Plot-level Biomass and NPP Estimations

TIER 1 Dataset

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For all plots in Tier1 dataset, above-ground biomass (foliage, branch, bark, stemwood) was calculated using the general functions reported in Gonzalez-Benecke et al. (2014, *in review*). Coarse root biomass was calculated using the unpublished function that correlates root/woody biomass ratio (RFRAC) to tree age. This function, that estimated a root fraction of about 25% for mature stands, was discussed with Harold Burkhart and we agreed to use it.

Missing Ht was calculated using the model: lnHt = a b/DBH. One model was calculated for each plot per each measurement time. Missing values were filled with estimated values. Some trees had DBH=0 or DBH>0 when Height<4.5 : Those DBH were assumed as missing values.

Functions used to estimate biomass (kg):

FOL = 3.746583*(dbh**0.883835)*(exp(0.062461*dbh))*(Ht**-0.284381)*(Age**-0.413381)*(Nha**-0.212743)*(Dp**0.174500)

BRANCH = 0.001568*(dbh**2.119937)*(exp(0.040940*dbh))*(Ht**0.667628)*(Age**-0.352632)*(Nha**0.414580)*(BA**-0.511470)

BOLE = 0.088273*(dbh**1.497337)*(Ht**1.462580)*(Age**-0.160971)*(Nha**-0.160969)*(Dp**0.383145)

TAGB= 0.347585*(dbh**1.515726)*(Ht**1.179694)*(Age**-0.183786)*(Nha**-0.214381)*(Dp**0.591226)

STEM= BRANCH + BOLE (For 3-PG)

BFRAC = exp(-0.765819 + -0.165263*log(Ht*(dbh**2)) + 0.117441*Dp)

WOOD = (1-BFRAC)*BOLE;

BARK = BOLE-WOOD;

RFRAC = 0.2479 + (1.8022-0.2479)*exp(-log(2)*(Age/3.0224))**2

ROOT = RFRAC*BOLE

DBH, Ht, Nha, BA, Dp : in metric units

Bole=Bark + Wood

BFRAC= Ratio of Bark to Bole

RFRAC= Ratio of Root to Bole (unpublished)

Dp = dbh/QMD

Above-ground Net Primary Production (ANPP, Mg ha^{-1} $year^{-1}$) was calculated for each measurement interval as the net increment in Woody Biomass + Foliage Production during that period.

Increment in woody biomass (Iw) includes the biomass of dead trees as suggested by Martin and Jokela (2004). In order to calculate the biomass of dead trees, the dead trees were identified and the biomass at the first measurement when that tree was not present was assumed to be the same as the previous measurement. Using this approach the net increment in woody biomass only included the growth of the living trees, not discounting the reduction in biomass due to absence of dead trees.

For each plot and measurement, mean annual projected leaf area index (LAI, m^2 m^{-2}), Needlefall (NF, Mg ha^{-1} $year^{-1}$) and Litterfall (LF, Mg ha^{-1} $year^{-1}$) were calculated using the functions reported by Gonzalez-Benecke et al. (2012). Woody component of litterfall (called "branchfall", BF) was determined using LF and the stand age-dependent needlefall/litterfall ratio reported in Gonzalez-Benecke et al. (2012).

For each measurement, interval time step (t, years) was determined as: t = Age2 – Age1

For each measurement, mortality (due to stochastic events, competition or thinning) was determined as: Mort = (TPA1 – TPA2)/ TPA1

Foliage production (If) was assumed to be equal to the average of annual needlefall for the measurement interval: If = (NF1 + NF2)/2

Woody biomass production (Iw) was assumed to be equal to net increment in woody biomass and including BF for the measurement interval: Iw = (WB2 – WB1)/t + BF

Root biomass production (Ir) was assumed to be equal to net increment in coarse root biomass for the measurement interval: Ir = (R2 – R1)/t

Average branchfall (BF) for the measurement interval was determined as: BF = (BF1 + BF2)/2

- ANPP was calculated for each measurement interval as ANPP = Iw + If.
- Using the values of ANPP, Total NPP (abobe and below ground, TNPP) was calculated as: TNPP = ANNP + Ir

To facilitate the analysis, average age, TPA and BA for each measurement interval were also calculated:

Age = (Age1 + Age2)/2

TPA = (TPA1 + TPA2)/2 (English units)

BA = (BA1 + BA2)/2 (English units)

We included some stand parameters at Age 1 that can be used as covariates in future analysis.

We also estimated foliage production (If) assuming two years of foliage retention: If was computed as the average of the half of foliage biomass (F) for the measurement interval: If = [(F1)/2 + (F2)/2]/2. We discarded this estimate as the values were too low, maybe due to underestimations of allometric functions due to winter sampling.

The dataset include thinned studies: IW has negative values in those cases. The problem is that not all thinned plots are marked as thinned, so it is difficult to analyze only unthinned plots.

Important:

- Due to problems with tree ID (sequence within each plot) in studies HGLOB87, SAGSP85 and WGCD01, those studies were not included in NPP determinations. However, those studies have no problems to be included in stand level determinations (volume, basal area, biomass, etc.).
- Several plots of Thinning Study (FMC) have problems showing BA too high (between 250 and 350 ft2/acre). The problem should be in plot size, but I have to check that with data manager of FMC. In the meantime, I discarded that study for this analysis.

References:

Gonzalez-Benecke, C.A., E.J. Jokela, and T.A. Martin. 2012. Modeling the effects of stand development, site quality, and silviculture on leaf area index, litterfall, and forest floor accumulation in loblolly and slash pine plantations, Forests Science 58: 457-471.

Gonzalez-Benecke, C.A., S.A. Gezan, T.J. Albaugh, H.L. Allen, H.E. Burkhart, T.R. Fox, E.J. Jokela, C.A. Maier, T.A. Martin, R.A. Rubilar, and L.J. Samuelson. Local and general above-stump biomass functions for loblolly and slash pine trees. Forest Ecology and Management, *in review*.

Martin, T.A., and E.J. Jokela. 2004. Developmental patterns and nutrition impact radiation use efficiency components in southern pine stands. Ecological Applications, 14: 1839-1854.

List of Variables in NPP file:

COOP2	Cooperative ID
Studyname2	Study Name code
FID	Pot ID linked to coordinates
Installation2	Installation ID
PLOT	PLOT ID
PlantDensity	Planting Density (if available)
Replicate	Replicate (block)
Culture2	Cultural treatment (0=Low; 1=High)
Treatment	Treatment Code
Thin	Thinning (0=Unthinned)
COOP	Cooperative
StudyName	Study Name
State	State
County	County
nd	Number of living trees with dbh measured
LAT_WGS84	Latitude
LONG_WGS84	Longitude
YearMeas	Year of Measurement at Age1
PlotSize	Plot Size (acre)
Age2	Age at end of measurement interval (second measurement)
FOL2	Foliage Biomass (Mg/ha) at Age2
WOODY2	Woody Biomass (Mg/ha; Branch + Stem + Bark) at Age2
ROOT2	Coarse Root Biomass (Mg/ha) at Age2
BA2	Basal Area (ft^2/acre) at Age2
TPA2	Trees per acre at Age2
SI	Site Index (ft), base age 25 years
Age1	Age at beginning of measurement interval (first measurement)

FOL1	Foliage Biomass (Mg/ha) at Age1
WOODY1	Woody Biomass (Mg/ha; Branch + Stem + Bark) at Age1
ROOT1	Coarse Root Biomass (Mg/ha) at Age1
BA1	Basal Area (ft^2/acre) at Age1
TPA1	Trees per acre at Age1
Step	Number of years between Age2 and Age1
Age	Average Age on measurement interval
BA	Average BA on measurement interval
TPA	Average TPA on measurement interval
Mort	Mortality on measurement interval
LAI	Average LAI on measurement interval
BF	Branch Fall (Mg/ha/year) on measurement interval
IF	Foliage Biomass Production (Mg/ha/year) on measurement interval
IR	Coarse Root Biomass Production (Mg/ha/year) on measurement interval
IW	Woody Biomass Production (Mg/ha/year) on measurement interval
ANPP	Above Ground Net Primary Production (Mg/ha/year)
TNPP	Total Net Primary Production (Mg/ha/year)
DBH	Average DBH at Age1 (inch)
Height	Average Height at Age1 (ft)
VOBi	Average stem volume over bark at Age1 (ft^3)
VIBi	Average stem volume inside bark at Age1 (ft^3)
GWOBi	Average stem green weight over bark at Age1 (lb)
GWIBi	Average stem volume inside bark at Age1 (ft^3)
VOB	Stem volume over bark at Age1 (ft^3/acre)
VIB	Stem volume inside bark at Age1 (ft^3/acre)
GWOB	Stem green weight over bark at Age1 (ft^3/acre)
GWIB	Stem green weight inside bark at Age1 (ft^3/acre)
Hdom	Dominant Height at Age1 (ft)