Assessing the Environmental Sustainability of Plantation *Populus* and *Pinus* in North America

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RATIONALE

Energy supply is a key 21st century National security issue for the United States. Identifying and developing woody feedstocks for transportation fuels and combined heat and power operations are a crucial component of our future National energy strategy and energy supply chain. Forest biomass constitutes ~30% of the total biomass that can be produced in the United States, making adequate woody feedstock availability necessary for environmental and economic sustainability. Improved woody biomass production and management systems are needed to: maintain healthy forests and ecosystems, create high paying manufacturing jobs, and meet energy demands. In addition to woody feedstock production, subsequent conversion, energy use, and climate change mitigation are closely linked via ecological, social, and economic factors, including **carbon sequestration**.

Short rotation *Populus* species and hybrids are renewable energy feedstocks for biofuels, bioenergy, and bioproducts that are strategically placed in the landscape to conserve soil and water, and recycle nutrients. Similarly, plantations of *Pinus* have been established throughout North America as key components of sustainable feedstock portfolios. ***A key to the sustainability of these feedstock production systems is the amount of carbon gained and lost.***

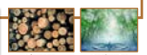
OBJECTIVES

The overarching objective of these regional studies is to assess the impacts of varying climatic and soil conditions on the growth, productivity, and wood properties of these purpose-grown trees, with special emphasis on carbon sequestration and the provision of additional ecosystem services, as set forth by the Millenium Ecosystem Assessment (see definitions of categories below).

As we are currently actively testing both genera, brief summaries for each are provided to stimulate discussions among conference participants. The *Populus* summary is from two regional testing networks throughout the north-central United States that were ten and twenty years old at the time of field sampling, along with a unique range-wide network of white pine (*Pinus strobus* L.) provenance trials established in the early 1960's in the eastern United States and Canada.

Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington. 155pp.

Provisioning Services
The goods or products obtained from ecosystems



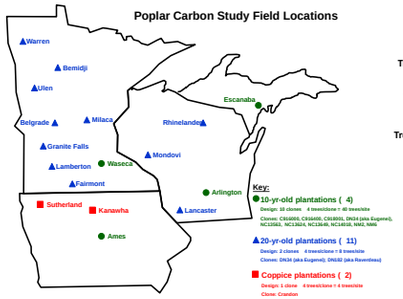
Regulating Services
The benefits obtained from an ecosystem's control of natural processes

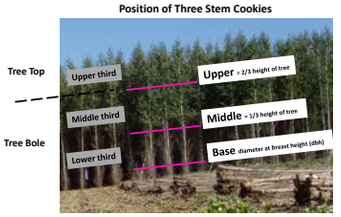
Cultural Services
The nonmaterial benefits obtained from ecosystems (e.g., values)

Supporting Services
The natural processes that maintain the other ecosystem services

POPULUS OBJECTIVES

Our overall objective is to determine the carbon sequestration potential of purpose-grown *Populus* energy crops across sites in the Midwest, USA, and to develop baseline carbon estimates for standing poplar biomass. **Specifically, we are testing whether carbon storage of specific genotypes differs among individual years throughout a rotation and among positional gradients along the bole of the trees.** These data contribute to estimates of aboveground long-term carbon storage pools of short rotation woody crops that will be useful for life cycle assessments and other biological, economic, and social indicators of these production systems.



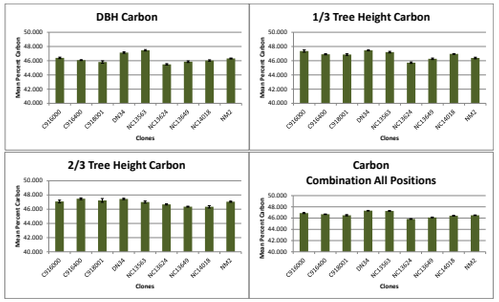


METHODS

Diameter at breast height was recorded before harvesting. Trees were felled, total height measured, and cross-sections (i.e., cookies) collected at breast height, mid-height, and just below the live crown (see figure above). Total tree dry biomass was determined. The cookies were sanded and digitally scanned for growth ring analysis, specific gravity is being determined, and wood from each ring is being sampled and analyzed for total carbon content (to date greater than 15,000 samples have been analyzed). Using biomass and volume estimates from data collected above and stand productivity estimates from process-based modeling (e.g., 3PG), yearly carbon sequestration potential will be estimated within a rotation, as well as rotation-age stand-level carbon sequestration rates.

PRELIMINARY RESULTS

The carbon content across growth rings for ten-year-old trees grown in Ames, IA is illustrated as an example of the data being collected.



PINUS OBJECTIVES

Our overall objective is to identify eastern white pine (*Pinus strobus* L.) provenances with enhanced adaptation to climate change pressures and carbon (C) sequestration potential. We measured survival, growth, and wood properties at seven test sites of a unique range-wide network of white pine provenance trials established in the early 1960's in the eastern United States and Canada. Combining these data with climate models, our objectives are to: 1) predict the effects of climate change on growth and wood properties of white pine; 2) estimate C sequestration potential of white pine under new climate regimes; 3) quantify range of genetic variation in climatic response and adaptive traits of white pine; 4) develop seed transfer models from historic climate data and provenance trial data; 5) use validated models from (4) and future climate projections to: a) predict growth response of white pine in the northeastern U.S., and b) contribute to provisional seed transfer recommendations for assisted migration of white pine seed sources.

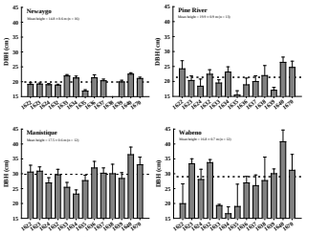
METHODS

At each site, height, diameter at breast height, and survival were recorded for trees belonging to 12-13 provenances. Increment cores from a subset of trees were used for analyses of changes in radial growth and wood density over time. Carbon sequestration rates will be evaluated at the stand level using FORCARB2. Quantitative genetic analyses will be conducted to examine genotypic variability in productivity and adaptation potential. Growth response and seed transfer functions will be generated using historical climate data for each combination of trial location and provenance.

Seven provenance trials sampled in the current study. All sites with green trees were part of an original range-wide IUFRO white pine study established in the early 1960's in the eastern United States and Canada. Trees with an "X" indicate trials that no longer exist, while the status of those marked "?" is uncertain. The Cass Lake, MN trial was visited but could not be sampled given lack of integrity of the plantation.

PRELIMINARY RESULTS

Variability in dbh among four of the seven sites.



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