PINEMAP
Mapping the future of southern pine management in a changing world
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE
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Regional Carbon Sequestration and Climate Change: It's All about Water

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Forest productivity is highly dependent on leaf area, light, and nutrient availability. Southern forests are the most productive in the nation due to plentiful rainfall and abundant sunlight. Within these forests, carbon and water cycles are highly coupled. Water stress in some parts of the South occurs only periodically; therefore water is a minor environmental control to southern pine productivity. However, projected drought frequency, duration, and severity are on the rise compared to the past decades. Thus, there is a possibility that water stress can become the top limiting factor for some forests such as loblolly pine (*Pinus taeda* L.), especially near the western edge of the native range of loblolly pine where climate is in transition from humid to arid.

Regional scale models with interlinked carbon and water cycles have the capacity to simulate the sensitivity of forest productivity and water yield to multiple stressors over a large geographic region. Most importantly, a model can predict what will happen in the future to forests under different climate change and forest management scenarios. We used the Water Supply Stress Index (WaSSI) model to identify 'hot spot' watersheds that are most vulnerable to droughts in the loblolly pine range. At the spatial scale of a watershed, WaSSI simulates monthly evapotranspiration, stream flow, and carbon balances (i.e., gross ecosystem productivity [GEP], ecosystem respiration, and ecosystem net carbon exchange). The basic assumption of the WaSSI model is that water availability is the dominant driver of ecosystem productivity. A series of hypothetical climate scenarios were developed to study how droughts may affect GEP and water yield (Q) across the 9,283 watersheds in the study region. We modeled monthly forest water and carbon balances using 20 years (1990 to 2009) of historic climate data (PRISM database). We examined two levels of hypothetical precipitation reduction (15% and 30% reduction below latest 20 year means) and two stand ages (7 and 17 years) to represent climate impacts on GEP and Q for two stages of forest development (Figure 1).

Our simulations indicate that when precipitation is reduced by 30%, loblolly pine forest productivity and water yield is dramatically reduced compared to current conditions. The reduction can be as high as 400 g C/m^2/yr or 22% reduction from baseline (Regional mean= 200 ± 145 g C/m^2/yr or 10 ± 7%) and water yield is expected to decrease even more, 320 mm/yr or 65% reduction from baseline on average. Conversely, a moderate reduction of 15% of rainfall may result in only marginal reduction in GEP (3.4± 6%), but still significant reduction in water yield, with regional average of 172 mm/yr or 35% reduction from current baseline. The preliminary results suggest that the effect of the two drought scenarios on the productivity of young stands (7 years old in our simulations) would be similar in magnitude for late-rotation stands (17 years old). Such simulations provide a predictive framework that can readily assimilate data from other PINEMAP Aims, such as transpiration and growth estimates from the Tier III sites.

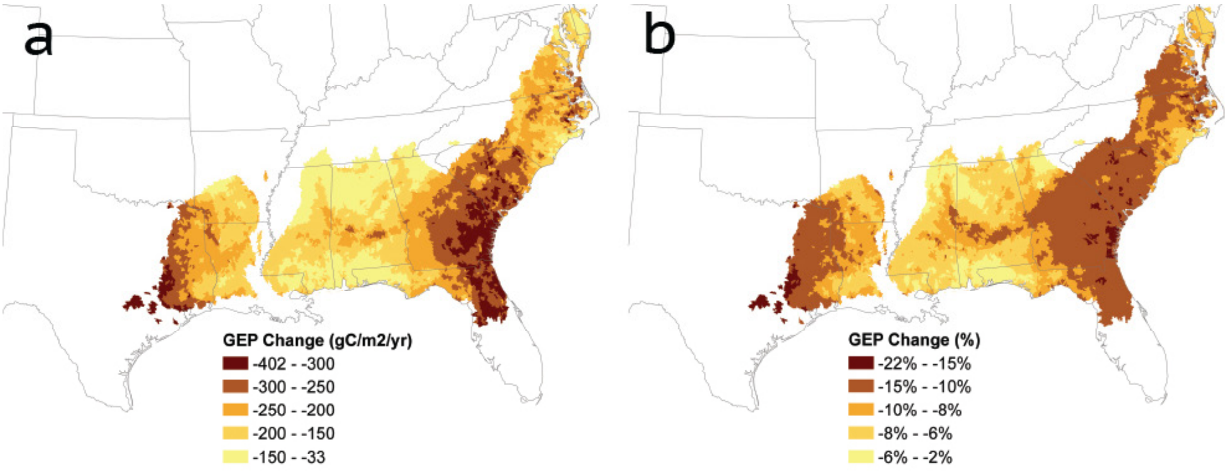

Figure 1. WaSSI model simulated drought (30% rainfall reduction year round) impacts on annual gross ecosystem productivity of watersheds covered by mid-rotation loblolly pine plantations (age 17) a) Absolute change and b) Relative change compared to historic climate.

This handout accompanies a presentation given at the 2013 PINEMAP Annual Meeting.
For more information, visit the project web site: http://www.pinemap.org.

USDA United States Department of Agriculture National Institute of Food and Agriculture

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