Roadside Management Strategies to Reduce Greenhouse Gases

Requested by
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June 10, 2010

The Caltrans Division of Research and Innovation (DRI) receives and evaluates numerous research problem statements for funding every year. DRI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field.

Executive Summary

Background

California's Global Warming Solutions Act of 2006 (AB 32), Sustainable Communities and Climate Protection Act (SB 375), and Executive Order S-14-08 direct Caltrans to develop actions to reduce greenhouse gases (GHGs). Air pollution reduction is a critical public health and ecologic challenge facing Caltrans, and the department is obligated to develop flexible, long-term and cost-effective strategies to combat air pollution.

Developing a better understanding of the environmental and economic value of the air pollution removal capacity of vegetation—primarily trees—in the highway roadside will help Caltrans further develop its toolbox of mitigation strategies. Highway roadsides may be an overlooked and undervalued component of the department's resources available to reduce GHGs and assist in meeting California Air Resources Board compliance goals. When managed properly, trees are proven cost-effective mitigation measures that sequester carbon. Trees have the additional benefit of reducing the heat-island effect by shading impervious surfaces. However, much of the existing information on vegetation management strategies that sequester carbon concentrates on the ecologic value of extremely large tracts of forest lands. Information is needed on the potential benefits of smaller tracts, especially linear roadsides in the highway environment.

This Preliminary Investigation aims to identify the literature that quantifies the economic and environmental value of carbon sequestration provided by trees and other vegetation in the right of way (ROW), and the strategies that will increase the amount of carbon sequestered. This investigation will also seek to uncover strategic plans or guidance employed by state departments of transportation (DOTs) and other state and national agencies in connection with managing vegetation for carbon sequestration. Finally, larger-scale carbon sequestration projects will be examined to cull lessons that might be applied by Caltrans on a microscale along highway roadsides, in either contiguous or noncontiguous environments.

Summary of Findings

The most significant findings are the publications associated with the Carbon Sequestration Pilot Program, which produced its final report in May 2010. This Federal Highway Administration (FHWA) project was established to assess the feasibility of a roadside carbon sequestration effort using sustainable forestry practices or alternative management of grasslands in the highway ROW. In addition to investigating this effort, we examined the various aspects of a carbon sequestration program, including a review of the U.S. market in which credits from carbon sequestration projects are traded, estimates of the carbon sequestration potential in the United States, ways to calculate carbon offsets and the possible unintended environmental consequences of carbon sequestration projects.

We gathered information in seven topic areas related to the carbon-removal benefits provided by trees and other vegetation, on a limited scale in the highway ROW and in larger-scale applications:

- Carbon Sequestration Pilot Program.
- Carbon Markets.
- Potential for Carbon Sequestration.
- Carbon Management.
- Carbon Evaluation Tools.
- Voluntary Offset Programs.
- Environmental Implications.

Following is a summary of findings by topic area.

Carbon Sequestration Pilot Program

- FHWA's recently concluded Carbon Sequestration Pilot Program (CSPP), which explored the feasibility of state DOTs reducing and sequestering GHG emissions in vegetation within the highway ROW, produced two reports and a decision-support tool.
    - The CSPP's February 2009 progress report documents the activities of New Mexico DOT, the state DOT selected to participate in the research project, in preparing to establish a carbon sequestration program. The report describes the next steps planned by New Mexico DOT, which include development of a protocol for determining carbon sequestration rates for grasslands that are not grazed.
    - The project's May 2010 final report quantifies the amount of unpaved National Highway System (NHS) ROW available for carbon sequestration. Appendices to the report provide state-by-state estimates of NHS ROW acres and the amount of carbon sequestered on NHS ROW.
    - The Highway Carbon Sequestration Estimator is an Excel-based decision-support tool designed to help transportation agencies calculate the amount of carbon that could be sequestered in highway ROWs. The tool, currently being beta-tested by several state DOTs, allows for entry of state-specific data.
    - A FHWA webinar scheduled for July 14 will provide an overview of project findings, give a demonstration of the decision-support tool and answer questions regarding the CSPP.
- A 2009 newsletter article discusses the recommendations arising from a Florida DOT research project undertaken in response to FHWA's pilot program. Findings suggest that Florida DOT should continue monitoring the possibility of selling carbon credits generated by its highway ROW and do not advocate immediate action.

Carbon Markets

- The Chicago Climate Exchange (CCX) is a voluntary but legally binding cap-and-trade system that trades in carbon dioxide-equivalent. In a project that developed as a result of the CSPP, New Mexico DOT is preparing a protocol for carbon sequestration on grassland that is not grazed for submission to and approval by CCX.
    - A brief glossary presents some of the terms used in connection with CCX's trading program.
    - The CCX protocol for forestry carbon sequestration might be used by a state DOT wishing to trade in carbon credits for this type of mitigation project.

Potential for Carbon Sequestration

- A September 2007 report by the Congressional Budget Office examines the potential costs of carbon sequestration in the United States.

- In a 2006 paper commissioned by the Society of American Foresters, the authors note that the absence of regulatory carbon constraints has kept buyers unmotivated in carbon markets, and suggest that a federal cap-and-trade compliance program for reducing GHG emissions will attract the level of capital required to sustain a U.S. carbon market.
- The benefits of planting bioenergy crops in degraded soils—highway ROW is often included in this category of soils—to boost carbon sequestration rates are presented in a 2005 journal article.
- In a 2004 journal article, researchers compare the costs and quantity of carbon mitigation by afforestation (planting seeds or trees to create a forest on land that is not currently a forest or has not recently been a forest) and biomass grown to displace fossil fuels.
- A 2007 journal article examines the potential of urban tree plantings to be cost-effective in carbon trading markets using four case studies in Colorado.
- A discussion of the possible use of roadsides for carbon sequestration appears in a 2008 report of the potential for terrestrial carbon sequestration in Minnesota.

Carbon Management

- A 2010 publication of the Ecological Society of America examines the science behind mechanisms proposed for increasing the amount of carbon stored in forests. The report also discusses the trade-offs, costs and benefits associated with each mechanism and explains how forest carbon is measured.
- An annotated bibliography of scientific literature on managing forests for carbon benefits is provided in a 2010 U.S. Forest Service publication.
- The California Climate Action Registry's Urban Forest Project Reporting Protocol provides guidance to account for and report GHG emissions reductions associated with tree planting and maintenance activities designed to increase carbon storage in trees.
- Two 2007 publications offer guidance to landowners and others interested in participating in a carbon sequestration project. One of the publications offers technical advice on quantifying, verifying and regulating offsets from agricultural and forestry practices.
- A web site developed in connection with a National Commission on Science for Sustainable Forestry research project provides information to forest landowners in the United States interested in entering the carbon trading market.

Carbon Evaluation Tools

- FHWA's Highway Carbon Sequestration Estimator will likely be of greatest interest to transportation agencies considering carbon sequestration in the ROW. We highlight a few other carbon evaluation tools that might be of general interest.
    - The National Commission on Science of Sustainable Forestry undertook a research project that resulted in the Carbon Calculator, which requires entry of data about the forested land in question and provides results in tonnes of carbon per hectare.
    - The Center for Urban Forest Research's Tree Carbon Calculator, programmed in an Excel spreadsheet, is the only tool approved by the Climate Action Reserve's Urban Forest Project Protocol.
    - CVal is a spreadsheet tool created by the U.S. Forest Service to evaluate the direct benefits and costs of entering into contracts for carbon sequestered in managed forests. The developers note that CVal was designed to evaluate forestry-related contracts on CCX.

Voluntary Offset Programs

- Carbon offsets are used as a tool to compensate for GHG emissions. In this Preliminary Investigation, we highlight several voluntary programs that provide the opportunity to register or trade carbon offsets.
    - American Carbon Registry is the first private voluntary GHG registry in the United States.

  - Climate Action Reserve is a national offsets program that issues credits known as Climate Reserve Tonnes. The California Climate Action Registry also operates under the Climate Action Reserve.
  - Considered a consumer-protection program, the Green-e Climate Program is the first certification program in the United States for carbon offsets sold to consumers on the retail market.
  - The Voluntary Carbon Standard program provides a global standard that issues voluntary offsets in the form of the Voluntary Carbon Unit.
- Carbon Offset Research and Education, an initiative of the Stockholm Environment Institute, provides policy information on voluntary offset markets, standards and protocols, and an extensive list of resources and publications.
- A 2008 report published by Stockholm Environment Institute offers a review of offset programs and notes that "offsets can pose a risk to the environmental integrity of climate actions, especially if issues surrounding additionality, permanence, leakage, quantification and verification are not adequately addressed."

Environmental Implications

- In a 2005 journal article, researchers contend that carbon sequestration strategies that advocate tree plantations do not consider the complete range of environmental consequences, including losses in stream flow and increase soil salinization. Although considered in connection with much larger-scale projects, this research may be of interest to agencies contemplating smaller-scale afforestation projects.
- In another 2005 journal article, researchers conclude that the accompanying increase in nitrous oxide emissions reduced or eliminated the benefits of carbon sequestration in soils.
- A 2004 study of afforested sites in Argentina suggests that grassland afforestation can compromise soil fertility and water quality.

Gaps in Findings

At the time of publication of this Preliminary Investigation, we are unaware of any state DOT that has traded in carbon offsets generated by mitigation projects in highway ROW. While the FHWA's Carbon Sequestration Pilot Program has provided a significant jump-start to transportation agencies interested in the carbon sequestration potential of highway ROW, many issues have yet to be resolved.

From a technical perspective, a protocol for determining carbon sequestration rates for grasslands that are not grazed must be developed and approved by a carbon trading market before trading in this type of carbon offset can occur. While a protocol for determining carbon sequestration rates on forest land already exists, a state DOT wishing to employ that protocol would have to verify with the carbon trading market that the protocol could be used on forested plots of a scale found in the highway ROW.

From an economic perspective, as the recently published final report of FHWA's Carbon Sequestration Pilot Project notes, the revenue generated from carbon sequestration will vary widely depending on carbon prices, management techniques and ecological variability. The FHWA's Highway Carbon Sequestration Estimator tool helps address that variability by applying state-specific considerations to a carbon sequestration calculation. The tool is being beta-tested by several state DOTs, and the tool's developers note that feedback received from testers may result in revisions to the tool.

We noted that some researchers have found evidence of unintended environmental impacts associated with large-scale carbon mitigation projects. Further investigation may be required to determine if those impacts may apply to smaller-scale projects such as those contemplated by Caltrans.

Next Steps

As Caltrans investigates the economic and environmental value of carbon sequestration provided by trees and other vegetation in the ROW, the department might consider:

- Comparing FHWA's projected amount of NHS acreage available in the ROW for carbon sequestration with ROW data maintained by Caltrans.
- Making use of FHWA's Highway Carbon Sequestration Estimator tool to calculate the amount of carbon that could be sequestered in California ROWs.
- Contacting Florida DOT to learn about any future plans to investigate the feasibility of using its highway ROW to sequester carbon.
- Contacting New Mexico DOT to learn more about the research project under way to determine sequestration rates for grasslands along highway ROW.
- Contacting Minnesota DOT to determine if its participation in FHWA's development of estimated NHS ROW acreage available for carbon sequestration has resulted in plans to include carbon sequestration in an expanded roadside management program.
- Learning more about FHWA's Carbon Sequestration Pilot Program by participating in FHWA's July 14 webinar.

Contacts

During the course of this Preliminary Investigation, we spoke to or corresponded with the following individuals:

National Agencies

FHWA
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U.S. DOT
Carson Poe
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Volpe Center
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Other Organizations

Wood+Partners Inc.
Shawn Kalbli
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(850) 391-0360, skalbli@woodandpartners.com

Carbon Sequestration Pilot Program

FHWA established the Carbon Sequestration Pilot Program (CSPP) in 2008 to assess whether a roadside carbon sequestration effort promoting sustainable forestry and replacing traditional ground cover with native grasses is feasible for state DOTs when balanced against ecological and economic uncertainties. The project's final report was recently published, together with a tool that can be used by state DOTs to assess the return on investment for various carbon sequestration scenarios. A 2009 progress report provides details on how a highway ROW carbon sequestration program might be structured.

Carbon Sequestration Pilot Program: Estimated Land Available for Carbon Sequestration in the National Highway System, FHWA, U.S. DOT Research and Innovative Technology Administration (RITA), May 2010. http://www.fhwa.dot.gov/hep/climate/carbon_sequestration/final_cs_pilot_report.pdf
Researchers used data from Minnesota DOT, which has geospatially enabled ROW maps, and other state DOTs with electronically accessible ROW maps to estimate the amount of unpaved NHS ROW available for carbon sequestration. This project is the first to quantify the amount of state DOT-managed soft estate acreage. Findings include:

- The NHS ROW has approximately 91 million metric tons (MMT) of carbon currently sequestered in vegetation and is currently sequestering approximately 3.6 MMT of carbon per year, or 1.06 metric tons of carbon per acre per year.
- At its carbon equilibrium, the entire NHS ROW is estimated to be able to sequester between 425 and 680 MMT of carbon. Using a hypothetical carbon price of $20 per metric ton, this equates to a total potential value of $8.5 billion to $14 billion nationwide.
- The report's estimates assume that all unpaved NHS ROW could be used for carbon sequestration of appropriate vegetation type. For example, the clear zone would continue to be managed for grasses but might be mowed less frequently or converted to native perennial species that store more carbon underground.
- Open space and low-intensity developed areas are generally expected to have the most carbon sequestration potential.
- According to the U.S. Environmental Protection Agency, trees can sequester carbon for 120 years and grasses up to 50 years.
- Carbon sequestration rates for afforestation activities (planting seeds or trees to create a forest on land that is not currently a forest or has not recently been a forest) in the United States have been shown to be higher than reforestation sequestration rates.
- The point of carbon saturation on the NHS ROW is expected to be between 425 and 680 MMT. At current sequestration rates, carbon saturation is not expected to occur on the NHS for at least 75 years, and perhaps longer for areas of woody vegetation.

See below for unpaved NHS acreage and carbon sequestration estimates for California taken from the report's appendices:

Unpaved NHS Acres

Estimated Total NHS Acres	Estimated Total Acres (Range)		Estimated Unpaved NHS Acres	Estimated Unpaved Acres (Range)	
	Lower	Upper		Lower	Upper
233,899	64,618	403,180	159,270	18,821	299,614

Carbon Sequestered on NHS

Unpaved Acres	Carbon Sequestered (metric tons/acre/yr)	Carbon Equilibrium (Metric Tons of Carbon)	
		Low Estimate	High Estimate
159,218	255,703	13,614,818	31,522,191

Note: The report indicates that these volumes represent calculations from aggregated data. States are encouraged to use FHWA's Highway Carbon Sequestration Estimator tool to assess the return on investment using more state-specific considerations.

Highway Carbon Sequestration Estimator, FWHA, U.S. DOT RITA, May 2010.
Developed in conjunction with the CSPP, this decision-support tool is designed to help transportation agencies calculate the amount of carbon that could be sequestered on highway ROWs.

The estimator tool is an Excel spreadsheet that combines a wide variety of information across plant types, timelines and uses. Users are encouraged to review the user guide and become familiar with the order to complete each of the steps, as some data are used to calibrate data in subsequent worksheets. The tool assumes a carbon sequestration value of zero for the baseline. (A *baseline* is used in connection with trading carbon offsets on the Chicago Climate Exchange (CCX), a voluntary carbon market in the United States. Find more information about baselines and CCX on page 10 of this Preliminary Investigation.)

The tool is available in two beta forms: a "lite" version that can be used as a rapid screening tool, and a full version. Several state DOTs are testing the tool; feedback from DOT testers may result in revisions to the tool. Specific questions about the estimator tool should be directed to:

Paul Minnice
U.S. DOT Volpe Center
(617) 494-2494, Paul.Minnice@dot.gov

FHWA will conduct a webinar on Wednesday, July 14, at 1 p.m. EDT to discuss final report findings, provide a demonstration of the estimator tools and answer questions regarding the CSPP.

Related resources:

- **Highway Right of Way Carbon Sequestration Estimator User Guide**.
  See Appendix A.

- **Right of Way Carbon Sequestration Estimator *Lite*** (beta).
  See separate Excel file accompanying this investigation.

- **Right of Way Carbon Sequestration Estimator** (beta).
  See separate Excel file accompanying this investigation.

Carbon Sequestration Pilot Program: Implementation and Next Steps, Progress Report, FHWA, U.S. DOT RITA, February 2009.
http://climate.dot.gov/documents/FINAL_C-Seq_Report_021109.pdf
This progress report of FHWA's CSPP documents the exploration of the feasibility of state DOTs reducing and sequestering GHG emissions in vegetation within highway ROWs. New Mexico DOT was selected to participate in this research project. The report's authors consider New Mexico DOT's efforts to be ground-breaking nationally, and perhaps globally.

One function of the pilot is to address a DOT's ability to measure and then divest the carbon captured. Divestiture options considered in the pilot are:

- Selling carbon credits on a GHG market or registry for revenue.

- Using carbon credits to offset the DOT's emissions.
- Using the credits toward meeting statewide objectives for GHG emissions reductions.

The process employed to establish a pilot program for carbon sequestration along highway ROW is expected to include:

- Quantifying acreage available for carbon sequestration.
- Estimating the vegetation costs for altered planting practices.
- Estimating the carbon credits available from the enhanced management techniques.
- Identifying a verifier that can confirm the amounts of carbon sequestered, enabling participation in an appropriate trading market.

New Mexico DOT decided to explore carbon sequestration in the grasslands along the ROW rather than carbon sequestration through woody vegetation, primarily because of the potential safety concerns related to tree planting along the roadside. Given the lack of a protocol for determining carbon sequestration rates for grasslands that are not grazed, New Mexico DOT has undertaken a four-year, $2 million research project to determine sequestration rates for grasslands along highway ROW. The primary goals of the project are to:

- Establish the carbon baseline.
- Establish management practices to attain a measurable net increase in carbon sequestration through active management of highway ROW.
- Develop applicable protocols for carbon cap-and-trade systems.

The project has received funding, but there are no significant results to report as yet.

If research indicates that this type of carbon sequestration is economically viable, New Mexico DOT will develop a quantification protocol and submit it to CCX for approval. (See page 10 of this Preliminary Investigation for information about CCX.) If approved, this protocol for carbon sequestration of grasslands along highway ROW could be used by other state DOTs.

Related Research

"Carbon Sequestration and the Florida Department of Transportation: An Investigation into the Feasibility of Providing Carbon Credits Through Revised Vegetation Management Practices," Shawn Kalbli, *Weeds*, Vol. 1, No. 6, April/June 2009: 1-2.
www.woodandpartners.com/weeds/issue6.pdf
This newsletter article describes preliminary research requested by Florida DOT's Central Environmental Management Office and State Management Office that assessed the feasibility of selling carbon credits through carbon sequestration using native vegetation management practices in highway ROW. The research was undertaken in response to the CSPP announced by FHWA in 2008. Recommendations arising from the research suggest that Florida DOT should continue to monitor the possibility of selling carbon credits generated by its ROW but do not include taking immediate action.

See Appendix B for memoranda associated with the Florida DOT research project that summarize the process for carbon offset project registration and the research project's findings.

Carbon Markets

Carbon trading brings together buyers and sellers of emissions credits earned by eligible projects that sequester, destroy or displace GHG emissions. The carbon market in the United States is voluntary. If a mandatory national cap-and-trade system is established in the United States, participation in a carbon market would not be voluntary for those entities with emissions greater than the established threshold.

Globally, mandated markets have been established by the cap-and-trade system prescribed by the Kyoto Protocol. Under the protocol, countries set "caps," or limits, on GHG emissions. Credits are awarded based on GHG emission reductions. Members of the mandated market meet their caps by reducing emissions or buying or trading credits from another member.

Carbon markets often trade in carbon offsets that are the result of *additionality*, which means that the project producing the carbon offsets goes beyond regulatory requirements and is specifically designed to increase carbon sequestration.

Chicago Climate Exchange
http://www.chicagoclimatex.com/
Self-described as North America's only cap-and-trade system for all six GHGs, CCX has global affiliates and projects worldwide. Launched as a pilot program in 2003, this international rules-based GHG reduction, audit, registry and trading program has nearly 300 members from all sectors of the global economy. The commodity traded on CCX—a voluntary but legally binding market—is the Carbon Financial Instrument (CFI) contract. Each contract represents 100 metric tons of carbon dioxide-equivalent (CO_2e).

The brief glossary below presents some of the terms used in connection with CCX's carbon trading program:

Additionality: An offset project that is a voluntary act and goes beyond regulatory requirements and usual practices.

Baseline: Hypothetical case that represents the conditions most likely to occur in the absence of a proposed offset-generating project.

Offset: Tradable credits produced by implementing mitigation projects in sectors not covered by the emissions cap. Every mitigation project enrolled in CCX must meet eligibility standards and undergo independent verification before it can be issued tradable offsets in the CCX registry. Offsets are grouped into lots of 100 metric tons of CO_2e.

Offset aggregator: A member of CCX that serves as an administrative representative, on behalf of project owners, of multiple CCX-qualifying offset-generating projects.

Offset provider: An owner of an offset project that registers and sells offsets directly on the CCX exchange.

Offset verifier: An entity that is approved by CCX to conduct verification of CCX offset projects to make sure the project has followed the protocol established by CCX. Verifiers charge a percentage service fee to the offset project owner. All offset projects are subject to initial on-site inspection as well as annual desk verification and periodic site inspection for the duration of the project's enrollment in CCX.

Related documents:

- **General Offset Program Provisions**, Chicago Climate Exchange, August 20, 2009.
  http://www.chicagoclimatex.com/docs/offsets/CCX_General_Offset_Program_Provisions_Final.pdf
  This document provides the general provisions for the offset program. Specific protocol guidance is found in project-related documents available on the CCX web site.

- **Forestry Carbon Sequestration Projects Protocol**, Chicago Climate Exchange, August 20, 2009.
  http://www.chicagoclimatex.com/docs/offsets/CCX_Forestry_Sequestration_Protocol_Final.pdf
  This document contains CCX requirements and guidelines for registering forest carbon offset projects. Forest carbon sequestration can come from afforestation and reforestation and sustainable forest

management. Page 10 of the PDF provides the definition of "Forest Land (U.S.)," which includes the following:

> Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. (Note: Stocking is measured by comparing specified standards with basal area and/or number of trees, age or size, and spacing.) *The minimum area for classification of forest land is 1 acre. Roadside, streamside, and windbreak strips of timber must have a crown width of at least 120 feet to qualify as forest land* [emphasis added].

- **Overview and Frequently Asked Questions: Afforestation Offset Projects in Chicago Climate Exchange**, Chicago Climate Exchange, 2007.
  http://www.chicagoclimatex.com/docs/offsets/Afforestation_Carbon_Offsets_faq.pdf
  This document provides information on trading offsets associated with afforestation projects. Eligible forestry projects involve afforestation initiated on or after January 1, 1990, on land that had been degraded or in an unforested condition.

Potential for Carbon Sequestration

Below we highlight reports and journal articles that consider the potential for carbon sequestration from a broader perspective than the small-scale application in highway ROW. National studies consider the benefits of carbon storage in forest, grasses, soil and biomass. The state perspective is provided in Colorado case studies that examine the cost-effectiveness of another planting program completed on a smaller scale—urban tree planting—and a 2008 report that discusses the potential use of Minnesota roadsides for carbon sequestration.

National Research

The Potential for Carbon Sequestration in the United States, Congressional Budget Office, Pub. No. 2931, September 2007.
http://www.cbo.gov/ftpdocs/86xx/doc8624/09-12-CarbonSequestration.pdf
This report examines the methods, technological potential and possible costs of carbon sequestration in the United States. It also examines the role that sequestration could play in the context of the full range of possible actions to mitigate GHG emissions.

Footnote 13 on page 12 of the PDF describes the share of sequestration attributable to each part of the forest:

> Carbon sequestration occurs in four parts of a forest: soil, trees, the forest floor, and understory vegetation. The share of total sequestration attributable to each part differs greatly depending on the region, the type and age of the forest, the quality of the site, and previous land use. On average, soil contains 59 percent of the carbon stored in a forest, trees contain 31 percent, forest litter holds 9 percent, and understory vegetation accounts for 1 percent. See Richard A. Birdsey, *Carbon Storage and Accumulation in United States Forest Ecosystems*, General Technical Report W0-59 (Department of Agriculture, Forest Service, August 1992).

From page 25 of the PDF:

> Carbon sequestration in soil might make its most substantial contribution to overall mitigation when CO_2 prices were low. At higher prices, afforestation, forest management, and the use of land to grow biofuel crops would become relatively more attractive to landowners.

Forest Carbon Trading and Marketing in the United States, Steven Ruddell, Michael J. Walsh, Murali Kanakasabai, October 2006.
http://www.fs.fed.us/ecosystemservices/pdf/forest-carbon-trading.pdf
This paper, commissioned by the North Carolina Division of the Society of American Foresters (SAF) and funded through the SAF's Foresters' Fund, presents an overview of the state of carbon trading and voluntary markets for forestry offset projects. The paper's conclusion and synthesis on page 15 of the PDF describes barriers to the development of a carbon trading market in the United States:

Barriers to trading and marketing forest offset projects include the transaction costs associated with these registries which are directly related to the different project eligibility rules. Of course, the expected price of carbon will also be a determining factor in the economic analyses required to justify an investment. Forestry markets in the U.S. have, until the emergence of the RGGI, been voluntary. As RGGI [Regional Greenhouse Gas Initiative] comes on line in 2009, mandatory emission reduction targets assigned to power plants in the Northeast will motivate buyers in the forestry offset market. This demand should, in the short term, raise carbon prices for forestry offset credits.

The lack of federal cap-and-trade legislation, on one hand, has stimulated innovative approaches to establishing trading and marketing systems. The CCX exchange platform is the best example of this innovation. On the other hand, the absence of long-term regulatory carbon constraints has kept buyers unmotivated in carbon markets, slowing the development of the required capital needed to sustain these markets. A well-defined, transparent, and credible federal cap-and-trade compliance program for reducing GHG emissions in the U.S. will help create clear price signals that are needed to attract the level of capital required to sustain a U.S. carbon market.

"Bioenergy Crops and Carbon Sequestration," R. Lemus, R. Lal, *Critical Reviews in Plant Sciences*, Vol. 24, No. 1, February 2005: 1-21.
Citation at http://www.informaworld.com/smpp/content~content=a713724022&db=all
The authors note that planting bioenergy crops in degraded soils is one of the promising agricultural options, with carbon sequestration rates ranging from 0.6 to 3.0 Mg C ha^{-1} yr^{-1}. Bioenergy crops consist of herbaceous bunch-type grasses and short-rotation woody perennials. About 60 million hectares of land is available in the United States to grow bioenergy crops.

"Trees for Carbon Sequestration or Fossil Fuel Substitution: The Issue of Cost vs. Carbon Benefit," Anil Baral, Gauri S. Guha, *Biomass and Bioenergy*, Vol. 27, No. 1, July 2004: 41-55.
Citation at doi:10.1016/j.biombioe.2003.11.004
This study compares the costs and quantity of carbon mitigation by afforestation and biomass grown to displace fossil fuels using simple mathematical models of carbon stocks and assumptions about the growth conditions of trees in the southern United States. Researchers conclude that significant carbon benefit can be obtained by substituting biomass derived from short-rotation woody crops (SRWC) for coal or gasoline as opposed to sequestering carbon in standing trees. This is due to high growth rates of SRWC and also because the use of land to grow biomass is not limited to just the period until the forest matures, as in the case of afforestation for direct carbon sequestration. If growth rates of trees in afforested/reforested lands could be increased to the levels that are comparable to SRWC, more carbon benefit could be realized in the short-term horizon from afforestation than using biomass to displace fossil fuels. Researchers note that currently, the added costs to harvest, process, transport, dry and store biomass make the price of biomass three times higher than the cost of growing trees. As technologies advance to convert biomass to bioenergy, growing biomass will be much more cost-effective than direct carbon sequestration.

The State Perspective

Colorado

"The Potential of Urban Tree Plantings to be Cost Effective in Carbon Credit Markets," Melissa R. McHale, E. Gregory McPherson, Ingrid C. Burke, *Urban Forestry & Urban Greening*, Vol. 6, No. 1, 2007: 49-60.
Citation at doi:10.1016/j.ufug.2007.01.001
To examine the variables that most influence the cost-effectiveness of using urban tree plantings in emission trading markets, researchers compared the cost-efficiency of four case studies in Colorado using a model sensitivity analysis. Researchers conclude that some urban tree planting projects in specific locations may be cost-effective investments. Modeling results suggest that carbon assimilation rate, which is mainly a function of growing season length, has the largest influence on cost-effectiveness. More effective projects can be created by minimizing costs and planting large-stature trees.

Minnesota

The Potential for Terrestrial Carbon Sequestration in Minnesota: A Report to the Department of Natural Resources from the Minnesota Terrestrial Carbon Sequestration Initiative, Minnesota Department of Soil, Water and Climate, Minnesota Department of Forest Resources, Minnesota Department of Ecology, Evolution and Behavior, University of Minnesota, February 2008.
http://wrc.umn.edu/prod/groups/cfans/@pub/@cfans/@wrc/documents/asset/cfans_asset_119302.pdf
This report evaluates the potential for a variety of land use/land cover changes applicable to Minnesota to sequester carbon, including afforestation and reforestation of unforested lands, restoration of peatlands and prairie potholes, planting of short-rotation woody crops for biofuels, conversion of low-diversity grasslands to diverse grasslands or prairies, and conversion of turf grass to urban forest.

A discussion of the potential use of roadsides for carbon sequestration appears on page 45 of the PDF:

> The Department of Transportation has jurisdiction over approximately 175,000 acres of vegetated highway right of way. The primary management considerations for these roadsides are driver safety and roadway maintenance. State statutes encourage management practices that benefit wildlife and improve water quality such as reduced use of herbicides and mowing and increased use of native grasses and wildflowers. To this end Mn/DOT supports the use of Integrated Roadside Vegetation Management (IRVM) practices by its district maintenance personnel. Though C sequestration is currently not a management consideration for Mn/DOT roadsides, many of the above-mentioned practices (IRVM, utilizing native species, reduced mowing), employed by Mn/DOT because of their cost-effectiveness, can have the added benefit of reducing atmospheric C.

Carbon Management

While the publications below provide recommendations for managing carbon on a larger scale than is contemplated by Caltrans, they may provide helpful perspective on the range of activities associated with generating carbon offsets for registration or trading.

"A Synthesis of the Science on Forests and Carbon for U.S. Forests," Michael G. Ryan, Mark E. Harmon, Richard A. Birdsey, Christian P. Giardina, Linda S. Heath, Richard A. Houghton, Robert B. Jackson, Duncan C. McKinley, James F. Morrison, Brian C. Murray, Diane E. Pataki, Kenneth E. Skog, *Issues In Ecology*, Vol. 13, 2010:1-16.
http://www.fs.fed.us/rm/pubs_other/rmrs_2010_ryan_m002.pdf
Abstract: Forests play an important role in the U.S. and global carbon cycle, and carbon sequestered by U.S. forest growth and harvested wood products currently offsets 12 percent to 19 percent of U.S. fossil fuel emissions. The cycle of forest growth, death, and regeneration and the use of wood removed from the forest complicate efforts to understand and measure forest carbon pools and flows. Our report explains these processes and examines the science behind mechanisms proposed for increasing the amount of carbon stored in forests and using wood to offset fossil fuel use. We also examine the trade-offs, costs, and benefits associated with each mechanism and explain how forest carbon is measured.

An Annotated Bibliography of Scientific Literature on Managing Forests for Carbon Benefits, U.S. Department of Agriculture, Forest Service, Northern Research Station, General Technical Report NRS-57, February 2010.
http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs57.pdf
Abstract: Managing forests for carbon benefits is a consideration for climate change, bioenergy, sustainability, and ecosystem services. A rapidly growing body of scientific literature on forest carbon management includes experimental, modeling, and synthesis approaches, at the stand- to landscape- to continental-level. We conducted a search of the scientific literature on the topic of managing forests for carbon, and compiled an annotated list of citations. We chose to focus specifically on studies that addressed carbon in aboveground carbon pools, at both the micro (tree, stand) and macro (landscape, policy) levels. Aboveground pools include: live tree, understory, standing dead wood, down dead wood, and forest floor. The temporal scope of the literature search was the period 2000-2008 and the geographical scope was the temperate and boreal forests mainly in the United States, but also Canada, Europe, Russia, Japan, China, New Zealand, and Australia.

Urban Forest Project Reporting Protocol, Version 1.0, California Climate Action Registry, August 12, 2008.
http://www.fs.fed.us/psw/programs/cufr/UrbanForestProtocol0812081ForBoardApproval.pdf
Guidance to account for and report GHG emission reductions associated with tree planting and maintenance activities to permanently increase carbon storage in trees is provided in this document. Project developers will find the information necessary to register GHG reductions with the Climate Action Reserve program, including eligibility rules, methods to calculate reductions, performance monitoring instructions and procedures for reporting project information. All project reports receive annual, independent verification by California Registry-approved verifiers. Guidance for verifiers to certify reductions is provided in the Urban Forest Project Verification Protocol. (See http://www.scscertified.com/docs/Urban_Forest_Project_Verification_Protocol_V1.0.pdf.)

A Landowner's Guide to Carbon Sequestration Credits, Center for Integrated Natural Resources and Agricultural Management, University of Minnesota Department of Forest Resources, The Commonwealth Project, 2007.
http://www.cinram.umn.edu/publications/landowners_guide1.5-1.pdf
From the introduction: This guide offers a path for local landowners to earn additional income while helping diminish adverse effects of global climate change through implementation of carbon sequestration and other stackable incentives. This document is a tool to help landowners make the decision whether or not to enroll their land in carbon sequestration. It discusses background information on carbon sequestration and global climate change; current methods of sequestration, including forestry, conservation planting, methane capture and others; and steps a land owner must take, including contracts, verification, and implementation, once they have made the decision to enroll their lands in a sequestration project.

Harnessing Farms and Forests in the Low-Carbon Economy, Zach Willey, Bill Chameides (Editors), Duke University Press, 2007.
Book excerpt at http://www.nicholas.duke.edu/institute/ghgoffsetsguide/ghgexerpts.pdf
This guide for farmers, other landowners and anyone else interested in creating GHG offsets as a tradable commodity contains a nontechnical section that offers methodologies for determining the costs and benefits of a proposed project, quantifying offsets under a range of situations and conditions, and verifying and registering the offsets. A technical section provides specific information for quantifying, verifying and regulating offsets from agricultural and forestry practices.

Carbon Trading: A Primer for Forest Landowners, National Commission on Science for Sustainable Forestry, Research Project A9, Part III, undated.
http://www.carbon.sref.info/
From the web site: This web site is targeted towards forest landowners in the USA that want to learn more about how they can enter the carbon trading market. Information is available regarding what states in the US are developing markets, what information is required by a landowner to trade carbon, what might be the costs, and what might be the income.

Related resource:

- **A9B: Accounting for Forest Carbon Sequestration: A Landowner Primer**, Final Report to the National Commission on Science for Sustainable Forestry, Daniel Markewitz, March 9, 2007.
  http://ncseonline.org/00/Batch/NCSSF/project_reports/Final%20Report%20A9b%20for%20Project%20A9(III).pdf
  This report describes the research project that resulted in the Carbon Trading web site.

Carbon Evaluation Tools

The Excel-based estimator tool associated with the CSPP will be of greatest interest to transportation agencies contemplating carbon sequestration in forested land in the highway ROW. Highlighted below are other tools that can be used to estimate the carbon sequestered for specific projects of afforestation or reforestation. Some tools look at the problem from the perspective of stand management while others assess individual trees.

Carbon Calculator, *Carbon Trading: A Primer for Forest Landowners*, National Commission on Science for Sustainable Forestry, Research Project A9, Part III
http://carbon.sref.info/estimating/calculator
The Carbon Calculator requires entry of the region, stand type, whether the tract in question is a case of afforestation or reforestation, stand management intensity (use of fertilizers or thinning treatments versus letting the forest take care of itself) and age. Results are given in metric tons of carbon per hectare for the following:

- Live tree.
- Standing dead tree.
- Understory.
- Down dead wood.
- Forest floor.
- Soil organic.
- Total nonsoil.

See http://carbon.sref.info/an-example for an example of how the calculator can be used.

Center for Urban Forest Research (CUFR) Tree Carbon Calculator
http://www.fs.fed.us/ccrc/topics/urban-forests/ctcc/
The CUFR Tree Carbon Calculator (CTCC) is the only tool approved by the Climate Action Reserve's Urban Forest Project Protocol for quantifying carbon dioxide sequestration from GHG tree-planting projects. The CTCC is programmed in an Excel spreadsheet and provides carbon-related information for a single tree located in one of 16 U.S. climate zones.

CVal: A Spreadsheet Tool to Evaluate the Direct Benefits and Costs of Carbon Sequestration Contracts for Managed Forests, U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, General Technical Report FPL-GTR-180, February 2009.
http://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr180/fpl_gtr180.pdf
From the abstract: This documentation is meant to accompany CVal, a downloadable spreadsheet tool. CVal was constructed for foresters, other land management advisors, landowners, and carbon credit aggregators to evaluate the direct benefits and costs of entering into contracts for carbon sequestered in managed forests and forest plantations. CVal was designed to evaluate Exchange Forestry Offset (XFO) contracts on the Chicago Climate Exchange (CCX), although the methodology could be adapted for other trading mechanisms and agricultural sequestration projects.

Links to the CVal spreadsheet (with and without macros) are available at
http://www.fpl.fs.fed.us/products/publications/specific_pub.php?posting_id=14478&header_id=p.

Voluntary Offset Programs

Carbon offsets are used as a tool to compensate for GHG emissions. Typically, carbon offsets are measured in metric tons of CO_2e. Below we highlight a few of the voluntary offset programs applicable to the U.S. market that provide the opportunity to trade or register carbon offsets.

American Carbon Registry
http://www.americancarbonregistry.org/
From the web site: The American Carbon Registry (ACR) is a leading voluntary offset program with strong standards for environmental integrity and over a decade of operational experience in high quality carbon offset issuance, serialization and transparent on-line transaction reporting. As the first private voluntary GHG registry in the U.S., ACR has set the bar for transparency and integrity that is the market standard today. ACR has issued over 30 million project based carbon offsets and in 2008 was the most widely used voluntary carbon market registry in the world.

Climate Action Reserve
http://www.climateactionreserve.org/
From the web site: The Climate Action Reserve is a national offsets program working to ensure integrity, transparency and financial value in the U.S. carbon market. It does this by establishing regulatory-quality standards for the development, quantification and verification of greenhouse gas (GHG) emissions reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system.

Two other programs—the Center for Climate Action and the California Climate Action Registry—also operate under the Climate Action Reserve.

Green-e Climate Program
http://www.green-e.org/getcert_ghg.shtml
From the web site: Green-e Climate is the nation's first certification program for carbon offsets sold to consumers on the retail market. This consumer-protection program strengthens the voluntary market by providing credible oversight and transparency to retail greenhouse gas (GHG) emission reduction products (offsets), from beginning to end. Consumers purchasing Green-e Climate Certified offsets have clear information about the projects their GHG reductions are sourced from, and are guaranteed that no one else can claim their offset.

Voluntary Carbon Standard 2007
http://www.v-c-s.org/
The Voluntary Carbon Standard (VCS) program provides a global standard and program for approval of credible voluntary offsets in the form of the Voluntary Carbon Unit. VCS offsets "must be real (have happened), additional (beyond business-as-usual activities), measurable, permanent (not temporarily displace emissions), independently verified and unique (not used more than once to offset emissions)."

Related Resources

Carbon Offset Research and Education, Stockholm Environment Institute
http://www.co2offsetresearch.org/
The mission of Carbon Offset Research & Education is to foster offset programs and policies that maximize potential benefits while minimizing potential risks. The web site includes policy information on voluntary and mandatory offset markets, standards and protocols, and an expansive list of resources and references.

Related resource:

- **Glossary**, *Policy Information*, Carbon Offset Research and Education, Stockholm Environment Institute
  http://www.co2offsetresearch.org/policy/Glossary.html
  This web page provides definitions of key terms associated with carbon offsets.

A Review of Offset Programs: Trading Systems, Funds, Protocols, Standards and Retailers, Research Report, Stockholm Environment Institute, December 2008.
http://www.co2offsetresearch.org/PDF/SEI-OffsetReview08.pdf
Abstract: Carbon or greenhouse gas (GHG) offsets have long been promoted as an important element of a comprehensive climate policy approach. Offset programs can reduce the overall cost of achieving a given emission goal by enabling emission reductions to occur where costs are lower. Furthermore, offsets have the potential to deliver sustainability co-benefits, spurred through technology development and transfer, and to develop human and institutional capacity for reducing emissions in sectors and locations not included in a cap and trade or a mandatory government policy. However, offsets can pose a risk to the environmental integrity of climate actions, especially if issues surrounding additionality, permanence, leakage, quantification and verification are not adequately addressed. The challenge for policymakers is clear: to design offset programs and policies that can maximize their potential benefits while minimizing their potential risks. This report is a systematic and comprehensive review of existing offset programs.

Environmental Implications

The journal articles below discuss unintended consequences of carbon sequestration—from increases in soil salinization and nitrous oxide emissions to compromised soil fertility.

"Trading Water for Carbon with Biological Carbon Sequestration," Robert B. Jackson, Esteban G. Jobbágy, Roni Avissar, Somnath Baidya Roy, Damian J. Barrett, Charles W. Cook, Kathleen A. Farley, David C. le Maitre, Bruce A. McCarl, Brian C. Murray, *Science*, Vol. 310, No. 5756, 2005: 1944-1947.
http://www.biology.duke.edu/jackson/science05.pdf
Although this article discusses carbon sequestration strategies that are employed on a much broader scale than is possible along highway roadsides, the researchers' conclusions may be of interest to those considering smaller-scale projects. The authors contend that carbon sequestration strategies that advocate tree plantations do so without considering their full environmental consequences. Combining field research, a synthesis of more than 600 observations, and climate and economic modeling, researchers documented substantial losses in stream flow and increased soil salinization and acidification associated with afforestation. Regional modeling of U.S. plantation scenarios suggests that climate feedbacks are unlikely to offset these water losses and could make them worse.

"Carbon Sequestration in Arable Soils is Likely to Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing," Changsheng Li, Steve Frolking, Klaus Butterbach-Bahl, *Climatic Change*, Vol. 72, 2005: 321-338.
http://www.dndc.sr.unh.edu/papers/SOC_N2O.pdf
Researchers conducted model simulations to evaluate the impact of different cropland management strategies on the coupled cycles of carbon and nitrogen, and concluded that the accompanying increase in nitrous oxide (N_2O) emissions reduced or eliminated the benefits of carbon sequestration in soils. *From page 13 of the PDF:*

> Evaluating the greenhouse gas benefit of regional-scale changes in management practices aimed at C-sequestration requires analysis of interacting biogeochemical cycles, coupled with spatial datasets of weather data and soil properties. Unless these biogeochemical interactions are incorporated into a comprehensive assessment framework, the value of agricultural systems in strategies for climate protection cannot be accurately determined. Our analysis indicates that increased C-sequestration in soils, by any mechanism, will be generally accompanied by increased N_2O emissions, reducing or eliminating the usefulness of C-sequestration in soils as a greenhouse gas mitigation strategy.

"Groundwater Use and Salinization with Grassland Afforestation," Esteban G. Jobbágy, Robert B. Jackson, *Global Change Biology*, Vol. 10, No. 8, 2004: 1299-1312.
http://www.biology.duke.edu/jackson/gcb04.pdf
Researchers present a general predictive framework for understanding salinization of afforested grasslands, testing the framework in 20 paired grassland and adjacent afforested plots across 10 sites in the Argentine Pampas. The framework and experimental data suggest that afforestation can compromise soil fertility and the quality of water resources in predictable ways based on water use, climate and soil texture.

APPENDIX A

Highway Right of Way Carbon Sequestration Estimator

User Guide

April 2010

U.S. Department of Transportation
Federal Highway Administration
Office of Project Development and Environmental Review

U.S. Department of Transportation
Research and Innovative Technology Administration
John A. Volpe National Transportation Systems Center

Table of Contents

Overview

Introduction

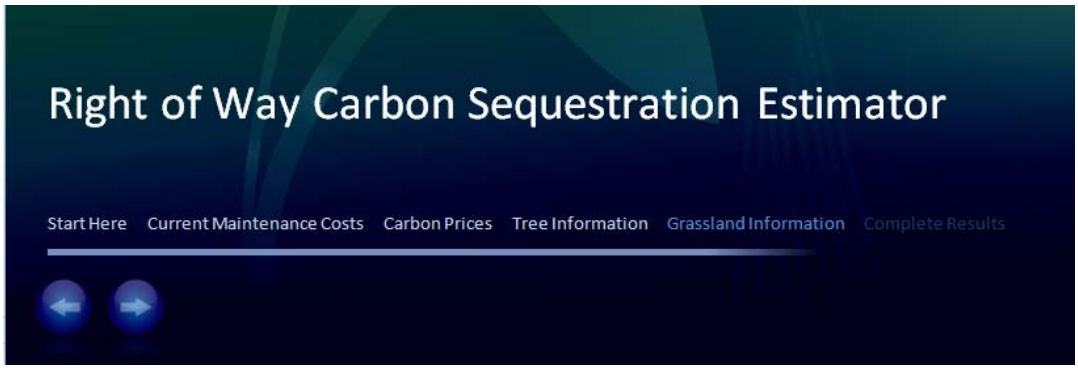
The Highway Right of Way Carbon Sequestration Estimator is an Excel spreadsheet tool that has been designed to help transportation agencies calculate the amount of carbon that could be sequestered on their highway rights of way. The goal of this tool is to estimate the potential economic or environmental effects of adopting carbon sequestration practices along highways. Due to changing market forces as well as other associated costs with carbon sequestration projects, this tool will only approximate revenues, expenditures, and savings.

The tool, which combines a wide variety of information and is flexible across plant types, timelines, and uses, has been designed to be as user-friendly as possible. However, while it may be possible to use the tool "out of the box," it is recommended that tool users read this guide first in order to maximize the tool's functionality. For example, the order in which steps in the tool are completed is important. Data input for one worksheet are used to calibrate data in subsequent worksheets. Failure to follow the recommended stepwise approach may result in problems generating output estimates.

Additionality statement: Carbon sequestration projects that request offsets on the Chicago Climate Exchange (CCX) must demonstrate additionality. That is, a new planting must sequester more carbon than previous land use management techniques on that land—the "baseline." This tool assumes a carbon sequestration value of zero for the baseline. Please note this when reading output from the estimator.

Progress Monitor

The top of the spreadsheet tool has a progress monitor:



The tool is broken down into several components, which users may notice as the tabs at the bottom of the worksheets. Components that have been complete appear at the left. The component currently being edited is shown in a medium blue, and the components remaining to complete out are to the right in dark blue. The arrow buttons allow users to move between components.

Cells

The tool requires the input of current maintenance costs, as well as information about each planting such as associated costs, growth and choices regarding lumber harvesting. Output fields will give results based on the data that are entered.

The general format is as follows:

Output Text Description	Output Field
Input Text Description	Input field

Hidden Cells

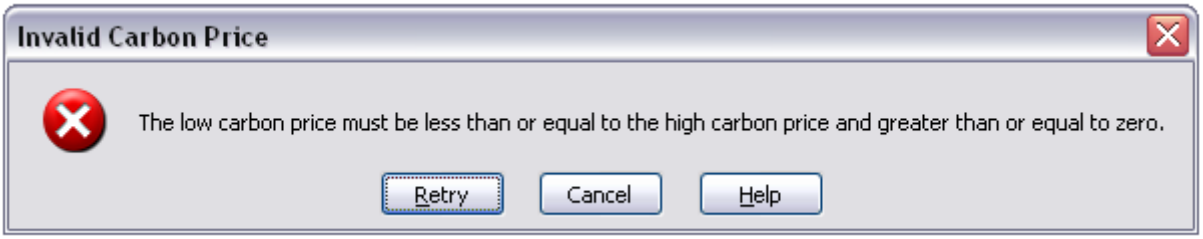
Please note that the tool hides certain cells depending on the responses that are given. It is possible that users will not use all cells that are explained in this guide. A hidden cell will appear like the second row of the following table:

Acres of Land under project management	1000

← Hidden cells

Alert Messages

If you type in a value that is not valid or may seem to be abnormal an alert will pop up. The example alert below occurs when the estimated low carbon price for a particular year is greater than the estimated high carbon price.



General Definitions

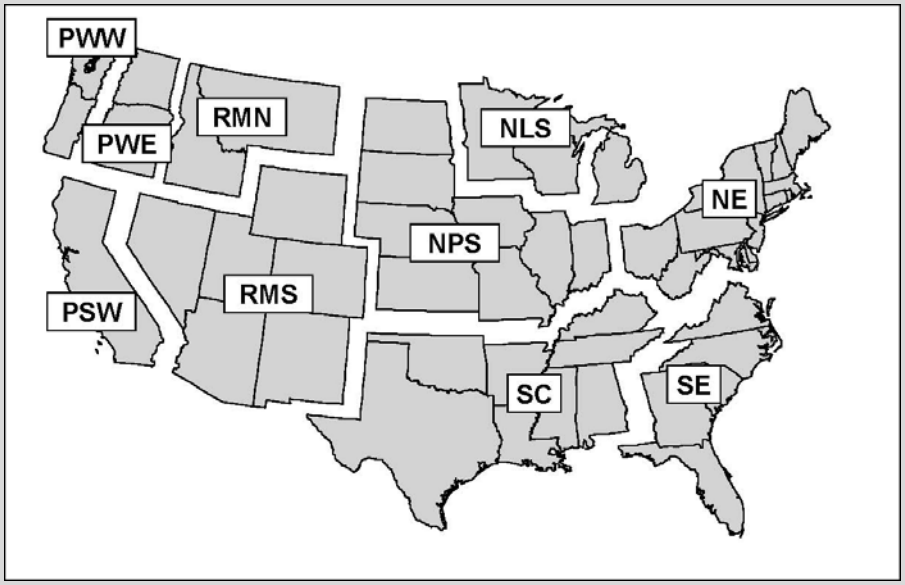
Nominal vs. Real Dollar—A nominal dollar refers to the amount of currency needed at a given point in time for a good. A real dollar refers to the amount of money needed to pay for something after adjusting for inflation. For instance, a product that costs $1.00 in 2000 and $1.03 in 2001 in a 3% inflation rate environment maintains the same real dollar cost in both years, but its nominal cost in 2001 is 3 cents more than in 2000.

Inflation Rate—the inflation rate is the annual rate at which prices in an index increase. Common indices include the consumer price index and producer price index, both compiled by the Bureau of Labor Statistics.

Discount Rate—the discount rate, here taken to be the same as the inflation rate, is the rate at which one must discount future values to understand them in today's dollars.

Net Present Value—net present value refers to the amount of monetary inflows and outflows. That is, if an agency has an investment that pays a real inflow each year for 10 years of $100 and an annual real outflow of $10, the NPV of that investment is (10*$100)-(10*$10)=$900

Start Here

The Current Year Is	Displays the current year
Please type in your agency name	Enter the name of your agency. This field is needed to generate a final report.
Please type in the inflation rate	Enter the inflation rate you would like to use. This is also used as the discount rate in discounting revenues to current dollars. If this rate is unknown, the tool's default value of 3% should be used (See "General Definitions" section for more information on inflation and discount rates).
Please select your agency state	Please select your state. If more than one choice is available, please consult the following map to learn the region that you should choose. "Washington – West" and "Oregon – West" refer to any area of Washington or Oregon that are located in the "PWW" region. Similarly, "Washington – East" and "Oregon – East" refer to areas located in the "PWE" region.  *Source: U.S. Forest Service*
Your Region Is	The tool will automatically select a region (as shown in the picture above) based on the state selected. This field cannot be changed.

Traditional Maintenance Costs

The Traditional Maintenance Costs sheet requires the input of the costs and variables associated with business-as- usual maintenance, that is, traditional maintenance methods. Please fill out the requested fields considering potential costs. Traditional maintenance costs listed here should be costs that your agency would incur if the land is not designated for carbon sequestration. The data entered on this sheet allow the tool to calculate cost savings that could result from undertaking the carbon sequestration activity.

Definitions

Mowing	
Calculation Method	This is a drop-down box that allows users to choose whether calculation will be itemized or not. An example of itemizing would be using in-house maintenance, while non-itemized maintenance may be appropriate if a contractor handles mowing activities.
Number of acres mowed/gallon fuel	If costs are being itemized, this is the number of acres that equipment can mow on one gallon of fuel.
How many acres per hour are mowed?	Enter the number of acres that one piece of equipment can mow in an hour
Number of hours it takes to mow one acre	This cell calculates how long it takes to mow one acre. Editing is not permitted.

Pesticide / Herbicide Application	
Calculation Method	This is a drop-down box that allows users to choose whether the pesticide/herbicide application calculation will be itemized or not. An example of itemizing would be using in-house maintenance, while non-itemized maintenance may be appropriate if a contractor handles pesticide/herbicide application activities.
Number of acres applied/gallon fuel	Enter the number of acres that can be applied with pesticide per machine per gallon of fuel.
How many acres per hour are applied?	Enter the number of acres to which one piece of equipment can apply pesticide in an hour.
Number of hours it takes to apply one acre	This cell calculates how long it takes to apply one acre with pesticide. Editing is not permitted.

Lower Part of Maintenance Costs Worksheet	
Current Year	This cell displays the current year. Editing is not permitted.
Calendar Year	Gives a reference to the calendar year for which a users is entering data

	in other cells.
Estimated Fuel Cost / Gallon	Enter the estimated fuel cost per gallon in nominal dollars.*
Mowing hourly wage rate (in nominal dollars)	If the itemized method of calculation has been selected, please enter the hourly wage rate for mowing in nominal dollars.*
Mowing Cost / Acre (Non-Itemized)	If the non-itemized method of calculation for mowing costs has been selected, please enter the mowing cost per acre in nominal dollars.*
Number of times mowed / year	Enter the number of times that an area under traditional maintenance is mowed per year.
Total mowing costs per acre	Displays total mowing costs whether itemized or non-itemized. Editing is not permitted.
Pesticide / Herbicide application hourly wage (in nominal dollars)	If the itemized method of calculation has been selected, please enter the hourly wage rate for herbicide/pesticide application in nominal dollars.*
Herbicide / Pesticide Application Cost / Acre (Non-Itemized)	If the non-itemized method of calculation for herbicide/pesticide costs has been selected, please enter the application cost per acre in nominal dollars.*
Number of times to apply / year	The number of times that herbicides/pesticides are applied to an area under traditional maintenance per year.
Total Herbicide / Pesticide Costs per acre	Displays total herbicide/pesticide application costs whether itemized or non-itemized. Editing is not permitted.
Other Costs (per acre)	Enter any other per acre costs incurred.

* A *nominal dollar* is a dollar not adjusted for inflation. That is a product price may change solely due to inflation. The nominal price will go up while the real price stays constant.

Carbon Prices

Definitions

Year	The year for which carbon price data is to be entered.
Low Carbon Price	The estimated low carbon price in nominal dollars in a given year.
High Carbon Price	The estimated high carbon price in nominal dollars in a given year.

Tree Information

Tree 1 Data Input

This datasheet is one of the most complex. It requires data input for the first tree species/community. Much of the data that needs to be inserted in this sheet can be found in a Chicago Climate Exchange (CCX) protocol. (www.theccx.com)

Tree 1 Data Input – Upper Section

Land Information	
Choose Method of Carbon Calculation (Drop Down)	The tool can calculate carbon sequestration in two ways. "Carbon Accumulation (Forestry)" is the method that most agencies are expected to use. It is appropriate for most plantings over relatively large areas. "Annual Sequestration (Per Tree)" was originally designed for urban areas.
Acres of Land under project management	This is the number of acres that will be managed by this particular carbon sequestration project, or in other words, the number of acres that will or might be planted.
Calculating trees/acre?	If "Annual Sequestration (Per Tree)" is selected as the method of carbon sequestration calculation, this cell asks will ask if there is an expected set density of trees per acre or if a count of individual trees to be planted is known. If the density is known, then "yes" should be selected. If a user decides to make an estimate on an individual tree basis for which a count of trees is known,, select "no."
Number trees / acre	If trees/acre is being calculated, enter this amount here.
Total Number of trees	If trees/acre are not being calculated, enter the total number of trees being planted.
Trees planted at start of project	This cell updates automatically. Editing is not permitted.
Number of acres no longer under traditional maintenance	This cell updates automatically. Editing is not permitted.

Protocol Information	
Minimum lifetime (age after acquiring eligibility)	This minimum age may be required by climate exchange (e.g. CCX, ECX) protocols. This refers to the minimum number of years trees must remain standing during the duration of the protocol. For example, in the CCX's Forestry Carbon Sequestration Protocol, land on offset projects is required to remain forested for at least 15 years. In this case, a user would enter 15 in this field. If unsure of the minimum lifetime, this value should be left as 15.
Age tree becomes eligible for calculation based on	CCX's Forestry Carbon Sequestration Protocol requires trees to have a diameter at breast height (DBH) of 1". Enter the smallest age for the tree

protocol	for which it will have met, during that calendar year, at all times, all of the criteria for qualifying for calculation.

Requirements/Recommendations	
The Minimum tree age you are allowed to start calculation is	After filling in other information in the top area, this field will display minimum age that carbon sequestration estimates can begin being made. The corresponding input field is located to the right.
Minimum age to end calculation	Given the constraints of the protocol, this is the youngest age of the tree that a user is allowed to end calculation at, which could also be the point at which an entity could exit the offset program or cutthe trees.
Best Available Cutting Age	Taking into account all model variables, including the protocol, current age of the tree, and carbon sequestration trajectories, this field displays the best age at which trees should be cut in order to maximize carbon sequestration. Carbon sequestration rates differ among trees, and this field displays the year at which a tree's sequestration rate has slowed to the point where it is advantageous to cut and replant in order to maximize carbon sequestration. Cutting trees on a forestry sequestration project may require a market participant to follow additional stipulations (e.g., CCX has additional requirements for projects that involve tree cutting) that are not captured in this spreadsheet tool or user guide.

Tree Information	
Tree/Community Name/Type:	Choose the tree community or type from this list. At this time, the carbon sequestration estimator does not permit altering this list.
Date of Planting	Enter the specific date that plantings are expected to be made. Enter the median date if plantings are expected to occur over a period of time. Please note that entering a date other than an exact planting date may cause output errors in the tool
Tree Age at the end of this year	This field displays the tree age at the end of the year. It counts only full calendar years in the age. Therefore, if a tree is planted in April of 2000, it does not reach age 1 until the end of 2001.
Age to start tree calculation	This is an input field that requires the entry of the start date for creating offsets. The criterion for the minimum is given by "The Minimum tree age you are allowed to start calculation is" field to the left.
Age to end calculation	This is an input field that determines the end of calculation for a particular stand/forest. The minimum age that this can be and a recommended age to cut trees are both shown to the left.
Cut trees?	This asks if the trees will be cut at the end calculation year. If a user completes this field, lumber price information must also be supplied. Saying yes to this field assumes that after cutting the trees the lumber will be sold. If the lumber will not be sold or cut, select "no." NOTE: If "yes" is selected, an agency must be obtain certification designating this

	planting a sustainable forest from the CCX. More information can be found in the CCX Forestry Carbon Sequestration Protocol at www.theccx.com/docs/offsets/CCX_Forestry_Sequestration_Protocol_Final.pdf.
Equivalent Year that calculation will start	This field takes the age given as the start tree calculation age and gives an equivalent calendar year. Editing is not permitted.
Equivalent Year that calculation will end	This field takes the age given as the end tree calculation age and gives an equivalent calendar year (if the agency opts to cut trees, it would need to occur at the end of this year). Editing is not permitted.
Percentage of carbon remaining after cutting	The percentage of carbon that remains after cutting in compliance with CCX protocols. This data must be approved by the CCX.

Lumber Price Information	
Estimated Low Lumber Price ($/ft^3)	Enter the lower estimate for lumber prices at the time of cutting ($/ft3).
Estimated High Lumber Price ($/ft^3)	Enter the higher estimate for lumber prices at the time of cutting ($/ft3).

Other Information	
Discount Rate	This is the discount rate entered on the first sheet. Editing is not permitted.
Region	This region is automatically detected based on the state entered on the first sheet. Editing is not permitted.

Tree 1 Data Input – Lower Section

Year	Data entered in each row correspond to years in this field. Editing is not permitted.
Tree age	This is the actual tree age at this point. Editing is not permitted.
Eligible years (this would be the age listed in the protocol)	This is the number of years that the tree has been eligible for carbon sequestration under the CCX protocol.
Mean Volume (ft^3/acre)	This field is the mean volume of the trees at this year/age if using the forestry carbon accumulation method.
Mean Volume (ft^3/tree)	This field is the mean volume of the trees at this year/age if using the per tree method of calculation.
Annual Carbon Sequestration Per Tree (Metric tons CO2 equivalent / Tree)	If using the annual sequestration (per tree) carbon method of calculation, this field will automatically be filled in based on the tree species chosen.

Annual Carbon Accumulation (Forestry) Metric tons CO2 equivalent /Acre	If using the forestry carbon method of calculation, this field will automatically be filled in based on the tree species chosen.

Tree 1 Startup Costs

Use this sheet to enter the startup costs associated with the tree planting. Entering accurate information into this sheet allows the tool to correctly calculate the net effects of the carbon sequestration project. Please enter costs in nominal dollars.

Year	This is the calendar year for which data should be entered. Editing is not permitted.
Preparation Cost	Costs associated with preparation. This designation is up to the interpretation of the agency.
Planting Costs	Costs associated with planting. This designation is up to the interpretation of the agency.
Materials cost	Costs associated with materials. Examples include saplings, seeds and fertilizer. This designation is up to the interpretation of the agency.
PV of Costs	Calculates costs in present dollars. That is, this field adjusts for inflation so that the costs displayed are displayed in the current year's dollars. Editing is not permitted.
Cumulative Net present value (NPV) of Total Costs	This is the cumulative present value of costs. Editing is not permitted.

Tree 1 Maintenance Costs

Maintenance costs refer to costs associated with maintaining the forested land.

Total NPV of Costs (given start and end time)	The total net present value of costs. This field calibrates based on the start and end calculation periods for "tree 1." See Tree 1 page above for more information.
Year	The calendar year for which data should be entered. Editing is not permitted.
Tree age	The actual tree age at this point. Editing is not permitted.
Eligible years	The number of years that the tree has been eligible under the CCX protocol. Editing is not permitted.
Costs (in nominal dollars)	Please enter all costs associated with maintenance of this tree planting. This includes labor and materials costs. Please also include capital costs if necessary.
Present Value of Costs	Calculates costs in present dollars. That is, this field adjusts for inflation so that the costs displayed are displayed in the current year's dollars. Editing is not permitted.

Cumulative Net Present Value of Total Costs	The cumulative present value of costs. Editing is not permitted. .

Tree 1 Results

Tables

NPV of costs associated with Tree 1	This field reports the net present value of incurred costs associated with tree 1 (See "General Definitions" for more information on net present value).
All avoided standard maintenance costs	This field reports the traditional maintenance costs that are avoided as a result of the tree 1 carbon sequestration project.
Revenue (NPV)	This field reports the revenue in current dollars of the project over the entire calculation period from the calculation start and end time.
Net Budget Impact	This field reports the net budget impact, which is defined as the revenue plus the avoided costs less the incurred costs. If this number is positive, the carbon sequestration project is estimated to be an improvement over the status quo (traditional maintenance).
Total CO2 Sequestered Over Time Period (Metric tons)	This field reports the total amount of CO2 sequestered in metric tons.
Best Available Cutting Age	Based on the tree data that was entered/selected, this field updates to display the best age at which trees should be cut in order to maximize carbon sequestration. It is based on the average carbon sequestration rate. Please note that this value assumes that trees will be replanted after being cut.
Lumber Volume at Recommended Cutting Age (ft^3)	This field reports the volume of lumber at the recommended cutting age.
Low Lumber Revenue at Recommended Cutting Age	This field reports the lower estimate for revenue that would be earned by cutting at the recommended cutting age and selling the lumber at the market rates entered.
High Lumber Revenue at Recommended Cutting Age	This field reports the higher estimate for revenue that would be earned by cutting at the recommended cutting age and selling the lumber at the market rates entered.
Lumber Volume at Cutting Age (ft^3)	This field reports the volume of lumber at the actual cutting age. This may or may not be the volume of lumber at the recommended cutting age.

Graphs

Annual CO2 Sequestered and Cumulative CO2 Sequestered	Displays the amount of CO2 (in metric tons) sequestered over time in both annual and cumulative amounts.

Net Budget Effect	The net budget effect for each year. This is defined as the revenue plus the avoided costs less the incurred costs.
Revenue Less Tree 1 Maintenance and startup costs	Displays actual revenue/expenditure in current dollars.
Cumulative Revenue Less Cumulative Incurred Costs in Current Dollars	The cumulative revenue less cumulative incurred costs. This takes into account inflation. A given point on the curve is the cumulative amount of money in current dollars.

Grassland Information

Grassland 1 Data Input

The second part of the tool deals exclusively with grasslands. The formatting for this section is analogous to the tree section. However, please note that there are some differences in the fields for the tree and grass inputs. Also note that the tree section described above is based on the CCX's forestry protocol and U.S. Forest Service data, whereas no CCX protocol has yet been written that pertains to ungrazed grasslands.

Grassland 1 Data Input – Upper Section

Upper Section	
Acres of land	The number of acres that this planting will use.
Minimum Lifetime (in years)	Enter the minimum length of time that land must be maintained as grassland under the appropriate protocol, if there is one.
Grass name/type	Users may type any value into this field. It is meant to serve as a reference and will not affect calculations made in the spreadsheet
Last Day of Planting	Unlike tree data, this field has no influence on the calculation of carbon.
Year to Start Calculation	Enter the year in which carbon sequestration calculation are projected to begin
Year to End Calculation	Enter the year in which carbon sequestration calculations are projected to end
Percentage of carbon stored below ground	Grass species store a certain amount of carbon below ground and a certain amount in above ground mass. Enter the percentage of carbon stored below ground.
Discount Rate	This cell updates automatically and cannot be changed.

Grassland 1 Data Input – Lower Section

Lower Section	
Year	The calendar year for which one must enter the annual carbon accumulation in metric tons CO2/acre.
Eligible Years	Reports the number of years that the grassland is eligible for calculation. Currently assumes there are no minimum eligibility requirements for grasslands.
Annual Carbon Accumulation Metric tons CO2/Acre	Enter the amount of carbon that the grass sequesters including aboveground mass. If only the amount that is sequestered below ground is known, ensure that the field 'percentage of carbon stored below ground' = 100%

Grassland 1 Startup Costs

Year	Displays the calendar year
Preparation Cost	Enter costs associated with preparation. This designation is up to the interpretation of the agency.
Planting Cost	Enter costs associated with planting. This designation is up to the interpretation of the agency.
Materials Cost	Enter costs associated with materials. Examples include saplings, seeds and fertilizer. This designation is up to the interpretation of the agency.
PV of Total Costs	Calculates costs in present dollars. That is, this field adjusts for inflation so that the costs displayed are displayed in this year's dollars. Editing is not permitted.
Cumulative NPV of Total Costs	This is the cumulative present value of costs. Editing is not permitted.

Grassland 1 Maintenance Costs

Total NPV of Costs (given start and end time)	This is the total net present value of costs. This field calibrates based on the start and end calculation periods for grassland 1.
Discount Rate	This cell updates automatically. Editing is not permitted.
Year	This is the calendar year for which data should be entered. Editing is not permitted.
Grassland Age	Actual Age of Grassland
Eligible Years	Displays the eligible age of grassland. Grasslands that have not been existence for at least a year are not considered eligible for calculation.
Costs	
PV of Costs	Calculates costs in present dollars. That is, this field adjusts for inflation so that the costs displayed are displayed in this year's dollars. Editing is not permitted.
Cumulative NPV of Total Costs	This is the cumulative present value of costs. Editing is not permitted.

Grassland 1 Results

Tables	
Present Value of costs associated with grassland 1	Reports the net present value of incurred costs associated with grassland 1 (See "General Definitions" section for more information on net present value).
All avoided standard maintenance costs	Reports traditional maintenance costs that are avoided as a result of the tree 1 carbon sequestration project.
Revenue (NPV)	Reports the revenue in current dollars of the project over the entire calculation period from the calculation start and end time.

Net Budget Impact	Reports the net budget impact, which is the revenue plus the avoided costs less the incurred costs. If this number is positive, the carbon sequestration project is an improvement over the status quo (traditional maintenance)
Total CO2 Sequestered Over Time Period (Metric tons)	Reports the total amount of CO2 estimated to be sequestered.

Graphs	
Annual CO2 Sequestered and Cumulative CO2 Sequestered	Displays the amount of CO2 in metric tons estimated to be sequestered over time in both annual and cumulative amounts.
Net Budget Effect	Displays the net budget effect for each year. This is defined as the revenue plus the avoided costs less the incurred costs.
Revenue Less Grassland 1 Maintenance and startup costs	Displays actual revenue/expenditure in current dollars.
Cumulative Revenue Less Incurred Costs in Current Dollars	Displays the cumulative revenue less cumulative incurred costs. This takes into account inflation. A given point on the curve is the cumulative amount of money in current dollars.

Printer Friendly Version

This sheet is designed for printing. A printed copy will display all relevant information including the estimated amount of carbon to be sequestered, revenues, costs, and avoided costs broken out by tree and grassland. Relevant graphs are included as well. If graphs or totals do not display as expected, please verify that requested data have been entered correctly into the other sheets of the tool.

Wood+Partners Inc.
Landscape Architects
Land Planners

Memorandum

Date: Tuesday, March 10, 2009
To: Jeff Caster, FDOT CEMO
From: Shawn Kalbli
CC: Tim Allen, FDOT Maintenance
Re: Carbon Sequestration and the Florida Department of Transportation

Project: Florida Department of Transportation CEMO – Miscellaneous Support Services
Project No.: 02-08-26

After reviewing the findings of research described below, the State Maintenance Office (SMO) and Central Environmental Management Office (CEMO) determined that it is in the best interest of the agency to postpone entry into the carbon credit market until further guidance is provided by FHWA. Under the Obama Administration anticipated changes to the United States' policy of carbon emissions are poised for closer examination. A nationwide cap and trade plan that would limit and reduce carbon emissions was included in the 2010 budget proposal delivered to Congress this year for evaluation. In response to a publication entitled *Carbon Sequestration Along Highway Rights of Way: Piloting Concept,* authored by the Federal Highway Administration (FHWA), the Florida Department of Transportation's CEMO and SMO conducted preliminary research into the process for becoming a provider (seller) of carbon credits and preliminary cost considerations.

In the FHWA publication the potential for state transportation agencies to become providers of carbon credits through carbon sequestration using native vegetation management practices in their state department of transportation (DOT) owned rights-of-way (ROW) is examined. The FHWA provides accurate information pertaining to the carbon cycle and the manner in which vegetation removes some excess carbon dioxide (CO_2) already in the atmosphere, thereby sequestering the greenhouse gas resulting in less harm for the environment and human health. Further, the publication presupposes that DOT's may use the existing ROW as a resource to earn income through the sale of sequestered carbon credits but only after they have become a member of a trading group such as the Chicago Climate Exchange (CCX), which at this time is a voluntary but legally binding market for buying and selling of carbon credits.

In order for the Florida Department of Transportation (FDOT) to join a trading group such as the CCX, an extensive verification process by an approved third party provider is required. At this time there is no precedent with another DOT in the country becoming a provider of carbon credits on the exchange, although the New Mexico DOT is working to establish criteria that would enable them to become a provider. Therefore, FDOT would need to establish baseline criteria for measuring carbon sequestration and then submit the proposal to the CCX for consideration. This effort would require extensive financial and staff support on the part of FDOT in collaboration with research institutions in the state university system.

If the proposal were approved by the CCX additional financial implications would arise through the procurement of a third party verifier who would formally establish the baseline level of emissions in the ROW following the approved methodology and report the information to the CCX. Additionally, once the baseline emissions are established the FDOT would need to subsequently revise its management practices within the ROW to the extent that it reduces carbon output in accordance with the CCX's prescribed emission allowances to create credits

that could then be sold on the exchange. While not fully explored during this research it is presupposed that changes in management practices may result in increased cost expenditures, such as replacing fleet vehicles in favor of more fuel efficient models, thereby offsetting the gain in carbon trading. Further cost would be incurred as the FDOT would be required to procure annual verification with the CCX through a third party provider.

The report accompanying this memorandum explores the findings above in greater detail and provides recommendations to FDOT that allow further exploration into the possibility of becoming a provider The intent of the recommendations in the report suggest that FDOT should continue to actively monitor this opportunity and engage in discussions with likely partners to more fully evaluate the possibility of becoming a provider of carbon credits in an emerging market place. As national policy continues to evolve and other DOT's across the country research the feasibility of becoming carbon credit provider's new opportunities may arise making this opportunity more advantageous to FDOT.

Wood+Partners Inc.
Landscape Architects
Land Planners

Memorandum

Date: December 12, 2008
To: Jeff Caster, Tim Lattner
From: Shawn Kalbli / Sine Murray / Meghan Mick
CC: Dave Malcolm
Re: Carbon Sequestration along FDOT Rights of Way

Project: FDOT Services Consultant
Project No.: 02-08025

The FHWA Carbon Sequestration Pilot Project (CSPP)

Wood+Partners Inc. (WPi) spoke with Steve Earsom of the FHWA Water & Ecosystems Team regarding the Carbon Sequestration Pilot Program (CSPP) in New Mexico. Mr. Earsom indicated that the pilot program is progressing well. They are still working through many details regarding baselines, quantification techniques, verification, and the eventual sale of credits. As such, specific details about the program are still forthcoming. Mr. Earsom expects the final report to be made available to all DOTs sometime between February and May of 2009. They have discussed expanding the project but have put those plans on hold for the time being due to staff constraints. WPi will follow-up with Mr. Earsom in early 2009 to obtain a copy of the final report for the pilot program.

Contact information for Steve Earsom:
FHWA Water & Ecosystems Team
1200 New Jersey Ave. SE
Washington, DC 20590
202.366.2851
steve.earsom@dot.gov

The Chicago Climate Exchange

In order to earn revenue from right-of-way (ROW) carbon sequestration the Florida Department of Transportation (FDOT) would have to become a member of a trading group, in this case The Chicago Climate Exchange (CCX). Information on becoming a member of the CCX can be found in Attachment 1 to this document, entitled *Chicago Climate Exhange® Membership for Cities, Counties and States*. The CCX is the only operational emissions reduction and trading system in North America. CCX has nearly 300 Members and Offset Projects worldwide. The CCX is a voluntary and legally binding integrated trade system that is dedicated to the reduction of all six major greenhouse gases byway of offset projects worldwide. The basic premise upon which CCX operates is to facilitate the exchange (cap and trade) of surplus / banked allowances and offsets of emissions. It is important to note that the CCX is not a regulated exchange but the Financial Industry Regulatory Authority (FIRNA) acts as CCX's regulatory provider. While not currently regulated, the premise of the CCX suggests that as more companies, and perhaps most importantly, countries move towards a regulated form of emissions reduction such as required in the Kyoto Protocol, the need for a regulated market will arise. The CCX is a proving ground of sorts for a cap and trade system of emissions surplus and offset trading. To date

membership on the CCX has attracted the likes of Ford Motor Company, DuPont, and the States of New Mexico and Illinois.

Both New Mexico and Illinois could serve as references as to the benefits, costs, and membership process for state entities. A conversation with Steve Reed of the New Mexico Department of Transportation (NMDOT) did provide some insight into the specific experience of the DOT and carbon sequestration within right-of-ways (ROWs). See the section below for a synopsis of the interview with Mr. Reed. An attempt has also been made to contact Illinois in regards to their experiences as a member of CCX. More information pertaining to IDOT will be forward as it becomes available.

Members of the CCX make a voluntary but legally binding commitment to the CCX Emission Reduction Schedule and are subject to annual emissions verification that is performed by a third party CCX approved verifier. An estimate of the costs associated with the verification process was briefly explored as part of this research. Additional information pertaining to costs associated with the verification process are explored in the section below. The process for offset project registration is outlined as follows:

- Step 1 – Submit project proposal and / or project question to CCX
- Step 2 – Obtain independent project verification
- Step 3 – Register as a CCX Offest Provider or Offset Aggregator
- Step 4 – Receive Carbon Financial Instrument contracts for project offsets

More information on the steps listed above can be found in Attachment 2 to this document, entitled *Chicago Climate Exchange Offsets Program*

All CCX emitting Members must include all direct emissions and may opt-in indirect emissions. Direct emissions result from the on-site combustion of fossil fuels, such as natural gas to power industrial operations and gasoline to operate vehicle fleets. Indirect emissions result from energy purchases, such as electricity, and their corresponding emissions. Members are allocated annual emission allowances in accordance with their emissions Baseline and the CCX Emission Reduction Schedule. In Phase I, Members commit to reduce emissions a minimum of 1% per year, for a total reduction of 4% below Baseline. In Phase II, CCX Members commit to a reduction schedule that requires year 2010 emission reductions of 6% below Baseline at minimum. Members who reduce beyond their targets have surplus allowances to sell or bank. Therefore, members can also become Offset Providers: Offset Providers are owners of title to qualifying offset projects that sequester, destroy or reduce GHG emissions. Offset Providers register and sell offsets directly on the CCX. FDOT would likely be considered an entity with direct GHG emissions, and as such it could not register with the CCX as solely an Offset Provider. The Department's potential to be a high provider of offsets cannot be determined until the verification process is complete.

The annual fees for membership in the CCX will depend on the baseline level of emissions and includes the cost of an annual verification audit. CCX members that will be entering into transactions on the CCX Trading Platform must also qualify as an Eligible Commercial Entity as defined in Section 1a(11) of the Commodity Exchange Act. It is recommended that FDOT work with staff to determine the applicability of the Commodity Exchange Act to more accurately assess eligibility for status as a Eligible Commercial Entity. More information regarding the Commodity Exchange Act can be found at http://www.cftc.gov/lawandregulation/index.htm.

The CCX and New Mexico Department of Transportation

WPi spoke with Steve Reed of the New Mexico DOT in regards to his department's experience as state members of the CCX. The NMDOT intends to use the vegetated ROWs to obtain carbon credits and become an aggregator. Mr. Reed explained that the current verification protocols for forest land and agricultural land do not apply to state highway ROWs. He and his team are currently developing the mechanism and protocols required to figure out credits produced in the ROWs. They are teaming with researchers at New Mexico State University that were involved in developing the protocols for agricultural carbon credits. As such there is no indication that any state has compiled verification protocols for ROWS.

Mr. Reed expressed interest in working with the FDOT to develop the protocols for carbon sequestration in the ROWs. He also stated that CCX has been cooperative in assisting his department to find needed research
.
Steve Reed's contact information is (505) 827-5254 or Steve.Reed@state.nm.us.

Verification

It was believed that a verifier would be able to answer lingering questions regarding costs and benefits of becoming a member of the CCX, as well as questions regarding protocols for Highway ROWs. After an attempt to contact a number of verifiers, WPi was able to speak with a CCX approved Forestry verifier. Ernest Lovett, of Larson McGowin explained that an approved verifier would not be able to help with the development of the protocols because it would be viewed as a conflict of interest. Verifiers serve mostly as auditors for the process. Mr. Lovett explained that the FDOT would need to provide scientific research to prove that carbon is being sequestered in the ROWs. He suggested working with the Florida state universities to develop the protocols. Since the ROWs are on state land, FDOT could probably receive grants and funding to have the research completed. At this time there no precedent available to suggest the cost implications associated with becoming a provider or for annual verification renewal.

Ernest Lovett's contact information is (870)304-9419.

Action Items

- WPi recommends that FDOT initiate a conversation with the NMDOT and / or the CCX about possibly teaming up to develop the protocols to determine carbon sequestration in ROWs.

- FDOT should consider working with the Florida state universities and extensions to begin their own research or pilot program for ROWs.

- FDOT should prepare a summary presentation outlining their findings for delivery to senior management in order to obtain support for further advancement of the process
- Upon further research and conversation FDOT should evaluate the opportunity to establish protocols for determining carbon offsets along the ROW

- If the decision is made to proceed with the development of ROW protocol the FDOT should strengthen their partnership with the CCX to guide the process and provide feedback

- During development of the protocol FDOT should solicit input from approved providers to fully evaluate one-time and annual costs associated with the program

- Upon completion of the above action items FDOT should reconvene with senior management to determine final project feasibility

Additional information regarding the Chicago Climate Exchange can be found at http://www.chicagoclimatex.com/index.jsf.

Additional information regarding the Financial Industry Regularity Authority can be found at http://www.finra.org/index.htm.

For more information about joining the CCX, FDOT may contact Steve D'Onofrio @ (800) CCX-4600

Successes in Stewardship

http://www.environment.fhwa.dot.gov/strmlng/es4newsltrs.asp

September 2008

Carbon Sequestration Along Highway Rights of Way: Piloting a Concept

State transportation agencies often find themselves balancing environmental concerns against the financial feasibility of actions to alleviate those concerns. As one major environmental concern — climate change — is increasingly understood, governors, state legislatures, and the federal government are exploring ways to reduce emissions of greenhouse gases, particularly carbon dioxide (CO_2). Because vegetation naturally removes ("sequesters") CO_2 from the air, state transportation agencies have an opportunity to reduce their total emissions and even earn revenue by changing vegetation-management practices in their state department of transportation (DOT)-owned rights-of-way (ROW).

To explore this potential, the Federal Highway Administration's (FHWA) Office of Natural and Human Environment is conducting a Carbon Sequestration Pilot Project (CSPP). The goals of the project are to quantify the amount of carbon that can be sequestered using native vegetation management on DOT lands and to estimate the revenue that could be generated through the sale of "carbon credits" on an emissions trading market.

What types of carbon sequestration are there?

Vegetative sequestration is the natural intake of CO_2 by plants, which incorporate it in their wood, leaves, and roots and also bind it to the underlying soil. Much of this CO_2 is not released into the atmosphere until the plant is destroyed (by decay or burning) or the soil is tilled and exposed to the atmosphere.

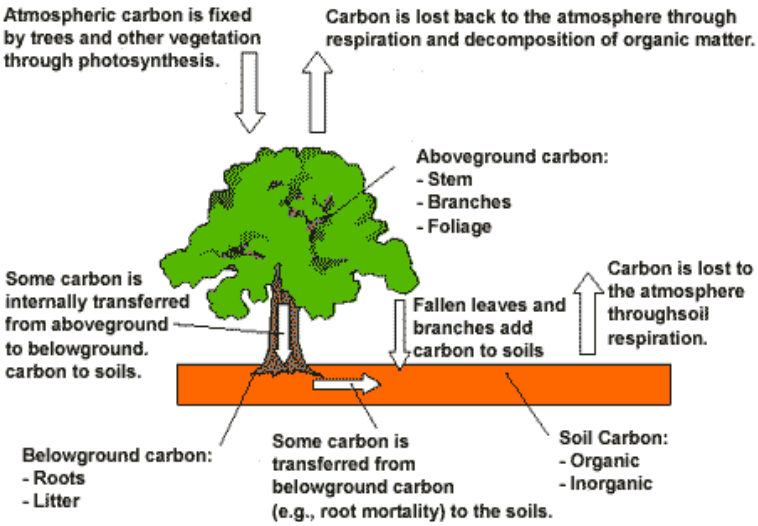
Geologic sequestration starts with the mechanical capture of CO_2 from an emissions source (e.g., a power plant). The captured CO_2 is injected and sealed into deep rock units.

Carbon Sequestration in Plants: the Basics

CO_2 is the greenhouse gas produced in the largest volume by human activities. Reducing CO_2 levels in the atmosphere is the goal of most efforts to slow global warming. There are two ways to reduce CO_2 concentrations in the air: (1) do not allow CO_2 to enter the atmosphere (i.e., control emissions), and (2) remove some of the excess CO_2 already in the atmosphere and "sequester" it where it does less harm.

Plants naturally perform this second action, capturing CO_2 for use in photosynthesis. Although individual plants die and decompose, grasslands and forests eventually reach steady states in which the amount of CO_2 released by dying plants is offset by new plants. Depending on the climate and vegetation type, forests annually sequester between 1.0 and 2.5 tons of CO_2 per acre, while grasslands sequester between 0.3 to 2.5 tons per acre. Young forests and grasslands can sequester substantially more than this on an annual basis, while "old growth" forests are closer to equilibrium.

An Illustrated Guide to the Carbon Cycle



(Source: USEPA at www.epa.gov/sequestration/local_scale.html)

With this in mind, FHWA selected the New Mexico Department of Transportation (NMDOT) to quantify and encourage the growth of existing trees, bushes, and native grasses growing in state-owned ROW that would sequester atmospheric CO_2.

Selling ROW Carbon: Cap and Trade

In addition to being good for the environment and human health, the appeal to state DOTs of sequestering carbon in highway ROWs is that it offers the opportunity to use existing resources to earn income. To earn revenue for the CO_2 sequestered in vegetation, an entity — in this case a transportation agency — must become a member of a trading group,

such as the Chicago Climate Exchange (CCX). CCX is a voluntary but legally binding market for buying and selling carbon credits. For more details on CCX, go to their website: www.chicagoclimateexchange.com.

The trading process is part of a "cap-and-trade" system, an economic incentive tool for reducing pollutants in the atmosphere. In the U.S., where cap-and-trade is already mandated by the Environmental Protection Agency for acid rain pollutants, a cap, or upper limit for the pollutant that can be emitted annually into the atmosphere, is established. The government then allocates portions of this total volume to the major emitters in the economy; i.e., each entity would be able to emit up to a certain annual allowance. The total of all allowances would equal the countrywide cap. Entities then either pay extra if they exceed their pollutant allowance or profit if they emit less than their allowance and sell the resulting credits. One potential advantage of cap-and-trade is that it does not mandate how the polluting entity meets it target, allowing the flexibility to reduce costs.

The CCX standard for carbon sequestered by forests is 1.0 metric ton per acre, and between 0.4 and 1.0 metric tons per acre for grassland. Market prices have recently varied between $1 and $30 per metric ton, meaning that 1,000 acres of forest could generate revenues between $1,000 and $30,000 annually.

NMDOT's Participation in the CSPP

Through an iterative process that narrowed the field of potential participants to three candidate state DOTs, NMDOT was selected to participate in the FHWA CSPP based on its alignment with various criteria, including, among other factors:

- National Highway System rural road mileage
- Total state acres of potential forest and grassland if allowed to grow naturally
- Data on the amount of different vegetation types
- Presence of state policies or indicators that would encourage participation
- Self-expressed interest in potentially participating
- State membership in an emissions-trading platform.

An example of the kind of native vegetation growing in the ROW that NMDOT will be quantifying to determine the amount of CO_2 that can be sequestered.

The state of New Mexico is already a member of CCX, and NMDOT is moving to register its qualifying native vegetation acreage of grassland and forest. As next steps in the pilot, which is scheduled for completion at the end of 2008, FHWA plans to work with NMDOT to help quantify and verify the acres available for carbon sequestration and to estimate the vegetation costs and potential value of marketable credits. The pilot is expected to substantially assist NMDOT in meeting its emissions reduction goals, thus reducing fuel costs from mowing and generating revenue. This emissions reduction can be used as carbon credits if the state comes in under its cap, and may be just as beneficial as carbon sequestration. However, the vegetation associated with carbon sequestration is beneficial in other ways, potentially providing habitat for wildlife, preventing erosion, and reducing storm water runoff.

With agencies facing the challenge of doing more while spending less, NMDOT's participation in the pilot project is expected to demonstrate the benefits of sequestering CO_2 in vegetation within the highway ROW and help inform future transportation and climate change legislation.

Contact Information

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Look What's New!

Read FHWA's new report on climate change and transportation – *FHWA Issues Report on Integrating Climate Change into Transportation Planning*

Read FHWA's new report on Meeting Environmental Requirements of Bridge Collapse, which details effective practices in expediting post-bridge collapse environmental review from five case studies around the country.

Successes in Stewardship is a Federal Highway Administration newsletter highlighting current environmental streamlining and stewardship practices from around the country. To subscribe, visit http://environment.fhwa.dot.gov/sis_registration/Register.aspx or call 617-494-3137.

CHICAGO CLIMATE EXCHANGE®

MEMBERSHIP FOR CITIES, COUNTIES AND STATES

"… governors… around the U.S. don't have to sit on their hands. Like major corporate partners who recognize the threat of climate change, they can make the binding commitment to the Chicago Climate Exchange, and move our nation forward to a new energy and emissions future."

- Governor Bill Richardson, State of New Mexico

WHAT IS CCX®?

Global climate change is one of the most pressing environmental issues facing our world and future generations. Climate change is associated with the direct and indirect emission of greenhouse gases (GHGs), primarily through the combustion of carbon-based fossil fuels. To address this problem and achieve reductions in GHG emissions, CCX administers the world's first and North America's only legally binding, rule-based and integrated GHG emission registry, reduction and trading system.

To date, CCX Members include utilities such as **American Electric Power** and **Green Mountain Power**; corporations like **Ford Motor Company** and **DuPont**; cities such as **Boulder**, **Oakland** and **Chicago**; educational institutions such as **Tufts University** and **University of Minnesota**; organizations such as **World Resources Institute** and **Rocky Mountain Institute**; farmers and the **Iowa Farm Bureau**; and the **State of New Mexico**, the first state to join CCX.

GOALS OF CCX

>> To establish GHG emissions trading with transparency, design excellence and environmental integrity

>> To build the skills and institutions needed to cost-effectively manage GHGs in both public and private sectors

>> To strengthen the intellectual framework required for cost-effective and valid GHG reduction

>> To incorporate a diverse portfolio of credible GHG emissions offsets from forestry, agriculture and other projects

>> To help inform the public debate on managing the risk of global climate change

"WHEREAS... BE IT FURTHER RESOLVED that the U.S. Conference of Mayors encourages U.S. mayors to strongly consider Membership for their cities in the Chicago Climate Exchange."

- Passed Unanimously June 13, 2005, U.S. Conference of Mayors Annual Meeting

BENEFITS OF MEMBERSHIP

>> MORAL SATISFACTION OF ACTION NOW – For citizens and future generations – the essence of sustainable development

>> "LEADERSHIP BY EXAMPLE" – Government leads, others follow

>> ONE-STOP IMPLEMENTATION FOR "GREEN GOVERNMENT" – Focus efficiencies across all departments - good governance and best practices for public budget

>> ACQUIRE "TURNKEY" EMISSIONS MANAGEMENT SYSTEM – State-of-the-art, no extra cost

>> MASTER EMISSIONS INVENTORY DATA – Essential for any GHG goal

>> BETTER LINK PROCUREMENT PRACTICE TO GHG POLICY – Weigh options, spend wisely

>> BE SURE OF THE NUMBERS – Independent verification via the NASD

>> LEARN BY DOING – Unique experience for energy management

>> DEVELOP NEW STAFF AND TECHNOLOGICAL CAPACITIES

>> EARN POSSIBLE REVENUE – Be a seller through emissions reduction

>> REDUCE COST-EFFECTIVELY, EVEN IF BUYER – While technology and policies advance, buying allowances may be most cost effective option

>> POTENTIAL TO BUY AGRICULTURAL OFFSETS FROM FARMERS – Link urban and rural constituencies

>> GOVERNMENTS SET STANDARDS – "First mover" role – CCX synergistic with all policy, precludes none, whether state, regional, national, voluntary or mandatory

>> JOIN THE GLOBAL CCX FAMILY – Multi-sectoral Members with a mutual goal

>> GAIN MEDIA RECOGNITION – CCX and its Members are widely covered in international press

>> PREPARE FOR GLOBAL TRADING ACTIVITIES AS STATE, NATIONAL AND INTERNATIONAL POLICIES EVOLVE

"My vision for Chicago is to become a national showcase for 21st century urban environmental stewardship, with a high quality of life for citizens and a reputation for economic innovation on behalf of the public good. Membership in CCX is an important step in fulfilling that vision."

- Chicago Mayor Richard M. Daley

"By joining CCX, we are joining a global family to address a global problem."

– City Council Report
Oakland, California

BECOMING A MEMBER OF CCX

CCX Membership for governmental entities covers emissions from public facilities only, i.e., emissions derived from operation of government. Direct emissions result from burning fossil fuels, such as natural gas and fuel oil; indirect emissions result from purchased electricity and its corresponding emissions. Membership fees are tiered and levels are based on total emissions tonnage.

STEPS TO MEMBERSHIP

1. Assemble inventory and baseline; gather aggregated energy data for CCX baseline period for all operations (energy generation, electricity and natural gas purchases, green power purchases, vehicle fleets).
2. Submit baseline data to CCX – CCX provides preliminary analysis and GHG conversions.
3. Weigh reduction trends planned - establish reduction schedule.
4. Make legally binding CCX reduction commitment – join CCX.
5. Demonstrate progress through annual true-up – buy, sell, trade.
6. Opportunity to participate in CCX committees.

REDUCTION COMMITMENT

Members make a voluntary but legally binding commitment to reduce GHG emissions. By the end of Phase I (December 2006), all Members will have reduced direct emissions 4% below a baseline period of 1998-2001. Phase II parameters, which extend the CCX reduction period through 2010, will require all Members to reduce GHG emissions 6% below baseline. Reductions are in absolute tons. Members that do not meet this goal must buy allowances to come into compliance, or purchase project-based offsets. For cities, membership includes emissions from city-owned operations only. Indirect emissions are included on an optional basis.

CCX REGISTRY AND ELECTRONIC TRADING

The internet-accessible CO_2 trading platform provides low-cost, real time trading of Carbon Financial Instruments™ (CFI™s). Electronic trading in CCX's standardized CO_2 commodity provides price transparency to the market. All trades are guaranteed by CCX and cleared through its proprietary clearing and settlement systems. The internet-accessible CCX Registry is the official holder of Members' emissions data and serves as the recording and transferring mechanism for CFIs. The CCX Registry is integrated with the CCX electronic trading platform.

AUDITING, VERIFICATION AND MARKET OVERSIGHT

CCX has contracted with the National Association of Securities Dealers (NASD), a leading provider of regulatory services, to assist in the registration, market oversight and compliance procedures for CCX Members. NASD audits a representative sampling of each Member's emission baseline and annual true-up, and reviews offset project verification procedures. NASD utilizes its state-of-the-art market surveillance technologies to monitor CCX trading activity. To ensure environmental integrity, offset verification services are provided by CCX-approved verifiers and are required for all offset projects.

CATEGORIES OF CCX MEMBERSHIP

CCX MEMBERS have direct GHG emissions from facilities in the U.S., Canada or Mexico and make a voluntary, legally binding commitment to reduce or trade emissions in order to comply with the CCX reduction schedule.

CCX ASSOCIATE MEMBERS have insignificant or no direct GHG emissions and make a voluntary, legally binding commitment to 100% offset indirect emissions, annually, entity-wide.

CCX PARTICIPANT MEMBERS include Offset Providers and Liquidity Providers.

OFFSET PROVIDERS are project owners, project implementers and registered aggregators that sell Exchange Offsets produced by qualifying CCX-registered Offset Projects.

LIQUIDITY PROVIDERS engage in market-making activities on the Exchange for purposes other than compliance with the CCX emission reduction schedule.

CCX EXCHANGE PARTICIPANTS are entities that establish a CCX Registry Account for the purpose of acquiring and retiring CCX Carbon Financial Instruments (CFIs), the CCX tradable commodity.

FOR FURTHER INFORMATION OR QUESTIONS CONTACT:

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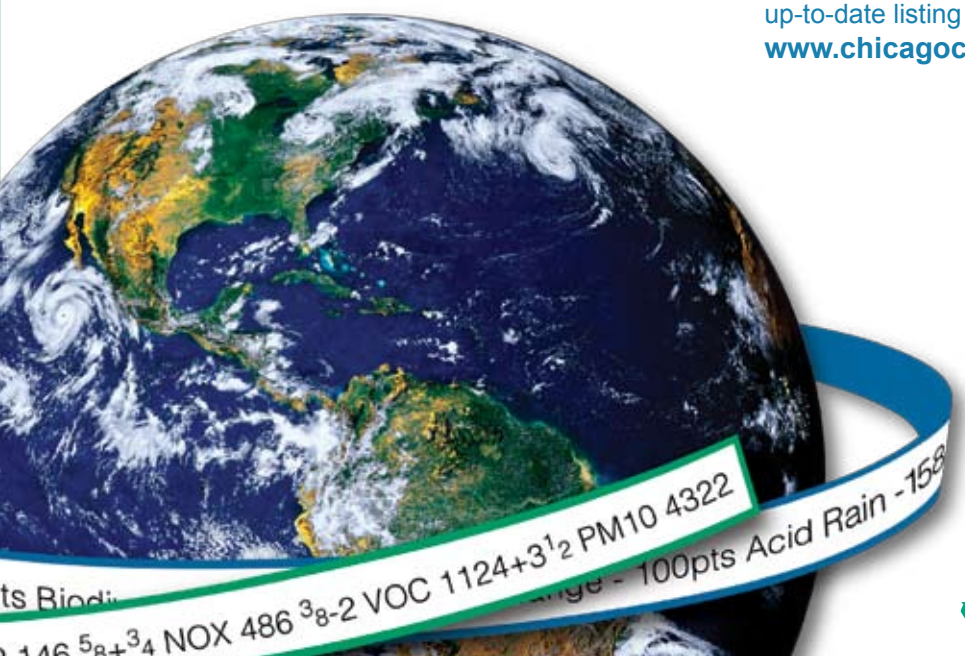
Please see our website for an
up-to-date listing of our Membership:
www.chicagoclimateexchange.com.



Chicago Climate Exchange Offsets Program

CCX Overview

Chicago Climate Exchange® (CCX®) operates the world's first and North America's only active voluntary, legally binding greenhouse gas (GHG) emission cap and trade program. CCX emitting Members execute legally binding commitments to reduce emissions, conform to standardized emission quantification and verification procedures and demonstrate annual compliance with specified emission reduction targets by achieving internal reductions and/or executing trades in surplus emission reductions and project-based emission reductions. The CCX tradable instrument is the Carbon Financial Instrument® (CFI®) contract. Each CFI contract represents 100 metric tons of CO_2 equivalent.

CCX Offset Project Overview

In order to broaden participation, increase cost-effectiveness of compliance and establish practical GHG mitigation initiatives in a broad range of sectors, CCX has established a defined set of categories of project-based emission offsets. Within these categories are prescriptive eligibility, evaluation and verification protocols. CCX has considered and approved a variety of unique offset projects, some of which were developed for participation within flexibility mechanisms of the Kyoto Protocol.

Eligible CCX Offset Projects

CCX, in cooperation with experts from the academic, industrial, government and non-governmental sectors, has developed and continues to establish eligibility criteria for a variety of offset project types. Currently, the following mitigation activities have prescriptive eligibility, evaluation and verification protocols:

- Landfill methane collection/combustion
- Forest carbon sequestration
- Agriculture methane collection/combustion
- Agricultural and rangeland soil carbon sequestration
- Coal mine methane collection/combustion
- Biogas digesters in rural India
- Renewable energy systems
- Best in class energy efficiency technologies

In addition to prescriptive projects, CCX has evaluated and approved several projects using eligibility criteria and evaluation and verification methodology developed for the United Nation's Clean Development Mechanism (CDM) and Joint Implementation (JI) mechanisms, including:

- HFC 23 destruction
- Renewable energy
- Waste heat recovery

CCX has reviewed and approved fuel switching and energy efficiency projects based in the U.S. and internationally on a stand alone basis. CCX also considers, through a committee comprised of Members and supplemented by respected experts, individual projects that do not fit in the above categories on a project-by-projects basis.

Chicago Climate Exchange

General Eligibility Criteria

CCX issues offsets to projects that result in the destruction or reduction of GHG emissions in the atmosphere, and to certain carbon sequestration initiatives. CCX has designed eligibility criteria that reward sustainable development, provide rules that are standardized and facilitate carbon finance and capital flows. In general, CCX requires that projects exceed regulatory requirements, are recent and are verifiable.

CCX rules allow projects from domestic and international markets. To prevent "cherry picking," CCX rules require that entities in developed countries with significant direct emissions take on the CCX emission reduction commitment in order to be eligible to register and trade offsets on CCX.

CCX Offset Project Approval Process

All CCX offsets must be evaluated and verified against CCX rules and methodologies approved by the CCX Offsets Committee. The Offsets Committee consists of individual representatives of CCX Member entities. The Committee meets monthly to review new project applications and to consider enhancements to existing rules and proposals for new offset project protocols.

Projects that are clearly consistent with established CCX protocols can receive an expedited approval. Projects that are not entirely consistent with CCX prescriptive protocols or are submitted using CDM or JI methodologies are presented to the Offsets Committee for consideration. The Committee may approve, deny or request further information concerning any proposed project.

All CCX offsets are issued on a retrospective basis, with the CFI vintage applying to the program year in which the GHG reduction took place. Projects must undergo independent third party verification by a CCX approved verifier. Verification occurs at least once per year for each year offsets are issued. All verification reports are reviewed by CCX staff and, if approved, are inspected for completeness by the Financial Industry Regulatory Authority (FINRA, previously NASD), the CCX auditor.

Upon review of the verification report, FINRA provides CCX with an assessment of its adherence to CCX verification protocols. Subject to final approval, CCX compliance staff issues offsets to the project owner or aggregator's CCX Registry Account. Once offsets are issued to the Registry Account, the project owner can access the CCX Trading Platform to offer the offsets for sale to other CCX Members.

CCX Offset Project Registration Procedure