Agroforestry as a Carbon Sink[1]

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Introduction

This paper will focus primarily on the topic of carbon sinks, and how the development of international climate agreements, national policies, and private market mechanisms might result in new incentives for agroforestry practices in North America. Please note the term Amight.@ Much of the detail is caught up in current political debate, and until those debates reach some consensus, much of this information must be treated as somewhat conjectural.

But it is fair to say that the progress in defining carbon credits, and including them in the calculation of project benefits, has proceeded to the point where we can be fairly sure about what can be achieved. There are active private market tests underway, as well as a great deal of policy study within North American governments. Several organizations are actively designing and implementing agriculture and forestry projects to achieve measurable carbon credits (often called Carbon Emission Reduction Credits or CERC=s) and convert those credits into financial return to the landowners. These tests and studies are identifying what is possible and feasible. Hopefully, those experiences will help shape workable policies, but as we all know, policy formulation is a complex process that can produce unintended outcomes. Whether or not policies will eventually create a climate in which agroforestry projects are given new impetus remains, for the moment, an open question.

I am convinced, however, that the carbon sink potential in agriculture and forestry must be included in any scientifically credible approach to measuring national efforts to reduce greenhouse gas emissions. That is consistent with the recent decisions made in Bonn on the implementation of the Kyoto Protocol, and even though there are many more steps in the international decision making process, I expect those decisions to hold firm. If that is true, carbon credits can be the basis for both public programs and private markets that provide new incentives for land management practices that increase the amount of stored carbon in soils and woody crops. Those incentives could provide an important impetus for the implementation of agroforestry practices.

Some cautions are needed, however, because it is easy to get so focused on the carbon situation that we lose sight of the context in which land management practices operate. First of all, future carbon incentives, taken alone, are likely to be fairly modest in terms of financial return to the landowner. In every case I have analyzed, the other benefits of good agricultural, agroforestry, or forestry practices are more important than the carbon benefit, and dominate the landowner=s decision process. Where carbon benefits are most critical is at the margin, where one more dollar can make the difference in getting a practice installed.

The second caution is that the carbon benefits of agroforestry practices, as with other agriculture and forestry practices, are small on a per-acre, per-year basis. That means that, in order to attract market or policy attention, large areas will need to be brought into the program and maintained for many years. That, in turn, means large numbers of private landowners willing

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to make significant commitments. The institutional challenges involved in assembling large numbers of individual owners into any program are not lost on this audience and remain, in my view, the most challenging aspect of this situation.

The Basic Biological Context

I suspect that the basic science in this topic is well known in this audience, but we should begin with a quick review. Scientific evidence continues to demonstrate a link between the amount of atmospheric greenhouse gases and climate change. While not the most effective heat-trapping compound on a molecular basis, carbon dioxide is by far the largest of the contributing greenhouse gases, estimated to represent over 85 percent of the global warming potential contained in U.S. emissions for 1998.

Carbon dioxide moves from the atmosphere into terrestrial ecosystems through the process of photosynthesis; then moves back into the atmosphere through respiration, decomposition and combustion. Thus, it is possible for land managers to either reduce or increase the annual flux of CO_2 between earth and sky through changes in the way plants are grown, harvested, and utilized.

Terms that will be commonly used to describe these transfers will be Asource@ and Asink.@ Those refer to the process as it would be viewed from the atmosphere. A source is transferring carbon from the earth to the sky, and a sink is removing more carbon from the air than it is releasing.

These biochemical transformations between gas and solid compounds raise an issue for analysts that can sometimes cause errors. In most of the scientific literature, the amount of carbon contained in wood and soil compounds will be expressed as the weight of elemental carbon, usually expressed in terms of metric tonnes per unit area. On the other hand, atmospheric concentrations are usually expressed as CO_2. National emissions data and mitigation targets may be expressed in either CO_2 and C. The ratio between the two is simply the molecular weight B a ton of C is equivalent to 3.67 tons of CO_2, so either expression can be readily changed to the other. But it is easy to lose track of which term is being used in a given context, and when that happens, a 4-fold error in an estimate can occur.

The International Political Process

While there are uncertainties about the linkage between the buildup of greenhouse gases and climate response, there is one absolute certainty. To the extent the problem exists, it is a global problem, and must be addressed by global action. The international political process to shape action has been underway now for almost 20 years. While much progress has resulted, the process is far from complete. Many critical decisions lie ahead.

In order to follow the process, it is helpful to know some of the players, and some of the acronyms that are commonly used. The United Nations Environmental Program (UNEP) was founded in 1972. In 1985, the ozone hole over Antarctica was discovered, and it became clear that human activity was having impact on the global environment. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was created. It has involved over 3,000 of the world=s scientists in a series of studies designed to help identify scientific and technical aspects of the climate change issue. IPCC findings were instrumental in encouraging 154 nations to sign the U.N. Framework Convention on Climate Change at the first AEarth Summit@ in Rio de Janeiro in 1992. That launched a continuing process, where the nations who signed the Protocol meet in a series of

AConference of Parties@ or COP meetings. Today, there have been 6 COP sessions. The 3rd produced what is known as the AKyoto Protocol,@ which called for legally binding reductions in emissions. The U.S. and Canada both signed the Kyoto Protocol, but neither country has formally ratified it.

The Kyoto Protocol introduced the concept that sequestering CO_2 through the creation of carbon sinks in agriculture and forestry could be counted against a Party's commitments for reducing emissions. It was agreed that the first commitment period would be 2008 through 2012, and the target would be the amount of emission compared to 1990 emissions. The U.S. agreed to cut overall emissions 7% below 1990 levels, the European Union agreed to cut to 8% under 1990, Canada and Japan agreed to 6% cuts. The details of exactly how those cuts would be achieved were left to further negotiation and decisions to be made in future COP meetings.

After the Kyoto Protocol was adopted, the IPCC was asked to produce a special report on the scientific and technical issues involved in implementing the articles pertaining to carbon sinks in agriculture and forestry. That special report, on which I had the honor of being lead author of one of the chapters, was released last June (Watson et al. 2000). In general, it pointed out that the inclusion of full accounting for the carbon exchanges between the earth and atmosphere would capture a major aspect of the issue, but that there were very important decisions to be made regarding how these activities would be defined and how the accounting systems would work.

The 6th COP began in The Hague last fall, studying the findings of the IPCC and grappling with the political issues involved. That session was suspended, then resumed in Bonn, Germany, in July of 2001, where several important decisions were reached.[3]

First, the definitions of afforestation, reforestation, and deforestation were linked to a change in land use. It may come as somewhat of a surprise, but the definition of Aforest@ was a major issue in the IPCC report. With dozens of different definitions in use, it was key to settle on something. By linking to a change in land use, the normal forest harvest and regeneration cycle is not considered part of Kyoto accounting. That is critical in making any national reporting system feasible. Some adjustments were made to reduce the possibility for "gaming" the accounting system in the first commitment period by shifting the timing of harvests or planting.

For the first commitment period, afforestation and reforestation projects may be used in the Clean Development Mechanism. That means that developed countries can sponsor projects in underdeveloped nations and receive carbon credits. The rules for those projects will be decided at COP 8, in a couple of years.

In addition, COP 6 decided that broadly-defined activities such as Aforest management,@ Acropland management,@ Agrazing land management,@ and Arevegetation@ may be used in the first commitment period if a Party chooses to do so. If those activities are chosen, the Party will need to demonstrate that the activities have occurred since 1990, and are human-induced. This is an important step in implementing Article 3.4 of the Kyoto Protocol, and is consistent with the scientific and technical findings in the IPCC Special Report.

These decisions also seem consistent with the political positions taken by Canada and the U.S. in the negotiating process. As we all know, the U.S. did not agree to the COP 6 decisions, and the future of the Kyoto Protocol remains uncertain in light of the U.S. position. About all we can say at this point is that when the U.S. agrees to cooperate with the rest of the international

[3] For current information on UNFCCC activities and the full copy of COP documents, see *www.unfccc.int.*

community on issues of climate change, it is virtually certain that agriculture and forestry will remain firmly established in the process.

<u>The Potential for a Market Process</u>

It is widely thought that the continuation of the UNFCCC process will result in national restrictions on greenhouse gas emissions that will affect industries that burn fossil fuels. It is also thought that such restrictions will be accompanied by creation of a trading regime that will allow companies to seek the most economic option for meeting their emission reduction needs. This Acap and trade@ approach has proven very successful in the U.S. as part of the Clean Air Act, and has been included in proposed legislation in the U.S. Senate.

Actions in the business community indicate that there will be a market for greenhouse gas reduction credits whether or not the Kyoto Protocol is ratified. The international attention to this issue, and the pressure from many governments for effective action, weigh heavily on multi-national corporations. Regardless of what the U.S. does, no large company can afford to be seen as an environmental laggard in the international arena where it does business.

Most governments and businesses agree that no matter what policies and regulations eventually emerge, the most cost-effective path to reducing overall emissions is to allow flexibility in mitigation actions. In practice, this requires a trading system, because not all companies face comparable challenges. Those that have technical opportunities to raise efficiency and reduce emissions will certainly take advantage of them. Those that enjoy no such opportunity will look elsewhere to see what can be done. It is those companies that will become the buyers of carbon credits in an emerging market B seeking to offset their carbon emissions by financing new efforts to increase carbon sequestration in agriculture and forestry projects. It is in this market where projects featuring agroforestry practices can find new supporters.

Many companies in the U.S. and Canada have been experimenting with carbon credit trades to gain experience and help speed the emergence of workable market mechanisms and policies. Much of the leadership has come from the electric power industry, where many of the leading companies are convinced that some form of carbon dioxide emission limits will be imposed in the next decade. These companies want to be ready, and they want to have the practical experience to speak authoritatively when new policies and programs are being shaped.

A new market trading center – the Chicago Climate Exchange – is operating to facilitate trading.[4] It was formed under a grant from the Joyce Foundation and administered by Northwestern University's Kellogg School. Through it, companies now have the chance to engage in a voluntary, clearly defined formal market. As companies begin to seek to become carbon credit buyers, opportunity opens up for others to become sellers.

There are organizations working with potential sellers, as well. For example, I work with the Montana Carbon Offset Coalition to develop partnerships with Resource Conservation and Development Areas, Conservation Districts, Indian Tribes, and other organizations in the U.S. These organizations work directly with landowners to develop carbon credit projects in agriculture, agroforestry, and forestry. The MCOC assembles these small projects into a larger portfolio and markets them through market trading experts. One forestry project has already been developed and sold; others are in the planning stages. A great deal of work is under way to establish guidelines and methods for agroforestry projects.

[4] For current information, see *www.chicagoclimateX.com*

Basic Requirements and Issues in Projects

Projects designed to reduce the amount of atmospheric greenhouse gases can include both those practices that reduce emissions and those that increase the sequestration of carbon in stable forms such as wood or soil organic matter. In agriculture, agroforestry, and forestry, we are primarily concerned with the latter type – increasing the amount of carbon stored in the system.

Carbon stored in forested ecosystems is usually measured in four Apools.@ They are:

$ Above- and below-ground woody material in live trees
$ Litter, understory plants, and small debris on the forest floor
$ Dead snags and large woody debris
$ Soil organic compounds (not counting large roots or surface debris)

In determining how carbon will be measured in a project, it is important to decide which of these pools merits the cost and effort of measurement. Since the objective of a carbon project is to increase the amount of carbon stored in the system, we need to think about the likelihood of a pool changing significantly under the proposed new management. If we are confident that the pool will change little, if at all, it will not be worth measuring as part of project activity. If we can demonstrate that the pool will not shrink, we can safely ignore it in the measurements.

In a forest project such as afforestation (tree planting on formerly unforested land), it is common to ignore the litter, understory, and dead snag pools in project measurements, since they are likely to be quite small and the change, while modest in a young forest, will be positive. By leaving these pools out of the measurements, we reduce the cost of monitoring and provide a bit of added Abonus@ carbon that is not claimed in the project accounting.

Clearly, we would count the aboveground wood and the large roots. They were zero at the start of the project, but will grow throughout the project=s life span and provide the bulk of the net gain in carbon. Most of our aboveground carbon data in forestry comes from the growth and yield models for various species created by forest research over decades. These models, which were developed to estimate merchantable timber yield, can be expanded to include the entire tree biomass, including branches, stumps, and large roots, so they reliably estimate the total amount of biomass in the forest over the period of the project. Since they are developed from forest-grown trees, however, they may significantly under-estimate the biomass in line-grown windbreak trees of the same species, a topic we will touch on later.

Once we know the total amount of woody biomass in a tree or a forest, we can calculate the amount of carbon fairly easily. If the biomass is given in cubic feet or cubic meters of woody material, we multiply that by the dry weight of a cubic foot or cubic meter to get the dry weight of biomass. There are specific gravity data for most tree species from which those weights can be calculated. We then multiply by 0.5, since most dry wood is about half carbon. These factors have been well researched and are readily available in the literature.

Creating marketable Carbon Emission Reduction Credits (CERC=s) in a project requires attention to some basic project planning needs, as well as followup monitoring and reporting. Again, not all of these methods have become widely published and accepted, but the general pattern seems to be fairly consistent.

The plan starts by developing a Base Case that describes the proposed project location and area, the current land use and condition, and current estimates of carbon in the pools to be considered. It establishes a project life, and estimates the change that will occur in those carbon pools over that period of time in the absence of any project action. Obviously, this will represent, in most cases, a counter-factual event. If we do the project, the Awithout-project@ situation will never develop. As a result, except where untreated control plots can be used, the base case will not be subject to future measurement and verification. Since the base case is a critical component in establishing the amount of CERC=s to be created, it is important that the methods used to develop it be credible and conservative.

The plan then describes the proposed project activities and provides an estimate of how much carbon will be stored in the various pools over the project life. The amount of increased carbon stored in the wood and soil pools as a result of the project (the project amount minus the base case amount), normally expressed in metric tonnes of C or CO_2 equivalent, becomes the amount that may qualify for CERC status. In most cases, landowners are given credit and payment for CERC=s at the time of installing the practice or project, and some provision is made for adjustments if future monitoring shows that the actual amounts differ significantly from the planned amounts.

The plan needs to also address some issues that have become a common part of the climate change and CERC debates. Those include:

$ Transparency B the methods and calculations used to establish both the base and project cases should be clear to a knowledgeable reader. It should be possible to re-do the carbon calculations using accepted procedures, with the information presented, and come to similar results. For most buyers or policy makers, saying that you calculated the amount of CERC=s in a Ablack box@ proprietary model won=t be acceptable.

$ Permanence – This issue has largely been raised in international discussions to compare sinks projects to fossil emission reductions. The latter, some say, are “permanent,” while agricultural or forestry gains can be reversed by a change in management, a disaster, or some other factor that causes the stored carbon to be emitted. The general approach to this in market-traded CERC’s has been to deal with it as a question of risk management and price. Risk can be reduced by good planning and installation supervision, long-term contracts to assure desired management, or crop insurance to cover disaster losses. Conservation easements can help reduce owner turnover risks. Payback or replacement contracts can assure CERC buyers that, if the CERCs are lost, they will be able to replace them. In market transactions, the steps to manage risks must satisfy the buyer at the price they pay. More risk, less price is the general rule. Whether these risk management approaches will be adequate to satisfy the international critics of sinks as a mitigation measure remains to be seen.

$ Monitoring, verification, and reporting B There needs to be periodic monitoring to assure that the project and its practices are functioning as planned. Some of this monitoring and reporting will be done on an annual basis by the landowner. Periodically, it will be necessary to develop measurements through sampling, cruising, or other accepted forms of developing carbon estimates. The frequency of these measurements will usually be established either by public policy or buyer demands, but will probably be every 5 years or so for woody plants and every 10 years or so for soil carbon. Most CERC contracts also require periodic verification audit by an independent 3rd party to increase credibility. The plan should set out how the monitoring, verification, and reporting will be done, who will do it, and with what frequency.

$ Additionality B This is a term you will encounter in the carbon credit literature that stems from the international debates on which sinks should be eligible for mitigating emissions. It basically means that CERC=s need to represent increases in the carbon pools that happened as a result of human activity rather than as the normal change in ecosystems over time. This is usually a non-issue in agricultural or agroforestry situations B everything that occurs is the result of human action. Where it can become an issue is in the management of existing forests, where the forest can be expected to change with or without management. If the base case adequately illustrates the carbon changes that would have occurred in the absence of project activity, that should take care of the issue.

$ Leakage B This is another term stemming from the international debates. It refers to the fact that some projects may cause changes on non-project land that will either increase or decrease the carbon on that non-project land. The classic illustration is the forest protection project that forces people out of the forest to stop timber harvest. Unless the need for timber is addressed in some way, the people simply move elsewhere and cut other forests. From the global point of view, the project accomplished little or nothing in reducing carbon emissions or increasing total forest carbon pools. The important question here is cause and effect. Will a project cause changes elsewhere? Chances are that leakage will seldom occur in an agroforestry project. The fact that a farmer plants a windbreak is unlikely to cause trees elsewhere to be removed. It will probably be important, however, for any CERC plan to consider the possibility of leakage and, where it exists, explain how it will be addressed. If it cannot be addressed, the amount of carbon increase created in the project needs to be reduced by the amount of associated leakage, and only the net gain would qualify for CERC status.

Opportunities and Challenges for Agroforestry Projects

Virtually any type of agroforestry activity should produce carbon credits. Where trees are included in a system that did not have them before, total ecosystem carbon is almost certain to increase. That increase will be most significant in the wood contained in live trees, but there may be measurable changes in the soil as well. Each situation needs to be assessed to see what those increases might be. The question is not just whether or not the carbon will increase; the real question is whether or not the increases will be large enough to warrant the additional work to measure and verify those increases and the additional restrictions that will be placed on the landowner to assure that the stored carbon is well managed and protected.

I don’t pretend to be an agroforestry expert, but it is easy to speculate on how some practices might provide enough carbon credit benefits to be worth considering as part of a carbon credit project. Windbreaks, shelterbelts, and living snow fences, for example, provide long-term wood storage in trees and roots. They may, in some places, change soil carbon fairly significantly, depending on the soil condition at the time the trees are planted. Where soil organic matter has been depleted by cultivation, it will likely be restored under tree cover over a period of 20-30 years. That may be significant. Where these practices will be most limited will be in the area involved. If that area is not large, the amount of total carbon sequestered will be modest, and the costs of measuring, monitoring, and verification may make a project infeasible.

Riparian forest buffers offer significant opportunities, and the addition of carbon credit payments may encourage landowners to widen buffers, straighten outside boundaries, and convert them into fairly large riparian forests. Where that is done, the fact that these are on the most productive area of the ecosystem, with good moisture and nutrient levels to support growth rates and carbon accumulation.

Fast-growing wood crops for energy production offer a major carbon opportunity, where the wood will reduce coal or petroleum combustion. Those crops produce a large carbon increase on an area basis, and even small areas may produce significant carbon credits. Again, whether or not to include soil carbon will depend on the initial condition of the soil when the project is initiated.

There are at least two challenges that will be important in agroforestry carbon projects, in my view. The first is the need to develop growth estimates for the species used in agroforestry, and the differences in growth pattern between forest, riparian, and windbreak trees of the same species. As noted earlier, the growth models used today were developed to predict timber yield in forests, and they simply don't apply to most riparian or windbreak situations. It has been estimated that a tree growing in an open or line situation may develop up to twice the biomass as one growing in a forest, and a far larger proportion of that biomass will be in large branches and roots, so the conversion factors that relate merchantable stem volume to total biomass will be way off as well. Many of the species used in agroforestry have little or no historic growth research, since they have never been commercially valuable. Estimating how much growth will occur with some of these species in a windbreak or riparian situation is key to developing carbon credit projects.

I think those scientific and measurement problems will be solved in a few years, due largely to the work of people in this room. That will leave the most significant problem of all – the institutional problem of getting landowners to install and maintain agroforestry practices over long periods of time. The conservation community has been promoting agroforestry for nearly a century in North America, and some of the practices like intercropping or trees in pastures have been common for centuries in traditional cultures. It is still fair to say, however, that landowners are not taking advantage of the opportunity that exists. These practices have not been an "easy sell" over the years, and the inclusion of carbon credits will not make them any easier. In fact, it may make the selling job more difficult.

Buyers of CERC's are going to demand a degree of legal certainty that practices are installed and maintained over a long period, and that the carbon stored is accurately documented. Particularly in those CERC's that are entered into a private trading market, the need for maintaining a credible basis is important. That may mean long-term contracts, conservation easements, or other binding instruments that landowners may not readily accept. Thirty to fifty years is an eyeblink in the global cycle, but much longer than the average tenure on farm and forest land, so these contracts must become a part of the land title, and follow it through many transactions. Permanent easements are likely to meet landowner resistance, as well as raise legitimate questions as to whether or not they can be considered valid.

The contracts have to be administered far into the future, and when someone violates the contract, the administering agency needs to take action. That agency might be a land trust, conservation district or some other local organization that will need money and a sense of permanence if it is to be credible. It is somewhat suspect when a local land trust that has been in business for less than 5 years and has no secure financial base undertakes such an administrative task. Organizations sponsoring soil and water conservation or forestry programs have not taken on these responsibilities often, and developing the needed capacity will take leadership and time.

The main wild card at this stage, of course, is the political dimension. Will the U.S. take a leadership role, and will that role include policies that provide incentives for landowners to establish agroforestry and other agricultural and forestry practices as carbon sinks? Will it establish a cap and trade system to spur the development of market incentives? I believe the answer to both questions is yes. It will be messy, but almost certain to happen in this decade. I won't try to predict Canada's response, although many of you can, I'm sure.

The bottom line is that carbon credits are likely to produce additional incentives for establishing agroforestry practices in the future. The amounts of additional financial support are likely to be modest, and there will be additional costs involved, so don't look to carbon payments to become the driving force for agroforestry. What they will be is one more tool in the toolbox of the conservationist who can understand, promote, and support their appropriate inclusion in landowner activities.

Reference

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