and tree DBH and hope to build upon this model in the future.

Accurate biomass predictions give great insight into a tree's competitive ability and also its role in carbon cycling within a habitat. As invasive species are becoming an ever increasing concern, it is critical that this component is understood to comprehend the full impacts of the non-native and as a baseline for any successful control program.