

# Opportunities for Greenhouse Gas Reduction through Forestry and Agriculture in Florida

EXECUTIVE SUMMARY

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# Executive Summary

## Key findings



Florida has the opportunity to help structure emerging carbon markets because it is uniquely endowed to participate through forestry and agriculture. The opportunities for forest management, afforestation, biofuels production, and soil carbon sequestration are greater in Florida than in most other regions of the U.S., giving Florida an advantage in carbon markets. Components reviewed in this study include biofuels, woody biomass for power generation, energy crops, agricultural biogas, managed pine forestry, soils management, and afforestation. All market values in this executive summary reflect an expected carbon market value of \$20 per tonne CO<sub>2</sub>e<sub>q</sub>, as herein defined, and do not reflect costs of creation and maintenance of mitigation projects.

- In the U.S., carbon markets could support greenhouse gas mitigation through forestry and agriculture throughout this century.
- In Florida, these components would be collectively valued at \$340 million per year as carbon credits in the near term. The annual values of individual components would be
  - Biofuels, energy crops and biomass—\$147.2 million
  - Biogas produced from livestock wastes—\$19.2 million
  - Increased management intensity on pine plantations—\$116.8 million
  - Conservation tillage on half of cropped lands—\$34.4 million
  - Afforestation of 5% of Florida range and pasture lands—\$22.8 million
- Additional annual income associated with traditional markets include:
  - Biogas as replacement for fossil natural gas—\$62.7 million
  - Sale of crop and logging residues as fuel—\$48 million
  - Reduced fuel costs from conservation tillage—\$14 million
- The total value of these components including traditional market value would be \$465 million.

Most environmental co-effects of managing lands for carbon offsets can be positive, resulting in enhanced ecosystem function. Key to proper management of lands for offsets is full accounting of the greenhouse gases emitted during a mitigation project, including those associated with land use change. If properly implemented, mitigation projects could provide an indirect means of economic valuation of additional ecosystem services such as watershed protection, biodiversity conservation, and maintenance of soil nutrients.

## Overview of carbon market opportunities in forestry and agriculture in Florida

Climate change caused by human activities is one of society's greatest challenges. Increasingly, various public and private stakeholders are working toward reducing the production of greenhouse gases (GHGs). Toward that end, policies and management practices are being developed to optimize the capacity of natural and managed ecosystems to mitigate climate change. One important option within this framework is the management of forestry and agricultural activities to offset GHG production. The forestry and agriculture sectors have enormous potential to reduce and avoid the release of the three most important greenhouse gases: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O). The global warming potential of each gas is expressed as carbon dioxide equivalents (CO<sub>2</sub>eq), which is the warming potential of an equivalent amount of CO<sub>2</sub>. This is typically measured in metric tons (tonnes).

Combined, the forestry and agriculture sectors in the United States have the capacity to sequester a vast amount of carbon. Over 90% of this sink occurs on forested lands, equivalent to 12 to 16% of U.S. GHG emissions. By contrast, the agricultural sector is a net emitter of GHGs, produces over 6% of U.S. annual emissions (primarily as CH<sub>4</sub> and N<sub>2</sub>O). Together these sectors compensate for at least 6% of U.S. annual greenhouse gas emissions. Florida ranks sixth among the states in total GHG emissions. Florida's emissions are predicted to grow 88% by 2020, while those of the U.S. as a whole are predicted to grow 50% within that same time period relative to 1990. The forestry and agriculture sectors of Florida represent an important tool for offsetting and mitigating the state's projected increases in fossil emissions over future decades.

Mitigation scenarios for lands are based on carbon-market drivers and the traditional markets for forest and agricultural products. The U.S. EPA model known as the Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG) shows that at \$15 per tonne CO<sub>2</sub>eq, it is reasonable for carbon markets to support GHG mitigation across the U.S. through forestry and agriculture throughout this century (Figure ES-1). As individual mitigation projects reach the peak amount of carbon they can sequester, land managers may move to alternative practices depending on the market value

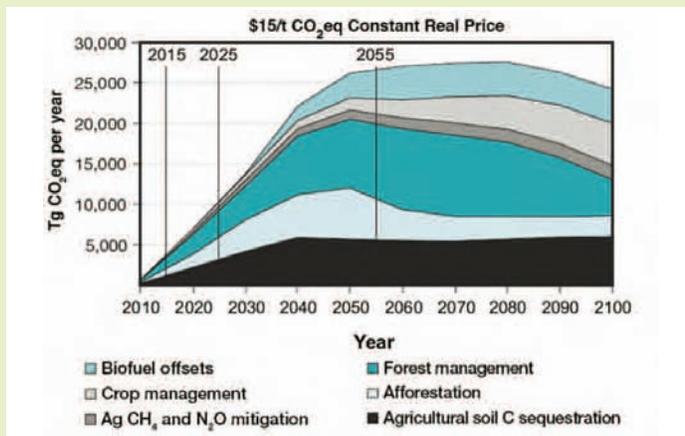


Figure ES-1. Cumulative GHG mitigation potential over time at a fixed price (Tg = 1 million tonnes). (Reproduced from Figure 4-6, U.S. EPA 2005)

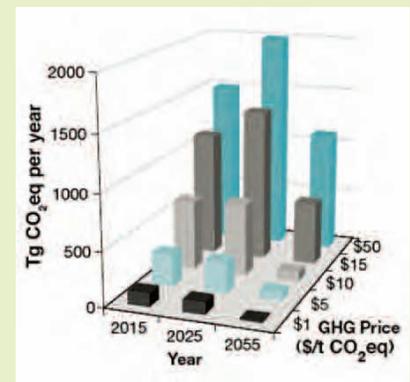


Figure ES-2. Average annual offset potential at three focus dates by GHG price (Tg = 1 million tonnes). (Reproduced from Figure 8-1, U.S. EPA 2005)

of carbon credits. Constant price scenarios show a decreasing rate of mitigation per year after 2025 for the U.S. as a whole (Figure ES-2).

The opportunities for afforestation, reforestation, and soil sequestration are greater in Florida than in other regions of the U.S., giving Florida an advantage in carbon markets. Similarly, there is great potential for biofuels in Florida, especially through woody biomass for power generation. These characteristics give Florida the opportunity to help structure the emerging carbon market while benefiting from the experience of markets elsewhere. The environmental co-effects of mitigation through forestry and agriculture are largely positive. Properly managed mitigation projects offer great potential for maintenance and enhancement of ecosystem services such as watershed function and soil nutrient content. Carbon mitigation projects in Florida using forestry, agriculture, and possibly natural lands, could have a significant effect on land use and land prices.



### Forests

Gross growth of Florida forests, before deducting for harvest and tree death, is about 9.5 million tonnes of carbon annually. Pine plantations cover 5 million acres of Florida, and switching from lower intensity management to higher intensity management could increase the biomass in these forests. The potential value of this increase on the carbon market is based on a market value of \$20 per tonne CO<sub>2</sub>eq, assuming a shift of 1.85 million acres from low intensity to medium intensity management, and switching 2.9 million acres from medium intensity to high intensity management.

This change in management intensity would be worth \$116.8 million (Table ES-1). In addition, afforestation of 5% of Florida range and pasture could result in an annual

**Table ES-1. Additional sequestered carbon and potential revenue from shifts in management intensity on commercial pine plantations in Florida**

Change in management intensity	Increase in carbon (million tonnes C)	Potential revenue from increase (\$ in millions)
Low to medium	0.46	33.8
Medium to high	1.13	83.0
<b>Total</b>		<b>116.8</b>

increase in 1.14 million tonnes C, representing \$23 million. Replacing fossil fuels with woody biofuels would also be eligible for carbon market value.

It is likely that managing Florida forests for participation in carbon markets will result in significant positive environmental co-effects. Both long and short rotation stands can be managed simultaneously for carbon offsets, watershed protection, and soil nutrient capacity. Switching to higher intensity management should include plans for maintenance of soil nutrients and assessment of GHG emissions associated with management treatments. Innovative forestry practice involving biotechnologies and novel substitution of energy-intensive products with long-lived wood products could provide additional opportunities to maximize the role of forests as carbon offsets.

## Biofuels



A promising opportunity for GHG reduction in the forestry and agriculture sectors is the production of energy crops, woody biomass, and various byproducts and waste materials for direct combustion or gasification to replace the coal, natural gas and oil currently used for heat and power generation. Although the combustion of biofuels directly releases CO<sub>2</sub>, that CO<sub>2</sub> was itself taken up from the atmosphere as the plants grew, and thus does not constitute a net increase in atmospheric CO<sub>2</sub>. Wood and woody waste materials together represent the largest segment of non-hydropower renewable energy, and the use of biomass for power production has nearly tripled in the past 15 years.

The likely delivered costs of woody biomass for electric power generation are competitive with coal and natural gas in Florida. A supply-curve analysis shows the range of prices at which quantities of woody biomass could be supplied to central plants (Figure ES-3). At a price of \$50 per tonne, Florida could produce about 5.5 million dry tonnes of biomass annually.

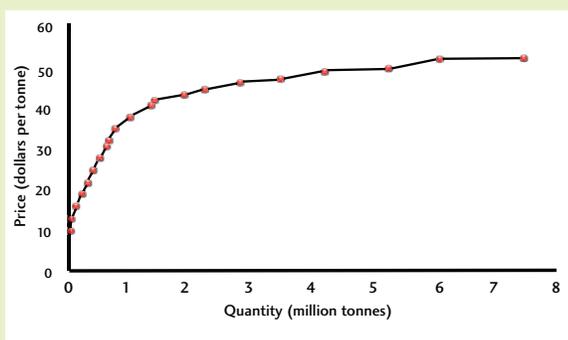


Figure ES-3. Supply curve for woody biomass in Florida.

Fuel ethanol produced from sugarcane in Florida is an unlikely source of biofuels because of current U.S. sugar policy. Corn, sorghum and citrus byproducts are produced in small quantities or have competing uses in Florida, and are limited near-term opportunities for ethanol production. Combined, these sources of ethanol could offset about 3.5% of Florida's demand for gasoline (2006 data) if produced at maximum potential.

The near-term carbon offset value of Florida biofuels is high (7.36 million tonnes, Table ES-2), representing a market value of \$147 million at \$20 per tonne CO<sub>2</sub>eq. GHG emissions from biofuels production, such as those associated with harvesting, processing, transportation, and distribution, must be considered for the development of a successful long-term public policy. Moreover, a full lifecycle assessment of emissions associated with production must include emissions resulting from any land use change resulting from the expansion of acreage for biofuel crops. Similarly, it is important that the preservation of critical ecosystems and species be part of plans for development of biofuels.

Table ES-2. Potential fossil carbon displaced from biofuels, biomass, and energy crops in Florida

Resource	Share currently utilized	Share potentially utilized	Fossil fuel CO <sub>2</sub> eq displaced (million tonnes)
Crop residues	5%	50%	1.762
Logging & thinning residues	5%	75%	1.465
Urban tree debris	10%	90%	1.793
Pulpwood	10%	30%	1.061
Energy crops	0%	50%	0.761
Ethanol from carbohydrates	1%	30%	0.516
<b>Total</b>			<b>7.360</b>

## Livestock waste management



Managing livestock wastes can reduce methane and nitrous oxide emissions. In Florida, the main opportunities for reducing GHG emissions in the agricultural sector occur in concentrated dairy and poultry operations. Methane emissions from manure management of confined animal populations in Florida total 24,900 tonnes of methane per year. The estimated biogas production potential of anaerobic digesters for dairy and poultry manure in Florida is 222 million cubic meters of methane per year, which could be used for power generation or included in the natural gas distribution network. This avoids CO<sub>2</sub> emissions resulting from fossil fuel usage. If this methane were used to replace natural gas, approximately 0.436 million tonnes CO<sub>2</sub> per year of fossil CO<sub>2</sub> emissions would be avoided. The value of the carbon credits associated with biogas production is shown in Table ES-3.

Table ES-3. Economic potential of livestock waste in Florida

Animal type	Annual value of carbon credits (\$ in millions)	Annual value of biogas as fuel
Dairy cows	5.4	\$16,779,312
Poultry layers	1.15	\$4,473,353
Poultry broilers	12.64	\$41,465,239
<b>Total</b>	<b>\$19.18</b>	<b>\$62,717,904</b>

Initially, some of this income might be used to help finance the further development of this practice. Opportunities for renewable biogas production are improving due to higher energy costs and a greater recognition of the environmental benefits associated with biogas production. Tipping fees taken from local organic waste delivered to on-farm biogas plants can further improve revenue prospects, and this added waste can increase biogas production. Wastes from ethanol and biodiesel production can also be used in biogas plants.

## Soils

Florida has a unique landscape that can store great amounts of carbon with proper land management and hydrologic manipulations. On average, Florida soils have the highest organic carbon content of soils in the conterminous United States. Mitigating climate change through soil management is a long-term, complicated issue because soil formation has a long response time for carbon storage, and carbon stored in soil is a function of multiple interacting factors (below right). Florida has high precipitation, and carbon tends to be stored in the lower soil horizons through leaching (dark spodic horizons, below left).



### DETERMINANTS OF SOIL CARBON

Climate—hydrology and temperature	Soil type
Land cover	Parent material/geology
Land use management	Topography
Organisms	Stressors—fires, tropical storms



In the near term, the most valuable strategy for increasing carbon sequestered in soils is through management of agricultural practices. Conservation tillage (low-till or no-till) improves the carbon and nutrient retention of soils. If 50% of agricultural lands in Florida were converted to no-till, 1.72 million tonnes CO<sub>2</sub>eq per year would be sequestered, representing an annual economic value of \$34.4 million at \$20 per tonne CO<sub>2</sub>eq. Soil nutrient and carbon content are also increased through optimized crop rotations and by fertilization with compost manure, sewage biosolids and other organic waste streams.

Over decades, manipulating the hydrology of an area and creation of wetlands offers a means of increasing the amount of carbon sequestered in subsoil. Note that wetlands naturally produce methane, which decreases the overall GHG mitigation potential of these soils. This report shows that the net long-term carbon sequestration value of creating a 1 cm layer of a Histosol (a wetland soil) through manipulating the hydrology of 1,525 km<sup>2</sup> of land would be \$58 million at \$20 per tonne CO<sub>2</sub>eq after 90 years. A similar strategy might be to increase the area of sandy Spodosols by 1%, assuming a 1-meter profile. Although it is not known how long this would take, it would be worth \$989 million total at \$20 per tonne CO<sub>2</sub>eq (because of the uncertain time horizon, this value is not included in the totals presented here).

Additional land management activities that can have net greenhouse benefits include increasing the area of meadow and forested wetlands and enlarging riparian buffers. Maintaining proper water levels also reduces the loss of stored carbon in wetlands. Other strategies include increasing the acreage of forest and wetlands, and matching land use to local water table conditions to minimize drainage in sandy or muck soils. Positive environmental co-effects of mitigation through soil management include improved soil nutrient content, greater soil biodiversity, and improved water retention.

## Potential market value

The near-term potential of these components of forestry and agriculture to sequester carbon and avoid fossil fuel emissions is conservatively estimated at 16.98 million tonnes CO<sub>2</sub>eq per year. While this is 7% of total Florida emissions (based on 2004 data), it more than offsets the projected annual increase of CO<sub>2</sub> emissions, which could be as high as 2% given high economic growth.

The activities shown in Table ES-4 below represent feasible changes in practice that could be implemented within the next 5 years. With carbon market prices at \$20 per tonne CO<sub>2</sub>eq, this portfolio would be valued at approximately \$340 million annually (Figure ES-4 below). As learned from the European carbon market, it is reasonable to expect values to be \$20 per tonne CO<sub>2</sub>eq or higher once federally mandated caps are in place. Biofuels, biomass, and energy crops represent the largest immediate potential of the sectors considered in this report, and there is also significant potential in managing pine plantations and soils.

Table ES-4. Summary emissions offset potential from components of Florida forestry and agriculture

Activity	Near-term carbon offset potential (million tonnes CO <sub>2</sub> eq yr <sup>-1</sup> )
Biofuels, biomass, and energy crops	7.36
Agricultural biogas	0.96
Conservation tillage on 50% of Florida agricultural lands	1.72
Shifts to medium and high intensity pine management	5.80
Afforestation of 5% of range and pastureland	1.14
Total	16.98
Market value @ \$20 per tonne CO <sub>2</sub> eq	\$340 million

It is significant that the data in Figure ES-4 do not include the market value of the products of these components. For example, the market value of biogas as a replacement for fossil natural gas would amount to an additional \$62.7 million annually (Table ES-3). Similarly, sale of crop and logging residues as fuel would be worth \$49 million per year at \$10 per dry ton. Additionally, reduced fuel costs from implementation of conservation tillage would save \$14 million per year. Including these values with the numbers in Figure ES-4, the total annual value of these components of forestry and agriculture is about \$465 million.

(Note that these figures are estimates of potential market size, not net income, as they do not reflect any incremental production or transaction costs.)

This report likely understates the potential for forestry and agriculture in Florida to participate in a low carbon economy. For example, pine forestry is only one component of industrial and managed forestlands in Florida. Management of other forest types and inclusion of long-term sequestration in new forest products, assuming that these products displace products produced with fossil fuels, would provide additional value. Similarly, production of cellulosic

ethanol feedstocks presents an expanding economic opportunity for Florida’s agricultural sector. Although the rate at which new soils can form is poorly quantified, creating soil horizons through hydrologic manipulation or other land management practices could sequester additional carbon and provide revenue in a low carbon economy. Finally, it should be noted that if the market price of carbon exceeds \$20 per tonne CO<sub>2</sub>eq, the economic opportunity for Florida’s forestry and agriculture sectors becomes correspondingly greater.

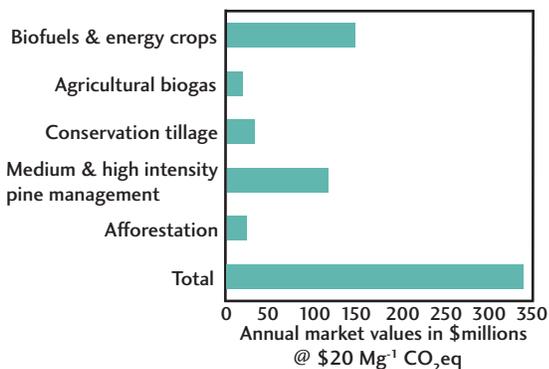


Figure ES-4. Annual carbon market value for the components of Table ES-4.

### Acknowledgments and credits

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