CHAPTER 4

Challenges

DEVELOPING WORKABLE POLICIES AND INCENTIVES IS DIFFICULT

The principle of "common but differentiated responsibilities" in the Kyoto Protocol regulates emissions for Annex I countries, but encourages developing country participation through the CDM. The current rules for the land-use, land-use change and forestry projects under the CDM, adopted at the Seventh Conference of the Parties (COP7) in 2001, resulted in an agreement that permits afforestation and reforestation carbon offset projects in developing countries, but with complex monitoring and reporting requirements, and the exclusion of emissions from deforestation or credits for agricultural or grassland sequestration (Schlamadinger *et al.*, 2007). Emissions from afforestation, reforestation and deforestation since 1990 are reported as part of United Nations Framework Convention on Climate Change (UNFCCC) official National Communications that will determine compliance with the Kyoto Protocol emission reduction targets. The CDM is designed to lower costs for achieving that goal while encouraging participation of non-Annex I countries and helping to foster sustainable development (Paulsson, 2009). Many developing countries strongly supported the inclusion of sinks in anticipation that emission caps would substantially increase the flow of aid – in the form of emission offset projects – from developed countries (Boyd, Corbera and Estrada, 2008). The inclusion of sinks through the CDM allows participation of a wide range of actors in emission reduction efforts, but places strict limits on only a subset of those participants. Balancing emission reductions for large emitters with mechanisms that engage small emitters remains a key component of international negotiations.

DEMONSTRATING ADDITIONALITY IS A FORMIDABLE CHALLENGE[1]

Under the Marrakesh Accords, projects that reduce GHG emissions "below those that would have occurred in the absence of the registered CDM project activity" are eligible for credit under the CDM (UNFCCC, 2001). Key challenges for projects from uncapped countries – for all types of offset projects, not just sequestration projects (Reilly and Asadoorian, 2007) – is proving to be counter-factual: convincingly demonstrating what would have been done in the absence of carbon sequestration incentives. Methods of assessment have been developed (Chomitz, 2002) and various rules have been proposed (Wiley and Chameides, 2007) and applied (see Paulsson, 2009; Palm, Ostwald and Reilly, 2008) to address additionality and leakage. To date, the results of carbon emission offsets under the Kyoto Protocol have been mixed (Paulsson, 2009). Several projects of dubious emission reduction value have been approved (Wara, 2007), and a few sequestration projects have been accepted. Research relating to the feasibility of the CDM continues to address this issue (Paulsson, 2009).

Demonstrating additionality requires information other than sampling of biomass or soil carbon stocks (Lovbrand, 2004). Policies that incentivize adoption of behavioural (i.e. land management) changes are confronted by additionality and the potential for perverse incentives, which in the case of forestry and agricultural sequestration could encourage landowners to get rid of ecosystem carbon through tillage, fire or harvest so that they could then be paid to re-sequester it. All policies, grants or investments that fund or incentivize some action implicitly assume that the action would not have taken place in the absence of policy implementation. The difficulty is compounded in terrestrial carbon sequestration projects because the direct, human-induced changes in carbon stocks must be distinguished from changes in carbon stocks driven by natural processes (e.g. biomass carbon stock recovery after a fire), and indirectly by human actions (e.g. enhanced biomass carbon stocks driven by CO_2 fertilization or N deposition; increased soil carbon stocks driven by shifts

[1] Greiner and Michaelowa, 2003; Schneider, 2009; Grainger, 2009

in species composition) (Lovbrand, 2004). In theory, such changes could be documented by sampling, but disentangling drivers of carbon stock changes remains challenging (Alexandrov and Yamagata, 2004; Canadell *et al.*, 2007; Smith, 2005).

The anticipated low costs of grassland carbon sequestration are intimately intertwined with the additionality issue – if barriers (costs) are low for adopting practices that sequester carbon, they are more likely to be adopted in the absence of policies to promote them. Documenting changes in biomass or soil carbon stocks will require some kind of measurement coupled with extrapolation or interpolation (Conant *et al.*, 2009). These measurements differ from those required for other types of offset projects; they contribute more significantly to project costs, and economies of scale may not be as effective at reducing costs. Enacting a project in which several landowners carry out carbon sequestering practices would require documenting the effect of those practices (collectively or individually) on each parcel. The difficulty lies not in measuring carbon stocks but in devising measurement/ monitoring/verification systems that are accurate yet cost-effective (Conant *et al.*, 2009).

CARBON SEQUESTERED IN GRASSLAND SYSTEMS IS SUBJECT TO REVERSALS

Disturbance can cause rapid reversals of previously sequestered carbon (Galik and Jackson, 2009). Such disturbances can be large or small, intentional or unintentional (Page *et al.*, 2002). The CDM has dealt with this issue by developing temporary Certified Emission Reductions (CERs) for five- or twenty-year periods (Dessai *et al.,* 2005), while other standards reduce emission reduction credits to buffer against losses[2]. Impermanence decreases the value of sequestration projects compared with emission reduction projects, and increases uncertainty and transaction costs (van Kooten, 2009). The resolution of additionality, leakage and permanence issues is critical for acceptance of REDD and terrestrial sequestration in a post-2012 climate agreement; the identification of a pre-agreement

[2] For example the Voluntary Carbon Standard (http://www.v-c-s.org)

baseline against which deforestation/degradation reductions can be evaluated (Karsenty, 2008) is of equal importance. There are benefits that are unique to carbon sequestration activities, despite the fact that they are not permanent. To achieve these benefits, policies must ensure accurate value of temporary carbon sequestration and minimizing costs associated with transactions (Marland and Marland, 2009).

WELL-INTENTIONED POLICIES DO NOT NECESSARILY LEAD TO GOOD PRACTICES

Scientific information is lagging behind the desire to craft robust terrestrial carbon sequestration policies; some argue that there are too many uncertainties to proceed. For example, conservation tillage is one of the largest potential sources of greenhouse mitigation within the agricultural sector (Smith *et al.*, 2008) and, coupled with associated declines in fuel use, could make an immediate, substantial contribution to offsetting and reducing GHG emissions (Kimble, 2004; Paustian *et al.*, 2004). However, the implementation of reduced- or no-tillage practices does not always lead to significant increases in carbon stocks (Ussiri and Lal, 2009; Blanco-Canqui and Lal, 2008).

In some cases, depletion of soil carbon stocks at depth offsets gains in surface soils; the mechanism driving this process is not well-understood (Angers and Eriksen-Hamel, 2008; Baker *et al.*, 2007). There is also uncertainty about how practices that sequester carbon impact local climate through albedo and water balance (IPCC, 2007c); practices that lead to reduced GHG concentrations could promote local warming (Chapin *et al.,* 2008). Practices that sequester carbon could also lead to increased N_2O (such as fertilization to enhance carbon inputs), or CH_4 (e.g. flooding to preserve organic soils; see Box 2) (Schlesinger, 2000). The contribution of erosion to the depletion of soil carbon stocks and the fate of eroded carbon are additional, important uncertainties (Berhe *et al.*, 2007). Finally, disturbances are stochastic and often unpreventable processes that can lead to carbon losses (Smith, 2005), and ecosystem and socio-economic feedbacks (i.e. leakage, unintended consequences) are capable of undermining the intended benefits of forestry and agricultural sequestration projects (Jack, Kousky and Sims, 2008).


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LAND TENURE AND GOVERNANCE ISSUES COMPLICATE POLICY IMPLEMENTATION

Smallholder households represent a serious challenge for documenting carbon sequestration (Coomes *et al.,* 2008). Aggregation across a variety of landowners increases monitoring transaction costs, implying that the cost-effectiveness of carbon sequestration projects conflicts with poverty alleviation goals (Jack, Kousky and Sims, 2008; Lipper and Cavatassi, 2004). Pastoralists occupy substantial portions of the land area in many parts of the world, with the potential to sequester carbon in grasslands. However, pastoralists are often socially marginalized and with insecure land tenure rights, making it very difficult for participation in carbon markets (Neely *et al*., 2009). In many of the places identified as having low-cost sequestration options, a large percentage of people make their living from the land. Compensation for foregoing land development could be financially beneficial, but may be of limited long-term development value. Uncertainty about land tenure among smallholders and weak institutions are key issues that discourage potential participants from adopting carbon sequestering practices (Greig-Gran, Porras and Wunder, 2005). Furthermore, practices that sequester carbon are not inherently coupled with other environmental benefits. For example, Nelson *et al*. (2008) found that in the northwestern part of the United States of America, sequestration policies did not necessarily achieve forest conservation goals and none of the conservation policies studied sequestered carbon. Similarly, the CDM has not yet led to forestry mitigation that successfully fosters adaptation to climate change (Reyer, Guericke and Ibisch, 2009).

SYSTEMS FOR DOCUMENTING CARBON STOCK CHANGES HAVE NOT BEEN AGREED UPON

Methods for analysing soil carbon concentration of a given sample are well established and easily carried out with high precision and minimal analytical error (Spark, 1996). However, soil carbon stocks vary as a function of soil texture, landscape position, drainage, plant productivity and bulk density, all of which vary spatially, and create heterogeneity that makes it difficult to quantify changes in soil carbon stocks over time (VandenBygaart, 2006; Robertson *et al.,* 1997; Cambardella *et al.,* 1994). Sampling error can be large and "the cumulative effects of managing small net sinks to mitigate fossil-fuel emissions will have to be understood, analyzed, monitored, and evaluated in the context of larger, highly variable, and uncertain sources and sinks in the natural cycle" (Houghton, 2006). Thus, the main challenge in documenting plot-level changes in soil carbon stocks is not in measuring carbon, but rather in designing an efficient, cost-effective sampling and carbon stock estimation system. Given higher rates of soil carbon sequestration, relatively low initial amounts of soil carbon, and modest spatial variability, the standard approach for a project – sampling and then future re-sampling of soil cores – would still require collection and analysis of dozens of soil samples to detect changes within a given field over a five- to ten-year time period that might be used for verification in an agricultural offset project (Conant and Paustian, 2002b; Yang *et al.,* 2008). Quantifying soil carbon changes at national or regional scales requires much more modest sampling densities (Makipaa *et al.,* 2008; Saby *et al.,* 2008), but such sampling precludes the possibility of attributing carbon credits to a particular practice or plot of land.

Practice-based estimates of soil carbon sequestration

One common approach to assessing changes in soil carbon stocks is to use information synthesized from previously published studies on how changes in management practices impact soil carbon stocks. Offsets can be verified by monitoring agronomic practices (e.g. monitoring no-tillage by surveying residue coverage on the soil surface). Such verification is already an established practice for other conservation programmes and can be relatively inexpensive. Syntheses of existing field experiments (Ogle, Breidt and Paustian, 2005) provide empirical estimates of the average soil carbon change for a particular practice within a broad region (see Figure 3). However, studies of management impacts on soil carbon stocks are so sparse that to rely on them for sequestration rates for a specific farm or group of farms in a given region (which are unlikely to be well represented by published studies) will lead to substantial uncertainty. This uncertainty is difficult to quantify using statistical methods with limited data. Moreover, the rates are typically based on relative changes in soil carbon stock changes, which could differ from the actual rates if there are other environmental drivers, such as climate change, that are also contributing to significant changes in soil carbon stocks. If uncertainty is high, permitted soil carbon offsets may be substantially discounted relative to estimated carbon sequestered, in order to limit the risk that the offsets do not represent real reductions in CO_2 emissions to the atmosphere (VCS, 2008). Another limitation of a broad practice-based approach is that it is economically inefficient (Antle *et al.*, 2003). Because of heterogeneity in the response of soils to specific management practices (due to differences in soils, climate conditions, land-use history), broadly based payments by practice will overcompensate poorer performance, and undercompensate better performance (hence disincentivizing their participation). Thus, even if the practice-based credit was an accurate estimate for the average performance within the region, the actual benefits achieved would be overestimated, and this inefficiency would increase as a function of the degree of spatial heterogeneity in soil response (Antle *et al.*, 2003). An estimation system that can account for more of the local variability in soil responses to a particular management practice will increase the economic efficiency of the mitigation policy, and provide a better estimate of the actual mitigation benefits achieved.

Combining measurement with mechanistic modelling

Terrestrial soil carbon offsets can be quantified using a mechanistic ecosystem model. A dynamic system comprised of a measurement database that is updated as new measured terrestrial soil carbon offset data become available could integrate measurements with state-of-the-art knowledge about ecosystem function, and enable the up-to-date calculation of model uncertainty estimates using established statistical methods (Ogle *et al.*, 2007). A system that combines measurement of soil carbon with models would have a number of unique benefits not possible with modelling or measurement alone. Systems that discount or withhold reserve credits to account for uncertainty, such as the Voluntary Carbon Standard, could use uncertainty derived from the model analysis associated with a particular offset activity to determine reserve requirement.

These systems would have the flexibility of a model-based approach, being able to account for all types of terrestrial offsets, unlike the measurement approach that is likely to have gaps, but would be reliable because the associated uncertainty is determined from on-the-ground observations. As a system, such a modelling-measurement approach would be robust because it would be continually updated as new sample data are made available, and it could be used to direct sampling towards those areas where uncertainty is greater relative to offset activity. Such systems could also potentially encourage more

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innovation by agricultural producers because new measurements would be incorporated from the latest management options, while using the model to allow all producers to receive credit from the latest innovations without necessarily requiring new measurements on each farm. Finally, a combined system could make use of published information on how other factors (like global change, widespread land-use changes, changes in land use prompted by terrestrial soil carbon offset programmes, etc.) affect soil carbon stocks both on- and off-site, to account for shifting baselines, additionality and leakage.

Data on management impacts on carbon stocks are limited in developing countries

Systems that integrate measurement and mechanistic modelling require robust sources of data that reflect the range of potential management practices. A variety of efforts are under way across the developed world to build up, test and implement such systems. However, all syntheses document that, in the developing world, observations of management-induced changes in soil carbon stocks are relatively rare (Conant, Paustian and Elliott, 2001; Smith *et al.*, 2006). Lack of accurate information can lead to greater uncertainty in estimates of soil carbon stock changes, and could result in climate-driven bias because developed country studies are more common in temperate regions. More importantly, practices that could be most beneficial risk being excluded from schemes to encourage carbon sequestration because the practices are not widely familiar to the scientists from the developed world, and to policy-makers who develop quantification tools. This paucity of data from developed countries presents a challenge to the creation of robust accounting systems that offer the same utility for quantifying soil carbon sequestration in developed and developing countries.

CHAPTER 5
The way forward

FOUNDATIONS FOR SOUND POLICIES

Current yields and economic returns can often be maximized by practices that boost forage harvest, deplete soil nutrients and reduce the long-term productive capacity of grassland systems. Indeed, economic pressures to "adopt unsustainable practices as yields drop" in response to a changing climate, "may increase land degradation and resource use" (IPCC, 2007d). This fact should further motivate support for policies and programmes that encourage the implementation of sustainable grassland management practices. Identifying and understanding situations in which short-term interests in harvest trump long-term interests in maintaining productive capacities, and developing technical solutions that involve research, education and technical assistance in implementing sustainable practices, should be a top priority. A key challenge is the large number of smallholders and pastoralists who may be among the hardest hit by climate change (FAO, 2009). Their challenge is often exacerbated because uncertain land tenure discourages investments that pay dividends in the long term. Thus, efforts to spread knowledge on sustainable grassland management practices are essential for ensuring their successful implementation and must address tenure-related motivations to implement sustainable practices.

Not all categories of producers have the same potential for implementing sustainable land management practices, and some producers will benefit more and sooner than others. Development–mitigation–adaptation strategies must be evaluated within the framework of local environmental conditions, institutions and capacities. Priority should be given to investments in sustainable land management practices that:

- show strong evidence of enhancing near- and longer-term productivity and profitability for farmers and pastoralists;

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- offer opportunities to enhance production, mitigate GHG emissions and enable adaptation to climate change;
- develop incentives that foster sustainability of existing resources – soil, water, air, labour, etc.;
- rehabilitate lands that can be improved at modest cost, and adopting low-tech changes in management practices;
- support research and education on best practices for maintaining fertility and production; and
- align with existing investment programmes.

Despite win–win situations in which practices that sequester carbon also lead to enhanced productivity and substantial biological potential to sequester carbon in grasslands, policies to encourage adoption of practices that sequester carbon in grasslands lag behind policies for forest and agricultural lands. Like forestry and agricultural sequestration, policies that promote carbon sequestration in rangelands could form an important part of a "no regrets" climate strategy. This is particularly true for practices that promote increased primary productivity or livestock production and practices that arrest rangeland degradation. In addition to sequestering carbon, implementing practices that sequester carbon can help to achieve the strategic objectives of the UN Convention to Combat Desertification: improving livelihoods, enhancing productivity and generating global benefits. Reducing emissions from grassland degradation is not only likely to pay dividends in maintaining carbon stocks, but also in sustaining the livelihoods of people making a living from grasslands.

GRASSLAND CARBON SEQUESTRATION IN CONTEXT

Much of the world's grassland, a disproportionately large share of the degraded grassland and a majority of grassland sequestration potential is found in the developing world. More importantly, the fate of large portions of the populations in these areas is intimately tied to livestock production systems directly dependent upon grasslands. Sustaining productivity and rehabilitating degraded grassland systems are crucially important to people right now. It is also clear that there are synergistic effects with other development agendas. For example, Kandji and Verchot (2007) point out several ways in which developing countries in semi-arid East Africa will be adversely impacted by climate change and the relationship of those impacts to the Millennium Development Goals. The relevant goals are: reduce hunger and poverty (Goal 1) by reducing vulnerability to extreme events; ensure environmental sustainability (Goal 7) by rebuilding ecosystem carbon stocks and restoring ecosystem processes; and build a global development partnership (Goals 8) while enhancing the ability for governments to invest in key socio-economic sectors. Synergies between environmental, development and agricultural activities indicate opportunities for engagement from multiple sectors.

RESEARCH PRIORITIES

A key barrier to identifying priority investments is lack of knowledge on the impacts of grassland management in most of the developing world. Despite a large estimated potential in the developing world, lack of direct observations makes these estimates highly uncertain (Conant and Paustian, 2002a; Ogle, Conant and Paustian, 2004). Moreover, best management practices are typically based on those identified in other regions, limiting the breadth of management alternatives and possibly overlooking those

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that could do more to build or rebuild soil carbon stocks and enhance productivity. Efforts to build capacity while enhancing environmental benefits, such as the participatory practice capture used by the World Overview of Conservation Approaches and Technologies (WOCAT), can simultaneously facilitate identification and implementation of best practices. Building soil carbon stocks through the implementation of improved/more sustainable management practices is just one component of developing more productive and efficient livestock production systems. Increasing livestock production could lead to greater CH_4 emissions, but improving feed quality by enhancing pasture management to produce forage with more balanced quality (Leng, 1993) could concurrently sequester carbon, and increase milk or meat production. If implemented in coordination with grazing practices that encourage consumption of a quality, mixed diet, CH_4 emissions per unit product could even decline. Improved grassland management can facilitate better breeding: reducing the number of replacement heifers, reaching slaughter weight at an earlier age, increasing milk production, bringing higher pregnancy rates, etc. This in turn could reduce GHG emissions per unit product, despite the fact that none of the practices mentioned above directly reduce emissions (Boadi *et al.*, 2004). A systems perspective is therefore crucial: research to assess carbon sequestration alone could miss important interactions with factors that control ruminant CH_4 emissions. This latter represents one of the largest sources of GHGs in developing countries.

Successful pilot projects carried out in collaboration with national scientists, grassland managers and development actors will play a key role in demonstrating the feasibility of new practices. At the same time, pilot projects are necessary to extend and divulgate information on the efficacy of grassland management practices as a mitigation strategy. Understanding the institutional requirements and testing carbon accounting procedures are crucial next steps for legitimizing mitigation through grassland management. Investing in pilot projects will engage community leaders, farmers and other resource users in programme development, and build up technical, organizational and human capacities (Pender *et al.,* 2009). An important component of a pilot programme consists of the conduct of desk reviews and collection of additional information on current and projected GHG emissions from other grassland projects and pilot studies. Outputs from this work built around a series of pilot study programmes could include:

- a comprehensive database of estimates of greenhouse emission factors by region, and a complete grassland emission inventory;
- a focus on documenting carbon sequestration responses for areas or practices that are understudied;
- an analysis of different global and regional scenarios for grasslands under different carbon constraints (different policy measures and prices for carbon), financing and crediting arrangements and the development of supporting models and tools;
- an analysis of the marginal costs of carbon sequestration in grasslands driven by changes in management practices, together with a detailed description of their implications for food security and livelihoods;
- policy and technical guidance for Nationally Appropriate Mitigation Actions that may affect grassland production and food security; and
- scientific underpinning in support of international (post-Kyoto) agreements on climate change.