REGIONAL MODELING OF LIVE AND DEAD WOODY BIOMASS FOR THE EASTERN U.S.

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ABSTRACT--Land managers need tools to enable them to classify, estimate, and monitor fuel loading, and to predict wildfire risk and behavior based on inputs of fuel, weather, and topography for a specific location. Spatially and temporally explicit estimates of vegetation landcover, canopy density, tree height, and biomass need to be assessed to improve wildfire risk assessments. Forest fuel loading biomass estimates can be spatially displayed across the landscape of the eastern U.S. to identify areas of low to high wildfire risk. Additionally, forest productivity modeling provides projections of future forest biomass across the landscape that enables land managers to identify areas for fuel reductions. Live and coarse woody debris forest biomass estimates were modeled for the eastern U.S. Live biomass was estimated using the forest productivity model PnET-II, FIA data, species-specific forest allometric biomass equations, and remotely sensed land cover. Live tree biomass was augmented with estimates of coarse woody debris modeled from available FIA variables and diameter-based forest biomass equations.

INTRODUCTION

Fire is one of the dominant disturbances in the US forests. Fire is a primary process that influences the vegetation composition and structure of any given location and helps to shape the landscape mosaic. Forest structure and composition in the past, present, and in the future are influenced by fire regime. Areas burned by prescribed and wild forest fires in North America can exceed 30 million hectares per year. Burning activity is projected to increase as managers on federal, private, and industrial lands seek to reduce dry fuel accumulation and minimize wildland fire risk. Wildfires can consume even larger areas than prescribed fires and typically have much higher fuel consumption rates per unit area.

If the projected changes in climate are realized during this century, an altered fire regime could have the most immediate and significant impact on forest ecosystems. Recent studies on the interaction of climate change and forest fires suggest that projected increases in atmospheric carbon dioxide, air temperature, and variability in precipitation will increase fire seasonal severity ratings by 10-50% over most of North America. The area burned in the US from wildland fire is projected to increase by 25-50% by the middle of the 21st century with most of the increases occurring in Alaska and the southeastern US (Flannigan et al., 2000).

The objective of the research described here is to utilize remotely sensed forest cover data linked to a productivity model to determine, evaluate, project, and map forest productivity from 1992 to 2050 in the eastern U.S. This approach was developed with the goal of integrating existing forest inventory data, climate, soil, landcover data, and the Hadley2Sul climate scenario for the eastern US as input parameters to forest process models to predict, validate, and project forest growth and forest biomass. This paper will introduce methodologies for linking remotely sensed Landsat Thematic Mapper land cover, Forest Inventory and Analysis (FIA) inventory data, and a productivity model (PnET) to estimate and spatially display forest productivity.

MATERIALS AND METHODS

Study Region

The study region encompasses 534,523,000 acres in 13 states from the Mid-Atlantic coast west to Texas and Oklahoma. The region represents approximately 24% of the land area, 60% of the forest land, 25% of the agricultural land for the entire U.S. In 1992, forest land–land at least 10% stocked by forest trees regardless of size–covered 211,838,000 acres or about 40% of the total land area in the region (Powell et al., 1993).

Forest Inventory Data

The primary source of forest land area, growth, and harvest estimates is the field sampling inventory data reported by the Forest Inventory and Analysis (FIA) unit. FIA data for the most recent field surveys (spanning 1988-1995) for the southern 13 states were obtained from the Eastwide Data Base(http://srsfia.usfs.msstate.edu/scripts/ew.htm). The predominant forest type of the field plot area and the number of acres that the plot represents was determined from the records. Forest type groups and forest type names were grouped into three forest classes (evergreen, deciduous, and mixed) that corresponded to Anderson Level II forest classes for each state. The area for each forest class was summarized and totaled for each state.

Remotely Sensed Forest Classification

Landsat Thematic Mapper and ancillary data in the NLCD set was acquired for the 13 southeastern U.S. states from MRLC (http://www.epa.gov/mrlc/nlcd.html). Forest area was displayed and summarized for NLCD land cover classes: deciduous forest (class 41), evergreen forest (class 42), and mixed forest (class 43). The mixed forest class was supplemented with woody wetland (class 91) for a new combined mixed forest class.

Climate Scenarios

To predict forest growth, historic and future monthly climate data were used as model inputs. An historic ~100-year gridded monthly and daily time series of climate for the conterminous United States that includes realistic interannual variability (Kittel et al., 1997) was acquired (http://www.cgd.ucar.edu/vemap/datasets.html). Two forest productivity model experiments were run. First, a forest productivity model was run with historic climate data from 1895 to 1993 to simulate current forest productivity. Second, this same model was integrated forward using the output from the Hadley2Sul scenario (http://www.met-office.gov.uk/research/hadleycentre/index.html) using climate results translated into a grid for the simulated period 1993-2100. Forest area for evergreen, deciduous, and mixed forest was summarized.

Soil Data

The State soil Geographic Data Base (STATSGO) was developed by the US Natural Resources conservation Service to store and distribute soil-survey information for US lands (Soil Conservation Service, 1991). STATSGO maps were compiled from more detailed soil-survey maps into soil associations at a scale (1:250,000) more appropriate for regional analysis. Soil water holding capacity (SWHC) derived from CONUS-Soil dataset (Miller and White, 1998) was converted into the 0.5^o x 0.5^o grid via area-weighted averaging of the CONUS soil series SWHC polygons.

Forest Productivity Modeling

We generated regional estimates of current and future aboveground live woody net primary production with the PnET model (Aber and Federer, 1992). PnET is a physiologically based, monthly time step model that has been used to predict changes in forest carbon, water, and nutrient cycling across the eastern US. Predictions of forest biomass from PnET have been well correlated with average annual basal area growth measured at sites across the region (McNulty et al., 1998). Forest biomass predictions for 1992 were estimated using a mean of NPP for the years 1991 to 1993 from the PnET model. Projections of forest NPP in 2050 are a decadal mean of NPP for the period 2046 to 2055.

Live Biomass and Coarse Woody Debris

Live tree biomass was predicted from biomass equations (Schroeder et al. 1997; Brown et al. 1999). County-level estimates of standing deadwood for all dead trees available in FIA’s Eastwide web-site database were assembled. Model predictions of county-level down deadwood (DDW) biomass were developed for the dead tree data. DDW was modeled as a function of average monthly maximum temperature, mortality/harvest disturbance, and quadratic mean diameter of live trees.

RESULTS AND DISCUSSION

The future composition of forest ecosystems due to the effects of global climate change and socio-economic responses to that change can only be hypothesized upon. The reported analysis provides an estimate of forest production for 1992 and 2050 for the Eastern U.S. using an uncalibrated model of forest carbon balance and forest cover from Landsat TM data. Future trends in climate suggest temperature limitations will be a contributing factor in lowering future forest productivity along the East and Gulf Coastal Plains, especially for evergreen forests (Fig. 1). Forest productivity for deciduous and mixed forest types is predicted to increase in the future for the Piedmont and Mountain physiographic provinces. Productivity increases for these two forest types contribute to a general trend of increased forest productivity at the regional scale, assuming a warmer and wetter climate projected under the Hadley2Sul scenario (Fig. 2.). Live biomass and coarse woody debris was modeled for the eastern U.S. (Fig. 3 and 4).

ACKNOWLEDGEMENTS

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Figure 1. Change in net primary production for evergreen (a), deciduous (b), and mixed (c) forest type group from current to 2050.

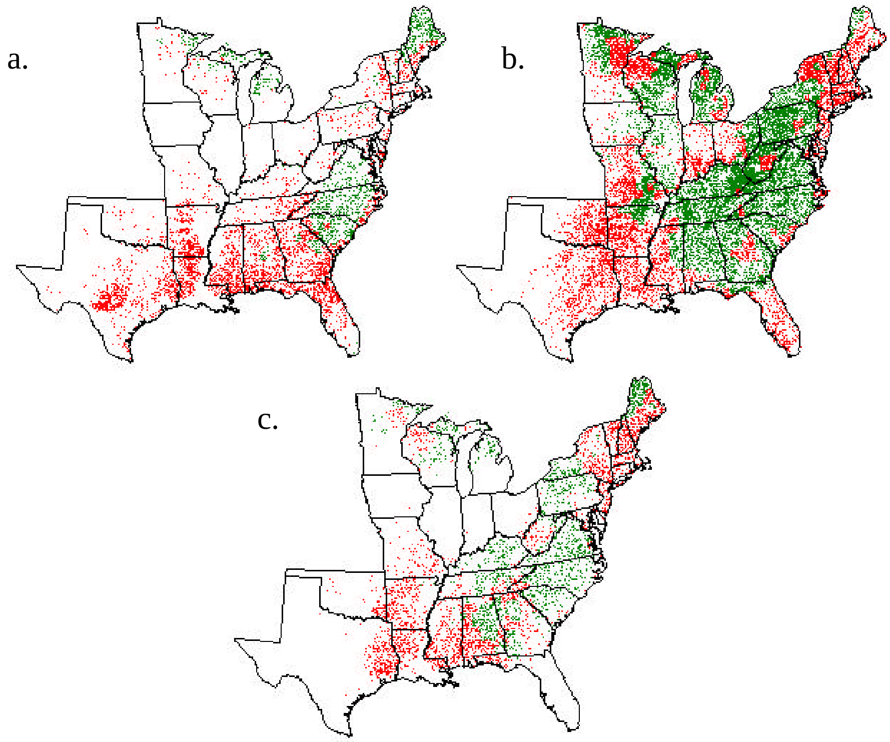

Figure 2. Current (a) and 2050 (b) total forest net primary production.

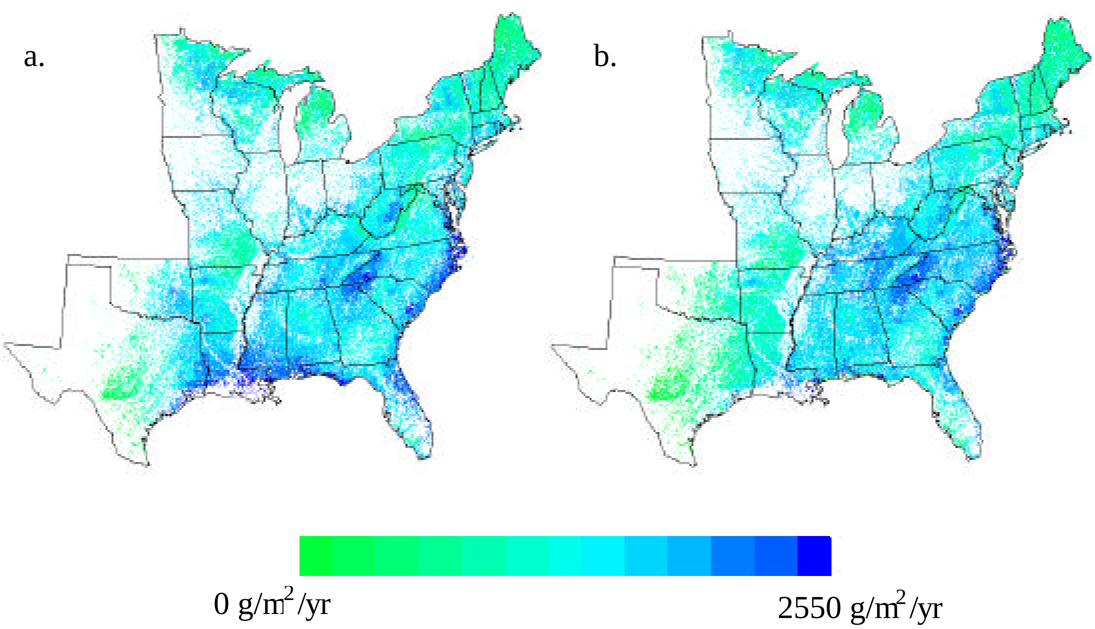

Figure 3. Predicted live forest biomass for eastern U.S.

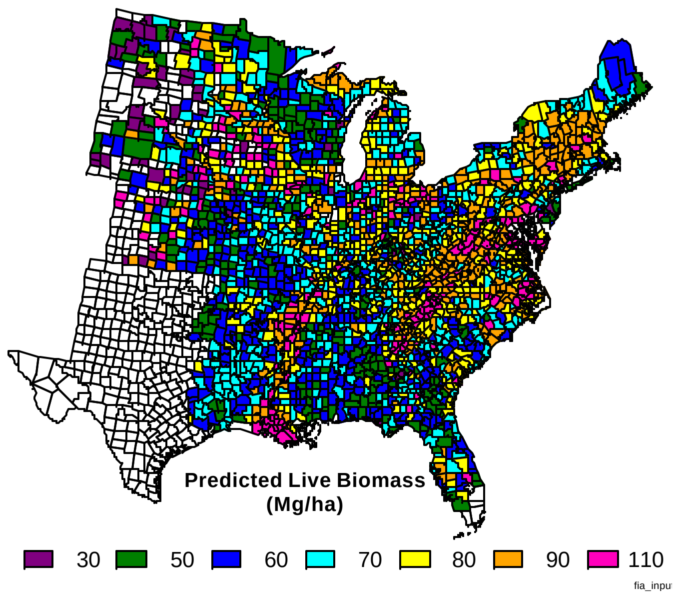

Figure 4. Predicted coarse down deadwood (>12.7 cm diameter) for eastern U.S.