Facing the Cadastral Challenges of Managing Carbon Property Rights to Mitigate Climate Change

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SUMMARY

Scientific evidence suggests that increasing amounts of carbon in the atmosphere are causing climate change which will result in global warming, sea- level rise and more extreme weather events. In response to anthropogenic climate change, market-based mechanisms have been proposed to mitigate these rising carbon dioxide emissions. One of these mechanism is known as REDD (reduction of emissions from deforestation and forest degradation) has emerged. This mechanism works to prevent the loss of forest which plays a key role in sequestering carbon and regulating the global climate. Globally, REDD has attracted increasing attention as a more cost-effective means of reducing emissions, and organizations such as the UN and World Bank have accumulated significant funds for its implementation.

From a cadastral perspective this raises three major questions: (1) who 'owns' or has rights to the resources like forests which contain the carbon pools; (2) how can the governance structure for REDD be designed so that incentives to conserve forest reach the level of those who derive their livelihoods from forest products; and (3) if carbon credits are to be exchanged on a carbon market what cadastral information would be required to secure these rights in a 'carbon cadastre.' This paper will draw on our land tenure experience in the South American Amazon, Central America and sub-Saharan Africa to address these three questions.

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INTRODUCTION

Scientific evidence suggests that increasing amounts of carbon in the atmosphere are causing climate change which will result in global warming, sea- level rise and more extreme weather events. In this paper we first summarize carbon fluxes, reservoirs and residence times and discuss how perturbations to the carbon cycle are altering climate regimes due to a number of factors, including human use of fossil fuels, land use change and unprecedented deforestation. The consequences of rising anthropogenic emissions is already underway with unprecidented predicted costs to the global economy and loss of ecosystem functioning and life.

Market based mechanisms have been proposed to mitigate rising carbon dioxide emissions using a cap-n-trade system. The cap-n-trade system was introduced in the United States in the 1980s to abate acid rain caused by sulfur dioxide emissions from the combustion of coal. This system effectively eliminated acidity in lakes and forests in the eastern U.S and western Europe. Carbon dioxide, by contrast, has more sources and sinks making abatement more challenging and the defining of property rights more ambiguous. As forests are a major sink and source of carbon, various strategies have been proposed to reduce emissions from deforestation and forest degradation (REDD), as well as to augment existing forests stocks through replanting and restoration.

Land tenure, and more specifically property rights to carbon stocks, is increasingly recognized as an integral part of the climate change debate. Property rights issues have been raised with respect to: communally held land (Randrianarisoa, Vitale and Pandya 2008) including indigenous lands Griffiths 2007); insecure tenure leading to deforestation (Porrua Garcia-Guerrero 2008; OCC 2008; Parker et al 2008); legal conceptions of a carbon property right (Boydell, Sheehan and Prior 2008; Takacs 2009; Quan and Dyer 2008) and the need to clarify who will be the beneficiaries of carbon payments through mechanisms such as REDD (Forest Dialog 2008). Property rights to forests and/or carbon have been recognized as a key issue in almost all the major climate change reports, such as the Eliasch (OCC 2008) and Stern Reports (Stern etal 2007) and the various IPCC reports (IPCC 2003; IPCC 2007).

In this paper we examine the complex bundle of rights in the Peruvian Amazon and make the case for focusing initially on forest carbon property rights. We explore the concept of a carbon conservancy as a meso-level organization for holding carbon property rights. Finally, we propose a governance structure which makes use of a carbon cadastre.

THE CARBON CYCLE

Understanding the nature and characteristics of a fugitive gas is a necessary first step in examining carbon within a property framework. Carbon dioxide is most commonly emitted to the atmosphere by the combustion of coal for electrical power; the burning of petroleum products for transportation; the removal of carbon during the production of cement; and the clearing of forests typically for agricultural expansion. Once combusted, oxidized carbon enters the atmosphere where it is sequestered by plants, via photosynthesis, or by the oceans where it resides as a carbonate or bicarbonate ion. Should the molecule be sequestered by a tree through a leaf stomata, it will be incorporated into a growing stem and exploited to fuel the synthesis of energy molecules to carry out various cellular functions.

This tree may be set on fire to clear land for pasture, bio-fuels or food crop farm, immediately liberating the carbon in the stem and causing the carbon to re-enter atmospheric circulation. If the tree is harvested for timber, the wood will decay and return its carbon to the atmosphere at a slow, steady rate, although this varies considerably depending on the region. The root mass left below ground will decompose and the resulting carbon will eventually migrate to rivers and oceans. Most importantly, the growing tree will no longer exist to grow leaves and biomass to sequester carbon. Aged leaves will no longer fall to the ground to form soil carbon. In summary, unless the carbon is locked in forest biomass over the long term, it will contribute to the growing greenhouse gases in the atmosphere with long-term climate change consequences.

The first measurements of atmospheric carbon were taken by Charles Keeling in 1958 in Mauna Loa, Hawaii and at the South Pole (Keeling et al, 2001; Houghton, 2007). Other methods exist for reconstructing pre-industrial (1750) carbon scenarios, such as the measurement of tree rings to compare annual growth rates, corals to determine the amount of oxygen atmospheric isotopes, or the measurement of CO2 bubbles at the poles over geologic times. From this, it has been estimated that pre-industrial carbon dioxide concentrations ranged between 275 and 285 ppm. Today there are roughly 100 monitoring stations collecting CO_2 data for a global data set (Masarie & Tans, 1995; Houghton, 2007).

The IPCC (2007) currently estimates anthropogenic CO2 emissions at 32 billion tons per year, of which 47% remains in the atmosphere until sequestered over longer periods of time. Approximately 20% is sequestered by oceans; and 15% by terrestrial systems. A recent study has found that tropical forests alone sequester 18% of anthropogenic carbon, representing one-half of the terrestrial carbon pool (Lewis et al 2009).

Terrestrial biomass and the oceans are transient reservoirs for CO_2 and serve as stopping points before a carbon molecule reaches its final destination in carbonate rocks or under buried sediments. The amount of time a molecule resides in a particular reservoir before transferring to the next varies for CO_2. After roughly 300 years, 70-85% of CO_2 will have entered the oceans or terrestrial biomass, and even after 100,000 years, a small amount (3-7%) of fossil fuel carbon may remain in the atmosphere (Archer 2005).

Of all the major terrestrial biomes, forests, especially in the tropics, make the greatest contribution to global climate regulation. They store 86% of the world's above-ground biomass and 73% of the world's soil carbon (Sedjo, 1993). Tropical forests comprise 47% of the world's forests; of this, 50% are in South America, 30% in Africa, and 20% in Asia. A 40-year study of forests in Africa, South America and Asia found that tropical forests sequester roughly 18% of carbon emitted from the burning of fossil fuels (Lewis et al, 2009). Tropical forests store approximately 50% more carbon than forests outside the tropics, due to their longer growing season and higher growth rates (FAO, 2005).

CARBON AND GLOBAL CLIMATE CHANGE

Anthropogenic climate change is well underway and its impacts to humans and ecosystems is evident. As the largest sink of carbon dioxide, oceans are bearing the brunt of climate change with significant impacts to human populations, climate systems and marine ecosystems. Eleven of the last twelve years are the warmest on record since 1850, and a total increase of 0.76 degrees C since this date. Oceans absorb 80% of atmospheric heating, which has led to the thermal expansion of ocean water and sea level rise. From 1961 to 2003, global average sea level rose at an average rate of 1.8 mm per year; from 1993 this rate increased to approximately 3.1 mm. Because so much uncertainty surrounds contributions to sea level rise from ice sheet loss, these are not incorporated into climate models. As a result, predictions of future sea level rise of upwards of one meter are conservative. Roughly ten percent of the global population or 600 million people reside in coastal areas and are especially vulnerable to a rise in sea level (IPCC, 2007).

The impacts of a warming earth are manifesting in a multitude of ways with new consequences arising all the time. Shifts in ranges of rainfall and temperature regimes are occurring with concurrent shifts in species' ranges, leaf-unfolding, bird migration and egg-laying. Increased ice melt and corresponding enlargement of glacial lakes, growing instability of permafrost, and changes in polar ecosystems and food webs are occurring. Growing seasons are lengthening and earlier greening in vegetation transpiring. The oceanic thermocline is deepening with implications for nutrient upwelling. Range changes are also occurring in lakes and rivers in response to warmer temperatures. Perhaps most dire of all is the observed drop in pH in the ocean, which can inhibit the the formation of calcareous shells for corals, molluscs, pteropod snails, and various phytoplankton species that form the bottom of the food marine food chain (IPCC, 2007).

*With growing evidence of anthropogenic climate change, it is important to identify the sources of emissions, as well as sinks. The largest source of carbon emissions has been from fossil fuels followed by land use change stemming predominantly from the conversion of forests to agriculture. Drivers of land-use change include agricultural expansion, urbanization, population increase, affluence, and technological change. Deforestation, or the conversion of forests to agricultural land, accounts for the loss of 13 million hectares each year (FAO, 2005). While forest degradation does not result in the total removal of forest, it does reduce ecosystem functioning and change in species composition, and is widespread in the tropics (Sasaski & Putz, 2009). Deforestation is estimated to have released 1.1 to 2.2 PgC/year (Houghton, 2007; Achard et al, 2004; Gullison et al, 2007), with degradation estimated to have emitted the same amount (Gaston et al, 1998). South America and Africa have suffered the largest net loss of forests, estimated at 4.3 and 4.0 million hectares respectively from 2000 to 2005 (FAO, 2005).

REDD

Inaction on reducing greenhouse gases is predicted to cost upwards of 20% of global GDP with the greatest impacts on the world's most economically vulnerable. The current level of atmospheric carbon is 430 ppm and is rising roughly 2 ppm per year; at this rate, greenhouse gas levels will be double that of pre-industrial concentrations by 2035. To stabilize carbon dioxide between 450 and 550 ppm it is estimated to cost approximately 1% of GDP (Stern, 2007). In terms of social benefit, the cost of abatement far outweighs the cost of climate inaction. With government regulation unpalatable to business and inefficient in the eyes of many economists, market-based mechanisms have been proposed to mitigate these rising carbon dioxide emissions.

The United Nations Framework Convention on Climate Change (UNFCCC) created the Kyoto Protocol in 1997 that bound industrialized signatories (Annex countries) to emissions reductions of five greenhouse gases. In 2005, the European Emissions Trading Scheme (EU ETS) was initiated as a market trading mechanism, whereby large-scale emitters such as power plants could purchase pollution credits, which are then used to invest in carbon reduction projects elsewhere. Under a cap-and-trade system, a limit or allowance is set on the amount of carbon a company can emit. If the allowance is exceeded, the company then buys an allowance or credit elsewhere, or faces heavy fines. The seller, in turn, is rewarded for having reduced emissions. Projects can range from energy conservation programs in commercial and industrial facilities to methane capture at landfill sites to investment in alternative energy sources. Other trading regimes emerged later under the compliance markets and include New South Wales and UK ETS.

Kyoto signatories from less industrialized or non-Annex countries can be recipients of carbon reduction projects through the Clean Development Mechanism (CDM). Article 12.2 of the Kyoto Protocol stipulates that non-Annex countries should be assisted with sustainable development with special emphasis on less advantaged populations. Since approximately 20% of global carbon emissions stem from loss of forests, which is greater than total emissions from the transportation sector, strategies to mitigate forest loss from non-Annex countries plays an integral role in climate stabilization (IPCC, 2007). The Stern Report (2007) also identified the forestry sector as one the more cost effective abatement strategies. In other words, compared to the development of costly pollution control devices in the industrial sector, forests represent the lowest hanging fruit in the range of options for reducing carbon emissions.

The EU ETS does not allow carbon forestry projects to be transacted directly between EU ETS investors and project recipients. For this reason project development through the CDM is channeled through the World Bank and UN. At this time only reforestation and afforestation (A/R) projects are allowed, but because of stringent CDM project development guidelines and higher transaction costs, most A/R projects have occurred through voluntary markets. These markets comprise the Chicago Climate Exchange (CCX) and the newly emerged Regional Greenhouse Gas Initiative (RGGI). Additionally, approximately 90 independent retail companies market 'charismatic carbon' projects in the forestry sector that offset emissions for various corporations interested in green imaging or individual consumers who wish to offset activities such as airplane travel. Such projects utilize any number of existing standards for project design and implementation (Hamilton et al, 2008).

The value of the formal carbon markets has achieved momentous growth every year – rising steadily from $10 billion in 2005 to $117 billion in 2008 (World Bank 2009). Of this, the voluntary CCX and Over the Counter (OTC) trades, which include companies that offset emissions for corporations and individuals, captured $99 million in 2006, $335 million in 2007, and $705 million in 2008 (Ecosystem Marketplace 2009). Unfortunately, the fantastic growth in the carbon markets has been constrained by the global economic downturn and declining industrial production, causing the price of carbon to collapse. Nevertheless, the carbon market is predicted to rebound and voluntary markets to grow to $50 billion by 2012 (Phillips and Razzuk 2007).

Despite enormous sums of money transacted for emissions reductions, forests have captured very little of this relative to other sectors. Under the CDM, only ten projects have thus far been implemented, up from one in 2008 (UNFCC 2009). Stringent CDM project development guidelines raise transaction costs making these projects less financially viable. Additionally, because the permanence of forestry projects are at higher risk, they capture short-term emission credits worth less money, making these projects less attractive relative to the energy sector. As a result, forestry projects have been streamlined into the voluntary markets where, again, the price of carbon is lower (Robiedo & Ok Ma 2008). By the end of 2009, the global market for carbon offset forestry garnered $150 million over the past few years representing two million hectares of forest sequestering 21 million tonnes of carbon. North America captured 39% worth $32 million, Latin America 22% worth $35.5 million, Australia 16% worth $37.8 million, and Africa 11% worth $20.9 million (Ecosystem Marketplace, 2010). UNFCC regulated CDM offsets are perceived as higher quality due to strict project development guidelines and procedures, and consequently capture a higher value (Ecosystem Marketplace, 2009). While obtaining information on pricing in voluntary markets is difficult (see Ecosecurities, 2009 for further discussion), a recent survey of off-setters revealed that investors are willing to pay a premium for co-benefits to carbon forestry projects that prioritize biodiversity conservation and sustainable development for communities (Ecosecurities, 2009).

As the first commitment period (2008 - 2012) approaches its end, recent Conferences of the Parties (COPs) have set out to renegotiate the upcoming second commitment period. In 2007 in Bali, Costa Rica and Papua New Guinea tabled a motion to include tropical forests in the Kyoto Protocol, establishing the Bali Roadmap, a two-year negotiation process to be concluded in Copenhagen that would address mitigation, adaptation, finance mechanisms, technology and capacity building with the aim of emissions reductions from the forestry sector and land-use change. Reducing Emissions from Degradation and Deforestation (REDD) was introduced to compensate countries for conserving existing tropical forests. Even though REDD has not been formalized due to numerous concerns over policy and technical hurdles, it is expected to be implemented by 2012. Initially REDD set out to preserve existing forest stocks, but it has been expanded to include A/R since many projects are likely to augment forest preservation with restoration or reforestation, earning it the name REDD+ (Earth Negotiations Bulletin, Dec. 2009).

In preparation for REDD, the UN and World Bank devised various funds to assist with capacity building and project planning. The World Bank Biocarbon unit, in conjunction with conservation groups and local NGOs, combines reforestation, agroforestry and forest conservation and has three REDD projects underway (Woods Hole Research Center, 2008), although the bulk of activities are reforestation projects. The World Bank's Forest Carbon Partnership Facility assists countries in REDD preparations and designing a large-scale system for incentive payments (World Bank 2009). In a similar vein, the UN-REDD Programme, in partnership with FAO, UNDP, and UNEP established a multi-donor fund in 2008 to provide funding for REDD activities (UNDP n.d.).

To the disappointment of many, no binding agreement on REDD+ emerged from the 15th COP at Copenhagen this past December, but there remains hope that one can be reached by 2012. Financing, baselines, monitoring, and leakage were some of the more difficult areas of negotiation. The lack of consistency between the UN Declaration on the Rights of Indigenous Peoples and the AdHoc Working Group documents was a disappointment for civil society groups. A so-called fast track fund was agreed upon worth $10 billion for climate mitigation and adaptation to be paid by European countries, the U.S., Australia and Japan of which $3.5 billion is expected to go to REDD+ activities through the Informal Working Group on Interim Financing for REDD+ (IWG-IFR). So while no formal agreement transpired, REDD+ is still expected to become officially binding by 2012 when the above issues will be finalized (Global Canopy Program, Dec. 2009).

CARBON PROPERTY

Carbon presents a challenge to conventional property systems for a number of reasons. It defies our conventional categorization of property into 'immovable' and 'movable' property. In addition, its ubiquitous nature (almost 20% of the human body, for example, is comprised of carbon) presents new challenges that go beyond those of water, air or intellectual property rights. Since carbon occurs in the sub-soil as well as in above-ground biomass, the ocean and the atmosphere, it presents a new challenge to the field of land tenure and property rights. Who owns the rights to the carbon in its various manifestations is a complex question that will vary from one country to the next and which gets particularly contentious when sub-soil rights to minerals and hydrocarbons are discussed. In this paper we will focus primarily on above-ground carbon stored in forests because this is the carbon that is targeted by REDD strategies.

Roman Law formed the basis for the legal systems and property concepts in many European countries. It was incorporated into the French Napoleonic Code which was subsequently exported through colonization to many other parts of the world and today civil law is by far the most common legal system (CIA 2008). The Romans classified property into five categories – open access, public, group private, individual private and unclaimed property (see Table I). Carbon in the form of CO_2 in the atmosphere and in the ocean may be *res communes*; *res universitasis* may cover a community's forest carbon stock; and sub-soil carbon may be under *res in patrominium* if forest carbon is located on private lands. This categorization of property rights is therefore not that helpful in defining a carbon property right.

Tenure Regime	**Definition**	**Examples**
Res Communes	Things open to all by their inherent nature *(CO_2)*	Air, sea (open access)
Res Publicae	Things belonging to the public and open to the public by law *(Sub-Soil C; forest C on state land)*	Roads, navigable rivers (public property)
Res Universitatis	Property belonging to a private or public group in its corporate capacity *(forest C in communities)*	Private university, condominium (community property)
Res in Patrominium	Things that could be privately owned by an individual *(forest C on private property)*	Land under private ownership
Res Nullius	Things belonging to no-one *(CO_2)*	Unclaimed land, fish or game

Table I. Property Classifications under Roman Law

The most common conceptualization of property rights is the ‘bundle of rights’ paradigm. In this paradigm property is conceptualized as a bundle of rights with each right being a ‘stick’ in the bundle. The privately held ‘sticks’ – alienate, develop, mortgage, subdivide, etc. – in the bundle are usually emphasized but in most property systems the government does hold some of these ‘sticks.’ Typically government will hold back the rights to tax, to control land use (police power) and eminent domain. Land and resource tenure in different cultures may be bundled differently, especially where new tenure forms (e.g. extractive reserve in Brazil) have emerged. The state in Latin America often holds back certain rights such as alienation *(inalienable)*, subdivision *(indivisible)*, mortgage (*inembargable*) in indigenous or peasant communities and protects them from prescription or adverse possession *(imprescriptible).*

Figure 1 illustrates how rights are bundled in the Peruvian Amazon. This distinguishes not only the three major tenure categories – state, native communities, and private – but also how rights are divided depending on whether they pertain to resources, land or sub-soil. Rights to above-ground and sub-soil resources are treated differently as they are often the dominion (patria) of the state which may transfer usufruct rights via concessions to non-state entities (e.g. timber companies, conservation groups).

Figure 1 also shows how bundles of rights vary across different resources and what fundamental divisions exist between bundles to above-ground resources like trees, land and subsoil resources. The layers also suggest the potential overlap in different tenure. For example, an indigenous community (*comunidad nativa*) may have title to land that is imbued with a forest concession, a brazilnut concession, a communal reserve as well as be subject to sub-soil mining and petroleum concessions. Similarly, forest and brazil nut concessions can be granted over state, indigenous or private land.

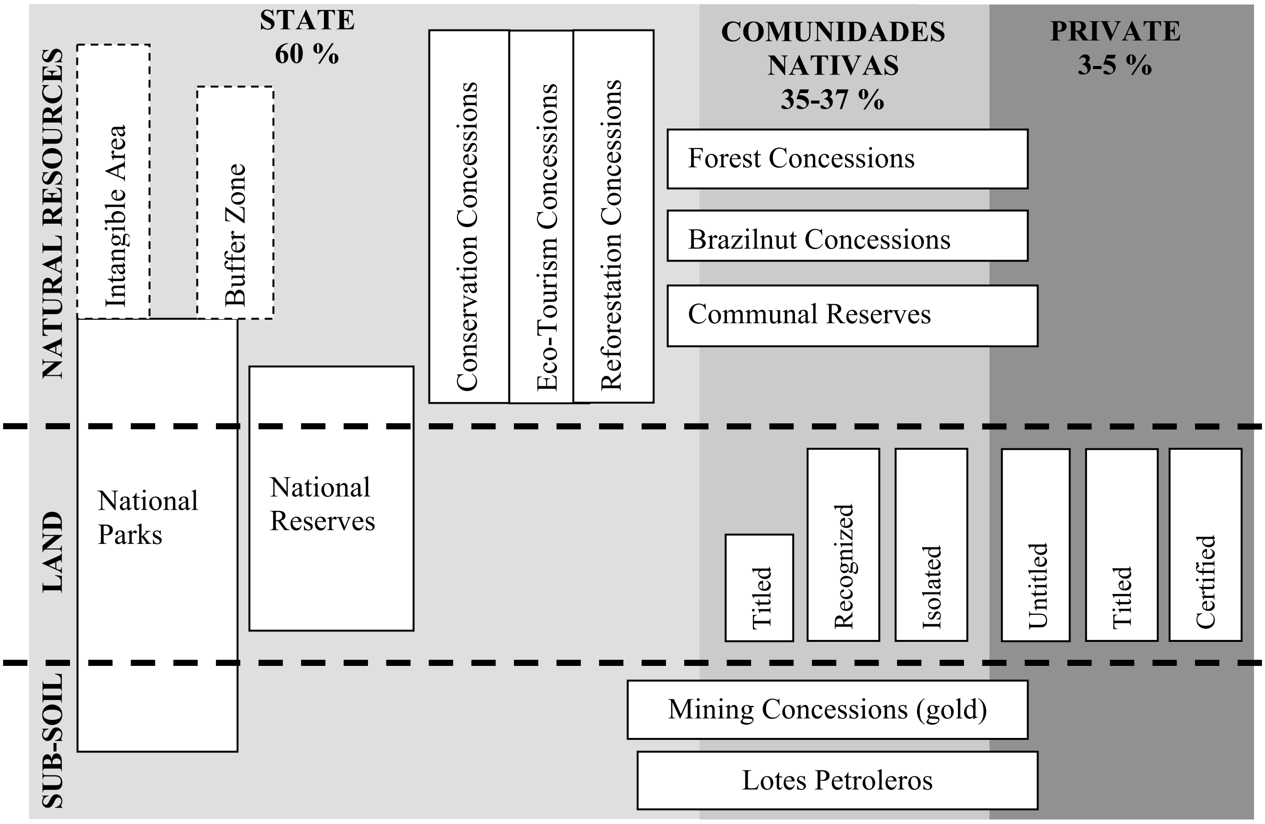

Figure 1. Bundles of Rights in the Peruvian Amazon

This separation has been institutionalized by charging different government entities with the management of rights and interests pertaining to different resources. In Peru, for example, the mining cadastre is handled by the National Institution of Concessions and Mining Cadastre (INACC), while rural land titling was until recently carried out by the Ministry of Agriculture. Forestry concessions and resource information, on the other hand, are the responsibility of the National Institute of Natural Resources (INRENA), which manages a cadastre of protected natural areas.

REDD is by definition focused on forest carbon pools and it is therefore important to know who controls the world's forests. White and Martin (2002), in their global survey of forest tenure in 24 countries covering about 93% of the world's natural forests, revealed that 22% of forests worldwide are either reserved for (via usufruct rights) or owned by community and indigenous groups. They also found that forests were home to approximately 60 million indigenous people. A follow-up study in 2008 Sunderlin, Hatcher and Liddle 2008) found a continuing shift from government ownership and administration to all other categories. Communities, indigenous and otherwise, are

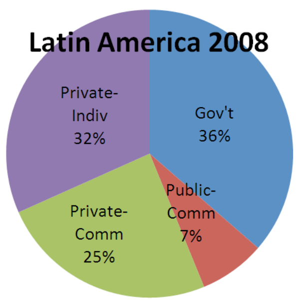

FIGURE 2. Forest Tenure in Latin America

therefore important stakeholders and stewards of the world's forests as shown in Figure 2.

A number of REDD studies conclude that "clear and secure property rights, either at the individual or the community level, are a necessary to establish PES systems" (Angelsen 2009, p. 135). For the most part these studies refer to security of land rights, and in some cases rights to trees. But what about carbon property rights that are separable from land or timber rights? Takacs (2009) distinguishes between five different types of carbon property rights - sequestered carbon, carbon sinks, carbon sequestration potential, carbon credits, and usufruct rights. Several Australian states have defined a carbon property or 'carbon sequestration right' that can be registered (Larson et al 2008). This right is treated as a type of English common law easement (profit *a prendre*) which allows the holder to take or use the soil or products of the land. However, questions have been raised about this interpretation (see Boydell et al 2008) and practical experience with these rights is minimal.

REDD GOVERNANCE AND CADASTRAL CHALLENGES

In an ideal world clear land title would be a prerequisite for defining and conveying carbon property rights. Experience to date with land titling and continued tenure insecurity shows that in reality this requirement would likely be the kiss of death to many carbon projects and would favor those who already have formal title. Except for increasing areas that are being titled to indigenous or traditional groups, titled land is still largely in the hands of the wealthy and politically connected. We suggest that other options be explored that do not rely on formal titles as a prerequisite for granting carbon property rights.

We have previously argued for aggregating carbon property rights and incorporating multiple land parcels (titled or untitled) and for these rights be attached to a new entity made up of these land holders (Barnes and Quail, forthcoming). The member landholders may be groups of communities or individual land holders, or a combination of both. Other authors have made the case for matching the scale of institutions with the scale of the natural resource that is being managed (Murphree 2000) and in most instances carbon stocks are best dealt with at a more meso scale than the individual parcel. What meso-level governance models of this kind already exist and how have they fared? Two that immediately come to mind are the wildlife conservancies in Namibia (NACSO 2008) and the brazil nut cooperatives in Bolivia (Duchelle 2009).

Wildlife "Conservancies" in Namibia were first implemented in the late 1990s following the passing of the Nature Conservation Amendment Act (5 of 1996) which laid out the governance structure and rules for communal conservancies. To create a conservancy, communities have to define the conservancy boundary, formulate a constitution, elect a conservancy committee, design a plan for the equitable distribution of benefits, and demonstrate the ability to manage funds. By the end of 2006 a total of 50 conservancies had been established covering an area of 118,704 km^2 (14.4% of the entire country) and incorporating 220,620 people (NACSO 2008).

A conservancy is given rights to a sustainable annual wildlife quota (e.g. 10 elephants, 3 crocodiles) and may enter into contracts with tourism and/or safari operators. Many conservancies sell their wildlife rights to safari operators who in turn bring in hunters from Europe, North America and elsewhere. These hunters pay tens of thousands of dollars to hunt an elephant and this provides an external market for these wildlife resources. The community may also gain other benefits, such as income or jobs from tourism lodges located on the conservancy and the meat from the commercial hunt. In this way conservancies are designed to promote sustainable resource management by transferring wildlife rights to the community and giving them access to the benefit stream from hunting and tourism (Suich and Child 2008). The success of this approach has been demonstrated through (i) the rapid growth in the number of members and areas under conservancies, (ii) increased incomes, and (iii) recuperation of key wildlife species (NACSO 2008).

Using these conservancies as a model for 'carbon conservancies,' we have illustrated a governance structure that connects international carbon funds and markets to individual and communal landholders through meso-level carbon conservancies (see Figure X). This model depends on groups of individuals or communities voluntarily forming conservancies (as is the case with Namibian conservancies) and formalizing these through the government. Once they have acquired this legal status, they may register their joint carbon property rights in a carbon cadastre and registry which is linked to the land cadastre and registry. Only de facto (with agreement of all neighbors) and de jure land holders will be eligible for membership in a conservancy.

One of the key elements in a REDD project is to the monitoring of deforestation and forest degradation. REDD projects are required to show that deforestation and degradation have declined when compared with a defined baseline or historical deforestation reference scenario. Monitoring is also necessary to determine if the REDD project has caused deforestation and degradation to "leak" to surrounding areas. Monitoring should therefore be focused on an area larger than the carbon conservancy to cover what we have termed a "leakage monitoring area." We believe this monitoring function should be done by an external, non-governmental entity (but with government representation) with no direct financial interest in the REDD project. Global Witness (2009), a non-profit company which has focused on monitoring logging, legal compliance and forest law enforcement and promoting transparent and equitable governance, is a good example of such an entity. They have developed an "independent forest monitoring" (IFM) approach which addresses many of the REDD monitoring needs.

The role of government in REDD projects located in weak governance states is a difficult issue. Sovereign rights and legal jurisdictions and mandates need to be respected, but at the same time REDD projects will only be effective if governance structures are transparent, accountable, and free of corruption. Government's role in REDD should be to (i) make relevant policies, laws, and standards, (ii) contract revenue and monitoring units and participate in their function, (iii) approves conservancy constitutions, (iv) control carbon and land cadastres/registries, and (v) build local capacity.

In 1998 FIG Commission 7 set out their vision for a future cadastral system termed Cadastre 2014. They envisaged that future cadastres would “show the complete legal situation of land, including public rights and restrictions.” (Kaufmann and Steudler 1998) They rightly call for the integration of more natural resource information in the cadastre, particularly when restrictions impact the rights to that resource. Presumably, this would now include the restrictions on forests through the implementation of REDD projects. Conceptually this makes good sense and our linkage between a carbon and land cadastre in Figure 3 are consistent with this integration. However, the problem we face in areas where most forest carbon is located is an almost complete absence of any cadastre. Even in Brazil, a recent study was forced to use catchment areas as a proxy for private land parcels because a cadastral map (or integrated cadastral database) is just not available (Stickler 2009). In those few cases where cadastral data is available for a whole jurisdiction (e.g. Pando, Bolivia), only a single parcel can be queried at a time and only small scale cadastral maps are available via the Internet. Public registries are rarely public.

It is against this institutional background that we have conceptualized a carbon cadastre. We cannot assume that the parcels underlying forest carbon are titled and registered (dark parcels in Figure XX are titled). REDD cannot wait 20 years for systematic titling efforts to cover the country or even province/state. In the governance scenario shown above, the conservancy will include both titled and untitled parcels, but carbon property rights will be assigned to the conservancy. A carbon cadastre therefore only operates at the scale of the conservancy.

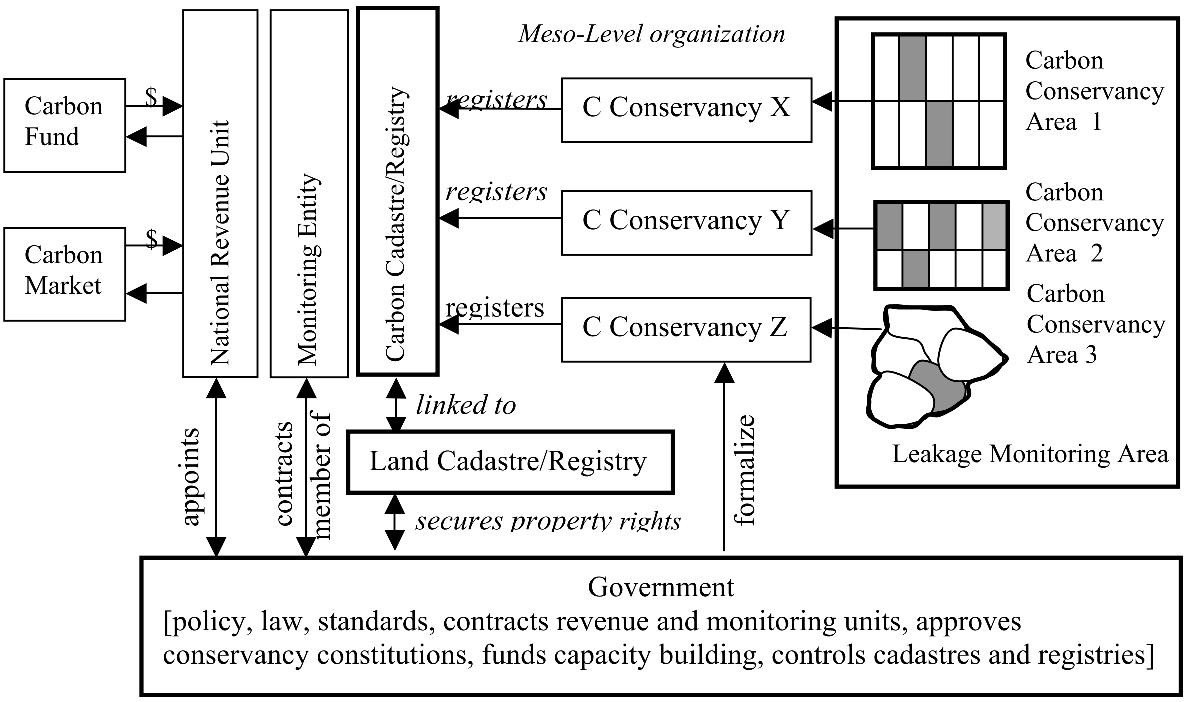

FIGURE 3. Proposed Governance Structure for REDD and Carbon Property Rights

At a minimum, the following information is required to secure carbon property rights and support the REDD process:

- Definition and description of boundary of carbon conservancy perimeter
- Unique identity of conservancy and names of members
- Constitution of conservancy, including how payments will be shared
- Legal status of underlying land and linkage to land cadastre if applicable
- Other secondary rights (e.g. concessions) over the land or resources
- Restrictions on forest/carbon use
- Carbon stocks and their spatial distribution

It is also important that the rules with respect to transferability, inheritance, extinction, subdivision, etc. of carbon property rights are clear and generally accepted. Beyond the specific information content in a carbon cadastre, it is essential that this cadastre serve as a vehicle for publicizing carbon property rights in as transparent and accessible manner as possible. It should not be used as a mechanism for asserting national control and may best operate below the national level.

CONCLUDING REMARKS

In this paper we have summarized the biophysical aspects of the carbon chain and how this has been radically shortened through unprecedented use of fossil fuels as well as land use practices that cause deforestation and release sequestered carbon. REDD has emerged as a viable mechanism for slowing and eventually reversing this trend. Since there is no legal history for identifying and registering a carbon property right, we have argued for a focus on these rights as they pertain to forest carbon. Land and forest tenure in places like the Amazon is complex (as illustrated by the case of Peru) and trying to define such rights through sequestration potential or in some other less tangible manner.

We have proposed a governance scenario which builds on the wildlife conservancy model in Namibia and identifies 'carbon conservancies' as the holding unit for carbon property rights that are formalized in a carbon cadastre/registry linked to the land cadastre/registry. We have made the case for an independent monitoring unit, especially where governance is weak. Finally, we have suggested what kind of cadastral information would be necessary to support the REDD process. If FIG is to repeat the exercise of looking ahead and defining a Cadastre 2030, it must focus on vital natural resources like carbon and not just on the land.

REFERENCES

Angelsen, A., ed. (2009). REDD+ National Strategy and Policy Options. CIFOR Publication, Denmark.

Achard, F., H.D. Eva, P. Mayaux, H.J. Stibig, A. Belward (2004), "Improved estimates of net carbon emissions from land cover change in the tropics for the 1990s," *Global Biogeochemical Cycles* 18, GB2008, DOI:10.1029/2003GB002142.

Archer, D. (2005). "Fate of fossil fuel CO2 in geologic time." *J. Geophysical Research*, 110 (C09505).

Barnes, G. and S. Quail (forthcoming). Property rights to carbon in the context of climate change. *Innovations in Land Rights Recognition, Administration and Governance*. World Bank/FIG Publication.

Basnet-Parasai, R. (2007). Who Owns Carbon in Community Managed Forest? Paper prepared for Amsterdam Summer School. http://www.2007amsterdamconference.org/Downloads/AC2007_Basnet.pdf (accessed 16 Jan, 2010)

Boydell, S., J. Sheehan and J. Prior (2008). Carbon Property Rights in Context. Draft paper submitted to *Environmental Practice*.

CIA (2008). *The World Factbook.* Washington, D.C. http://www.bartleby.com/151/fields/56.html (accessed 16 Jan, 2010)

Duchelle, A. (2009). Conservation and Livelihood Development in Brazil Nut Producing Communities in a Tri-National Amazonian Frontier. PhD dissertation, University of Florida, Gainesville, FL

Earth Negotiations Bulletin (Dec. 22, 2009), UN Climate Change Conference in Copenhagen COP 15/CMP 5 - Summary and Analysis, Vol. 12 No. 459, http://www.iisd.ca/download/pdf/enb12459e.pdf.

Ecosystem Marketplace (2010). State of the Forest Carbon Markets 2009: Taking Root and Branching Out. http://moderncms.ecosystemmarketplace.com/repository/moderncms_documents/SFCM.pdf

Ecosecurities (2009). The Forest Carbon Offsetting Survey 2009 http://www.ecosecurities.com/Registered/ECOForestrySurvey2009.pdf

Ecosystem Marketplace (2009). State of the Voluntary Carbon Markets 2009, http://ecosystemmarketplace.com/documents/cms_documents/StateOfTheVoluntaryCarbonMarkets_2009.

FAO (2005). State of the World's Forests. Rome: Food and Agriculture Organization of the United Nations.

Forest Dialogue (2008). Beyond REDD: The Role of Forests in Climate Change - A Statement from The Forests Dialogue. 8p.

Gaston, G.S., S. Brown, M. Lorenzini, K.D. Singh (1998), "State and change in carbon pools in the forests of tropical Africa," *Global Change Biology* 4: 97-114.

Global Canopy Program Blog "**REDD+ makes progress but ultimately fall short amid chaotic climate talks,"** http://www.globalcanopy.org/main.php?m=120&sm=169&bloid=49**.**

Global Witness (2009). A Decade of Experience Lessons Learned from Independent Forest Monitoring to Inform REDD. http://www.globalwitness.org/media_library_detail.php/894/en/a_decade_of_experience_lessons_learned_from_indepe (accessed 16 Jan 2010)

Griffiths, T. (2007). Seeing 'RED'? 'Avoided deforestation' and the rights of Indigenous Peoples and local communities. http://www.forestpeoples.org/documents/ifi_igo/avoided_deforestation_red_jun07_eng.pdf

Gullison, F.R., C.P. Frumhoff, G.J. Canadell *et al*. (2007), "Tropical forests and climate policy," *Science* 316: 985-986.
Hamilton, K. et al. (2008). *Forging a Frontier: State of the Voluntary Carbon Markets 2008*. Ecosystem Marektplace and New Carbon Finance.
Houghton, R.A. (2007). Balancing the global carbon budget, *Annual Review of Earth Planetary Sciences* 35: 313-47.
IPCC (2003). IPCC (2003). IPCC Workshop Report on the Detection and Attribution of the Effects of Climate Change. (C. Rosenzweig and P. Neofotis, Eds.) NASA/Goddard Institute for Space Studies, New York, 87 pp. http://www.ipcc.ch/
IPCC (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, Eds.). Cambridge Univ. Press, Cambridge, 996 pp. http://www.ipcc.ch/
Kaufmann, J. and D. Steudler (1998). Cadastre 2014: A Vision for a Future Cadastral System. http://www.fig.net/cadastre2014/translation/c2014-english.pdf (accessed 16 Jan, 2010
Keeling, CD, SC Piper, RB Bacastow, M Wahlen, TP Whorf, et al (2001). Exchanges of Atmospheric CO_2 and $^{13}CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. I. Global Aspects. Scripps Inst. Oceanogr., Tech. Rep. SIO Ref. Ser., No. 01-06 (Revised from SIO Ref. Ser., No. 00-21), San Diego.
Lewis et al (2009). Increasing carbon storage in intact African tropical forests, *Nature* 457:1003-1006. Masarie, KA and PP Tans (1995). Extension and integration of atmospheric carbon dioxide data into a globally consistent measurement record. *Journal of Geophysical Research*, 100: 11593-610.
Murphree, M. (2000) Constituting the Commons: Crafting Sustainable Commons in the New Millennium". "Multiple Boundaries, Borders and Scale" at the Eighth Biennial Conference of the International Association for the Study of Common Property (IASCP), Bloomington, Indiana, U.S.A., 18p.
NACSO (2008) Namibia's communal conservancies. A review of progress and challenges in 2007. Windhoek: Namibian Association of CBNRM Support Organizations, 120p
OCC (2008). Eliasch Report – Climate Change: Financing Global Forests. Office of Climate Change, U.K.
Parker, C., A. Mitchell, M. Trivedi and N. Mardas (2008). The Little REDD Book: A guide to governmental and non-governmental proposals for reducing emissions from deforestation and degradation. Global Canopy Programme, Oxford, UK.
Porrua, M. and A. Garcia-Guerrero (2008). Case Study: The Noel Kempff Climate Action Project, Bolivia. In *Climate Change and Forests: Emerging Policy and Market Opportunities* (eds. C. Streck, R. O'Sullivan, T. Janson-Smith and R, Tarasofsky), Brookings Institution Press, Baltimore, MD.
Phillips, G. and A. Razzouk. (2007). A trillion dollar marketplace. *Environmental Finance*.
Quan, J. and N. Dyer (2008). Climate change and land tenure: the implications of climate change for land tenure and land policy. FAO Report.
Randrianarisoa, J., B. Vitale and S. Pandya (2008). Case Study Creative Financing and Multi-sector Partners in Madagascar. . In *Climate Change and Forests: Emerging Policy and Market Opportunities* (eds. C. Streck, R. O'Sullivan, T. Janson-Smith and R, Tarasofsky), Brookings Institution Press, Baltimore, MD.
Robiedo, C. and H. Ok Ma (2008). Why are there so few forestry projects under CDM? *ITTO Tropical Forests Update Online Newsletter*, 18(3).
Sasaki, Nophea & Francis E. Putz (June 15, 2009), "Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements," *Conservation Letters*: 1-7.

Sedjo, Roger A. (1993). The carbon cycle and global forest ecosystems, Terrestrial Biospheric Carbon Fluxes: Quantification of Sinks and Sources of CO_2. Joe Wisniewski and R. Neil Sampson, eds. Boston, MA: Kluwer Academic Publishers.
Stern, N. et al (2007). Stern Review on the Economics of Climate Change, Cambridge Univ. Press, Cambridge, UK.
Stickler, C. (2009). Defending public interests in private forests: land-use policy alternative for the Xingu River headwaters region of southeastern Amazônia. PhD dissertation, University of Florida, Gainesville, FL
Suich, H. and B. Child, eds. (2008). Evolution and Innovation in Wildlife Conservation. Parks and Game Ranches to Transfrontier Conservation Areas. Earthscan, London.
Sunderlin, W., J. Hatcher and M. Liddle (2008). From Exclusion to Ownership? Challenges and Opportunities in Advancing Forest Tenure Reform. Published by Rights and Resources Initiative. http://www.rightsandresources.org/documents/files/doc_736.pdf
Takacs, David (2009). Forest Carbon: Law and Property Rights. Conservation International, Arlington, VA, USA
UNDP (n.d.) UN-REDD Program Fund. http://www.undp.org/mdtf/UN-REDD/overview.shtml
White, A. and Martin A. (2002). Who Owns the World's Forests? Report published by Forest Trends, Washington, D.C. (pg. 22) http://www.rightsandresources.org/publication_details.php?publicationID=98
Woods Hole Research Center (2008). An overview of Readiness for REDD: A compilation of readiness activities prepared on behalf of the Forum on Readiness for RED. (T. Johns and E. Johnson, eds.)
World Bank (2009). State and Trends of the Carbon Markets. World Bank Institute, Washington D.C. http://wbcarbonfinance.org/Router.cfm

BIOGRAPHICAL NOTES

Grenville Barnes received his early education at the University of Natal and completed his PhD at the University of Wisconsin, Madison in 1988. His work has dealt with technical, institutional, legal and policy issues associated with cadastral surveying and property information systems in developing countries. He has worked as a researcher, consultant or educator in over twenty countries, primarily in Latin America, the Caribbean and Southern Africa. Grenville has published in a wide variety of professional journals in the US, Canada, South Africa, India, and Brazil. He currently serves as the Co-Director of the Masters in Sustainable Development Practice (MDP) Program at the University of Florida.

Sheryl Quail is a Ph.D. student at the University of Florida in the School of Forest Resources and Conservation, Geomatics Program. Her research interests are concerned with community carbon offset forestry, property rights, land use land cover change, spatial analysis and modeling of deforestation. Sheryl received her Master in Environmental Studies from the Evergreen State College and conducted research in southern Kenya on livestock development, land tenure, and grassland ecology. As an undergraduate, she studied marine science, as well as agroecology. Prior to coming to Florida, she taught oceanography, biology and environmental science. As she relies on the products of viticulture to mitigate parental stress, she is concerned with the impact of climate change on the wine industry.

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