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Carbon banking: Creating flexibility for forest owners

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ABSTRACT

The focus of forest-based systems for sequestering carbon has largely been on creating permanent stores of carbon on defined areas of land with a single payment to the forest owner for the carbon. In terms of forest management, this focus leads to two outcomes, continuing production of timber if the forest area is sufficiently large to create an effective permanent carbon pool, or a cessation of harvesting if the forest area is too small. In addition, the payment system for carbon is generally based on matching a specific buyer and seller of carbon using a single payment to the forest owner. In combination, both of these factors create a carbon sequestration system that is too inflexible to attract anything but the largest land or forest owners. The paper presents an alternative system for carbon sequestration, carbon banking. Carbon banking treats sequestered carbon in the same way that a financial institution treats capital. In essence, forest owners 'deposit' carbon, in exchange for an annual payment, and those who need carbon offsets 'borrow' carbon by making an annual payment. The role of the carbon bank is to aggregate deposits of carbon and use these to meet various demands for carbon. There are a number of benefits of this system. It provides an opportunity for small forest owners with different types, age classes and management strategies to participate in carbon markets because payments are based on current carbon sequestered. It also allows participants in the carbon market to receive current value for carbon rather than what effectively represents the capitalised value of the future benefits of sequestering carbon, thus removing some uncertainty about locking into the wrong value for carbon.

1. Introduction

Sequestration of atmospheric carbon in trees has been identified as a way of mitigating the effects of greenhouse gas emissions (Van Kooten and Sohngen, 2007; Chomitz, 2000; Sedjo et al., 2001; Marland et al., 2001b; Marechal and Hecq, 2006). This has brought about the development of systems to bring forest carbon into a broader carbon accounting framework, usually done by creating some form of carbon asset that is traded in a market. Examples of forest carbon markets include the Chicago Climate Exchange (Chicago Climate Exchange, 2008a), the New South Wales Greenhouse Gas Abatement Scheme (NSW, 2008), and the New Zealand Emission Trading Scheme (Ministry for the Environment, 2007).

Carbon trading requires a defined carbon asset. An example of a carbon asset is the Chicago Climate Exchange which has created a *Carbon Financial Instrument*, defined as 1 metric tonne CO_2 (Chicago Climate Exchange, 2008b). For trading, contracts are built around increments of 100 metric tonnes CO_2. Since trades will always be done in terms of CO_2 equivalence but the actual carbon is stored in various pools, such as trees or soil, a mechanism is required for converting any of these to a measure of carbon that meets the specific definition of a carbon asset. Generally, this will involve a calculation of CO_2 equivalence, specification of the length of time the asset is under contract, and specification of the forest management that results in the CO_2 equivalence (Ellis, 2001; Chomitz, 2000; Hamburg, 2000; Chomitz and Lecocq, 2003).

The way that forest carbon trading systems have developed creates particular constraints for forest owners that limit participation in carbon trading schemes for many forest owners. The purpose of this paper is to outline the characteristics of current forest carbon trading schemes, highlight the effect this has on participation in carbon trading, and to propose an alternative structure that would provide more opportunities for a wider range of forest owners.

2. Implications of current carbon trading schemes

There are two outcomes of the current system for matching those who need carbon with those who have carbon. These are to do with the nature of the underlying forest asset that forms the

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carbon reservoir, and price that is paid for the carbon. The underlying forest asset in current schemes ends up having a number of key characteristics that influence what type of forest owner can effectively participate in the system. While there is substantial literature on permanent as well as temporary carbon storage in forests (Ellis, 2001; Marland et al., 2001b; Marechal and Hecq, 2006; Dutschke, 2002), the standard approach to carbon trading is project-based and either requires or assumes that sequestered carbon is provided by an entity that has a large enough forest area under management to provide a stable reservoir of carbon over the usual cycle of growth and harvest for individual forest stands so that it is 'permanent'. For example, the list of carbon funds and projects included in the World Bank's Carbon Finance Unit shows that projects are expected to yield 50,000 tonnes of CO_2 equivalent per year (Carbon Finance, 2008). This is analogous to the constant level of growing stock found in the classic normally structured forest estate model.

In addition, the seller is required to undertake a long-term commitment to maintain a forest. In the case of the NSW Greenhouse Gas Abatement Scheme this is for 100 years (State Forests NSW, 2004). In the New Zealand Permanent Forests Sinks Initiative the commitment is for perpetuity, although there is an option to exit after 50 years (MAF, 2007). There are also restrictions on forest management. This may be in the form of a commitment to long-term forest estate plan that governs harvest volumes and reforestation activities. It may also place restrictions on the species chosen, or the silviculture options available to the forest owner. In some cases it may even require a change in the harvesting system from clear fell to continuous cover harvest systems (MAF, 2007).

Taken together these characteristics mean that the implicit 'optimal' forest owner for participation in carbon markets is either a large scale forest owner with a normally structured forest with constant annual harvest, or an owner who will never harvest. Although is not possible to get statistics, it is likely that these two categories of forest owners currently dominate the forest carbon market. The net effect is that carbon stored in trees is treated similar to an aboveground coal deposit. That is, a permanent physical item that can be traded.

Another feature of forest carbon market is that the price paid for carbon is a single payment for (at least notionally) permanent ownership of the carbon. There is a risk for buyers and sellers inherent in a single, permanent price for carbon. One key component of this risk is that a forest is a biological asset (Ellis, 2001; Sedjo and Marland, 2003; Dutschke, 2002). A forest is subject to the risk of catastrophic disturbance from natural dangers such as wind or fire. A forest is also susceptible to pests and diseases that can injure or kill trees. Any of these events can reduce the carbon reservoir and expose the forest owner to a liability for the carbon they have sold but not longer hold.

A second component of this risk is that carbon trading is done through new and evolving markets that must reflect changing legislation, sequestration technology, and climate change science (Williams et al., 2005; Katila and Puustjärvi, n.d.). As such, the future price of carbon is uncertain. Forest owners are exposed to the risk that future price changes make their future liability for forest losses higher than what the carbon was sold for. Carbon buyers are also faced with the uncertainty of when to purchase carbon since markets are only just developing and current prices may not reflect true value for carbon.

For many forest owners this can create an additional uncertainty about participating in carbon markets because the cost of any change in silviculture or land use will be based on the possibility of repurchasing future carbon credits at an unknown price. Since the initial carbon payment reflects a particular silvicultural regime, any change to silviculture (e.g. rotation length, harvesting intensity, species, stocking) will potentially change the amount of carbon sequestered and force the forest owner to compensate with credits purchased elsewhere. The main risk is if the cost of the purchased credits is significantly higher than the value of the credits that were initially sold. The same would apply for a change in land use out of forestry.

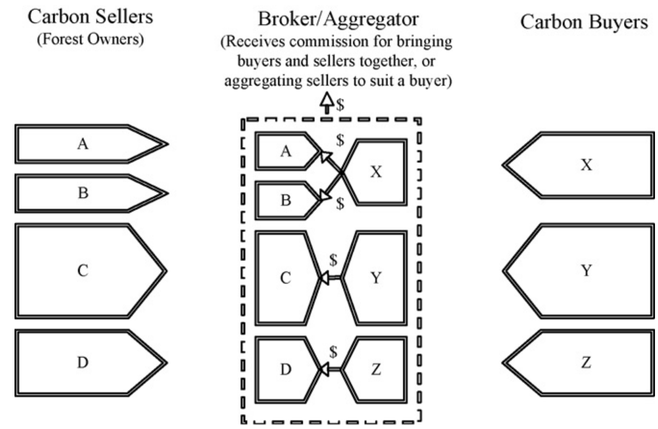

Fig. 1. The Carbon Brokering System where the broker matches buyers and sellers, or aggregates sellers to match buyer needs, and receives a commission from the transaction.

The combination of the requirements for the physical forest asset (forest estate) and the price of carbon (permanent ownership) leads to an approach for marketing carbon that is one of a broker. The job of the broker is to match specific sequestration requirements of buyers with the owners of corresponding carbon reservoirs (Fig. 1). The broker is paid for facilitating the trading of carbon but does not take ownership of the carbon in any sense. This also means that the broker must find buyers and sellers with the same transaction size requirements, or find ways of aggregating sellers or unbundling buyers to meet market needs.

3. Issues for small forest owners

The current system of carbon trading, while facilitating the development of a market for forest carbon for some forest owners, still leaves a significant part of the potential forest carbon reservoir outside the system. While some size and structure issues have been addressed through aggregation or pooling of smaller forests in different schemes, a number of issues remain. The first issue is that there are many forests where the ownership is too small or too fragmented to ever approximate the scale or forest structure required for current carbon trading. There are roughly 15 million private forest owners in European Union, with an average forest size of 13 hectares (EU, 2006). Of the forested land in the U.S., 38% is private, non-corporate forest (USDA, 2008) and in some regions average size of forest ownership is small. For example, the average size of private forests is 4 ha in Massachusetts and 9 ha throughout New England (Kittredge, 2005).

In particular, this means the effective exclusion of all forest owners that do not have a forest that is normally structured and that will provide a steady reservoir of carbon through cycles of harvesting and replanting. For example, Fig. 2 shows outcome of an afforestation project based where the trees are managed on a 30-year rotation, so that after 30 years the forest has a steady state reservoir of carbon. The forest structure shown in Fig. 2 is the preferred forest structure for carbon markets and similar approaches have been used as the basis of forest carbon projects (Sedjo et al., 2002).

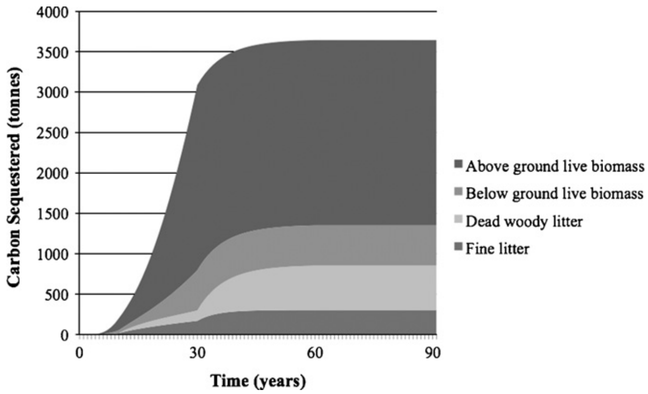

Fig. 2. The preferred forest structure in carbon trading is one where the forest is normally structured and maintains a relatively steady pool of carbon. *Source*: Based on a normally structured 30 ha plantation harvested on a 30-year rotation using sequestration data from Paul et al. (2008).

Fig. 3 shows the same type of afforestation but in a structure that is more typical of small forest owners where they do a single planting that is harvested after 30 years then replanted. This results in a cyclical pattern of 'temporary' sequestered carbon rather than a steady state (Paul et al., 2008; Ellis, 2001; Cathcart, 2000). It should be noted that soil also stores carbon but for the purposes of this discussion is assumed to remain constant is not shown in Figs. 2 and 3.

Forest that does not fit the normally structured, forest estate model in Fig. 2 still has the potential to contribute to increased sequestration if the owners of these forests could participate in carbon trading. In addition, much of the land that afforestation can take place on is under agricultural land uses where the average farm size is not very large. Since some mix of agricultural and forestry is often the optimal land use, this further reduces the potential size of areas for afforestation on any particular land ownership.

The third issue is that all forest owners who have not committed to one particular permanent land use or silvicultural prescription cannot be in the system. Not considering more than one rotation of a plantation, or a desire to have flexibility in rotation age, harvesting intensity, spacing or species, precludes these forests from being considered as part of the carbon market. In addition to issues related to the size and structure of forests for small land owners there are the additional issues of time frame of commitment, loss of management flexibility and risk of forest (and carbon) loss discussed earlier (Ellis, 2001). While many of these issues are common to a range of forest owners, they may be amplified for small forest owners.

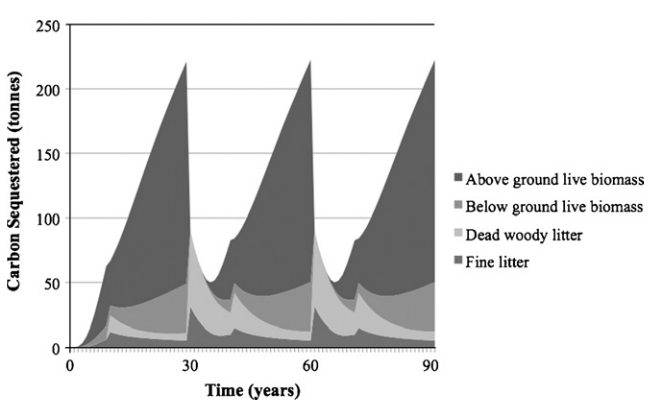

Fig. 3. Typical forest structure with small forest owners is one where the forest is not normally structured and the carbon pool fluctuates significantly as harvests take place. *Source*: Based on sequestration data from Paul et al. (2008).

4. Strong and weak sequestration

An important component of how sequestration has been defined is the concept of permanence. The essence of permanent sequestration is the notion that once sequestered, the same carbon must continue to be held in the place and form it was first sequestered. For some, this means that only the sequestration of the same carbon molecules can be considered to be permanent (e.g. underground injection of CO_2), while for others the concept of permanence extends to a pool of carbon sequestered in a forest under some steady-state management regime with a formal contract the requires the forest owner to permanently follow that management regime. In either case, anyone could identify a specific location with a quantifiable amount of sequestered carbon.

An alternative concept is that of temporary sequestration. Temporary credits are those that are created with explicit recognition that they have a finite life or where there is uncertainty about the permanence of the sequestered carbon (Marland et al., 2001b; Dutschke, 2002; Chomitz, 2000; Sedjo et al., 2002; Marechal and Hecq, 2006). In temporary sequestration, the location and form of a specific carbon molecules or pools of carbon are not important, only the aggregate number of molecules sequestered. In other words, one carbon molecule in a particular location and form is substitutable for another.

The difference between permanent and temporary sequestration is analogous to the concepts of strong and weak sustainability. Weak sustainability focuses on sustainable flows rather than the source of the flow, while strong sustainability focuses on sustainability of a specific resource (Pezzey and Toman, 2002a,b). Permanent credits could be thought of as 'strong' sequestration, with a focus on continued sequestration of the same carbon molecules or pools. Temporary credits, with substitution of carbon molecules and pools, could be thought of as 'weak' sequestration.

Although temporary, weak sequestration through the use of temporary carbon credits is still valuable in the wider context of climate change because these carbon sinks postpone the effects of climate change and allow for the development of new technology to replace CO_2 emitting technology or to permanently sequester CO_2, bypass problems of perpetual insurance in permanent forestry projects, make additionality easier to validate and impose fewer sovereignty constraints than permanent credits. Three practical approaches to dealing with temporary carbon sequestration have been identified (Van Kooten and Sohngen, 2007; Ellis, 2001; Sedjo and Marland, 2003; Marland et al., 2001b):

- Use a conversion factor to translate years of temporary storage to a permanent equivalent storage (tonne-years).
- Issue Temporary Carbon Emission Units (TCER) for a temporary carbon offset credit that would need to be continuously replaced by the purchase of new TCERs as the old ones expired.
- Use the market system by renting carbon for a finite period of time at which point the renter would have to renew the rental agreement or find replacement carbon to rent.

The first two approaches still lead to the project-based approach to forest carbon sequestration (e.g. Marechal and Hecq, 2006). The last approach, renting carbon, is the one that provides the greatest opportunities for developing carbon markets. It makes intuitive sense to buy and sell carbon credits if the sequestration is permanent but to rent if it is not, or to rent if there is an environment where there is unequal responsibility for sequestration or an unwillingness of some parties to make long-term commitments given the uncertainty or form of control over emissions (Marland et al., 2001b; Sedjo and Marland, 2003; Chomitz and Lecocq, 2003; Kerr, 2003). Most important, the rental approach provides the kind of flexibility required by small forest owners.

5. Carbon rental

A number of authors have explored the use the carbon rental concept to accommodate carbon sequestered in biological assets such as forests and soils (Sedjo et al., 2001, 2002; Marland et al., 2001b; Sedjo and Marland, 2003; Van Kooten and Sohngen, 2007; Van Kooten, 2004; Sohngen and Mendelson, 2003; Lewandrowski et al., 2004; Tavoni et al., 2007; Cacho and Lipper, 2007; Kerr, 2003; Dutschke, 2002). The essence of the rental concept is to apply capital concepts to payments for carbon. Consider how the current system uses an upfront, single payment that is effectively the purchase of a carbon asset. What is needed is to change this to renting carbon (sequestration) services on an annual basis. This can be derived from the carbon purchase market in the same way that bond yields and prices are determined in financial markets or property prices and rentals are determined in the real estate market (Marland et al., 2001b; Sedjo and Marland, 2003; Van Kooten, 2004). A capital value (CV) for an asset can be determined from its annual yield (y) and the interest rate (r).

$$\mathrm{CV} = \frac{y}{r} \tag{1}$$

Since we already have a capital value for carbon (CCV) from existing markets and interest rates from financial markets, the terms in Eq. (1) can be rearranged to solve for an annual carbon rental (ACR).

$$\mathrm{ACR} = \mathrm{CCV} \times r \tag{2}$$

With the development of carbon rental market the annual carbon rental could also be derived directly from a (future) carbon rental market. The carbon rental market should reflect the same time preferences as financial markets, resulting in a similar upward sloping 'Yield' or rental curve (Fig. 4). Longer commitments on the part of both carbon borrowers and lenders will require higher annual payments to compensate for the reduced flexibility or increased security. The differential between borrower and lender yield curves, similar to financial markets, provides the return to the carbon bank.

This carbon rental approach in Eq. (2) has been used in models incorporating the economic value of sequestration, but these models also assumed the existence of some type of institution where the rental agreements could be arranged (Sun and Sohngen, 2007; Sohngen and Mendelson, 2003; Tavoni et al., 2007; Cacho and Lipper, 2007; Lewandrowski et al., 2004; Ellis, 2001). What is missing from the discussion is the type of market that would facilitate rental of carbon.

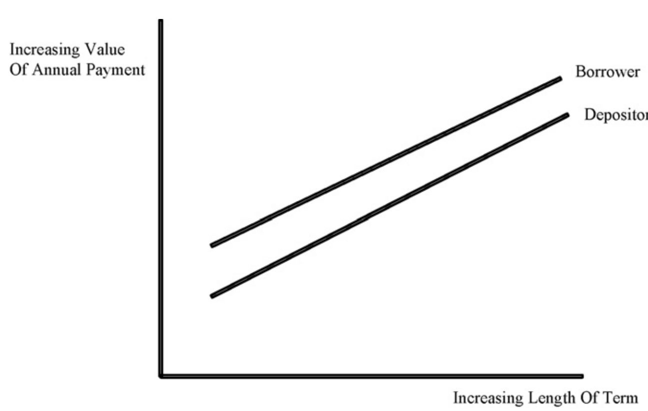

Fig. 4. Carbon rental 'yield' curve.

6. Carbon banking

An approach which provides a market for carbon rental is *carbon banking*. The term here is used differently than other authors who use it to refer to a process of 'banking' credits under the Kyoto protocol during an interim period to be used during the commitment period (e.g. Parkinson et al., 1999; Bosetti et al., 2008). In this paper the basic idea behind carbon banking is to create a carbon market that is analogous to a capital market and which functions similar to a financial institution. There are a number of key aspects of financial institutions that can be applied in carbon banking. First, capital is not 'purchased', just 'rented' through the use of interest payments for the use of capital. Second, in capital markets, depositors with varying amounts and commitment terms create a pool of capital that can be separately loaned to borrowers also with varying amounts and commitment terms. A similar concept has been outlined by Eusola and Weersink (2006), although their approach is more akin to developing a bond market by focussing on a minimum 5-year time periods for rental agreements.

The basic structure of an institution that could facilitate this market (the carbon bank) is shown in Fig. 5. A key element of the bank is how carbon is characterised, or how the deposits denoted by A–G in Fig. 5 are created. The carbon assets on deposit during a year are measured on an annual basis that can change from year to year, rather than being a single long term, steady state figure. This allows the carbon in the forest to change as the processes of harvest and regeneration take place, land use changes occur or natural disasters take place.

A 'deposit' of carbon happens when a forest owner registers their forest for a defined period of time. The initial carbon deposit is determined and subsequent carbon deposits will need to take into account changes to factors such as area and stocking. As with other carbon accounting systems yield tables, growth models, annual or periodic measurements, or some combination of these can be use to establish initial carbon levels and subsequent changes. The forest owner will be paid an annual amount based on the minimum carbon sequestered throughout that year.

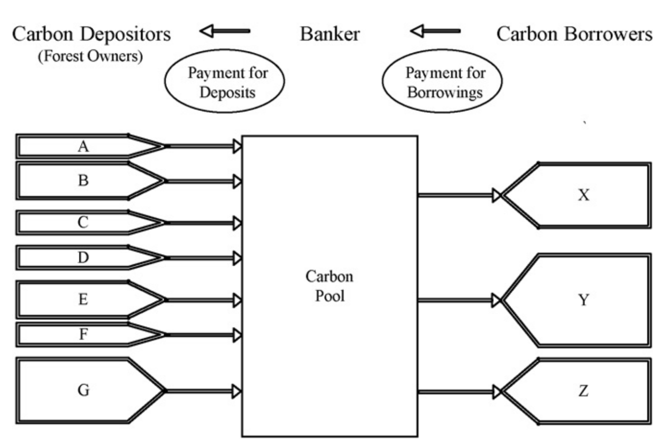

Fig. 5. The carbon banking approach where the bank creates a carbon pool by taking deposits from carbon owners in exchange for an annual payment and then loans the carbon to borrowers who pay an annual rental.

The deposits of a number of forest owners create a carbon pool at the bank. There will be annual 'withdrawals' due to net harvest reductions and catastrophic events, for example fire or insect damage, as well as annual 'deposits' through new forest owners registering forests and net forest growth. The net balance creates a pool of carbon that the Carbon Bank can loan out. Unlike a financial institution, there is no credit multiplier. The carbon bank can only loan out the physical carbon assets it has on deposit. In fact, the carbon bank may be subject to a 'reserve requirement' to account for unexpected reductions in the carbon pool during a year that means it will always have a loan portfolio that is smaller than its deposits. Chomitz and Lecocq (2003) suggest that an appropriate portfolio of sequestration projects might maintain 80–90% of carbon over the long term, implying a 10–20% reduction in what can be loaned out. The Forest Resource Trust in Oregon uses a reduction of 20% to create what is called an insurance pool against unanticipated withdrawals (Cathcart, 2000). For those who need carbon it is 'borrowed' for a specified period of time at a given rate per unit of carbon per year. This can be structured similar to a loan agreement.

7. Conclusion

The development of a carbon bank has a number of advantages over the current broker-based system of trading carbon. In particular, it adds a significant degree of flexibility to forest owners, allowing any forest owner to potentially be involved in the carbon market. This includes reduced financial risk due to catastrophic loss and management flexibility for the forest owner. Since annual payments are based only on sequestered carbon in that year, a reduction in carbon through fire means only that there is no payment for the carbon, rather than a potentially significant liability for replacement of the carbon as in the current system. The carbon bank does not place the same long-term management constraints as the current system, allowing forest ownership to change, whether that is through family succession or sale, and not impinging on the new owner to pursue their own plans.

For both forest owners and those who borrow the carbon that is sequestered, an important difference between carbon banking and the current system is the annual payment structure. With carbon banking, there is a positive incentive to maintain forests because current payments rely on the presence of the forest in the contracted state. In the current system, the forest owner gets an upfront payment and no further income. This means that over time maintenance of the forest for carbon becomes tied to a past payment and may be less relevant to the interests of the current management. The other advantage of the annual payment is that no party is locked into one value of carbon. At present, both parties are forced to take a position on the price of carbon in a rapidly developing and dynamic market. As such the potential for either party being significantly financially affected is high. Carbon banking removes this risk by allowing the rate at which carbon is paid for to fluctuate according to the market and the term of the sequestration.

Transaction costs can be a significant part of project based carbon sequestration (Cacho and Lipper, 2007). The use of a carbon bank should however reduce transactions costs associated with the carbon market by reducing the number of parties who are involved and having a single agency dealing with both lenders and borrowers.

Another advantage of carbon banking is that it could potentially be extended to other forest services such as water, wildlife or other ecosystem services, either as 'co-benefits' with carbon (Van Kooten and Sohngen, 2007), or independently. Incorporating a non-carbon forest service only requires developing a value for any of these services and a link between the level of the service and the forest management or forest structure.

There are some issues that will need to be addressed to make carbon banking work. One is that there will likely need to be the creation of appropriate carbon assets through the creation of a right to the carbon. An example of how this can be done is the New Zealand Forestry Rights Registration Act. This legislation facilitates the creation of tree ownership that is separate from the land. In principle, this type of legislation should be able to be extended to the carbon contained in trees or in the soil. Another issue is verification of the carbon sequestered and the cost of verification. Obviously, payments based on annual levels of sequestered carbon will require an annual audit or in the case of changes, a remeasurement. This could be addressed using some type of trade off between the level of accuracy or detail in measurements and a discount from the maximum potential value (Hamburg, 2000; Chomitz, 2000; Marland et al., 2001a). This type of trade off is typical in any inventory system and should be easy to implement in this context. Given the context here, the payment might be discounted to represent the lower bound of measurement error for whatever system is used, similar to what has been suggested for the New Zealand PFSI (PFSI Team, 2007). However the measurement is done, forest owners must weigh up the relative costs and returns of accuracy versus the cost of measurement.

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