Toward Carbon Governance: Challenges across Scales in the United States

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Introduction

Nations, regions, local communities and individuals are currently moving toward or are in the process of implementing actions to reduce carbon dioxide emissions because of concern over global warming (Moser this issue). Managing "carbon sinks," i.e. deliberately storing carbon in land vegetation and soils or ocean waters, has been strongly promoted and accepted by some as a mechanism to accomplish the goal of reducing atmospheric carbon dioxide concentrations while allowing additional flexibility beyond reducing emissions from fossil fuel use.[1] Articles 3.3 and 3.4 of the 1997 Kyoto Protocol of the UN Framework Convention on Climate Change (UNFCCC) formalized the option for nations to utilize certain types of "carbon sinks," although details continue to be negotiated and studied after general rules were agreed upon in November 2001.[2] While international rules for accounting and reporting creditable carbon sink actions are being established through this process, these rules do not specify the mechanisms by which nations and subnational institutions will effectively govern carbon sinks.[3] Furthermore, even nations such as the United States and Australia that are not party to the Kyoto Protocol are nonetheless considering a variety of measures and proposals with which to manage carbon.[4] While

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1. For example, US Position paper presented at the 5th Conference of the Parties in 1998 available at http://yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/SHSU5BURBS/$File/land_use.pdf, accessed 21 November 2005.
2. http://unfccc.int/2860.php.
3. Young 1999, 17.
4. Examples include Section 1605b, US Energy Policy Act of 1992. DOE implementation website available at http://www.eia.doe.gov/oiaf/1605/frntvrgg.html, accessed 7 November 2005; Presidential directive on agricultural sink research, available at http://www.usgcrp.gov/usgcrp/agencies/usda.htm, accessed 7 November 2005; The Climate Trust in Oregon, available at http://www.climatetrust.org/index.php; and Chicago Climate Exchange, based in Chicago, available at http://www.chicagoclimatex.com/.

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international negotiation is providing input at one level toward carbon governance, achieving the goal of reducing atmospheric carbon dioxide through land sinks will require effective governance criteria and mechanisms that address problems such as permanence, leakage, and verification across scales.[5] In practice, mechanisms will be difficult to establish and implement for carbon governance because the emission of carbon to the atmosphere is controlled by many diverse decision makers at different scales and within different sectors. In this paper I will focus on the example of land use-related sinks in the United States to describe some of the challenges to effective carbon governance across scales.

I use the term carbon management to describe the category of suggested strategies that aim to deliberately affect the amount of carbon dioxide that is present in the atmosphere. Carbon management strategies currently under consideration or being implemented include terrestrial carbon sequestration, ocean sequestration, and geologic sequestration, altering the amount of carbon dioxide emitted through the production or use of energy such as switching to less carbon intensive fuels or implementing carbon capture and storage, and reducing overall demand for energy by implementing efficiency and conservation measures.[6] The term management is used to simply imply that there is deliberate thought of how the particular activity involved affects carbon. For millennia, societal activity including agriculture and energy production has been inadvertently altering the carbon cycle, but such activity is not considered management when actors are not aware of the impact of these activities on atmospheric composition.

Carbon governance, on the other hand, I define as the planning, influencing and conducting of the policy and affairs of institutions that aim to minimize the amount of carbon dioxide released to the atmosphere or maximize the amount of carbon stored stably away from the atmosphere. Such governance is effective, therefore, when carbon dioxide is controlled in the atmosphere. Carbon governance might take the form of policy instruments such as taxes, incentives, regulations, subsidies, market-based mechanisms, voluntary measures, or new societal norms. As has been discussed extensively elsewhere, governance can encompass notions of both state and nonstate actors, as well as behavioral norms, operating at multiple scales.[7] As a loose analogy, carbon management relates to carbon governance in the way that installing a catalytic converter on automobiles might relate to air pollution legislation.

This paper focuses on carbon management through land use and management to illustrate the challenges of carbon governance across scales. Land use and management for carbon are especially of interest because they have gained the most traction thus far as carbon sink flexibility mechanisms in the international arena under the Kyoto Protocol and are being widely considered and even implemented in the United States, not a party to the Protocol. Other types

5. Young 1999, 17.
6. Pacala and Socolow 2004.
7. Young 1999.

of carbon management share some similarities in the challenges that they pose for carbon governance, but also have important differences and are beyond the scope of this paper. Geologic sequestration is also being tested by private corporations and governments but may have a much smaller number of potential actors involved in decision making given that such activities have a limited number of potential application sites.[8] Ocean sequestration, both in the form of deep ocean injection and ocean fertilization, has some entrepreneurs and researchers involved, but does not appear to be as widely discussed or promoted as terrestrial sequestration. Energy-related carbon management would likely also contain many cross-scale carbon governance issues but is also beyond the scope of this paper.[9]

Carbon management through land use encompasses a broad range of activities on a wide variety of land cover types. The Intergovernmental Panel on Climate Change (IPCC) categorizes these activities into two broad types—improved management within an existing land use, and land use change.[10] Improved management within a land use includes management of forests, cropland, grazing land, agroforestry, rice paddies and urban land management. Reduced tillage, or no tillage, where one reduces or ceases mechanical plowing of the soil as part of crop cycles, is one example of land management on agricultural land that results in more carbon sequestered in soils. Land use change includes conversion of cropland to grassland (which stores more carbon generally per acre than cropland), agroforestry (the intentional growing of trees), wetland restoration, and restoring severely degraded land. Globally, some of these types of activities have significant potential, strictly from a biophysical perspective, of carbon uptake into biomass. For example, if improvements in cropland management were implemented globally, they are estimated to result in an additional 125 Mt C/yr stored in soils by 2010.[11] As a comparison, the annual emissions of the United States in 2003 was 6900 Mt C/yr CO_2 equivalents, or 1882 Mt C/yr.[12]

Carbon management through land use activities is of course a controversial subject in many of the world's nations.[13] The European Parliament and the Council of the European Union have allowed some flexibility mechanisms to go forward such as emissions trading, but carbon sinks have so far not been included in the suite of options available to meet emissions targets. As stated by a memo issued by the European Commission in February, 2005: "Carbon sinks—planting forests to soak up CO_2—have been a contentious issue at UN level because they do not bring technology transfer, they are inherently temporary and reversible, and uncertainty remains about the effects of emission removal by

8. IPCC 2005.
9. But see Wilbanks and Kates 1999 for a full discussion.
10. IPCC 2000, 14.
11. Ibid., 14.
12. EPA 2005.
13. Amano and Sedjo 2003.

carbon sinks."[14] The memo goes on to say that "a number of technical and political issues remain to be resolved before such credits can be used by companies in the EU trading scheme." Some individual nations, Sweden for example, have ruled out the use of forest sinks to meet commitments to emissions reductions targets.[15] Canada and Japan, on the other hand, are parties to the Protocol and intend to utilize carbon sinks to the limit provided by negotiations in Bonn and Marrakesh.[16] 2006 is the year by which countries must decide if they are going to implement sink activities to be counted under the Kyoto reporting framework.

The challenges to cross-scale carbon governance derive from previously identified problems with managing carbon for climate mitigation purposes. Such challenges include quantification, additionality, separation, permanence, leakage and unintended consequences, such as linkages to other environmental values such as biodiversity.[17] The key concerns revolve around accurate accounting for activities, ensuring that nations are receiving credit for additional effort rather than "business as usual," curbing perverse incentives, ensuring long term carbon storage, and in general developing rules such that activities result in overall a reduction in atmospheric carbon dioxide, rather than simply displacing emission-causing activities to another region or another time period down the road. These difficulties associated with implementing carbon sinks as part of the Kyoto Protocol framework have resulted in heavily negotiated rules and reporting guidelines for national level accounting of such sinks.[18]

How these challenges to effective carbon governance are dealt with at levels below the international framework remains to be seen. Certainly some activities occurring within the United States and elsewhere do aim to various degrees to build in mechanisms within their projects to guard against perverse incentives and attempt to construct a robust set of rules to promote effectiveness with respect to climate protection. Such activities may be thought of as an example of "governance without government"[19] in that the projects are aware that their activities must in the end be effective in reducing carbon concentrations in the atmosphere, but no national level governmental policy exists to require it. Whether these activities would result in an effective governance regime that results in reductions in global atmospheric carbon dioxide is not yet known. This paper aims to set forth the challenges to effective carbon governance at multiple scales, using management of land for carbon sink purposes in the United States as an example.

14. MEMO/05/49 of 16/02/2005. Available at http://europa.eu.int/rapid/pressReleasesAction.do?reference?MEMO/05/49, accessed 4 April 2006.
15. Amano and Sedjo 2003.
16. Ibid.; and Pohjola et al. 2003.
17. Dilling et al. 2003.
18. http://unfccc.int/documentation/documents/advanced_search/items/3594.php?such=j&symbol=%22FCCC/SBSTA/2005/7%22#beg, accessed 4 April 2006.
19. As cited in Young 1999, 7.

Diverse Decision Makers

One of the challenges to carbon governance arises from the diversity and large number of decision makers making decisions that affect carbon storage on land. Given that carbon governance is not currently, and will not likely be in the future, achieved by a single entity that manages activity on land and accounts for goals related to carbon, the variety of decision makers will continue even if land carbon sinks are to be deliberately governed. This diversity makes it difficult for effective carbon governance to be established, whether through behavioral norms, laws, or economic incentives.

Land in the United States is a patchwork of highly diverse vegetation types and land ownership patterns. All of the land in the US is managed to some degree, whether publicly or privately owned. In 2002, the greatest percentage of land was classified as forest (651 ma, million acres, 29%), followed by grassland, pastures and range (587 ma, 26%), cropland (442 ma, 19%), and special uses, such as parks and wilderness (297 ma 13%).[20] Urban land and "miscellaneous, including desert" make up the rest. In each land use category there are public and private land owners. The Federal government manages 29% of the land, most (70%) through the US Department of Interior, which comprises Bureau of Land Management, Fish and Wildlife Service, National Park Service, Bureau of Indian Affairs and the Bureau of Reclamation.[21] The rest of the Federally-managed lands are managed through the U.S. Forest Service of the Department of Agriculture (27%) and the Department of Defense (3%).[22] The majority of land in the US is privately owned (71% of contiguous 48 states).[23] Of course even privately-held lands are greatly influenced by public policies, as well as by economic factors.[24] A very small amount is also held as state public lands.

From this brief survey of land ownership categories in the United States it is clear that a myriad of types of decision makers are directly involved in managing land with a variety of missions and incentives. Decision makers for public lands include elected officials, who set national policy, and agency civil servants, often long-term career government employees who implement their respective agency missions. At the county and local scale, both elected officials and local government staff are responsible for determining land use zoning laws and regulations. National, state and local policies all impact the decisions of private landowners, who range from very small individual household land owners to industry-scale agriculture and forestry corporations. Non-profit groups such as

20. USDA, Economic Research Service, Available at http://www.ers.usda.gov/Briefing/LandUse/majorlandusechapter.htm, accessed 7 November 2005.
21. US Department of Interior, http://mits.doi.gov/quickfacts/facts.cfm, accessed 7 November 2005.
22. US Forest Service, http://www.fs.fed.us/aboutus/meetfs.shtml, accessed 7 November 2005.
23. US Department of Agriculture, Natural Resources Conservation Service, National Resources Inventory 2002, available at http://www.nrcs.usda.gov/technical/land/nri02/nri02lu.html, accessed 7 November 2005.
24. Lambin et al. 2001.

the Nature Conservancy can also influence land use decision making, although such efforts are quite localized.

The range of diverse decision makers involved in land use management in the US as well as land vegetation types pose a complicated challenge to effective carbon governance for three reasons. To make a significant difference to atmospheric carbon dioxide, carbon management on land will have to be sufficiently widespread.[25] For example, Pacala and Socolow (2004) estimate that in order to reduce carbon emission rates in 2054 by 1 GtC/yr, or 1/7 of the amount need to stabilize atmospheric concentrations at 500 ppm (parts per million, 120 ppm higher than 2006 levels), conservation tillage practices would have to extend to all available cropland, about 10 times the current rate of application. While changing agricultural practices has been promoted to offset a significant portion of US emissions,[26] costs and limits on policy incentives will likely limit adoption of these practices.[27]

The diversity of decision makers is a direct problem for governance when dealing with the issue of leakage. Leakage occurs when demand for traditional land services does not decrease, and gains in carbon storage in one location are negated by losses in carbon elsewhere.[28] Harvest of timber in the 1980s and 1990s in the US provides a particularly illustrative case. Forests in the Pacific Northwest of the US are largely publicly owned and managed. When policies shifted to reduce harvest in public lands, harvests of timber correspondingly increased in privately-owned forests in the Southeast of the US, because demand for wood products had not diminished overall.[29] Overall, timber harvest did not decrease but merely shifted to a different set of land owners. In addition, this implies that any system of governance that creates incentives for creating or enhancing new sinks, such as planting new forests, will need to also create an equally strong incentive for maintaining existing sinks, such as older forests.[30] Otherwise, pressure for timber will shift to existing forests, thereby negating any carbon gains and potentially leading to perverse incentives regarding other environmental goals such as biodiversity.[31]

While many theoretical frameworks have been advanced for dealing with leakage, it remains an issue for both land use and energy projects.[32] As pointed out by Richards and Stokes because of the uncertainty in interaction between various markets for agricultural and forest land and word products, "governments may spend billions of dollars and achieve no net increase in long term carbon sequestration."[33]

25. E.g. Pacala and Socolow 2004.
26. Lal et al. 1998.
27. McCarl and Schneider 2001; Uri 2001; and Smith 2004.
28. Richards 2004.
29. Smith et al. 2004; and Alig and Butler 2004.
30. Richards 2004.
31. Schulze et al. 2002.
32. Aukland et al. 2003; and Richards and Stokes 2004.
33. Ibid.

As Richards suggests, a comprehensive solution to the issue of leakage and unresolved questions about markets might require a system of universal coverage for all sinks, with payments or restrictions on land use, neither of which is politically or economically palatable. A more optimistic assessment offers that the issue of leakage is only problematic at present, when projects are few and far between and access to credits is limited.[34] With the growth of the market and expansion of a credit system, proponents of carbon sink projects argue, issues such as leakage will become less important.[35]

Carbon Lacks Immediacy and Intrinsic Value

While more and more agricultural producer groups, forestry corporations, government agencies, and local governments are becoming aware of the value of carbon management for addressing climate change, carbon has not been a commodity that people have explicitly managed or valued in the past. Carbon in soils, for example, has been indirectly valued for its contribution to soil quality, soil resilience and prevention of erosion.[36] But quantifying carbon or monitoring its accumulation in soils as a goal in itself has not been a priority. To date, no land owners or managers have a "climate protection mandate" and so they will continue to manage lands for a variety of other purposes, such as food production, timber production, profit, recreation, minerals recovery, wilderness preservation, and so on.

Demand for land services other than carbon such as lumber, paper, housing, grazing for livestock, and recreation continues to increase.[37] The need for carbon governance therefore is superimposed on these primary needs for land use and implies that effective governance will need to be achieved through negotiating trade-offs that balance primary needs for the land against secondary needs, such as storing carbon. Sometimes primary needs are compatible, as in the case of specific agricultural practices such those that increase carbon storage in soils and increase soil quality and reduce erosion. The trade-offs will not always be win-win, however, and may not be even fully known.

Taxes have been widely discussed as instruments that would provide a price signal to value carbon, either in the energy sector or the land management sector. A carbon tax imposed on energy use is perennially unpopular among members of the public in the United States,[38] and one government, that of New Zealand, that previously proposed such a tax has now withdrawn the proposal.[39] Taxes of course have been considered in great depth in the literature and are beyond the scope of this article. One issue that is highly pertinent to the dis-

34. Aukland et al. 2003.
35. Ibid.
36. Uri 2001.
37. Alig 2003.
38. Leiserowitz 2006
39. http://www.beehive.govt.nz/ViewDocument.aspx?DocumentID=24671, accessed 5 April 2006.

cussion, however, is how taxes might be implemented to ensure appropriate carbon governance. For example, in the land use sector, one might levy a tax on every acre of land that is deforested. This would provide no incentive, however, to reforest land. Taxes would therefore need to be combined with subsidies in order to address both cases.[40]

However, at the present time, concepts for national policies to enhance carbon sequestration on land in the US proposed thus far all require the government to bear the financial cost, e.g. through subsidies, rather than the private sector, e.g. through taxes.[41] US policy makers at the national scale representing agricultural states or concerned with climate change have already introduced over 50 bills to create incentives to store carbon in agricultural lands.[42] Mechanisms proposed include tax incentives, grants for research, managing carbon on federal government lands, public education, and so forth.[43] To date, payments to farmers specifically for sequestering carbon have not been authorized, although carbon sequestration is encouraged in the 2002 US Farm Bill.[44]

Verification of Cause and Effect

As effective carbon governance assumes minimizing carbon dioxide released to the atmosphere or maximizing carbon stored stably away from the atmosphere, mechanisms must be developed to evaluate performance with respect to these requirements. The international negotiating and policy analysis communities have gone to great effort to develop reporting measures and rules for carbon accounting that try to address these goals. The evolution of rules governing carbon sinks after the Kyoto Protocol agreement has become heavily dependent on scientific resolution of issues which, even if the science was more certain, often ignores the social factors that temper the ability of science to influence policy.[45] In addition, the ability of scientific knowledge and tools to support definitive policy in these areas remains quite limited, even though the scientific community has provided voluminous information to document what is known and not known about quantifying carbon storage for policy purposes at the international level.[46]

Moreover, the role of scientific information in adaptive governance structures operating at multiple scales such as would be the case for carbon governance is not straightforward.[47] The scale of information needs and information supply are often "mismatched." Information is also critical to the verification stage and providing input as adjustments are made in the course of adaptive

40. Newell and Stavins 2000.
41. Richards 2004.
42. Ibid.
43. Ibid.
44. http://www.ers.usda.gov/Features/farmbill/titles/titleIIconservation.htm#compliance.
45. Lovbrand 2004.
46. IPCC 2000; IPCC 2001; and Apps et al. 2003.
47. Cash and Moser 2000.

governance. Methods to quantify and track carbon would therefore be central to this formulation of carbon governance. At the moment, however, carbon cycle science is not well suited to inform decision makers at multiple scales and in multiple sectors.[48] While some carbon science is conducted specifically for use in the agricultural sector, there are many other needs at local, state and federal levels, as well as in the corporate sector, of which the carbon cycle science community is currently not aware.

Carbon emissions and storage depend greatly on the vegetation type, current land management practices, land use history, soil characteristics, and climate.[49] In short, carbon release and storage can be highly heterogeneous even at small scales. Available methods to quantify carbon exchange range from direct inventory of carbon in soils and vegetation at the individual site level to atmospheric methods that integrate signals over much larger, often hundreds of kilometers, scales.[50] Atmospheric methods integrate all carbon exchange over a given area, and therefore are not able to distinguish among sequestration accomplished through management practice, vegetation type or even sequestration by sediment burial in a given region. Moreover scientific methods and analysis are currently inadequate to separate out whether carbon stored in a biospheric project is stored as a result of human action or as a result of natural influences such as climate change or carbon dioxide fertilization.[51]

Direct monitoring of carbon sequestration in forests or soils at the national level is not currently operationalized. While the National Resources Inventory (NRI)[52] of the US Department of Agriculture monitors land use change and various characteristics of non-Federal land in the US, it is not conducted for carbon governance purposes. Similarly, the US Forest Service conducts a Forest Inventory and Analysis (FIA) to report on status and trends of forest health, timber volume, land ownership, etc., although not carbon directly.[53] Translating measurements of land vegetation into carbon storage and emissions is not straightforward, but can be done to estimate the amount of carbon stored in various biomes.[54] The US uses these methods to report changes in forest carbon uptake to meet UNFCCC requirements through the Energy Information Agency (EIA) of the Department of Energy and the US EPA.[55] These particular national programs serve national level reporting needs, but the data are difficult if not inappropriate to apply at a smaller spatial scale.

Emissions and sequestration are reported voluntarily by participating corporations through a program authorized by Section 1605b of the Energy Policy Act of 1992. Through this mechanism, corporations may choose to report their

48. Dilling 2007.
49. Baldocchi and Valentini 2004.
50. Dilling et al. 2003.
51. Apps et al. 2003.
52. http://www.nrcs.usda.gov/technical/NRI/, accessed 12 November 2005.
53. http://www.fia.fs.fed.us/, accessed 12 November 2005.
54. Birdsey and Heath 2001.
55. http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html, http://www.eia.doe.gov/oiaf/1605/1605b.html, accessed 12 November 2005.

greenhouse emissions or carbon sequestration to the US government and thus document reductions or gains. Those who chose to report can select the data they wish to report and reports made under 1605b are not independently certified by a third party or the US government to verify claims.[56] Of the emissions reductions voluntarily reported non-confidentially (some can be reported confidentially, but those data are not publicly available) in 2003, approximately 2%, or 7 million metric tons of carbon dioxide equivalent were reported as sequestration projects.[57] Total US emissions in 2003 were approximately 6900 million metric tons carbon dioxide equivalent.[58]

A major limitation to widespread carbon governance is the cost of complying with monitoring or reporting requirements, not to mention the cost of implementing measures in the first place. Cost estimates of both implementation and monitoring vary greatly—a review of cost estimation studies for forestry projects from all over the globe ranged from less than zero, i.e. income resulting from the project, to more than a thousand dollars a ton.[59] A 2005 study commissioned by the Pew Center for Global Climate Change estimated that costs for US-based forest sequestration would range from $30–90 a ton, comparable to costs for energy-related projects.[60] Depending on the approach taken and the nation, costs for monitoring can be a barrier to implementation.[61] Certainly, approaches to measuring carbon developed for scientific research purposes are cost-prohibitive to deploy on a massive basis for the most part, and would need to be adapted or replaced if required as part of a carbon governance structure.

One of the most contentious topics in measuring progress on carbon emissions or storage is deciding on the baseline against which progress will be measured. While certainly some pilot projects have developed ways to reconstruct or determine baselines, these methods rely on assumptions about land use history and trajectories, and are therefore by definition subjective.[62] In addition to being important for determining whether a project is accomplishing the goal of storing additional carbon, assumptions about baselines are critical factors influencing the estimated cost of a project.[63]

The Cross-scale Challenges of Permanence

If the goal is to keep the atmospheric concentration at some arbitrary controlled level, i.e. lower than it would be in the absence of deliberate action, carbon must be managed for the foreseeable future. One of the major concerns about

56. http://www.eia.doe.gov/oiaf/1605/getstarted.html, accessed 12 November 2005.
57. US DOE, EIA March 2005. http://www.eia.doe.gov/oiaf/1605/0503news.htm, accessed 12 November 2005
58. US EPA 2005.
59. Richards and Stokes 2004.
60. Stavins and Richards 2005.
61. IPCC 2000.
62. Ibid.
63. Ibid.

carbon management through land use is that land carbon sinks are easily reversible, that is, carbon can be quickly released back to the atmosphere in a short time. For example, carbon stored for decades in forest can be released in a day back to the atmosphere through a forest fire. Carbon built up in soils through no-till or other practices can be released quickly by reverting to conventional tillage practices.[64] Actions to govern carbon must therefore consider the permanence of various reservoirs for carbon, or the length of time for which the carbon stored, as well as the vulnerability of that storage to disturbance and loss back to the atmosphere.

Climate change itself may also cause a positive feedback that accelerates release of carbon dioxide to the atmosphere.[65] As the climate warms, higher temperatures result in higher soil respiration rates and in turn, result in greater carbon dioxide release to the atmosphere. It is estimated that, through the combined effects of human activity such as land uses and natural processes, that about 25% of the total soil carbon pool globally, or about 400 billion metric tons is vulnerable to loss to the atmosphere over the next century.[66] Increasing forest lands, particularly in high latitudes, can also have an unintended effect that would be in opposition to the goal of decreasing global warming. Forest cover in general has a lower albedo, or surface reflectivity, and therefore increased forests could cause an increase in surface temperature, working in opposition to the effects of storing carbon away from the atmosphere.[67]

Markets, populations and drivers of land use are dynamic. Significant shifts from one type of land use to another can also occur as a result of economic opportunity or hardship, government policies, migration, changes in diet, cultural trends and advances in agriculture.[68] These drivers will not disappear with climate change or the imperative of carbon governance should it be deemed as such. If carbon sinks become a significant portion of the portfolio used to address climate change, carbon governance will need to be nimble and adapt to all of these various circumstances in order to ensure the permanence of carbon sequestration on land. Options such as "temporary emissions credits" or establishing a rental contract for emissions credits have been suggested as potential mechanisms for establishing long term markets for carbon storage that is reversible.[69]

The notion of managing carbon on privately-held land poses special challenges for carbon governance and permanence as well. Property-rights norms are strongly held within the United States, and constraints on what private property owners can do with their land are very politically contentious.[70] Just re-

64. Uri 2001.
65. Gruber et al. 2004.
66. Ibid.
67. Betts 2000.
68. Lambin et al. 2001.
69. Marland et al. 2001.
70. Raymond 2003.

cently, for example, the state of Oregon passed a law that requires a public entity to reimburse landowners for actions taken, e.g. policies enacted, that might negatively impact the value of their land.[71] Restrictions on the use of land, or even protection of land such as for endangered species and so forth are not lightly accepted as they run up against these deeply held norms.

Permanence is also important in a different sense—in the sense of the perceived longevity of institutions embarking on carbon markets, incentive programs or mandatory government policies. Participants must trust that an institution will still "be around" when it comes time to collect benefit or accrue penalties, even for credits due 10, 20 or 50 years from now.[72] Similarly, actors may delay participating in a regime if they feel the rules are subject to change, and more favorable situations may be available in the future.[73] Institutional rules must therefore span over generations, a difficult challenge for carbon governance but not unheard of in the US—the social security system and the preservation of national parks are examples of long-term policies that have survived many decades.

Carbon sinks have also been thought of as a way to "buy time" in order to implement more difficult infrastructural changes such as conversion of the energy system or changes in transportation.[74] Their original use in the Kyoto Framework and in the subsequent Bonn and Marrakesh accords was to allow parties who had signed on to binding emissions targets more flexibility (and potentially lower costs) in meeting their targets.[75] Even if they are viewed as a "bridging strategy," to a carbon-constrained energy system, the long term implications for carbon governance remain. If excess carbon released from fossil fuel combustion is stored deliberately in the land biosphere, it must remain there even if alternative energy technologies are put in place—if released to the atmosphere at some future date, it will again raise atmospheric carbon dioxide levels.

"Governance without Government" across Scales

Governance can be achieved through state-established arrangements such as centralized government and private property, widely-held behavioral norms, and through formal and informal user institutions.[76] Unlike well-established and identified resources, such as fisheries, grazing land or water resources, carbon is not yet a common currency of concern among the potential actors for carbon management on land. Economic incentives rule the day for most private land ownership decisions.[77]

71. http://www.sos.state.or.us/elections/nov22004/guide/meas/m37_text.html, accessed 6 April 2006.
72. Richards 2004.
73. Ibid.
74. Herzog et al. 2003.
75. Schulze et al. 2002; Pohjola et al. 2003; and Lovbrand 2004.
76. Dietz et al. 2003; and Raymond 2003.
77. Lambin et al. 2001.

One of the potential problems in the implementation of a widespread market for carbon sequestration in the US is that markets only work under conditions of scarcity. Unless mandatory limits for carbon emissions are put in place, or carbon is given a market value through price signals, there is no scarcity or constraint on emissions, and therefore little incentive to participate in the market. There is also no incentive to independently verify claims or make the accounting system vigorous, and thus programs run the risk of low quality, low value trades.[78]

One company trying to prove the exception to this rule is the Chicago Climate Exchange, a private concern offering a system for participating companies that wish to experiment with carbon trading in a pilot phase.[79] Participants such as the Iowa Farm Bureau and the North Dakota Farmers serve as aggregators of carbon credits from changed agricultural practices. The Chicago Climate Exchange does have independent "verifier" firms that certify the claims of various participants. In late 2005, carbon was trading at the Chicago Climate Exchange at a value of approximately US$2 a ton, much less than the approximately 22 euros (US$26) that carbon traded for on the European market under carbon-constrained conditions.[80] In a non-profit model, The Climate Trust, based in Oregon, provides a mechanism for companies or individuals to offset their emissions through purchase of credits in renewable energy, energy efficiency, carbon sequestration, etc.[81] The projects they invest in must demonstrate additionality through a "barriers" test—that the project would not have occurred in the absence of Climate Trust funding—and be rigorously certified by an independent third party with no financial interest.

It is clear that various large companies are strategizing on how best to respond to the possibility of a carbon-constrained future.[82] Some companies such as the midwest utility giant Cinergy state that they are participating in experimental projects, offsets, and policy formulation because they anticipate a carbon-constrained future, and actively participate in the national legislative debate.[83] In their view, it is not a question of "if" there will be a carbon-constrained future, but "when" and "under what rules." If the European experience is any guide, such electricity producers are likely early targets for regulation or emissions trading. The EU emissions trading market covers only the large industrial sectors of fossil fuel power generators over 20MW, oil refining, cement production, iron and steel production, glass and ceramic production and paper and pulp production.

78. King 2004.
79. Price as of 20 November 2005. http://www.chicagoclimatex.com/about/, accessed 20 November 2005.
80. Price as of 20 November 2005. http://www.pointcarbon.com/, accessed 20 November 2005.
81. http://www.climatetrust.org/index.php.
82. See for example, the membership of the Pew Center for Climate Change's Business Environmental Leadership Council. Available at http://www.pewclimate.org/companies_leading_the_way_belc/company_profiles/, accessed 20 November 2004.
83. "Air Issues Report to Shareholders," Cinergy Corporation, December 2004. Available at http://www.cinergy.com/pdfs/AIRS_12012004_final.pdf, accessed 20 November 2005.

Conclusions

Managing the land surface for carbon storage is a particularly difficult challenge because of the diversity of uses for the land, the variety of institutions and decision makers involved, and changing needs of human populations over time. Whether the existing situation will evolve into an effective governance arrangement across scales remains to be seen. The challenge for *effective* carbon governance is to create a consistent incentive structure, fairly set the rules for participation, build in adaptive capacity for adjustment to new information, and ensure the actions are effective toward the ultimate goal of limiting atmospheric carbon dioxide concentrations. Dietz et al. (2003) are "guardedly optimistic" that governance of the global commons for climate purposes can be achieved, especially given the success of adaptive governance systems for stewardship of resources. They suggest several criteria that are particularly relevant for this scale of issue—analytic deliberation, nesting and institutional variety. I would offer that while some of these conditions may be emerging for carbon governance of land sinks, others are not yet in evidence. Much work therefore remains to be done to transform existing carbon management activities into effective carbon governance.

"Analytic deliberation" is defined as the process of dialogue between interested participants, including scientists, resources managers and interested publics that eventually can result in consensus on rules under which to govern.[84] Thus far, such a dialogue for carbon governance is only happening within certain groups in society, primarily scientists, government negotiators, very limited land owners, and nongovernmental organizations. Much of the public remains unaware of carbon management strategies or what is being discussed.[85]

The concept of nesting, that institutional arrangements are complex, redundant and nested in many layers certainly would apply here, but the number of institutions and actors involved are not yet clearly linked by a common framework. Nonetheless, some limitation on carbon-related behavior and decisions must be agreed upon across scales in order for carbon governance to successfully prevent significant leakage and achieve permanence. While individual projects and actors have attempted to build in rules that would address permanence, the leakage issue is particularly problematic for carbon governance and cannot be addressed through single actors alone. Establishing societal norms with respect to carbon governance might aid in developing such a cross-scale framework, but clearly much work remains to be done in terms of public awareness, and resolving potential conflicts with existing values about property use.

Institutional variety is partially being achieved, and it is clear that multiple strategies and actors are and will continue to be involved. Because carbon governance relates to a global atmospheric problem, it might seem tempting to try to establish a top-down governance system. However, in this case, which has the characteristics of a nonpoint source problem and a problem for which we need

84. Dietz et al. 2003.
85. Curry et al. 2004; and Shackley et al. 2005.

to "encourage innovation in behaviors or technologies rather than to require or prohibit familiar ones," command and control may actually be less effective.[86] While no organized structure exists to manage carbon governance at all scales, several actors ranging from state, international organizations, and nonstate actors are evidence of some institutional variety.[87] Nonetheless, the public is not yet engaged, and the issue of potentially conflicting norms about private property rights and protecting the climate has yet to emerge and be openly considered.

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86. Dietz et al. 2003.
87. Najam et al. 2004.

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