A Bridge to Climate Protection

SLOWING GLOBAL WARMING BY MARKETING CARBON STORED IN FARMS AND FORESTS

ENVIRONMENTAL DEFENSE

finding the ways that work

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Environmental Defense staff who contributed to this report include: Janine Bloomfield, Robert Bonnie, Melissa Carey, Joe Goffman, and Zach Willey.

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Cover photos by Melissa Carey (left) and Getty Images (right).

Our mission

Environmental Defense is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

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Executive summary

The world's scientists have reached a broad consensus that the climate is warming as a result of human-caused emissions of greenhouse gases. While the primary culprit is the combustion of fossil fuels, land-use activities are also an important source of greenhouse gases. In considering policy options to confront global warming, U.S. policymakers must address the significant opportunities to change land-use activities to protect the earth's climate.

Forests and agricultural soils store vast amounts of carbon. As forests are cleared and soils are tilled, carbon dioxide (CO_2), the most abundant greenhouse gas, is released. Conversely, conserving forests, planting new ones, restoring grasslands, and reducing soil disturbance in croplands removes carbon dioxide from the atmosphere and stores it in plants and soils. Thus, forests and agricultural lands can, if managed properly, act as a carbon "sink," helping curtail global warming. Indeed, carbon sequestration in forests and agricultural lands can provide an effective, low-cost way to offset a portion of greenhouse-gas-emissions.

The global nature of greenhouse-gas emissions has sparked substantial interest in market-based approaches, particularly cap-and-trade programs, to address global warming. A market-based approach that allows businesses to offset their greenhouse-gas emissions by purchasing credits from landowners who increase carbon sequestration in forests and agricultural lands would result in faster and steeper overall reductions in emission concentrations. Such a market would also produce other significant environmental benefits such as wildlife conservation, reduced soil erosion, enhanced water quality and increased income for farmers and forest landowners.

Creating incentives for carbon sequestration could prove to be an important "bridging strategy" in U.S. efforts to combat global warming. By providing a ready source of low-cost emissions offsets, a market in carbon sequestration credits would allow U.S. businesses to make cost-effective cuts in greenhouse-gas concentrations while developing new technologies to dramatically reduce emissions from fossil fuels. This is especially important since the nation must begin reducing net greenhouse-gas emissions now if we are to avoid significant and dangerous warming.

U.S. lands already constitute a sizeable carbon sink. U.S. forests and agricultural lands sequester about 246 million metric tons of carbon annually, taking up about 13% of annual U.S. greenhouse-gas emissions. With appropriate incentives, carbon sequestration in U.S. forests and agricultural lands could be increased by 50% or more, further reducing the U.S. contribution to global warming.

Environmental gains from a market in carbon sequestration credits depend, of course, on appropriate rules to ensure that land-use activities produce real, verifiable greenhouse-gas reductions. This report discusses challenges associated with incorporating carbon sequestration into a cap-and-trade program and concludes by offering a broad outline of how carbon sequestration activities can be integrated into a market-based framework to address global warming.

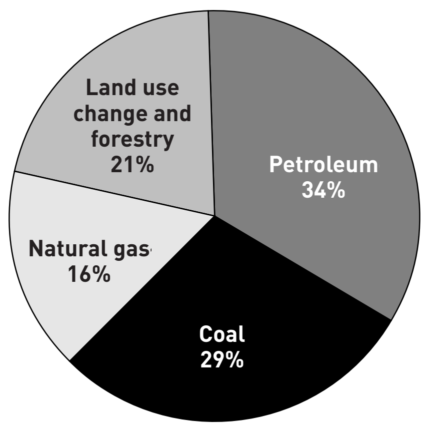
Introduction

Land-use activities contribute to climate change

Decades of research have confirmed that increasing concentrations of atmospheric greenhouse gases are major contributors to warming the Earth's climate.* Though much of this trend is attributable to fossil-fuel emissions, land-use change and forestry play important roles in climate change as well.

Forests and farmlands can act as natural carbon storehouses or "sinks" offering major opportunities to reduce global warming stemming from all sources of greenhouse gases. As forests grow, they absorb carbon dioxide (CO_2) from the atmosphere through photosynthesis. This carbon is then sequestered in wood, leaves, roots and soils.† The world's forests store vast amounts of carbon, but when they are harvested, burned, or cleared for agriculture much of the carbon stored in plant matter and soils is released into the atmosphere as CO_2.

FIGURE 1
Mean global CO_2 emissions: deforestation vs. fossil fuels



Source: Land use change and forestry emissions from IPCC, 2000. Fossil fuel emissions from USDOE, 1999.

Croplands and grasslands can contribute CO_2 emissions to the atmosphere in a similar way. Clearing and plowing land releases CO_2 by exposing soils to air and sunlight. Practices such as conservation tillage, grassland restoration and use of cover crops enhance carbon storage in agricultural soils, delivering benefits to the atmosphere as well as to the local environment.

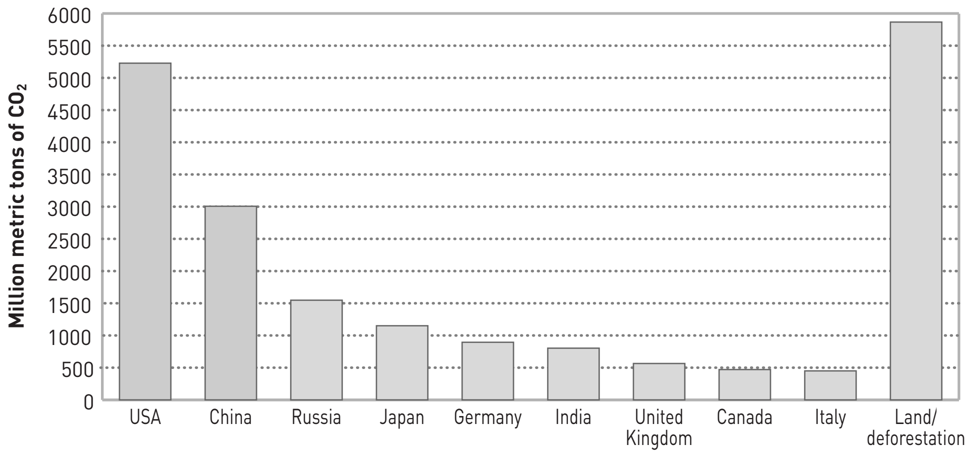
On a global scale, deforestation, land clearing and other practices cause a significant net increase in the total amount of CO_2 in the Earth's atmosphere. We can reduce this impact. By protecting and restoring forests, reducing tropical deforestation, restoring grasslands and improving cropland-management practices, we can help reduce atmospheric greenhouse-gas concentrations by "sequestering," or storing,

* The most abundant greenhouse gas is carbon dioxide (CO_2). Other greenhouse gases, including methane (CH_4) and nitrous oxide (N_2O), also contribute to climate change.

† Younger forests capture and store carbon faster than mature forests. In older forests, which store far larger amounts of carbon in total, sequestration rates can be low or even negative as older trees die and the carbon stored in tree biomass is released as CO_2.

FIGURE 2

Comparison of mean annual deforestation emissions (1989–1995) to fossil fuel emissions from selected countries (1995)



Source: National emissions figures from UNEP, 1996. Land deforestation figures from IPCC, 2000.

increasing quantities of carbon that would otherwise be released to the atmosphere. In addition to atmospheric benefits, these activities provide significant ancillary environmental benefits such as conservation of biodiversity, reduced soil erosion and protection of watersheds (Frumhoff et al., 1998).

Historically, releases of CO_2 from some land-use activities have contributed substantially to increased concentrations of greenhouse gases. A few hundred years ago, atmospheric concentrations of the gas were around 280 parts per million (ppm). Today, CO_2 concentrations have increased by nearly 100 ppm to approximately 371 ppm (Keeling and Whorf, 2002). According to the Intergovernmental Panel on Climate Change (IPCC), a significant proportion of this increase is the result of clearing forests and growing crops. The most recent report of the IPCC notes, “Hypothetically, if all the carbon released by historical land-use changes could be restored to the terrestrial biosphere over the course of the century (e.g., by reforestation), CO_2 concentration would be reduced by 40 to 70 ppm” (IPCC, 2000).

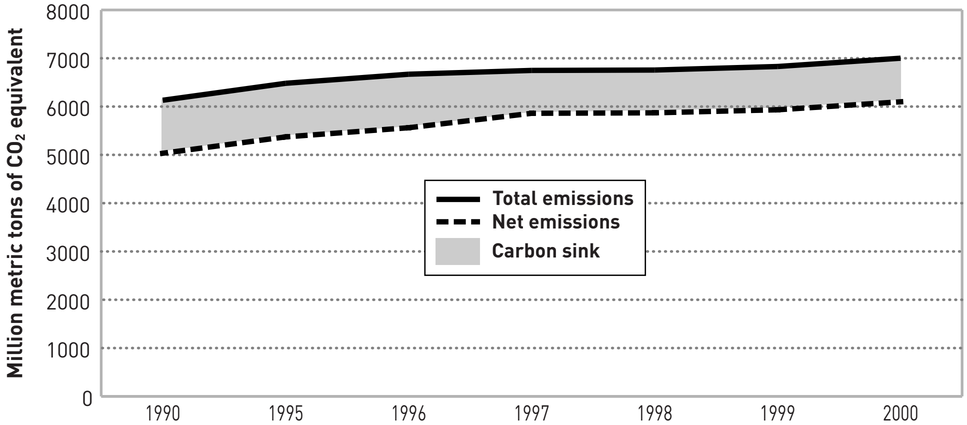
Land-use change continues to be a major source of emissions: in many parts of the world, land-use activities, particularly tropical deforestation, produce substantial greenhouse-gas emissions. Globally, 14.2 million hectares of tropical forest are deforested annually, contributing about 20% of human-caused CO_2 emissions (FAO, 1997 and IPCC, 2001). CO_2 emissions from global land-use change and forestry are of nearly the same magnitude as emissions from fossil-fuel combustion in the United States (see Figure 2).

Carbon sequestration in the United States

When Europeans arrived in North America, massive mature forests and vast native grasslands covered the continent. As population and settlement increased, intensive forest clearing and agricultural development changed the landscape dramatically. As noted earlier, these practices changed the composition of the atmosphere, as well.

FIGURE 3

U.S. net greenhouse gas emissions, 1990–2000



Source: USEPA, 2002.

Forest clearing in the United States peaked in the late 19th and early 20th centuries. Since that time, forest acreage in the United States has rebounded. As a result, today, the U.S. land base is a sizeable net carbon sink. (Caspersen, et al., 2000). According to the Environmental Protection Agency, lands in the United States annually sequester the equivalent of about 13% of total U.S. CO_2 emissions caused by the combustion of fossil fuels (USEPA, 2002). Figure 3 illustrates the size of the U.S. sink relative to total U.S. emissions. A Princeton University study estimates that U.S. lands sequester more CO_2, corresponding to approximately 20% to 46% of annual U.S. CO_2 fossil-fuel emissions (Pacala, 2001).* Even a modest expansion of the existing U.S. sink could substantially boost efforts to curb greenhouse gas emissions.

Biological carbon sequestration alone will not provide the reductions needed to stabilize atmospheric greenhouse-gas concentrations at a safe level. Over the next century, the vast majority of reductions must come from fossil-fuel emissions. During the next 50-100 years, however, carbon sequestration can play a crucial role in efforts to slow climate change. This "bridging" benefit can help jump-start actions to stabilize atmospheric concentrations of greenhouse gases and gain time to develop technologies to reduce CO_2 emissions from energy use. As discussed in subsequent sections of this report, biological carbon sequestration will be most effective if integrated into a market-based "cap-and-trade" program. Such a program would allow businesses to offset their greenhouse-gas emissions by purchasing credits from landowners who increase carbon sequestration in forests and agricultural lands.

Credible and transparent rules are necessary to guarantee that land-use activities produce real, verifiable greenhouse-gas reductions. Such rules are critical for biological carbon sequestration credits to be fully fungible and tradable in a market for greenhouse gas credits and offsets. The following sections discuss challenges associated with incorporating biological carbon sequestration into a cap-and-trade program and offer a broad outline of how carbon sequestration activities can be integrated into a market-based framework to address global warming.

* The EPA estimate is 902.5 million metric tons CO_2 ($MMTCO_2$) per year, while the Princeton estimate is 1,100–2,569 $MMTCO_2$ per year.

Creating market incentives

Learning from a proven model

Cap and trade, or "emissions trading," was pioneered in the United States. In 1990, Congress amended the Clean Air Act, establishing a cap-and-trade program to regulate power plant emissions of sulfur dioxide (SO_2), a precursor to acid rain. The acid rain program places an absolute limit, or cap, on industry-wide SO_2 emissions and allows electric utilities flexibility in how they meet their individual emissions caps. Companies either can reduce emissions from their own plants using the technology of their choice or they can strike a deal: a company that is unable to reduce its own emissions enough to comply with its cap can purchase "surplus" reductions—in the form of "allowances," or credits—from another company that was able to reduce its emissions *even lower than* its cap. Companies are free to seek out the most cost-effective means to meet their cap. Failure to meet the cap results in significant financial penalties. The acid rain program has seen 100% compliance, and SO_2 emissions have been reduced far beyond required limits at a fraction of previously projected costs.

Interestingly, greenhouse gas emissions are even better suited than SO_2 to a cap and trade program. SO_2 emissions cause impacts only downwind from the source. Global warming, by contrast, is the result of the cumulative release of greenhouse gases, particularly CO_2, worldwide. Therefore, a decrease in CO_2 emissions anywhere on the Earth will result in a global-level reduction of greenhouse gases. This characteristic of greenhouse gases makes them extremely well suited to a cap-and-trade program, as emitters can search an unlimited geographical area to find cost-effective emissions reductions and carbon sequestration opportunities.

At the international level, a market in greenhouse-gas-emissions-reduction credits is already emerging. Significant market activity is occurring in Europe, where many nations have adopted national emissions caps pursuant to the Kyoto Protocol and European officials have officially endorsed creation of a European market in greenhouse gas emissions reductions. And the volume of transactions is growing. Countries and companies traded an estimated 12 million metric tons of emissions credits in 2001, and transactions totaling 24 million metric tons have closed over the first six months of 2002. Some observers have estimated that number could rise to 68 million metric tons by the end of 2002 (World Bank, 2002).

A U.S. cap-and-trade program to address global warming would follow the model of the SO_2 reduction program by requiring electric utilities, manufacturers and other emitters to cap their greenhouse-gas emissions while allowing flexibility in the means to meet those caps. As in the acid rain program, regulated companies would have the option to purchase emissions credits through a market system.

Carbon sequestration and markets: Building a bridge

It is unlikely that industries will develop less polluting technologies overnight. However, if industries are subject to greenhouse-gas-emissions caps in the near term and if they know that further substantial reductions of these emissions are inevitable, they

U.S. potential for additional carbon sequestration: How much impact can we make?

Carbon sequestration has the potential to contribute substantially to efforts to address global warming. While the theoretical potential for carbon sequestration is significant, there are, of course, practical limitations, including competition for land for other purposes such as timber production, agricultural production and development.* Determining how much atmospheric CO_2 can be removed through carbon sequestration depends on a number of other factors as well, including the capacity of lands to sequester carbon, demand from industrial emitters, and the resulting price per ton of carbon sequestered. Price per ton is one the most important factors governing our use of carbon sequestration. The extent to which policymakers embrace the use of economic incentives to practice carbon sequestration will greatly affect the extent to which it is used. Simply put, higher prices for sequestered carbon will encourage higher levels of carbon sequestration activity.

Economic modeling techniques make it possible to assess the importance of economic incentives in determining how much carbon sequestration will likely be undertaken by U.S. land managers. Professors Bruce McCarl and Uwe Schneider recently published in Science magazine the most comprehensive modeling assessment to date of the sequestration potential of U.S. agricultural lands (McCarl and Schneider, 2001). McCarl and Schneider modeled the entire agricultural sector and examined the potential for soil sequestration, reforestation and production of biofuels. The authors found that if farmers were paid $50 per ton of carbon ($13.51 per ton of carbon-dioxide equivalent), the agricultural sector would sequester an additional 146.4 million metric tons of carbon-equivalent annually. This result suggests that if the United States were to attempt to reduce greenhouse-gas emissions to 1990 levels by 2008, then about one-third of the target could be garnered through sequestration on agricultural lands. It is important to note that it would take U.S. landowners several years to reach this level of annual sequestration output. Additionally, sequestration of this magnitude would not continue indefinitely: all forest and agricultural lands have a finite capacity for sequestered carbon. Over time, land will approach its maximum capacity for sequestering carbon and the rate of carbon sequestration will slow. The time taken for any given plot of land to meet its maximum capacity depends greatly on how degraded the land was to begin with.

The results of McCarl and Schneider's study is presented in Table 1 along with those of other economic analyses of sequestration potentials from various land use activities. Though the results of each individual analysis differ, the potential for carbon sequestration to reduce our impact on the atmosphere is clear.

TABLE 1

Summary of studies of projected potentials of various sequestration activities at given prices

Study author(s)	Land-use activities examined	Assumed value of each metric ton of carbon equivalent sequestered	Potential sequestration gains at assumed prices (MMTC)†	Estimated contribution to stabilization of U.S. greenhouse gases at 1990 levels (percent)
McCarl & Schneider (2001)	Agriculture reforestation	$10 $50	52 146	12% 33%
Adams et al. (1999)	Forest management and reforestation	$5–$21	16–73	4%–16%
Parks & Hardie, (1995) as reported in Adams et al. (1999)	Reforestation of agricultural lands	$21–$51	44–88	10–20%
Faeth & Greenhalgh (2000)	Agriculture	$23	3	<1%
Richards et al. (1993) as reported in Adams et al. (1999)	Reforestation	$9–$22	44	10%

* See, for example, R. Lal, J. Kimble, R. Follett, C. Cole. *The Potential of U..S Cropland to Sequester Carbon and Mitigate the Greenhouse Effect* (Sleeping Bear, Chealsea, MI, 1998), p. 128.

† Million metric tons of carbon

will seek easier, low-cost reduction options today while investing in research to develop new energy technologies for the future. Carbon sequestration can provide that low-cost option, acting as a "bridge" to a lower carbon future. We do not have to wait, nor *can* we, for a technological revolution to begin reducing greenhouse gases.

Carbon sequestration can be fully integrated into a cap-and-trade program, providing an immediate and low-cost option in a greenhouse-gas-reduction strategy. Regulations that cap greenhouse-gas emissions can grant industries the option of offsetting emissions by purchasing carbon sequestration credits from landowners who increase carbon storage in forests and agricultural lands. A market that allows carbon sequestration offsets will reduce the cost of compliance and the savings will, in turn, allow deeper and more rapid cuts in emissions than would otherwise be possible. Restricting emissions trading and the use of offsets, on the other hand, raises compliance costs and limits potentially productive and environmentally beneficial investments, making it more difficult to reduce emissions now and in the future.

In addition to helping address climate change, carbon-sequestration activities can bolster environmental protection in other ways. By storing vast quantities of carbon, forests, croplands and grasslands provide a valuable "ecosystem service" to society. They also provide many other benefits, such as protecting water supplies, wildlife habitat and open space. Despite these benefits, however, the marketplace traditionally has undervalued carbon sequestration and the many other services provided by ecosystems (Bonnie, et al., 2000). This stems from the lack of markets to establish economic values—prices—for these ecosystem services. As a result, it is difficult for a landowner to profit from protecting an ecosystem service by, for example, protecting wildlife habitat or restoring a native ecosystem and marketing these benefits. Ecosystems are often degraded or lost altogether because lands are economically valued through payments received for their production of food, fiber and wood and for commercial development. At the same time, ecosystem services such as endangered species habitat or watershed protection do not result in payment for their production.

Establishing a market value for carbon sequestration will generate significant additional environmental benefits, because the improved land-use practices that sequester carbon also benefit the local and regional environment.

The incentive provided by a price is important, because in the absence of economic incentives for enhanced sequestration, carbon storage rates in the United States will decrease. In fact, this decline is already underway. In 2000, U.S. forests (excluding carbon stored in wood products) sequestered 18% less carbon than they did in 1990 (USEPA, 2002). Creating a market for carbon-sequestration credits can help reverse this trend.

Sequestration as part of a comprehensive strategy

Given the potential of carbon sequestration to provide low-cost emissions-reduction credits, some fear that carbon sequestration will be the only compliance mechanism used by companies. Market forces and competition from energy alternatives, however, will preclude this outcome. Facing emissions constraints, businesses will most likely establish balanced portfolios of emissions-reduction and mitigation strategies, including investments in energy efficiency, fuel switching, offsets from other sectors

Project by project: Practical limits on carbon sequestration rates and returns

The potential benefits of carbon sequestration will only be realized if economic returns from sequestration are sufficient to motivate large numbers of landowners to alter their land-management practices. Landowners will factor in their lands' original productivity, the returns from current land-use practices, and the compatibility of sequestration activities with other land uses. Measurement, monitoring, verification and other transaction costs will affect the amount of viable carbon sequestration as well. These factors will vary widely across regions, landowners and sequestration activities.

Potential for forest lands to sequester carbon

Forest lands tend to accumulate more carbon per acre over time than agricultural lands. The U.S. Forest Service has examined the potential of individual lands in different regions of the United States to store carbon and found that forests can sequester as little as .3 tons of carbon per acre annually, and as much as 2 to 3.5 tons per acre annually (Moulton and Richards, 1990). However, the age and density of the forest, as dictated by previous harvesting or natural disturbance (e.g., fire, wind damage), significantly influence the rate at which carbon accumulates in trees, plants and soils. Certain forest-management practices, such as allowing managed forests to grow for longer periods between harvests (i.e., longer rotations or cutting cycles) and reducing soil disturbance, increase the total amount of carbon that accumulates in that forest.

Old growth forests, which because of their age accumulate carbon slowly, represent an enormous store of carbon. Loss of this carbon represents a far larger danger to the atmosphere than loss of a young forest that is sequestering carbon at a high rate, but without much density. The slowly accumulating—but large—forest is far more valuable in atmospheric terms than the smaller, newer forest. Thus, while some have suggested it, replacing mature forests with younger forests is a counter-productive mitigation strategy.

Potential for agricultural lands to sequester carbon

Agricultural carbon sequestration rates and total carbon storage potential depend on a number of factors including soil type, past management practices and weather. As with forest lands, other factors being equal, more nutrient depleted croplands will sequester carbon at a faster rate than more fertile lands. Soils that have been plowed repeatedly may be highly nutrient depleted. Alternatively, an agricultural field on which conservation tillage (tillage practices that conserve soil carbon) has been practiced for decades will sequester carbon at a slower rate because it is nearer its total capacity for carbon storage.

The Intergovernmental Panel on Climate Change estimates carbon could be sequestered at a global average of .2 tons per acre per year on moist, temperate agricultural lands under management activities that enhance sequestration. (IPCC, 2000). One Indiana farmer reported in testimony before the U.S. Senate Agriculture Committee that 27 years of no-till farming had yielded an average of 11 additional tons of carbon per acre to his soils (or .4 tons per acre per year, equivalent to 1.1 metric tons) (Kinsella, 2001).

A landowner's decision to enter the carbon market will depend on the economic returns from carbon sequestering practices as compared to alternative land uses and practices that do not integrate carbon crediting. In the case of conservation tillage, for example, income from carbon credits supplements crop income, and conversion to conservation tillage also reduces costs associated with operating tillage equipment and undertaking nitrogen fertilizer applications. In the case of reforestation of low-yield agricultural lands, the farmer could increase revenues from the land because of the value of the carbon stored, timber production and hunting leases. Income from carbon credit sales will not always be enough to tip the balance toward carbon sequestering practices. In some cases, farmers will see increased costs or risks in converting practices. Here, wider successful adoption by other farmers will be necessary to convince such farmers to switch. In other cases, selling the property to commercial developers may be an option for some farmers, and income from carbon credit sales and other ecosystem services alone will not likely be enough to forestall such sales.

Factoring in the cost of measurement

When calculating potential returns on a carbon sequestration project, both the buyer and seller will have to consider the cost of monitoring and verifying changes in carbon stocks on their land. Carbon stocks can be accurately measured. For decades, landholders have made highly accurate measurements of the carbon in forests and soils using direct sampling, remote sensing (e.g., aerial photography, satellite photos) or computer modeling. The existing challenge is balancing accuracy and cost-effectiveness on a large scale.

New techniques are showing that highly accurate, cost-effective measurement methodologies are available. Winrock International has developed techniques that measure carbon stocks in forests with precision levels above 95% at a cost of less than 25 cents per ton for large projects (Winrock International, 2001). However, carbon measurement will likely be more expensive among small- to medium-sized landholdings. In order to keep costs low, landowners may need to pool their lands in order to spread the fixed costs of measurement across many tracts. New measurement technologies offer the prospect of further reducing costs as well.*

*See, for example, Cremers, et al, 2001.

(e.g., methane capture from animal feedlots) and carbon sequestration.* A business' portfolio of emissions-reduction strategies will account for both the price of continuing emissions and the risks associated with different emission-reduction strategies. Relying solely on carbon sequestration activities to meet greenhouse-gas-emissions-reduction targets would not be a wise business decision with respect to reducing risks and minimizing costs.

In summary, carbon sequestration can provide ample, low-cost emissions reductions in the short to medium term, and for this reason sequestration offsets will be an important component of a comprehensive business strategy to build a bridge to a low carbon future.

* For an example of this portfolio approach to greenhouse gas emissions reductions, see Entergy Corporation, "Greenhouse Gas Reduction Commitment and 2001 Progress Report," www.entergy.com/content/corp/environment/ghg.pdf.

Nuts and bolts: integrating land-use activities into a cap-and-trade program

Integrating land use activities into a greenhouse-gas-cap-and-trade program requires that emissions-reduction credits from land use activities provide the exact same benefits as emissions-reduction credits produced in the energy, industrial or any other sector. In other words, emissions reduction credits produced in one sector must be fully equivalent to credits produced in any other sector in order to be fully fungible, or transferable, between sectors. Therefore, a cap-and-trade program that allows for the use of carbon sequestration offsets requires appropriate accounting mechanisms to ensure the environmental integrity of the program while at the same time avoiding overburdening land-use projects with excessive administrative and accounting costs.

The section below addresses accounting issues unique to biological carbon sequestration projects. These include, (1) the measurement of carbon in forests and soils, (2) the permanence of carbon sequestration, and (3) environmental safeguards. The subsequent section addresses so-called "additionality" and "leakage" issues, which are not unique to carbon sequestration but instead relate to emissions trading between sectors of the economy that operate under an emissions cap and other sectors that do not.

Key accounting issues: carbon sequestration projects

MEASUREMENT

Any accounting program for carbon offsets must ensure accurate measurement of carbon stocks. Carbon measurement in land use is quite feasible using field-based statistical sampling. New measurement technologies promise to reduce measurement costs, as well (Cremers, et al, 2001). Thus, a cap-and-trade program must simply require that measurement of carbon stocks in forests and soils meets some minimum standard for accuracy (such as a 90% confidence interval). Carbon sequestration projects should also be subjected to third party verification to ensure appropriate measurement techniques.

PERMANENCE: ENSURING THAT LAND-USE CREDITING RESULTS IN LONG-TERM ATMOSPHERIC BENEFITS

Carbon can be stored for very long periods in forests, grasslands and soils—witness, for example, old-growth forests of the Pacific Northwest. However, carbon sequestration in vegetation and soils can also be reversed by changes in management practices (e.g., plowing, timber harvest) or natural disturbances (e.g., forest fire, hurricanes). Integrating land-use activities into a greenhouse-gas-cap-and-trade program requires a mechanism to address the reversibility of carbon storage. Fortunately, methods can be devised to address this issue.

Accounting for permanence requires that users of credits generated through carbon sequestration be fully liable for replacing credits when carbon stocks are reduced for any reason. Thus, users of carbon credits generated through land-use activities must account for a loss of carbon stocks in one of two ways: they must either immediately replace any land-based carbon credits that are lost with an

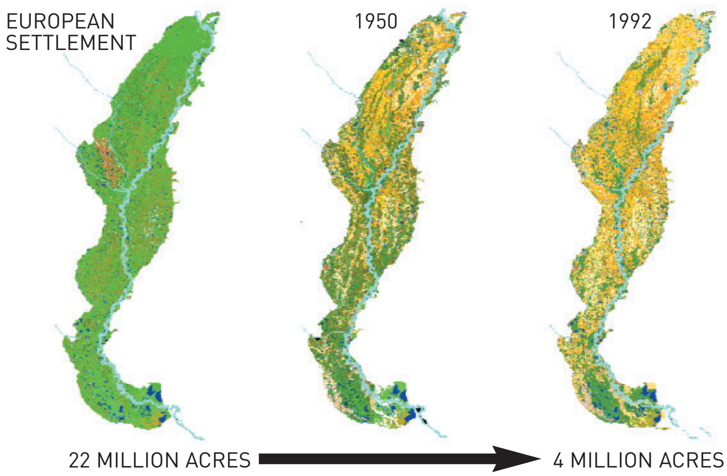
PILOT PROJECT

Mississippi delta reforestation

A viable U.S. carbon sequestration market would create a tangible value for important environmental services, creating an economic incentive for sustainable management of forests and farmland. Though there is not yet an official U.S. market for carbon sequestration, several pioneering projects demonstrate that such a market has the potential to advance protection of the climate and natural resources.

One of the regions of the country of greatest interest for its carbon sequestration potential is the lower Mississippi River valley. From southern Illinois south along the Mississippi River much of the former extensive bottomland hardwood forest has been converted to agricultural land. In the 1950s, this forest covered some 22 million acres; today it covers 4 million. These croplands are flood prone and can be marginally productive as a result. Conservation groups, the U.S. Fish and Wildlife Service and others show increasing interest in marketing sequestered carbon as a source of funding for reforesting the lower Mississippi River valley. For example, The Conservation Fund has worked with American Electric Power (AEP), Entergy and Texaco to restore bottomland hardwoods to the Mississippi delta. In one project, AEP provided funding to acquire 18,732 acres in Louisiana that will be reforested using native bottomland hardwood trees. Of this, over 8,115 acres will be added to the National Wildlife Refuge system. These lands will continue sequestering carbon for many decades as the trees mature.

The Lower Mississippi Alluvial Valley: A disappearing floodplain forest



Source: U.S. Fish and Wildlife Service.

equal number of credits from another source, or reflect the loss of the credits in their accounts. Such an accounting system will require on-going monitoring of all credited carbon stocks. Given on-going liability for credited carbon stocks, credits must be assigned a unique serial number so that they can be tracked through the trading system.

The requirement of full liability for any carbon losses will foster innovative mechanisms to manage the risk that carbon stocks may be lost. For example, carbon insurance could be developed to "back" carbon credits produced through land-use activities. Alternatively, some project developers might choose to "self insure" by accruing and holding, or "banking", unused sequestration tons to cover any potential future carbon stock losses.

From an investor's standpoint, the risk that carbon stocks may be lost as a result of fire, altered management regimes or other disturbance is no different than any other risk associated with investments in greenhouse-gas-emissions reductions. Investments in new pollution control equipment in power plants, in renewable energy projects, and in other emissions reduction activities all carry unique risks. Those risks can be managed. Thus, full liability for credit users, on-going monitoring, and the ability to track land-use credits will ensure that the reversibility of carbon stocks does not hamper efforts to reduce greenhouse gases.

ENVIRONMENTAL SAFEGUARDS FOR LAND-USE PROJECTS

As noted previously, crediting carbon sequestration activities in the land-use sector can produce substantial environmental co-benefits. Even so, an accounting system for land-use activities must include safeguards to ensure that carbon crediting does not create perverse incentives for degradation of ecosystems. Three primary areas merit the attention of policymakers.

First is the concern that carbon crediting may create incentives for converting an intact, natural ecosystem to other land uses, resulting in a diminution of wildlife

PILOT PROJECT

Sustainable agriculture in the Pacific Northwest

U.S. farmers have a growing interest in tapping the potential profits from cropping practices that increase carbon in soils. The Pacific Northwest Direct Seed Association (PNDSA), representing 300 farmers in Washington, Oregon and Idaho who collectively own approximately 500,000 acres, has joined with Entergy, a Louisiana-based energy company, to promote direct seeding. This minimal-tillage technique enhances soil carbon sequestration and provides a host of other benefits such as improved soil productivity, reduced erosion and better wildlife habitat. Entergy will lease 30,000 tons of carbon offsets over a 10-year period from participating landowners. Upon signing the deal with Entergy, Karl Kupers, vice president of PNDSA, explained, "We are excited about the positive implications this arrangement has for farmers, forward-looking industries and the environment."

Direct seeded lands, like these wheatfields in Northwestern Idaho, provide atmospheric benefits through soil carbon sequestration. Direct seeding practices also improve water quality by reducing agricultural runoff, benefiting endangered salmon and steelhead. (MELISSA CAREY)

Accounting for wood products

The treatment of wood products in a market framework has important effects on environmental protection and market integrity. Accounting for gains in carbon sequestration from wood products creates additionality issues that may be intractable because the creditable carbon would have to be additional to the existing supply of such products.* Determining what fraction of wood products produced by carbon sequestration projects is additional to the current supply will be very challenging. Crediting wood products could also create incentives for shorter timber rotations, thereby negating both greenhouse-gas benefits and some co-benefits of carbon sequestration activities. Thus, demonstrating net carbon credits stored in wood products appears to be infeasible in a U.S. carbon offsets program.

*For a discussion of the term "additionality", see page 14.

or other environmental benefits. This is of concern, for example, if a native forest were to be converted to a fast-growing tree plantation. This problem is most acute in existing forests and can easily be solved by requiring that reforestation activities be creditable only where the land has been in non-forest use for some minimum period (e.g., 10 years) prior to tree planting. Conversion of native grasslands to tree plantations is far less likely since grasslands tend to exist where water availability or climate prevents trees from growing, but the potential for this phenomenon nonetheless bears watching.[†]

Conversion is also an issue on croplands, not because of concerns about losing native ecosystems but because of potential gaming by landowners. For example, a landowner who has been practicing conservation tillage for years (and whose soil is thus near capacity for storing carbon) might plow his field in order to reduce carbon stocks. This would allow the landowner to establish a lower carbon baseline against which to measure carbon stock increases under conservation tillage, allowing the landowner to sell more credits. (In fact, this type of gaming actually may not work particularly well since soils can remain a net source of carbon for years after plowing.)

A potential way to prevent gaming of this sort is to reward landowners that have been using carbon-conservation practices for a number of years by granting them a fixed pool of carbon allowances for their past stewardship. Because cap-and-trade programs require a set number of greenhouse-gas allowances, allocating allowances in this way does not hurt the environmental integrity of the program.

A second issue that requires an environmental safeguard is the potential use of nonnative or genetically engineered species in carbon sequestration practices. Given the wide availability of native tree seedlings in the United States (including many that are very fast growing) and the substantial co-benefits of reforestation with indigenous species, reforestation with exotic or genetically engineered tree species should be closely regulated.

A third issue requiring safeguards pertains to international projects. Legal contracting in all land-based projects requires complete clarity of land title and ownership. If international land-use projects are allowed under a U.S. greenhouse-

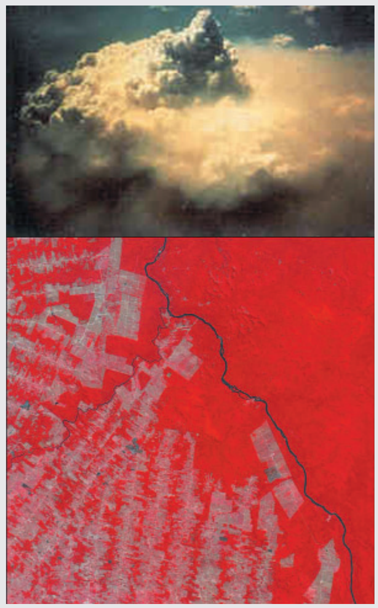
[†] Such perverse incentives to convert ecosystems for carbon purposes would be greatly reduced or eliminated in a full carbon accounting (FCA) system that records carbon debits (CO_2 releases) resulting from ecosystem lands conversions. Environmental Defense will outline a FCA system in a future publication.

PILOT PROJECT

Avoided deforestation in Brazil

International projects, particularly conservation of tropical rainforests, can combine atmospheric, ecological and social benefits. The Nature Conservancy has several projects in tropical countries designed to reduce rates of deforestation and restore native forests. The Conservancy's Noel Kempff Mercado Climate Action Project covers some 1.5 million acres of Bolivian rainforest. Partners include the Bolivian government, American Electric Power, Pacificorp and BP. These companies have contributed nearly $10 million to the project and, in return, will receive prospective carbon credits for reducing deforestation in the project area. Ecologists have shown that deforestation is a predictable process that tends to follow roads, human settlement and recently deforested areas.* Therefore, estimating the amount of carbon that would be sequestered required the partners to establish a baseline for deforestation trends for the area and calculate the project's impacts in slowing land clearing. This calculation was one of the first of its kind and has served to inform similar projects. The project also provides a path forward with respect to another issue, which is ensuring that forest protection at the project site doesn't simply result in increased demand for the timber in another location. As part of the project, the Conservancy is working with a local nongovernmental organization and the Bolivian government to reduce timber harvest in the area, provide funds for more sustainable activities such as agroforestry and heart-of-palm plantings, and assist local communities with medical facilities. The Conservancy's project will help reduce deforestation pressures, curbing greenhouse-gas emissions from the region, while simultaneously meeting the needs of the community in a sustainable manner.

* See, for example, Bonnie et al., 2000; NISR, 2002; Nepstad et al., 2002.



Top: NASA satellites help us appreciate the magnitude of tropical deforestation, as in this satellite photo of just one forest fire in Brazil (NASA, GODDARD SPACE FLIGHT CENTER). Bottom: An infared image delivered by satellite shows a predictable pattern of deforestation associated with roadbuilding in the Amazon (NASA, GODDARD SPACE FLIGHT CENTER).

gas-cap-and-trade program, then projects must respect the traditional land tenure of native people. In many developing countries, land tenure for native people is ill-defined. International sequestration projects should promote stewardship by native people and must respect their property rights. Thus, international projects must address, through a written and publicly available assessment, land tenure as it relates to indigenous people.

Key accounting issues: projects and the cap and trade system

All effective emissions trading systems contain one critical element: an absolute limit, or cap, on emissions of the regulated pollutant. This sector-wide cap is implemented by allocating a fixed number of emissions allowances—equal to the number of tons in the annual emissions budget—to individual sources of emissions within a sector.

Use of projects, however, essentially allows sectors that are not covered by the cap to produce new allowances (or, rather, “credits”) that can be used to meet the obligations under the cap. For example, an electric utility subject to a greenhouse-gas cap might purchase emissions-reduction credits from a landowner who has planted trees on abandoned agricultural lands. In all likelihood, that landowner (or any other landowner) would not be subject to a greenhouse-gas cap. Thus, such a trade occurs between a capped sector (power plants) and an uncapped sector (agricultural lands).

Trading between capped and uncapped sectors creates two issues: (1) “additionality”—or the need to ensure that carbon-sequestration activities result in real atmospheric gains that would not have otherwise occurred and (2) “leakage”—or the loss of atmospheric benefits from project activities because of changes in activities on nonproject lands.

ADDITIONALITY: CREDITING REAL REDUCTIONS IN ATMOSPHERIC GREENHOUSE GASES

It is important to ensure that credits purchased from an uncapped sector represent real, “additional” greenhouse-gas reductions; otherwise, the purchase and use of such credits will result in increased greenhouse-gas emissions. The fundamental question is how can it be assured that credits from uncapped sectors are indeed “additional?”

This question is best addressed by examining the U.S. land-use sector as a whole. As noted previously, the Environmental Protection Agency estimates that the United States land-use sector represents a net sink of about 246 million metric tons of carbon equivalent annually. Even though the size of the net sink is declining, it is still projected to occur for many more years, and is essentially therefore part of the U.S.’s baseline condition. It would not make sense to allow greenhouse-gas emitters to offset their emissions with credits resulting from this existing sink, since this would effectively allow an increase in their greenhouse-gas emissions without corresponding reductions elsewhere. Sequestration activities must increase the U.S. above and beyond this existing sink to be creditable.

About 93% of the United States’ net sink results from carbon sequestration by *existing forests.* Thus, the total tonnage of greenhouse gas offsets in question due to the additonality problem is much larger for existing forestlands than for agricultural and other non-forested lands. The issue of additionality is more complex with respect to management of existing U.S. forest lands. Ensuring that carbon credits produced in the forest sector are indeed additional would require projecting carbon stock changes under a “without-project” scenario and then comparing that to carbon stock changes from actual measurements. Domestically, there is little practical experience in undertaking carbon sequestration projects in existing forest lands and in proving additionality through “without-project” baselines. It is critical, therefore, that efforts be made to undertake projects in existing forest lands so that U.S. landowners and companies can gain practical experience in measuring real carbon gains in existing forest lands. In the meantime, legislation authorizing EPA to investigate and propose project-level methodologies for assessment of additionality should be enacted.

Principles and rules determine validity of sinks offsets as GHG credits

Effective policies on carbon sequestration will ensure the highest possible quality of greenhouse gas offset credits. Five broad categories of eligible carbon sequestration activities provide a framework for principles of quality control: (1) reforestation of forest lands that are currently not forested; (2) cropland management; (3) rangeland management; (4) domestic forest conservation; and (5) conservation of threatened tropical forests in developing countries.

Each of these five categories of activities should be subject to the same principles of measurement, permanence and verification. These rules should require minimum standards for measurement precision; assignment of full liability for any re-releases of credited carbon; periodic re-measurement; and third party credit verification. As described below, rules addressing additionality, leakage, and environmental safeguards should be applied to each activity category according to the significance of these issues within that project category:

1. Reforestation of currently nonforested lands

From an accounting standpoint, conversion of nonforested land to forested land is perhaps the most straightforward carbon sequestration activity. Additionality and leakage are not major hurdles to crediting: carbon is clearly added to the land, and agricultural production leakage is insignificant. Two important environmental safeguards are needed: first, in order to ensure that incentives are not created for land clearing (and the associated greenhouse-gas emissions) eligible lands must have lacked forest cover for a minimum of ten years prior to reforestation. Second, native species should be used whenever possible: strong carbon sequestration projects will benefit ecosystems as well as the atmosphere.

2. Cropland management

Carbon credits from changes in cropland management practices—such as switching from conventional to conservation tillage—have a clear "additional" benefit to the atmosphere. Such a switch has a neutral to positive effect on supply and thus a negligible leakage effect. To reward landowners who have historically been good land stewards, legislation creating a carbon sequestration offsets program should establish a fixed pool of carbon credits (or allowances) for landowners who are already using conservation tillage or no-till. Cropland management projects should account for non-sequestration benefits, as well. These range from reductions in use of fuel-intensive tillage equipment to reductions in NH_4 and N_2O-intensive fertilizer inputs.

3. Rangeland management

Rangeland management, including grassland restoration, altered grazing regimes and other practices, increases the carbon content of soils. Sequestered carbon can be measured through establishment of clear baselines and measurement and monitoring of increased carbon stocks. On-farm leakage—restoring grasslands in some areas while converting grasslands to crops in others—can be prevented using "whole farm," or entity-wide GHG accounting. USDA and EPA should be authorized to propose market leakage assessment methodologies for grassland restoration projects. Rangeland management projects should incorporate accounting for non-sequestration benefits, including reductions in non-CO_2 greenhouse gases.

4. Domestic forest management

Landowners can enhance carbon sequestration through lengthened timber rotations, thinning to encourage old growth, and other management practices. However, addressing leakage and additionality concerns is a special challenge for this activity category. New, legally-binding carbon contracts, including conservation easements, would provide some assurance that resulting carbon would provide additional atmospheric benefits. Such agreements could reduce the amount of the United States' existing sink brought into the greenhouse-gas-cap-and-trade program. They could also help ensure sequestration and environmental co-benefits over the term of the agreement.

USDA and EPA should be authorized to propose methodologies for assessment of both additionality and leakage for domestic forest conservation projects.

5. Conservation of threatened tropical forests

Projects addressing threatened tropical forests could be an important component of a carbon sequestration program. Tropical deforestation contributes about 20% of human-caused CO_2 emissions annually. Protecting these forests could produce low-cost emissions reductions, deliver needed capital to regions experiencing deforestation, and produce substantial environmental co-benefits.

As with U.S. forest-management projects, additionality and leakage are significant accounting issues for projects addressing tropical deforestation. USDA and EPA should be authorized to propose methodologies for assessment of both additionality and leakage in the context of tropical deforestation projects.

In any international project, land ownershipmust be clearly-defined to assure protection and maintenance of carbon credits. Well-established ownership patterns should be a requirement for carbon crediting from tropical-forest-conservation projects. Such projects should also explicitly address the effect of the proposed project on local peoples through a written assessment provided according to methodologies to be established by appropriate U.S. agencies.

LEAKAGE: ENSURING GREENHOUSE-GAS EMITTING ACTIVITIES AREN'T MERELY DISPLACED TO OTHER LANDS

Like additionality, leakage is an issue common to any greenhouse-gas-emission-reduction project that takes place in a sector without a cap on total emissions. Generically, leakage occurs when activities to reduce emissions or sequester carbon at one site result in increases in greenhouse-gas emissions in some other area. The classic example of leakage is a project that sequesters carbon by reducing logging of forests in one area and, in so doing, increases the intensity of logging in another area. Reducing logging in one section of forest may well *increase* carbon stocks in that location, but if it results in a *net decrease* in carbon stocks (i.e. through more intensive logging elsewhere to compensate for lost timber supply), then the result may be no net reduction in greenhouse-gas emissions.

It is important to note that leakage (like additionality) is not an issue for all land-use project types. Reforestation of marginal agricultural land, for example, is unlikely to result in significant leakage. Because U.S. farmlands over-produce agricultural commodities, it's unlikely that converting marginal agricultural lands to forests will cause other farmers to convert forests to agricultural lands to replenish the supply of agricultural products.*

On croplands, conservation tillage may actually increase crop yields because of improved soil fertility, eliminating leakage altogether. In grasslands, leakage could be a concern if farmers restore grasslands in one area while being allowed to convert grasslands elsewhere on their farms to crops. This can be addressed by requiring that carbon stock baselines for grassland restoration projects be established based on the extent of grasslands on a farmer's entire property three to five years prior to project initiation.

As in the case of additionality, leakage is of most concern for carbon sequestration projects in existing forest lands. Forest products markets in the United States are robust, and changes in supply in one region can be (and generally are) quickly compensated for in other regions. For example, when logging in the Pacific Northwest slowed to protect the spotted owl, harvesting shifted to the Southeast, and timber prices in that region rose accordingly. Reduced supply in one region increased harvests in another. This is leakage on a grand scale.

Measuring leakage in the forest sector is technically challenging. This gives more weight to the strategy described earlier: EPA should be authorized legislatively to investigate and propose methodologies to address leakage at the project level. Meanwhile, carbon projects on forest lands should be designed to minimize leakage problems, and should be undertaken with the clear understanding that successful crediting ultimately will depend on the effectiveness of this design.

The bottom line

U. S. forests and agricultural lands represent a sizeable carbon "sink." By creating incentives for foresters and farmers to increase carbon sequestration, the United

* Theoretically, reforestation of agricultural lands could also cause leakage by increasing timber supply, thereby lowering timber prices and causing some lands to shift to agriculture, which may be more profitable than remaining in forest use. Researchers at Resources for the Future have concluded that this type of leakage will be "very modest" (Sedjo and Sohngen, 2000).

States has a unique opportunity to leverage its expansive natural resources for the benefit of the atmosphere. A market for sequestered carbon and greenhouse gas emission reductions produced by changes in U.S. land management practices would offer U.S. businesses a readily available source of low-cost emissions reductions. Creating a cap-and-trade system for carbon sequestration activities can provide a critical "bridging strategy," giving U.S. businesses a means to reduce greenhouse-gas emissions immediately as they develop long-term technologies to reduce emissions from fossil fuels.

Through effective use of carbon sequestration:

- Businesses can meet greenhouse-gas-emissions targets more quickly and inexpensively.
- Farmers and foresters can increase their income.
- The United States can achieve faster and steeper overall emissions reductions.
- The rate of climate change can be reduced while society reaps the collateral environmental benefits of forest and biodiversity conservation, reduced soil erosion and enhanced air and water quality.

Because changes in land management practices can sequester carbon, reduce emissions of greenhouse gases, and provide so many additional benefits, policymakers have every reason to embrace carbon sequestration within a market-based policy to reduce greenhouse gases.

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finding the ways that work

National Headquarters
257 Park Avenue South
New York, NY 10010
212-505-2100

1875 Connecticut Avenue, NW
Washington, DC 20009
202-387-3500

5655 College Avenue
Oakland, CA 94618
510-658-8008

2334 North Broadway
Boulder, CO 80304
303-440-4901

2500 Blue Ridge Road
Raleigh, NC 27607
919-881-2601

44 East Avenue
Austin, TX 78701
512-478-5161

18 Tremont Street
Suite 850
Boston, MA 02108
617-723-5111

Project Office
3250 Wilshire Boulevard
Suite 1400
Los Angeles, CA 90010
213-386-5501