Comparing Standing Dead Tree Carbon Stock Estimates Derived from Field Inventories and Models

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Standing Dead Tree Importance

Indicator of Succession and/or Past Disturbance

Fig. 1. Standing dead forest following wildfire, Bob Marshall Wilderness, MT

Fire Hazards

Fig. 2. Over-stocked, competition induced mortality, Great Smoky Mountains, TN

Habitat Diversity

Fig. 3. Standing dead birch, northern MN

Carbon Stocks

Fig. 4. Large, standing dead redwoods, CA

Objectives and Methods

Given the importance of standing dead trees to numerous forest ecosystem attributes/processes such as carbon (C) stocks (Figs. 1-4), the USDA Forest Service's Forest Inventory and Analysis (FIA) program began sampling standing dead trees in 1999. Since standing dead tree inventories were initiated gradually across states, standing dead tree C stocks were simulated for every FIA plot based on phase 2 stand attributes (e.g., stand age). Modeled standing dead tree C stock estimates are currently used as the official C stock estimates for national greenhouse gas reporting (NGHGI). Given the enhanced rigor of empirical estimates of standing dead C stocks, assessing the differences between empirical and modeled C stocks for standing dead trees is paramount. The goal of this study was to compare plot-level (FIA plots) estimates of standing dead tree C for the United States.

Using data all available FIA plot-level data, sampled between 1999 and 2008 (using periodic inventories that sampled standing dead; e.g., New Mexico), the standing dead C stocks from FIA plot measurements (volume based on Heath et al. 2009) and simulated stocks (USDA 2010) at the plot/condition level were reported individually and in comparison.

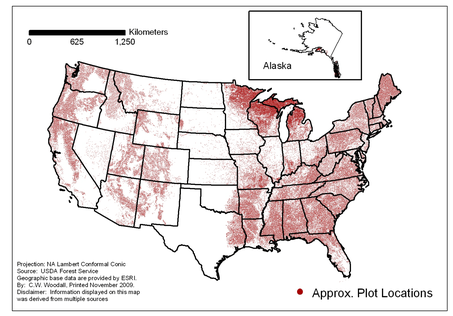

Fig. 5. Forest inventory sample plots used in this study, U.S.

Field-Based Estimates of Standing Dead Tree Carbon Stocks

There is a tendency for forests to have more above-ground standing live C to standing dead by a factor greater than 6 (Fig. 6). While almost all forests (99%) will not have standing dead wood C stocks exceeding 30 Mg/ha, most often they will have standing live above-ground C stocks exceeding 27 Mg/ha.

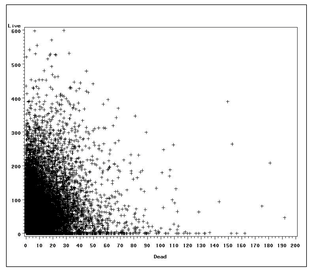

Fig. 6. Scatterplot of above ground standing live and dead C stocks (Mg/ha) on FIA plots across U.S.

There is sizeable divergence among forest types with considerable amounts of total standing dead tree C (above- and below-ground) (> 10 Mg/ha; Fig. 7) and forest types with very little total standing dead tree C (< 1 Mg/ha; Fig. 8). West coast forest types (e.g., western hemlock and redcedar) have some of the largest C stocks while eastern forest types (e.g., oaks and cherry) have some of the lowest stocks.

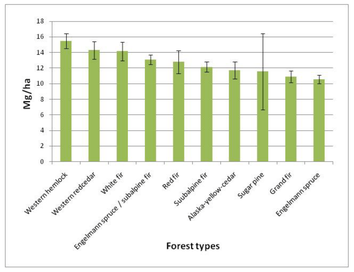

Fig. 7. Top ten forest types in terms of mean above- and below-ground standing dead tree C, U.S.

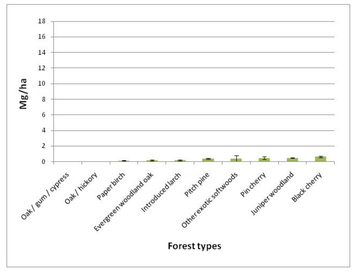

Fig. 8. Bottom ten forest types in terms of mean above- and below-ground standing dead tree C, U.S.

The largest live and dead tree above-ground C stocks occur on U.S. Forest Service forest land (58.6 and 6.5 Mg/ha, respectively) (Fig. 9). The lowest dead tree carbon stocks occur on private forestland (< 1.6 Mg/ha). The ratio of mean live to dead aboveground carbon is 9 and 26.5 for Forest Service forestland and private land, respectively

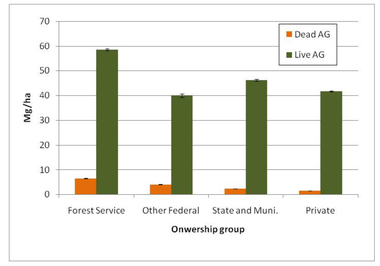

Fig. 9. Mean and associated standard errors for above-ground standing live and dead C stocks by ownership group, U.S.

Field-Based vs. Model Comparisons

Field estimates of total standing dead tree C are highly skewed towards zero with a slight increase in the 10+ Mg/ha class (Fig. 10). In contrast, the modeled estimates of standing dead tree C are more uniformly distributed. Across large populations of interest (multi-state), field- and model-based population estimates of standing dead tree C may be more similar due to a Gaussian distribution (modeled) being partly matched by a slightly bimodal distribution (field). However, at the individual plot level there is tremendous divergence in standing dead tree carbon estimates between both approaches.

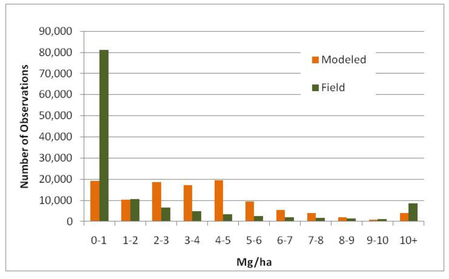

Fig. 10. Frequency distribution of mean standing dead C stocks (Mg/ha) estimated by field measurements and models, U.S.

On the majority of inventory plots, estimates of standing dead tree C derived from models overestimated the C stock with the most frequent (i.e., mode) difference being in excess of 5 Mg/ha (Fig. 11). When viewed together with Fig. 10, it may be surmised that a forest with no standing dead wood is a very common occurrence, while models almost always predict at least some standing dead wood on every FIA plot.

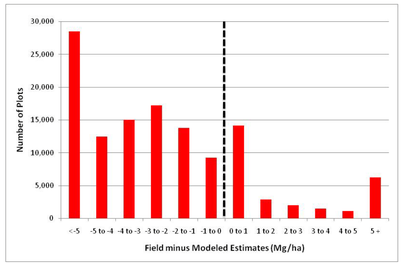

Fig. 11. Frequency distribution of estimates of the difference between field and modeled standing dead tree C, U.S.

When viewed by individual plots, modeled estimates of standing dead tree carbon are the most frequent occurrence but only up to a limit of 40 Mg/ha (Fig. 12). In contrast, field-based estimates of the same C stock can infrequently range up to nearly 200 Mg/ha.

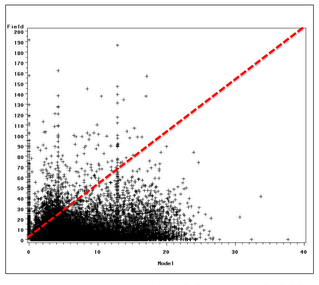

Fig. 12. Comparison of model- versus field-based estimates of plot-level standing dead tree C ,U.S.

The greatest divergence in field versus model-based estimates of standing dead tree C occur in stands with lower levels of standing live tree C stocks (Fig. 13). It appears that models cannot predict stochastic events that might kill many standing live trees resulting in a low live tree C stock, but a very large dead tree C stock.

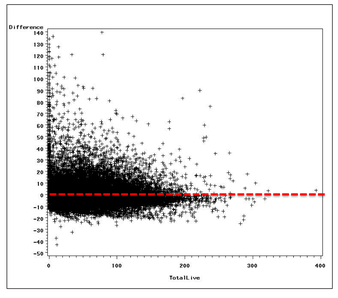

Fig. 13. Plot level estimates of the difference in field based estimates of standing dead tree C stocks minus modeled-based estimates by total standing live tree C stocks, U.S.

The highest correlation for the differences between field- versus model-based estimates of standing dead tree C stocks was with modeled estimates of understory C stocks (Table 1). Standing dead tree models may be inferring that sites with higher productivity have greater amounts of standing dead trees, while in reality stochastic disturbance processes may be the primary driver.

Table 1. Correlation coeffs. between the difference in field and model-based standing dead tree C and plot-level variables.

Variable	Correlation Coefficient
Latitude	-0.09
Longitude	-0.14
Elevation	0.08
Physiographic Class	-0.07
Modeled Down Dead Carbon	-0.10
Modeled Soil Organic Carbon	-0.09
Modeled Understory Above-ground Carbon	0.18
Modeled Understory Below-ground Carbon	0.18
Above-ground Live Tree Carbon	-0.06
Below-ground Live Tree Carbon	-0.06

Conclusions

1. Although most forests have little to no standing dead trees (especially in privately-owned forests), stochastic disturbance events ensure that some forests/forest types will have large standing dead tree C stocks easily in excess of 10 Mg/ha.

2. Relative to the total forest C stocks, standing dead tree C models may have adequately represented the C stock at multi-state/national scale in NGHGI's since 1990. However, model based-estimates at the plot-level substantially differ from empirical, field-based estimates. Carbon dynamic models based on modeled standing dead tree C stocks could be erroneous.

3. This study only examined plot-level dead C stocks, a thorough evaluation of population-level (e.g., state or national) estimates should be undertaken to enable the segue way from model- to field-based estimates of these stocks in NGHGI's.

4. It is suggested that field-based estimates of standing dead tree C stocks be immediately utilized in U.S.NGHGI 's following a more thorough evaluation of field- and model-based divergences.

Literature Cited

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For more information with regards to the FIA program please refer to: http://fia.fs.fed.us/ For citation information please email lead author at cwoodall@fs.fed.us