From Forest Nursery Notes Winter 2013

102. © Carbon sequestration from 40 years of planting genetically improved loblolly pine across the southeast United States. Aspinwall, M. J., McKeand, S. E., and King, J. S. Forest Science 58(5):446-456. 2012.

Carbon Sequestration from 40 Years of Planting Genetically Improved Loblolly Pine across the Southeast United States

Michael J. Aspinwall, Steven E. McKeand, and John S. King

Abstract: Highly productive, widely deployed genetically improved loblolly pine (*Pinus taeda* L.) may play an important role in mitigating rising atmospheric CO_2 via carbon (C) sequestration. To understand the role of loblolly pine genetic improvement in future C sequestration strategies, we examined the historical (1968–2007) impact of operationally deploying improved families of loblolly pine on productivity and C sequestration across the southeast United States. Since 1977, nearly 100% of loblolly pine plantations in the southeast United States have been established with genetically improved loblolly pine. In recent years, more than 400,000 ha of genetically improved loblolly pine are planted annually. Between 1968 and 2007, we estimate that genetically improved loblolly pine plantations have produced a total of 25.6 billion m^3 of stemwood volume and have sequestered 9,865 Tg C in live and dead biomass. Our estimates also indicate that genetic improvement has resulted in an additional 3.7 billion m^3 (17% increase) and 1,100 Tg C (13%) of volume production and C sequestration, respectively, relative to volume production and C sequestration with no genetic improvement. We expect that loblolly pine plantation C sequestration will increase as more productive families and clones are deployed and as currently deployed genetic material continues to mature. Together, genetic improvement, intensive silvicultural, and longer rotations aimed at producing long-lived wood products will be important tools for maximizing C sequestration in loblolly pine plantations. FOR. SCI. 58(5):446–456.

Keywords: biomass, carbon, climate change, genotype, genetic gain

BECAUSE FORESTS STORE roughly 45% of global terrestrial carbon (C) (Bonan 2008) and play a fundamental role in regulating the amount of CO_2 in the atmosphere, C sequestration in forested ecosystems, as well as in wood products, is often cited as a potential means for mitigating further increases in anthropogenic CO_2 (Dixon et al. 1994, Nabuurs et al. 2007, Ryan et al. 2010). For example, during the 1990s, C fixation by forests was estimated to be 2.6 Pg C $year^{-1}$, which was roughly 33% of global C emissions by fossil fuels and land-use change (Denman et al. 2007). In 2003, growth of US forests and subsequent sequestration of C in wood products offset 12–19% of US fossil fuel emissions (Ryan et al. 2010). In the United States alone, forests are currently estimated to be sequestering roughly 13% of annual greenhouse gas emissions (Johnson et al. 2009, US Department of Agriculture [USDA] 2011).

Forest ecosystems in the United States vary in their rate of C sequestration and C storage capacity depending on species, soils, climate, management, and total land area (Dixon et al. 1994). As of 1995, the highly productive forests of the southcentral and southeastern United States contained more C than any other region of the country; an estimated 12.2 Pg C (Turner et al. 1995). The bulk of this C storage was spurred on a rapid increase in loblolly pine (*Pinus taeda* L.) plantation area and implementation of more intensive silvicultural practices, which have drastically increased productivity (Conner and Hartsell 2002, McKeand et al. 2003, Fox et al. 2007, Ryan et al. 2010). For instance, between 1952 and 1999, pine plantation area in the South grew from 0.75 to 12.16 million ha (152% increase) (Conner and Hartsell 2002). Moreover, before the use of intensive silvicultural management practices, mean annual increment for southern pine stands averaged 2–6 m^3 ha^{-1} $year^{-1}$ over a 25-year rotation (Coile and Schumacher 1964, Stanturf et al. 2003). Today, with genetically improved seedlings (progeny of parent trees selected based on assessments of productivity, straightness, and disease resistance) and good silviculture, operational pine plantations will routinely produce 9–12 m^3 ha^{-1} $year^{-1}$ over a 25-year rotation (Carter and Foster 2006, Fox et al. 2007). When the best genetic material is coupled with the best management, mean annual increments can reach 21–28 m^3 ha^{-1} $year^{-1}$ (McKeand et al. 2003, Allen et al. 2005, Fox et al. 2007).

Whereas silvicultural practices such as competition control, fertilization, and site preparation have had enormous

Manuscript received May 3, 2011; accepted March 7, 2012; published online April 12, 2012; http://dx.doi.org/10.5849/forsci.11-058.

Michael J. Aspinwall, Department of Forestry and Environmental Resources, North Carolina State University, and University of Texas at Austin, Section of Integrative Biology, 1 University Station, Austin, TX 78712—Phone: (919) 902-9428; mike_aspinwall@mail.utexas.edu. Steven E. McKeand, Department of Forestry and Environmental Resources, North Carolina State University— steve_mckeand@ncsu.edu. John S. King, Department of Forestry and Environmental Resources, North Carolina State University, and Department of Biology, University of Antwerp, Belgium—john_king@ncsu.edu.

Acknowledgments: This research was funded by the North Carolina State University (NCSU) Donald Moreland Endowed Graduate Fellowship, the NCSU Cooperative Tree Improvement Program, and the NCSU Department of Forestry and Environmental Resources. The Department of Biology and the Plant and Vegetation Ecology Research Group of the University of Antwerp, the Belgian Francqui Foundation, and the U.S. Council for International Exchange of Scholars-Fulbright Program, provided sabbatical support to J.S.K. during the writing of this manuscript. Historical planting data was provided by Raphael De La Torre, and Phil Fay (USDA-ARS) and Tom Juenger (University of Texas at Austin) provided assistance with publishing this manuscript. Additional support was provided by the USDA Forest Service Eastern Forest Environmental Threat Assessment Center and the National Institute of Food and Agriculture Coordinated Agricultural Projects Grant 2011-68002-30185.