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# Aboveground Biomass Estimation for Three Common Woody Species in the Post Oak Savannah of Texas

Brian P. Oswald
*Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, Texas 75962*

R R. Botting

Dean W. Coble
*Arthur Temple College of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962-6109*

Ken W. Farrish
*Arthur Temple College of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962-6109*

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The Post Oak Savannah occupies about 3.4 million hectares of gently rolling to hilly lands in east central Texas. Large post oak (*Quercus stellata* Wangenh.) blackjack oak (*Quercus marilandica* Munchh.), Eastern redcedar (*Juniperus virginiana* L.) and honey mesquite (*Juniperus virginiana* L.) usually form the overstory, often above thickets of yaupon (*Ilex vomitoria*), winged elm (*Ulmus alata*), gum bumelia (*Sideroxylon lanuginosum* Michx. Subsp. *Oblongifolium* (Nutt) T.D. Penn.), and live oak (*Quercus virginiana* Mill.). Historically limited to rocky hillsides and draws (Owens and Ansley 1997), these species have migrated over the last several hundred years into bottomlands where grasses once dominated, and the increase in abundance and range has fluctuated due to both the modification of the historic fire regime and overgrazing (Smeins and Fuhlendorf 1997).

The primary focus of previous fire studies in the Post Oak Savannah have been ignition time, mortality rate and the effect of burning to the understory vegetation, not standing shrub biomass estimation. Biomass estimation equations developed in different regions may not be applicable to the Post Oak Savannah since these substitutions may result in substantial error (Grier and Milne 1981, Gottfried and Severson 1994). With better prediction equations for this region with an increasing Urban-Wildfire Interface, managers can more accurately estimate the potential severity of wildfires or the effects of prescribed burns (Martin *et al*. 1978).

Biomass estimation methods that involve juniper species have focused on Pinyon-Juniper (*Pinus edulis* and *Juniperus spp.*) and overstory-understory interactions in the western states. Schnell (1976) developed biomass prediction equations tables for eastern redcedar in Georgia, Alabama Tennessee and Virginia, that required diameters at breast height (DBH) > 12.7 cm. Clark *et al.* (1986) and Phillips (1981) developed equations for estimating post oak biomass in North Carolina, South Carolina and Georgia, using DBH and total height; Phillips (1981) also age, but neither included foliage. Common in both studies was a DBH > 15.2 cm and total height as independent variables. There is little biomass estimation information available for gum bumelia, although Bryant and Kothmann (1979) suggested a quadratic equation might work best.

The objective of this study was to develop regression models to predict the total above-ground biomass for three species commonly found in Post Oak Savannah plant communities.

## Methods

Camp Swift Military Reservation is located in south central Texas, 45 km east of Austin and 11 km north of Bastrop, with an elevation of 122-183 m MSL. Established in 1942, 4,735 hectares were retained as a military reservation after

World War II (Leatherwood 2002). The climate is humid with a mean January temperature of 4 C°, a mean July temperature of 36 C° and mean rainfall of 94 cm (Odintz 2006). The terrain is characterized by rolling uplands and broken hills with primarily sandy and loamy surface soils. The Axtell-Tabor soil association was found where sampling was performed on nearly level to strongly sloping terrain with a loamy surface layer and very slowly permeable lower profiles on streams terraces and uplands (USDA 1979).

The study area included four sites adjacent to urbanized development. Each site contained 12 plots, 50m X 20m in size, with six plots placed randomly on opposing aspects. All plots ran lengthwise parallel to the slope. The location for each plot was determined using GPS coordinates and a random numbers table, with the GPS coordinate considered the starting corner of the plot.

Each plot contained five 20m transects perpendicular to the length of the plot. The first transect was no less than 3m from the starting corner, and all transects were placed 5-10m from each other. Each transect contained one randomly placed sample point. The nearest representative to the sampling point of any of the three species was labeled and recorded. If the plant was a species whose target quota (30) was filled, the nearest plant of another species was sampled until the quota was reached.

Mean basal diameters (cm) were measured using a caliper above the root crown or above the swelling of the root crown, usually within 2.5- 5.0 cm above the top of the litter, with perpendicular readings taken for each plant and basal area ($cm^2$) calculated. The heights of each plant (m) and crown area ($m^2$) were also recorded. Crown area was measured by taking two readings from the center of each plant; one taken at the longest dimension and the second perpendicular to the first. Each plant was cut and segmented into fuel size classes (Brown 1976, Frandsen 1983), had all foliage removed, and placed in separate bags. The samples were oven-dried at 60°C for 48 hours (longer for heavier fuel samples) and dry weights (g) recorded.

Five models (Full Model, Full Log Model, Combined Variable Model, Logarithmic Model, and a Combined Variable Model with Crown Area (Clutter *et al.*, 1983)) were fitted to the data for each species and evaluated for the best fit. Best fit was determined by a high $R^2$, low root mean square error (RMSE), and Furnival's Index of Fit (FI, Furnival 1961). FI reflects the size of the residuals and possible departures from normality and non-constant variance, so it is a useful fit index to evaluate these five models. Regression parameter estimates were evaluated at the $\alpha=0.05$ level. The models were:

Full Model: $Y = \beta_0 + \beta_1 D + \beta_2 H + \beta_3 C + \beta_4 B + \epsilon$

Full Log Model: $\ln Y = \beta_0 + \beta_1 \ln D + \beta_2 \ln H + \beta_3 \ln C + \beta_4 \ln B + \epsilon$

Combined Variable model: $Y = \beta_0 + \beta_1 D^2 H + \epsilon$

Logarithmic Model: $\ln Y = \beta_0 + \beta_1 \ln D + \beta_2 \ln H + + \ln \epsilon$

Combined variable model with crown area: $Y = \beta_0 + \beta_1 D^2 H + \beta_2 C + \epsilon$

Where Y=total above-ground biomass or total above-ground dry-weight (g); D= basal diameter (cm); H=height (m); C= crown area ($m^2$); B=Basal area ($cm^2$); $\beta_0$ ,$\beta_1$ ,$\beta_2$ ,$\beta_3$ ,$\beta_4$ regression parameters to be estimated; $\epsilon$ = error or residual.

SAS ver. 8 (SAS Institute Inc., 1999) was used to estimate the regression parameters. Due to redundancy in this model since basal diameter was used to find the basal area and only some of the variables were significant at the 0.05 level, models were consolidated to use basal diameter, height and crown area.

## Results and Discussion

Mean total above-ground weight (g) per plant, and height (m), basal diameter ($cm^2$) and crown area ($m^2$) per species are presented in Table 1. For all species $R^2$ values exceeded 64% for the full regression model, and 25% for the full log model, although a majority of the variables were not significant. The logarithmic and combined variable with crown area models had $R^2$ values $\geq$72% for all species. The combined variable model results had $R^2$ values $\geq$ 17%, non-constant variance was present and the variables were significant. The logarithmic model had the best fit for all three species based on the values for $R^2$, RMSE, and FI (Tables 2 and 3). The logarithmic model with regression parameter estimates was back-transformed to original units for ease of use (Table 4). These equations include a correction for log-normal bias (correction factor = CF = $e^{MSE/2}$, where

MSE = Mean Square Error = $RMSE^2$, Baskerville 1972) since the dependent variables were transformed to logarithmic units for fitting.

The larger individual foliage of post oak and gum bumelia compensated for smaller, more numerous Eastern redcedar foliage. Natural variation in the size of the individual plants contributed to different diameter and height results. Post oak and eastern redcedar had large basal diameters that contributed to the heavier weights in comparison to gum bumelia.

The equation by Schnell (1976) for eastern redcedar requires a DBH > 12.7cm. For this study basal diameter was used because DBH was not found on small plants. Since his tables leave a size class gap, the prediction equations provided here can fill a portion of the size class gap. The post oak collected here were smaller in height and diameter than those used by Clark *et al.* (1986) and Phillips (1981) and did not have a measureable DBH. Therefore, their prediction equations are impractical for this size plants, even if basal diameter was converted to DBH. Bryant and Kothmann (1979) suggest a quadratic model for gum bumelia, but they fail to provide regression coefficients for the model. Here, a logarithmic model for gum bumelia is provided with regression coefficients instead of the suggested quadratic model.

## Conclusions

Biomass prediction equations using the logarithmic model with corrections for log-normal bias for total above-ground biomass were found for eastern redcedar, post oak and gum bumelia. To calculate the potential energy (heat) release, total above-ground biomass (g) estimation can now be made for three of the most common species in the Hill Country of Texas. Additionally, the prediction equations found for post oak foliage can have implications in wildlife management areas if managers want to determine available foliage in small trees < 10.2 cm in basal diameter or < 3.0m in height.

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