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Potential for Carbon Storage and Technology Transfer in the Southeastern United States

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Potential for Carbon Storage and Technology Transfer in the Southeastern United States

Abstract
As the concern over global warming grows, interest in sequestering carbon in terrestrial ecosystems is expected to intensify. Nonindustrial private forest (NIPF) landowners in the southeastern United States can play a major role in sequestering atmospheric carbon. Sequestering carbon through reforestation/afforestation incentive programs requires participation by university Extension personnel to effectively communicate knowledge to landowners. This article discusses above and belowground carbon sequestration, carbon sequestration programs available to nonindustrial private forest landowners, and activities university Extension personnel may engage in to facilitate the implementation of such programs.

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Introduction

Global warming is believed to be caused by a phenomenon known as the "greenhouse effect," which is an important natural process regulating and maintaining the Earth's climate (World Resources Institute, 2003). Rapid increases in the atmospheric level of CO_2, due to human activity such as the burning of fossil fuels and deforestation, result in increased amounts of radiant heat trapped near the Earth's surface. It is predicted that this interference will gradually increase the mean global temperature, causing dramatic climatic changes as atmospheric levels of CO_2 rise.

The increase in mean global temperature, attributed to greater amounts of trapped incoming radiation, has been estimated at 0.6^{o}C during the 20th century and is projected to increase by 1.4 to 5.8^{o}C by 2100 relative to 1990 (Lal, 2003). Changes are expected in the amount, distribution, and intensity of rainfall/precipitation with impacts on soil quality, growing season duration, and biomass productivity.

Recognition that the world's forests play a major role in the global carbon cycle brought forestry into the arena of international climate change policy. In 1997, 150 countries negotiated and signed the Kyoto protocol to the United Nations Framework Convention on Climate Change (Murray, 2000). The United States is currently not an active member of this global climate change treaty. However, many U.S.-based industries are involved in carbon sequestration projects and carbon trading as a means to mitigate CO_2 emissions.

As carbon credit programs become more common, university Extension personnel will be called upon to provide information on the basics of carbon sequestration and the specifics of carbon credit programs. Effective communication between Extension personnel and nonindustrial private forest (NIPF) landowners may yield better investment returns and greater carbon storage above and belowground. This article discusses the basics of forest carbon storage both above and belowground, available carbon credit programs, and activities university Extension personnel can engage in to assist NIPF landowners.

Carbon Storage in Forests

Carbon dioxide is continually exchanged between forest ecosystems and the atmosphere through photosynthesis, respiration, and decomposition (Karjalainen, et al., 2003). Photosynthesis leads to the conversion of carbon dioxide into organic carbon in growing plants, where it is trapped until decomposition releases it once again into the atmosphere as carbon dioxide. Some of this sequestered carbon is also lost through cellular respiration and decomposition of dead plant material such as leaf litter and shed branches. The most rapid rate of sequestration into organic materials occurs during early tree growth.

The net rate of exchange will decrease with time due to increasing losses through respiration and decomposition of plant material (USDA, 2004). Other mechanisms of carbon loss from forest systems include physical removal of organic matter or rapid loss through natural disturbances such as fire.

The potential for promoting carbon sequestration through forestry practices varies by region and depends mainly on soil type and growth rates of each region's native tree species. All trees are approximately 50% carbon based on dry weight (Matthews, 1993). Given that carbon storage rates are positively correlated with the rate of volume accumulation, intensively managed stands will sequester carbon at a faster rate than natural stands (Birdsey, 1992). Also, the decreased rotation age of managed stands should increase carbon storage rates through the more rapid growth rates of juvenile trees. Carbon sequestration rates in forests left to mature will gradually decrease with time due to decreasing growth rates and increased losses through respiration, organic matter decomposition, and mortality related decomposition (Birdsey, 1992).

Aboveground storage rates have been established with the understanding that the temporal scale at which carbon in aboveground biomass is stored depends on whether the material is harvested or, if harvested, the type of final products produced. For example, some carbon contained in harvested material may remain sequestered, as organic carbon, in wood products such as lumber for potentially long periods of time (Thompson & Matthews, 1989). Carbon contained in other products such as paper may have extremely variable storage times.

Forest Soils

The amount of carbon in forest soils is typically greater than the quantity in living biomass (Post & Kwon, 2000). Belowground carbon sequestration is a dynamic process involving many factors such as microbial and human activities, soil physical properties, climate, and vegetation (Londo, Messina, & Schoenholtz, 1999). Carbon is added to the soil primarily through root turnover and litterfall. However, the mass of the forest floor is also influenced by the age and elapsed time since the last fire or disturbance (Fisher & Binkley, 2000).

The increase in forest floor thickness is rapid in stages of early stand development and in the first decade or so following burning. In forest soils, a state of near equilibrium may be achieved where annual organic inputs are near equal to the annual decomposition rate (Wells, 1971). Johnson (1992) thought that this equilibrium was reached in about 10 years in mature southern pine stands protected from fire. However, Gholz and Fisher (1982) found that slash pine (*Pinus elliottii*) plantations on nutrient poor sites in the same region were still accumulating on the forest floor layer after 35 years.

The potential for soil carbon storage is greatest in areas with extremely low soil carbon levels. These areas include agricultural fields or deforested areas where human activity and land-use change have resulted in a loss of much of the initial soil carbon pool.

Carbon Credits: An Emerging Issue

A carbon credit is a unit of carbon stored in newly established forest biomass or soil and may be purchased as a means to offset carbon dioxide emissions. It is typically denominated in tons of pollutants reduced. A company or utility that exceeds government-imposed emission limits can stay in compliance with environmental law by applying 1 or more tons of credit against every ton of excess emissions. This is generally done to extend the period of time a company has to introduce new technologies that are more environmentally benign. Industries having excess credits may choose to sell them to other companies that have not met emission requirements.

Recently, carbon sequestration programs have become available for private landowners in Mississippi. The primary target properties for these projects are holdings currently enrolled in government cost-share assistance programs such as the Conservation Reserve Program (CRP) or the Wetlands Reserve Program (WRP). Nevertheless, any landowner or business that wishes to participate may enter land into a carbon storage easement, if the requirements for the specified easement program are met. An easement is the right to use the property of another for a specific purpose. The easement is a real property interest, but legal title to the underlying land is retained by the original owner for all other purposes.

One carbon sequestration easement offers landowners an initial one-time payment of $400-$450/acre for placing their land in a 70-year easement (The Carbon Fund, 2003). Revenues resulting from carbon payments may allow longer rotation lengths, more densely stocked stands, and make the planting of hardwood species a more attractive investment (Price & Willis, 1993). Carbon storage easements provide landowners the right to harvest, plant, cultivate, construct firebreaks, and otherwise manage forest resources on a sustained yield basis in accordance with prudent forestry practices. Landowners also reserve the right to explore for and develop subsurface minerals with the exception of gravel, salt, and sand.

Discussion

Carbon dioxide levels in the atmosphere are increasing at a rate that makes forestry practices alone an inadequate means of stabilization. However, terrestrial sinks of carbon such as natural and plantation forests have a great potential for emission mitigation. Researchers examining the effects of including carbon revenues into forestry investments have varied the value applied to a unit of stored carbon as well as the discount rate (Niskanen, Saastamoinen, & Rantala, 1996; Enzinger & Jeffs, 2000).

Also, since growth and carbon sequestration rates are positively correlated, the same silvicultural practices that are traditionally implemented to improve timber production can also improve the amount of carbon stored per unit time on a given tract (Hans & Solberg, 1994). In addition, revenues obtained from marketing stored carbon make some silvicultural practices associated with intensive forest management more economically feasible. This can potentially improve forest health on a large scale.

Given the ability to manage and harvest timber, as specified in an approved forest management plan, carbon values can improve the attractiveness of forestry as an investment opportunity. This fact should increase the incentive to practice forestry, thereby expanding forested areas while simultaneously allowing silvicultural practices that maximize timber growth. The end result will be a terrestrial ecosystem more capable of sequestering carbon from the atmosphere.

However, easements currently available to private landowners do not consider specific carbon storage values (The Carbon Fund, 2003). Standard, one-time payments are made at stand establishment despite the particular management regime (The Carbon Fund, 2003). Carbon sequestration provides additional justification for silvicultural practices only in the case of commercial carbon sequestration projects where tradeoffs between financial inputs and returns, in the form of stored tons of carbon, are considered.

Limitations to using terrestrial ecosystems to mitigate CO_2 emissions are the absence of sufficient data regarding the capacity of different soil types to store carbon over long periods of time. Each soil type (and corresponding forest type) reaches different carbon storage equilibriums depending on factors such as climate, soil physical and chemical properties, and tree species. However, little information exists on how much carbon soil can store and how each of these and other factors affect this storage. Information on this subject, in addition to those areas currently being studied (i.e., soil carbon fluxes resulting from management practices), will have to be better understood before the extent of forestry's contribution to global greenhouse gas reductions can be defined.

Research conducted to better understand the terrestrial carbon cycle and how it may be affected by land use practices, coupled with the growing incentive to remove CO_2 from the atmosphere through natural processes, should improve the incentive for NIPF landowners to practice forestry. Carbon payments have the potential to be the primary motivation for storing carbon in forests. Carbon payment incentives can dramatically improve the profitability of forestry projects. The southeastern United States has many acres suitable for reforestation or afforestation (Birch, 1997) and should play a major role in the creation of carbon sequestration forests and tradeable carbon credits for the purpose of greenhouse gas emissions mitigation.

What Is the Role of Extension Personnel?

Extension is uniquely suited to provide expertise and training in carbon storage/sequestration issues for a number of reasons. First, most county Extension agents have university or college degrees and experience in agronomy, soils, or animal science, and a few have degrees in forestry or another natural resources area. These backgrounds are not directly related to carbon storage issues; however, these county level personnel have a basic understanding of plant growth and development and, by default, the processes affecting carbon sequestration.

Second, county and state level Extension personnel have been involved with various federal land management programs. Examples include the CRP, WRP, and the Forest Land Enhancement Program (FLEP), among others. These programs require participants to sign contracts, grant easements, or agree to specific management practices for a set period of time. Extension personnel's familiarity with these programs and, more important, their pitfalls help landowners avoid problems associated with carbon sequestration contracts with private organizations and companies.

Third, Extension agriculture and forestry programs have a history of providing educational opportunities in productivity. Extension forestry in particular has focused on conducting workshops, field days, and short courses to educate landowners in various aspects of forest productivity (Londo & Monaghan, 2002; Londo, 2004). These programs will often focus on some measure of volume or timber production per acre over a given unit of time. These volumes, usually expressed as tons of biomass per acre, can be easily converted into tons of carbon per acre. Examples of two programs that could be converted into a carbon storage program or adapted to incorporate some carbon sequestration materials are the Is My Pine Plantation Ready to be Thinned? workshop and the Forestry Herbicides short course, both held at Mississippi State University.

The format of the Is My Pine Plantation Ready to be Thinned? workshop is discussed in Londo (2004). The workshop provides landowners with an estimate of green volume, expressed in tons, per acre (Dicke, Londo, & Traugott, 2002). Green wood has an approximate carbon content of 25% (Vogt, 1991). For example, if the measurements collected during the workshop showed that the landowner had 25 tons of pine pulpwood on site, that would translate to approximately 6.5 tons of carbon stored aboveground.

This simple conversion will allow the landowner to determine the additional revenue generated from a carbon credit contract, in relation to the current and future timber value. With the assistance of county Extension personnel and state specialists, the economics of timber versus carbon, based on a carbon sequestration contract, can be examined so that the landowner can make a well informed decision regarding his or her land and what management track (e.g., managing for timber or carbon) should be taken.

The Forestry Herbicides short course is an 8-hour program, typically conducted in 2-hour sessions on 4 nights, once a week. The course goal is to familiarize NIPF landowners with all aspects of herbicide use in forestry. This includes herbicide safety and toxicology, economics, application methods, and implications for wildlife management. Nationwide, much research has been conducted on the effects of herbicides on forest productivity. While much of this information is not currently included in the short course, it could be added to show herbicide effects on productivity. This productivity could then be converted into tons per acre and discussed. This workshop could serve as an additional conduit to transfer current carbon management technologies to interested landowners.

In effect, any Extension program that deals with plant productivity at any level can be adapted to include carbon storage. The general carbon content value of 25% green weight can be used or other more specific values can be found in the scientific literature for the species in question. This will provide additional opportunities for county and state level Extension personnel to work together to create programs and educational materials for their clientele. This will create greater visibility for county and state level Extension personnel while also creating a new and potentially innovative program.

Conclusions

Researchers have yet to fully understand the terrestrial carbon cycle; however, forests and forest soils have long been recognized as a means of long-term carbon sequestration. The southeastern United States is well suited to this purpose, with nearly 200 million acres of privately owned forest land. Carbon sequestration programs are now utilizing these private ownerships in conjunction with industry to mitigate CO_2 emissions. Financial compensation provided by incentive programs promotes reforestation and sustainable management of NIPF ownerships.

Extension personnel can help to increase landowner awareness of carbon sequestration in forest ecosystems by making landowners aware of the potential of their lands to sequester carbon. Information can also be provided by Extension personnel regarding the benefits and pitfalls of different carbon storage programs.

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