CHAPTER 11

FOREST SECTOR STRATEGIES

Brooke Brownlow
Neal Lineback
Jennifer DeHart
Appalachian State University

Overview

Carbon (C) sequestration in plants can be an important mitigation strategy for atmospheric CO_2. Although the process does not reduce emissions, it is capable of significant C up-take and storage, both in trees and in long-term products made from trees. Therefore, we chose to conclude with a brief chapter about the potential role that North Carolina forestlands can play, not in reducing emissions of GHGs outright, but in mitigating them through the sequestration of C.

The most recent forest inventory in North Carolina was completed for 1990 (Brown 1993). In that year, forested land accounted for 60% (or 19.3 million acres) of the total land area of North Carolina (Brown 1993). Of this, timberland dominated the forest categories with 18.7 million acres. Other stands of forestland included 0.5 million acres in reserved timberland (areas where harvesting is forbidden, such as forested parks, wilderness areas, etc.) and 43,000 acres in woodland, which is considered to be relatively unproductive.

Non-industrial private landowners (NIPF), who include individual- and corporate-owned lands, owned the majority (78%) of North Carolina's timberland in 1990. This category of forests is most susceptible to removal or conversion into non-forest uses as compared to public or forest industry timberlands. In 1990, 13% of the state's forestland was controlled by the forest industry, and the remainder was owned by federal, state, and other governmental agencies (Brown 1993). Of the 2.4 million acres under forest industry control, 85% was located within the Coastal Plain, 3% in the Mountains, 4% in the Piedmont (Brown 1993).

There have been considerable changes in land use in North Carolina over the last half-century (Table 11-1). Between the forest inventory years of 1938 and 1964, acreage in timberland increased from 18.1 million acres to 20.0 million acres. This trend reversed since 1964, with timberland declining to its 1990 level, 18.7 million acres (Brown 1993). In the most recent interval, 1984 to 1990, total timberland dropped 0.1 million acres with considerable conversion between land uses (Brown 1993). In particular, regeneration and planting on established and idle land grew in North Carolina. Most of the positive change occurred on former agricultural lands (Brown 1993).

Table 11-1: Changes in North Carolina Timberland between 1984 and 1990, in Thousand Acres

Area of Timberland					Changes						
					Additions from		Diversions to				
					Non-forest	Other forestland		Other forest land	Agri-culture	Urban and other	Water
	1984	**1990**	**Net Change**	**Total Gain**			**Total Loss**				
State	18788.1	18710.4	-77.8	301.2	299.8	1.4	378.9	65.9	102.3	191.5	19.2

Source: Brown 1993, 1.

Hardwoods covered more than half the timberland acreage in North Carolina in 1990, but this tree class had declined by 2% between 1984 and 1990 (Brown 1993). Natural and planted pine stands accounted for 6.3 million acres or one-third of the timberlands in 1990. The remaining 14% of timberland represented oak-pine stands (where pines comprise between 25 to 50% of the stocking). Pine plantations have accounted for a sizable growth in the pine timberland in the state between 1984 and 1990.

Natural regeneration accounted for 37% of the new pine stands and, on harvested or poorly stocked timberland, it accounted for up to 82%. Natural reversion of non-forest land increased 25% between 1984 and 1990. Artificial and natural regeneration had almost doubled on NIPF lands by 1990 (Brown 1993). North Carolina and Georgia have the two highest biomass pools (>1200 Tg) in the country and about 65-75% is in hardwood trees (Brown et al 1999).

Assumptions

Sequestration of C is the capture and storage of carbon that would otherwise be emitted or remain in the atmosphere. There are five main C sinks in the environment: the atmosphere, the oceans, fossil fuel reservoirs, other geologic reservoirs, and terrestrial ecosystems. The main focus of this section is the uptake of C through terrestrial ecosystems, specifically forests. Terrestrial ecosystems store a vast amount of C. It is estimated at 610 billion tons for terrestrial organisms, primarily plants, and an additional 1,580 billion tons in ground litter and soils (IPCC 1995). Our forests are important when considered as a C sink, as they possess 90% of the world's above ground terrestrial C and 40% of the below ground C (Davis 1997).

An increase in tree planting and intensive management of existing forest stands combined with a decrease in fossil fuel energy use can produce a significant reduction of GHGs. The greatest realistic potential to reduce C releases into the atmosphere can be through sensible programs and actions, including broad public education, forestation of degraded areas, smart energy use, and recycling.

Emissions Reduction Strategies

Below we have listed some of the strategies that can be very beneficial in lowering GHGs through C sequestration. These include increasing forest area, forest management, conversion of cropland, and recycling and reuse of paper and wood products, basically following recommendations by USEPA's ***Climate Change Mitigation Strategies in the Forest and Agriculture Sectors*** (1995). The recycling strategy is mentioned here, although it is also discussed in **Chapter 10**, **Waste Sector Strategies.**

According to USEPA (1995), U.S. forests captured about 9% of the increase in CO_2 emitted in the United States from the combustion of fossil fuels in 1990. This figure fell to only 5% in 1997 (USEPA 1999). According to the North Carolina Greenhouse Gas Inventory for 1990 (Appalachian State University 1996), forest sequestration between 1984 and 1990 was equivalent to 6% of the eCO_2 in 1990, despite the trend of decreasing forest acreage during that time period. If we assume a model of steady state growth and harvest of forests in North Carolina, we could model a 10% increase of forestland in during the period from year 1990 to 2010, ramping in at a rate of 0.5% per year for 20 years. The consequential uptake of carbon in the 20^{th} year would give us the effects of this strategy.

In 1990, 19.3 million of North Carolina's 31.2 million acres of land was forestland, according to Brown (1993). Annual growth rates varied across the state from 79 cubic feet per acre in the Coastal Plains to 44 cubic feet per acre in the Mountains. For the purpose of modeling this strategy, we used the state average of 62 cubic feet per acre per year.

Thus, if we strategize a 10 percent increase of forestlands beyond the 1990 acreage, by 2010 an additional 1.93 million acres would be added to North Carolina's forestlands. By year 2010, the additional sequestration of C would be 1.35 million tons.

This formula is:

Annual uptake of CO_2 = (10% of 193 million acres) * 62 $ft.^3$ per acre growth rate * 0.5 volume to mass* 0.5 C units * 1.6 total tree mass * 0.0283 $meters^3$ to tonnes* 0.91 tonnes to tons].

The outcome of this proposed strategy is that, all else being equal, this scenario would remove 4.95 megatons of CO_2 in 2010 through the expansion of forestland, representing 2.1% of the projected 2010 eCO_2 output for North Carolina. (Gregg Marland of the Oak Ridge National Laboratory assisted the authors in the development of this formula and the calculations of sequestration of C and uptake of CO_2.)

Although this represents a single large strategy -- increasing forestland by 10% --the outcome is significant and demonstrates the potential of the forest sector's ability to impact atmospheric CO_2. Forests play an important role in global carbon cycles through sequestration of C, and there are many ways to create additional forestland. Below we discuss some of the existing tree planting programs and issues of forestland ownership, followed by some important strategies.

***Tree planting programs*.** Tree planting became a popular concept in 1990 when President Bush initiated the America the Beautiful Program. This program aimed to beautify the environment, enhance natural and recreational resources, and address concerns about increasing atmospheric CO_2 (USDA 1991). The key elements of the program began with rural areas and urban communities. The rural component addressed the tree planting and forest improvement needs of private lands through the use of technical assistance and cost shares for private landowners (USDA 1991). The community component addressed tree planting and care, and retention of tree and forest cover in cities (USDA 1991). An important aspect of the America the Beautiful Program is the potential of what an additional one billion trees to sequester atmospheric CO_2. According to the program based on U.S. emissions of 1.4 billion short tons of CO_2 released a year, a tree planting and management program limited to marginal agriculture and forest lands could sequester up to a 56.4% of net annual emissions (USDA 1991).

Forestland ownership. In discussing how to increase C sinks in North Carolina, it is important to consider the likelihood of turning abandoned crop and pastureland into forest areas and feasible C sinks. North Carolina forests cover about 19.3 million of North Carolina's approximately 32 million acres. Of the 11.8 million acres of non-forested land, 55%, or 569,000 acres, is idle cropland (Brown 1993). This land will be an important consideration when discussing ways to increase C sequestration in our forests. Converting idle pasture and cropland to managed forests is a starting point in controlling C release and C capture.

Providing aid to private forest landowners allows for increased funding and education, leading to better management of forests and higher prices for timber products. Today, federal and state governments provide programs to improve conservation, management, and production of forest resources. Aid to private landowners began with the Cooperative Forest Management Act of 1950, which provided technical assistance, before expanding to require states to match federal funds. Landowners receiving governmental support have generally been found to practice more sustainable forestry and have overall better forest management than non-assisted landowners. For example, landowners assisted by foresters preferred to leave more trees for future growth or reseeding than most non-assisted landowners (Moulton and Cubbage 1990). Nonetheless, aided versus unaided landowners showed a difference in harvest practices. Private landowners aided by foresters had generally less timber removed, more softwood volume after harvest, and more pine seedlings (Moulton and Cubbage 1990). Continued support to private non-industrial landowners will insure better land use practices. Managed forests will have a lower risk of unhealthy trees and degradation of forestland.

Three programs currently in use to convert idle cropland and pasture into managed forests have shown good results in maintaining a majority of the forest acreage planted. These three programs are the Soil Bank Program, the Forestry Incentives Program (FIP), and the Agricultural Conservation Program (ACP). Under these USDA established initiatives, idle cropland and pasture are converted to managed forests. The programs involve private landowners, who receive financial and technical assistance, being bound by contract to maintain tree plantings for at least ten years. Since the beginning, 12.4 million acres of trees were planted through the fiscal year 1992.

Under the Soil Bank Program, which was designed originally for soil conservation and reduction of surplus farm production, 28.7 million acres were taken out of agricultural production. Although most of the acreage converted was readopted for agricultural use after ten years, 2.2 million acres remained out of crop production. The ACP was designed to include tree planting, timber stand improvement, and wildlife habitat enhancement. However, under the program, federal cost sharing of tree planting expenses in North Carolina encouraged annual reforestation of 200,000 to 300,000 acres. Unfortunately, this number fell to less than 10,000 acres, when by 1986 the total spent on reforestation and timber stand improvement fell from $24 million to $7 million. Despite the eventual decline in funding, the program was moderately successful, with 76% of the trees still in original planting. The FIP has been quite successful in keeping forested areas from converting back to nonforest uses. Ninety-two percent of the acres planted since 1975 are still in the original plantings. Only 3% of the plantings were converted to nonforest uses by 1990.

By keeping these programs active in North Carolina, a great potential to increase total managed forest area and form an effective C sink is presented. Keeping North Carolina's base timberland and noncommercial forest uses protected from rapid conversion into nonforest uses will have potential for maintaining and increasing forested area. Since 1984, North Carolina's total area of timberland dropped less than 1% to 18.7 million acres (Brown 1993). Also between 1984 and 1990, 301,000 acres were added to the timberland base, while at the same time 379,000 acres were lost or converted to nonforest or noncommercial forest uses (Brown 1993).

Available education and aid are important to NIPF landowners. Many costs are incurred when creating C sinks, whether improving on natural sinks or inventing new ones. A private landowner may have to face costs related to maintenance, insurance against damage, management, and much more. If proper management practices are utilized, it will make for maximum potential in increasing forest area and C sequestration via terrestrial ecosystems.

Some of the strategies listed below may help to increase the potential sequestration of C by prompting better forest sector management procedures and progressive programs that deal with recycling and urban tree planting.

Strategy: Increase Forest Area

Increasing forest area 10% would boost managed forests from the current acreage of 19.3 million acres to almost 21.5 million acres.

Improve forest area management. Through the ACP, FIP, and the Soil Bank programs, managed forests and the private landowners will largely benefit. Over the past several years, these programs have lent a vast improvement to managed forest area; not only has forest quality improved, but private landowners also received more from their managed forests in terms of stumpage prices and quality of raw forest products.

Convert unimproved pasture and cropland to managed forests. Abandoned pasture and croplands are able to sequester C through the natural re-growth process. However, converting this land to managed forests allows for more C to be sequestered at a faster rate because youthful trees, generally through the first 10 to 20 years, maximize their uptake of CO_2.

Promote urban and residential tree planting. Tree planting derives several benefits beyond those discussed in this paper. Among these are the obvious aesthetics and mental and physical relief they provide. Other benefits of urban tree planting include reduced soil erosion and water pollution. In a residential area, trees placed strategically around a home can reduce home energy use significantly. As few as three trees around a home can cut air-conditioning bills in half. Trees also serve as a buffer to environmental conditions such as wind, snow, rain, or solar rays and therefore help control temperatures. Planting trees in urban and residential areas will help further initiatives to sequester C. Urban tree planting has the potential to annually sequester from 3 to 5 million tons of C at a cumulative cost of $30 to $75 million in the United States (Trexler 1991). In addition to removing atmospheric C, planting trees in cities aids in water purification, slow water flowing into drainage systems, thus enhancing flood control efforts, and provide other energy savings through heating and cooling of buildings.

Increase urban parks or tree cover. Federal or state grants may be used to buy open land for public parks, greenways, or managed forests. Building parks in cities provides an aesthetic value to the city and may provide a healthy environment for mental and physical wellness. Because cities create “heat islands,” where the temperature can be several degrees higher than areas outside of the city, implementing urban tree planting and maintenance may help in cooling and, at the same time, beautify the city. As in residential areas, properly placed trees around an office building will provide shading in the summer and buffering in the winter to help in reduce the need of cooling and heating.

Community or public participation. Involving local citizens in supporting urban park and greenway development and urban tree planting helps educate the general public about an environmental cause important to their city and beneficial to their own health.

Strategy: Recycling Paper and Wood Pulp Products

Since 1950 the demand for wood has doubled, and paper use has increased more than five fold (Abramovitz 1998). Such statistics indicate the urgent need for recycling programs. Utilizing recycling programs greatly reduces the amount of wood products used and discarded; it also reduces the amount trees harvested for such items. Nearly one-fifth of all lumber in the United States is used to make shipping crates and pallets; this accounts for 40% of all wood waste (Abramovitz 1998). To increase C sinks three ideas are offered: First, manufacturers of pulp and paper products should use more recycled fiber than virgin material, thus reducing harvest of pulpwood-sized trees. Second, trees left uncut grow larger and C storage remains in place well past their maturity. Thirdly, utilization of recycled wood fiber and new wood fiber for manufactured goods, such as building materials, represents long term storage of C (USEPA 1995). This strategy is more specifically analyzed in ***Chapter 10, Waste Sector Strategies.***

Mandatory curbside recycling for all households and businesses. Getting communities involved and educating local citizens on programs and initiatives for recycling will provide an avenue to begin and activate such programs.

Impose a price per pound on all recyclable items. One way to insure community recycling program success is to impose a tipping fee on all trash recyclable items being thrown away.

Strategy: Encourage Use of Wood Residues for Production of Durable Products and Fuel

Encouraging the use of durable wood products is another strategy to capture C and keep it from re-entering the atmosphere. Utilizing durable wood products provides a long-term C sink and keeps a significant amount of C out of the atmosphere for years or even decades at a time. It is estimated that 42 billion cubic feet of wood, the equivalent of 390 million tons of C, are removed from United States forests annually and only a fraction of this amount is used in producing durable wood products (Trexler 1991). In the case of North Carolina, products of the furniture industry are examples of long-term sequestration (Jahn 1997). However, construction wood also exemplifies this process.

Production of construction materials. Utilizing wood products in construction of homes and office buildings helps in sequestering C long-term.

Corporations and businesses to use wood residues as fuel. In many states across the United States corporations and businesses alike have begun to use waste from wood products for a fuel source. For example, the state of Vermont started a program to heat several area schools with wood chips. The program proved very successful in many ways. First, switching to wood chips from oil or electricity saved the schools not only space but notable amounts of money. Electricity cost about $32 per million Btu, oil came to about $6 per million BTU, and wood came to $3 per million Btu (Vermont Department of Public Service 1993). Another benefit from using wood chips was noticed in the emissions. Almost all of the combustible fuel is consumed in the high temperature boilers, so emissions are slight, mostly water vapor and CO_2. An additional consideration is that combusting biomass as a fuel source keeps an equivalent amount of C in fossil fuel from being released to the atmosphere (Lineback et al 1999). Smart use of harvested wood products is needed. As begun in Vermont and practiced in numerous states, including North Carolina, “wood residue,” defined as wood chips or sawdust, can be effectively utilized as an energy resource.

Effects of C Enrichment .

It is still unclear what effect higher concentrations of CO_2 have on woody plants’ growing potential. Recent research in young, rapidly growing loblolly pine forests indicated that with exposure to twice the current concentrations of atmospheric CO_2, net primary production increased by 25% (DeLucia et al 1999). It should be noted these results may indicate the upper limit of C sequestration under the modeled conditions. Furthermore, conditions other than CO_2 concentrations can limit growth, including moisture availability, nutrient availability, etc. Prior results turned out by Kramer and Sionit (1984) describe some perceived effects:

- Dry weight and stem diameter, and height of seedlings generally are increased by CO_2 concentrations rations in the range of 400 to 700 ppm.

- CO_2 concentrations above 500 to 600 ppm usually produce little additional growth and sometimes even cause a decrease.

- Seedlings of various species react differently to increases in CO_2 concentrations, making it necessary to study each species individually.

- A high concentration of CO_2 seems to have morphological effects, causing increasing branching, leaf area, and leaf thickness in some but not in all species.

The full impact of a CO_2-rich atmosphere on the overall sequestration of C by existing forests in North Carolina is uncertain, since species perform differently under different concentrations of CO_2. DeLucia et al. (1999) were dealing with pine forests, whereas the majority of North Carolina’s total biomass is held within hardwood forests (Brown, Schroeder and Kern 1999). Another consideration is the potential of further sequestration of C by current forest stands. Brown, Schroeder and Kern (1999) indicate that the average biomass of eastern hardwood forests is less than 50% of what could be stored in large diameter trees of mature forests. However, North Carolina ranked far above average (first with 1284 Tg) in total forest biomass (above and below ground) in 1990, suggesting limits to C sequestration without significant expansion of forestlands. These are important issues for climate change research. Extensive research is currently going on around the world, including at Oak Ridge National Laboratory, Duke University and Kansas State University, among many others.

Conclusions

The role of forestland in the up-take and sequestration of C amounted to 7% of total annual U.S. emissions in 1990. Forests play a significant role in the overall scheme of GHG emissions mitigation strategies.

Although this study primarily deals with strategies that reduce the GHG emissions, forestland's role in mitigating the effects of the emissions cannot be understated. The one example of a strategy of increasing forestland by 10% over 20 years demonstrates the potential impact of forests (Table 11-1). Although the other strategies were not modeled, they too have considerable potential for positively impacting GHGs. In the case of combustion of wood residues for fuel as a substitute for fossil fuels, reduction of GHG emissions takes place because no "new" C enters the above-ground C cycle can be huge. At issue, however, is whether IPCC and EPA rules (and ultimately, perhaps, the Kyoto Accord) will allow this substitution to be counted.

Table 11-2: Emissions Impacts from Mitigation Strategies - Forestry

	Reductions	
Strategies	**eCO_2 (Megatons)**	**Percent of Total**
Increase Forest Area by 10%	4.95	4.7
Improve Forest Area Management	Unknown	
Recycling Paper and Wood Products	See "Waste"	
Encourage Use of Wood Residues for Products and Fuel	Unknown	
Total	**4.95**	**4.7**

Additional benefits of trees, particularly through shading and windbreaks, are considered in other sections of this study. But these also demonstrate the breadth of positive effects that this sector can potentially play in the GHG problem.

References:

Abramovitz, Janet. 1998. "Sustaining the World's Forests". In *State of the World,* ed. Lester Brown et al., 21-40. New York, NY: World Watch Institute.

Appalachian State University. 1996*. The North Carolina Greenhouse Gas Emissions Inventory for 1990*. Boone, NC: Appalachian State University Department of Geography and Planning.

Brown, Sandra L., Paul Schroeder, and Jeffrey S. Kern. 1999. "Spatial distribution of biomass in forests of the eastern USA." *Forest Ecology and Management* 123: 81-90.

Brown, M.J.1993. *North Carolina's Forests, 1990*. USDA Forest Service Technical Report. Asheville, NC: USFS.

Davis, Joel. 1997. *The Spatial Distribution of Carbon in Watauga County, North Carolina*. (unpublished Master's paper.) Boone, NC: Department of Geography and Planning Appalachian State University.

DeLucia, Evan H., Jason G. Hamilton, Shawna L. Naidu, Richard B. Thomas, Jeffery A. Andrews, Adrien Finzi, Michael Lavine, Roser Matamala, Jacqueline E. Mohan, George R. Hendrey, William H. Schlesinger. 1999. "Net Primary Production of a Forest Ecosystem with Experimental CO2 Enrichment." *Science* 284: 1177-1179.

Harmon, Mark E., William K. Ferrell, Jerry F. Franklin. 1990. "Effects on Carbon Storage of Conversion of Old-Growth Forests to Young Forests." *Science* 247: 699-701.

IPCC (Intergovernmental Panel on Climate Change). 1995*. Climate Change 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emission Scenarios.* Reports of Working Groups I and III of the Intergovernmental Panel on Climate Change, forming part of the IPCC Special Report to the first session of the Conference of the Parties to the UN Framework convention on Climate Change. eds. J.T. Houghton, L.G. Meira Filho, J. Bruce, Hoesung Lee, B.A. Callander, E. Haites, N. Harris and K. Maskell. Cambridge: Cambridge University Press.

Jahn, Larry G. 1997. *Forestry and Forest Products Data Book.* Raleigh, NC: North Carolina State University Department of Wood and Paper Science.

Hall, David O., Frank Rosillo-Calle, Robert H. Williams, Jeremy Woods. 1993. "Biomass for Energy." In *Renewable Energy Source for Fuels and Electricity,* ed. Thomas B. Johansson et al, 593-615. Washington, D.C.: Island Press.

Kramer, Paul J. and Sionit, Nasser. 1987. "Effects of Increasing Carbon Dioxide Concentration on the Physiology and Growth of Forest Trees." *In The Greenhouse Effect, Climate Change, and U.S. Forests.* eds. W.E. Shands and J.S. Hoffman, 219-246. Washington, D.C.: The Conservation Foundation.

Lee, Charles J. and Paul J. Kramer. 1987. "Forestry Research Needs and Strategies." In *The Greenhouse Effect, Climate Change, and U.S. Forests,* ed. W.E. Shands, and J.S. Hoffman, 295-302. Washington, D.C.: The Conservation Foundation.

Lineback, Neal G, Taylor Dellinger, Lori Felix Shienvold, Brian Witcher, Audrey Reynolds and Lawrence E. Brown. 1999. "Industrial greenhouse gas emissions: Does CO2 from combustion of biomass for energy really matter?" *Climate Research.* Oldendorf/Luhe, Germany: Inter-Research 13: 221-229. .

Moulton, Robert J. and Frederick W. Cubbage, 1990. *Technical Assistance Programs for Non-Industrial Private Forest Landowners*. State and Private Forestry.

Steinhart, Peter. 1990. "Replanting the Forest." *Audubon* 92: 26-29.

Trexler, Mark C. 1991. *Minding the Carbon Store: Weighing the U.S. Forestry Strategies to Slow Global Warming*. New York: World Resources Institute.

U.S. Department of Agriculture. 1991. *America the Beautiful National Tree Program*. [pamphlet]. Washington, D.C.

U.S. Department of Energy. 1999. Working Paper on Carbon Sequestration Science and Technology. Accessed July 1999. Available at http://www.fe.doe.gov/techline/tl_seqrpt.html. Internet.

U.S. Environmental Protection Agency. *1995.Climate Change Mitigation Strategies in the Forest and Agriculture Sectors*. Office of Policy, Planning, and Evaluation Climate Change Division, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1999. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1997.* EPA-230-R-99-003. Office of Policy, Planning and Evaluation, Washington, D.C. Accessed 22 December 1999. Available at http://www.epa.gov/globalwarming/inventory/1999-inv.html. Internet.

Vermont Department of Public Service. 1993. *Heating Schools With Wood Chips.* [videocassette]. Montpelier, VT: Videosyncracies. VHS; 44 min.