International Journal of Wildland Fire 2018, **27**, 742–755
doi:10.1071/WF18025_AC

Supplementary material

Estimating canopy fuel characteristics for predicting crown fire potential in common forest types of the Atlantic Coastal Plain, USA

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In order to determine if calculating canopy bulk density estimates using national scale estimators is adequate for our study, we compared canopy bulk density estimates using national foliage biomass estimators from Jenkins *et al*. (2003) to those from species-specific equations. The species-specific foliage biomass equations were obtained from Clark *et al*. (1985, 1986*a*, 1986*b*) for hardwoods; Gonzalez-Benecke *et al*. (2014) and Baldwin (1987) for loblolly pine, Gonzalez-Benecke *et al*. (2014) and Lohrey (1984) for slash pine; and Baldwin and Saucier (1983) and Samuelson *et al*. (2014) for longleaf pine (Table S1). National biomass estimators appear to be acceptable for local foliage biomass calculation and facilitate modelling canopy fuel variables across spatial scales.

Methods

National-scale estimators for individual tree crown foliage biomass are equations developed by Jenkins *et al*. (2003) from composite datasets for many individual species within a group such as pines or hardwoods. These estimators are widely applicable and easily obtainable (Jenkins *et al*. 2003). We used the national-scale estimators to calculate crown foliage biomass by DBH and aggregated the foliage biomass results into DBH classes. Bias and precision of the crown foliage biomass estimates derived from species-specific equations were compared to those derived from national-scale estimators. Bias was defined as the average difference between the species-specific estimates and the national estimates while precision (absolute bias) was the average absolute difference.

Results

The magnitude of the bias and the absolute bias of the foliage biomass estimates for all pine species groups increased with the DBH classes (Table S2). For all three pine species, percent bias fell in the range of 15–30%. For loblolly pine, the national-scale estimators usually underestimated foliage biomass compared to the two species-specific equations. Compared to slash pine models and one longleaf model by Samuelson *et al*. (2014), the national equations overestimate foliage biomass. However, two other equations from Baldwin and Saucier (1983), which are based on different methods of adjustments to calculate foliage biomass, show that the national equations can lead to both over- and under-estimates compared with local equations (Table S2).

Conclusions

The use of national-scale allometric equations to estimate crown foliage biomass facilitates computation of CBD for a wide range of species and conditions in the region. We expected to see differences between local species-specific estimates derived from pure stands and national equation estimates. This method increased bias and reduced precision when compared to the use of local equations, but the latter data are often cost prohibitive to obtain at the landscape scale across many forest conditions. However, because available crown fuel is based on foliage biomass plus twig biomass determined from the ratio of twig to foliage biomass, the potential error can be enhanced if there are major differences between local equations and national estimators. It is not possible to empirically validate the national-scale estimators used to calculate CBD at SRS, but the comparison with other species-specific equations is a reasonable alternative. Our results suggest that the differences in allometric equation estimates in terms of bias are consistent with the known differences between studies for individual species. For example, Gonzalez-Benecke *et al*. (2014) found the same pattern and magnitude of bias for loblolly and slash pines between species equations as well as an increase in bias (percent) as the stem DBH increased. Unless local sample equations are developed, there appears to be no justification for developing species-specific allometric equations. One factor in providing CBD estimates that we did not explicitly consider is seasonal pine foliage dynamics. Most studies that relate foliage to DBH and/or height do not report the season of sampling. Pines in the south-eastern US that retain multiple year cohorts for a portion of the year can have major variation in foliage biomass simply as a result of seasonal litterfall dynamics (Baldwin *et al*. 1997).

Table S1. South-eastern US individual tree foliage biomass allometric equation sources for selected pine species used for comparison with national-scale estimators

Reference for allometric equations and species	Equations used to estimate foliage biomass	National forest inventory species codes
Gonzalez-Benecke *et al*. 2014 Loblolly pine	Table 6 page 263. Uses DBH and height. Eq(s). F4 for loblolly pine	131
Baldwin 1987 Loblolly pine	Table 4, page 215. Uses DBH and height. Eq. for foliage dry weight	131
Gonzalez-Benecke *et al*. 2014 Slash pine	Table 6 page 263. Uses DBH and height. Eq(s). F4 for slash pine	111
Lohrey 1984 Slash pine	Table 8, page 71. Uses DBH and height. Eqs. for foliage dry weight	111
Baldwin and Saucier 1983 Longleaf pine	Table 4, page 4. Uses DBH and height. Eqs. estimates include a) total biomass or b) crown biomass only	121
Samuelson *et al*. 2014 Longleaf pine	Table 4, page 482. Uses DBH and height. Eqs. for stands 12 to 87 years	121

Table S2. Average bias and average absolute bias criteria for seven species-specific foliage biomass estimates relative to five national-scale foliage biomass classes (kg tree^{-1}) aggregated by ranges of diameter at breast height (DBH, cm)

Species (Author)	N	Criteria	Foliage biomass classes (kg tree^{-1}) Class DBH range: 0+ to 10 cm	10+ to 20 cm	20+ to 30 cm	30+ to 40 cm	40+ cm
Loblolly (Gonzalez-Benecke *et al.* 2014)	**2749**	**Bias**	-0.09	-3.91	-6.09	—	—
		Absolute bias	0.91	3.94	6.09	—	—
Loblolly (Baldwin 1987)	**3968**	**Bias**	0.98	0.22	-2.85	-4.79	-7.15
		Absolute bias	1.25	2.95	4.85	6.55	9.45
Slash (Gonzalez-Benecke *et al.* 2014)	**471**	**Bias**	0.73	1.56	4.77	—	—
		Absolute bias	0.74	1.56	4.77	—	—
Slash (Lohrey 1984)	**799**	**Bias**	0.10	2.09	6.52	13.47	22.39
		Absolute bias	0.56	2.51	6.53	13.47	22.39
Longleaf (Baldwin and Saucier[A] 1983)	**1348**	**Bias**	0.70	1.45	-2.13	-7.40	-16.02
		Absolute bias	0.82	1.87	2.45	7.40	16.02
Longleaf (Samuelson *et al.* 2014)	**1352**	**Bias**	0.78	7.04	9.79	11.36	11.21
		Absolute bias	1.07	7.06	9.81	11.48	11.42
Longleaf (Baldwin and Saucier[B] 1983)	**1004**	**Bias**	1.01	0.91	-1.35	-4.68	-10.53
		Absolute bias	1.19	1.62	2.10	4.74	10.53

[A]Estimates of foliage biomass based on Table 4, page 4 using total tree wood, bark and foliage equation minus equation for total tree wood and bark. Separate equations used for trees greater than and less than 12.7 cm DBH.

[B]Estimates of foliage biomass based on Table 4, page 4 using total crown wood, bark and foliage minus equation for total crown wood and bark. Only trees greater than 12.7 cm DBH are included.

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