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Policy Perspective

Addressing problems of global scale, like climate change, requires coordinated action by people around the world. Although decision makers do not always view problems and solutions the same way scientists do, in many cases they seek scientific input to inform their decisions. This chapter summarizes workshop discussions on the policy context for the science of direct and indirect human contributions to terrestrial carbon fluxes.

TERRESTRIAL ECOSYSTEMS, CARBON STOCKS, AND INTERNATIONAL ACTION

At the workshop, Bob Watson, chief scientist at the World Bank, described terrestrial carbon stocks and the activities of the Intergovernmental Panel on Climate Change (IPCC). He noted that land use, land use change, and forestry (LULUCF) affect both carbon emissions and land-based carbon sinks. The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol incorporate a set of principles to guide the treatment of LULUCF issues. The UNFCCC principles are intended to exclude carbon removals from CO_2 fertilization, indirect nitrogen deposition, and pre-1990 activities from greenhouse gas accounting. The Kyoto Protocol includes specific text on accounting for changes in carbon stocks related to direct human-induced

BOX 2-1
Carbon Sinks in the Kyoto Protocol

Articles 3.3 and 3.4 of the Kyoto Protocol address issues related to land use, land use change, and forestry in the following excerpts:

> Article 3.3: The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I.
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> Article 3.4: The COP [Conference of the Parties] serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the IPCC, the advice provided by the SBSTA [Subsidiary Body for Scientific and Technical Advice] in accordance with Article 5 and the decisions of the COP. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990. (UNFCCC, 1997)

LULUCF activities that have occurred since 1990 (see Box 2-1). Article 3.3 addresses afforestation, reforestation,[2] and deforestation and is compulsory for all Annex I countries—the industrialized nations. Article 3.4 covers forest management, cropland management, grazing land management, and human-induced revegetation that has occurred since 1990. Article 3.4 specifies that nations may choose the activities they wish to declare in the first commitment

[2] "Afforestation" is defined as the conversion of land to forest that has not been forested for a period of at least 50 years. "Reforestation" is the conversion to forest of land that has been forested within 50 years but was not forested at the end of 1989.

period,[3] although Annex I countries have a cap at about 100 Megatons (Mt)[4] of carbon per year (equivalent to 0.1 Petagrams (Pg C/yr) of carbon per year) on the amount of forest management credits they can use. Rules for the second commitment period have not yet been set.

Watson noted that, in principle, significant amounts of carbon could be taken up through these various activities. However, an Annex I country can claim no more than 1 percent of its 1990 emissions through LULUCF activities. Moreover, only afforestation and reforestation are eligible in the first commitment period under the Kyoto Protocol's Clean Development Mechanism (CDM).[5] Countries are also not likely to include activities that are costly to measure. Because forest management, logging reduction, and land management are excluded from the CDM, Watson stated, "The types of activities that are probably the most useful for developing countries are probably excluded in the first commitment period." He stated that the potential carbon sink in non-Annex I countries could be 0.4 Pg C/yr (mostly in agroforestry), but that potential has been capped by political agreement to 30 million tons per year across all countries. Watson speculated that if all deforestation were avoided, perhaps 1.6 Pg C/yr could be captured.

Watson noted that accounting for all carbon sinks (direct and indirect) is necessary to ensure the tracking of important carbon fluxes. The proper management of carbon sinks can deliver enormous atmospheric and social benefits; however, the inclusion of carbon sinks in greenhouse gas accounting creates significant and currently unresolved challenges. For example, year-to-year natural global carbon uptake varies by as much as 2 Pg C/yr, and fluctuations from natural causes such as El Niño can be large compared to the yearly commitments specified in the Kyoto Protocol.

The mandate of the IPCC is to assess the natural, technical, and socioeconomic science relevant to anthropogenic climate change. The IPCC LULUCF special report (IPCC, 2000b) concluded that with current scientific tools it may be very difficult, if not impossible, to distinguish that portion of the observed carbon stock change that is directly human induced from that caused by indirect and natural factors. For activities involving land management changes (e.g., tillage to no tillage agriculture), the report concluded that it should be feasible to partially distinguish direct and indirect human induced complements through control plots and modeling but not to separate out natural factors.

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[3] The Kyoto Protocol sets targets that must be achieved as an average over the first commitment period from 2008 until 2012.

[4] Megatons are equivalent to 10^{12}g or 1 teragram.

[5] The Clean Development Mechanism allows Annex I countries to help meet their own emissions targets through sustainable development projects that reduce emissions in non-Annex I countries.

A recent IPCC meeting concluded that there is no practicable methodology for factoring out direct human-induced effects from indirect human-induced and natural effects for any broad range of LULUCF activities (IPCC, 2003). While recognizing that a significant amount of research on CO_2 fertilization is under way, the IPCC noted that paired treatment and control plots do not allow full separation of direct, indirect, and natural effects and provide little information about large landscape effects. The IPCC meeting concluded that many of the effects are nonlinear and nonadditive and that more work is needed to examine synergistic effects and the underlying processes.

Watson suggested three broad approaches for LULUCF that could be applied during the second commitment period or as an alternative to the Kyoto Protocol. First, forest and land management activities in Article 3.4 could be handled on a project-by-project basis, with more manageable monitoring requirements. However, most emissions would not be incorporated at the project level, and Article 3.3 would need to be retained to capture afforestation, reforestation, and deforestation.

As a second approach, Watson proposed comprehensive accounting to include all sources and sinks, although he noted that governments might agree to exclude certain lands (e.g., those with small fluxes that are difficult to monitor). Comprehensive accounting would capture the bulk of greenhouse gas fluxes, but it would also include the current net terrestrial uptake of about 1.4 Pg C/yr, which would occur without any additional effort to reduce emissions or increase sinks (Watson termed this the free ride). Interest in reducing credit for this so-called "free ride" in Annex I countries, he said, was part of the motivation for limiting forest-based credits. Watson commented that there is some debate as to whether the pre-1989 human-induced terrestrial uptake can be factored out with existing scientific capabilities and, if not, whether simple discounting can be fairly applied. He also noted that comprehensive accounting has problems due to the natural variability in carbon fluxes from year to year, but this variability might be addressed by using longer accounting periods, a carbon credit to "banking" system across commitment periods, or continental-scale reporting units to spread out the spatial variability.

Watson presented a third alternative for approaching LULUCF issues, stating that it might be possible to use separate accounts for sinks and nonsink activities and thereby set different targets for emission reductions in the energy/industrial sector and targets for uptake by carbon sinks. An additional issue would need to be addressed as to whether there should be any fungibility between energy sectors and LULUCF.

In summary, Watson stated that sinks are too important to be excluded from greenhouse gas policy. Watson asserted that sinks can be accounted for in an accurate and nondistorting way, addressing issues of permanence of the carbon sink credit based on the land use change enacted. He also commented that the United States is unlikely to reengage in Kyoto (or a successor treaty)

without a relatively comprehensive inclusion of sinks. Watson noted some political issues that have hindered the identification of equitable solutions regarding sinks and stated that active cooperation between developed and developing countries will be necessary to effectively address climate change. For example, loss of sovereignty has been a major concern with regard to clean development in non-Annex I countries, although temporary crediting regimes might provide a remedy for these concerns.

GREENHOUSE GAS INVENTORY SYSTEMS

Dina Kruger, chief of the Environmental Protection Agency's Non-CO_2 Gases and Sequestration Branch and a member of the IPCC Task Force Bureau on Greenhouse Gas Inventories, described the national greenhouse gas inventories and emphasized that they must be seen in the context of the UNFCCC and the Kyoto Protocol. She noted that the national inventory serves at least three purposes. First, with its score-keeping function, the inventory is the mechanism by which it is determined whether or not countries are meeting their commitments. As the Kyoto Protocol comes into effect, the national inventory will be the backbone of determining compliance under these targets. Second, the inventory can be used to focus mitigation policies and recognize the major emissions sources and removal sinks. Third, inventories can improve our understanding of global greenhouse gas budgets, helping to determine whether all the sources have been included.

Kruger stated that national greenhouse gas inventories provide average annual point estimates for the six greenhouse gases covered by the UNFCCC and the Kyoto Protocol (CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorochemicals, and sulfur hexafluoride) The inventories estimate anthropogenic emissions and removals and are completed each year by developed countries and on three- to five-year cycles by developing countries. The inventory is a sizable undertaking, as it covers all sectors of the economy: energy, industry, agriculture land-based and livestock emissions, land change and forestry, and wastes. Developed countries are now preparing annual inventories that cover the time period from 1990 to the present.

The IPCC task force on the national greenhouse gas inventory develops the methods to calculate greenhouse gas emissions and removals (IPCC, 1996, 2000a). There is a range of methods, from very simple (default or "Tier 1" methods) to more data intensive ("Tier 2 or 3"). Because Tier 1 methods are based on global default factors, they will not be as accurate on a regional level, and the two approaches can result in substantive differences. Recognizing that most of the data are collected for other purposes, countries can choose methods based on their more important emissions sources and available data, capacity, and resources, while also following the Good Practice Guidance (IPCC, 2000a).

Kruger explained that in the reporting process the IPCC's role is to identify the types of information that should be included to ensure transparency and facilitate review. The UNFCCC has standardized two-part reporting requirements, which must be submitted annually by Annex I countries. The first part is an extensive set of data tables, including the input data used for the estimates; the second part is the national inventory report, which describes how the estimates were developed and provides documentation and reference material. Under the Kyoto protocol, the parties provide the greenhouse gas inventory, as defined by the UNFCCC, along with supplemental information required for the Kyoto Protocol. For example, supplemental reports may include information on emissions or removals related to Articles 3.3 and 3.4 and activities such as emissions trading, new development mechanisms, and joint submissions.

Consistency across countries is secured through specification of the inventory development process and the types of activities required, along with very extensive reporting guidelines. Each year all the inventories are reviewed by a group of experts. The first step is a quick assessment of the quality of the data, followed by an in-depth review, where teams of 10 to 12 international experts examine the inventory and publish a report considering the following:

- Have appropriate methods been used?
- Are the data appropriate and well documented?
- If a category is particularly important in the inventory, is a higher-tier method used?
- Does the time series date from 1990 forward, and is it internally consistent?
- Are there discontinuities or changes in input data that are not explained or that raise questions?
- What is the system for quality assurance and quality control on the inventory and for assessing the uncertainty?

Data must be sufficient to document the reported achievement of mitigation projects with confidence and credibility.

The Good Practice Guidance (IPCC, 2000a) improved on the 1996 guidelines by including specific direction about quantifying uncertainties in the inventory, so that systematic over- or underestimations can be identified. Because uncertainty depends on both the nature of the sources and the level of effort, there is no prescribed uncertainty threshold. In countries where the bulk of emissions come from energy, such as the United States, good data quality leads to relatively low uncertainty. However, in a country that has a majority of its emissions sources in agriculture, such as Australia or New Zealand, data would express greater interannual variability due to natural fluctuations in the weather and other environmental factors. All developed countries will report

quantitative uncertainty of the sources in their inventory and their overall inventory to the UNFCCC.

Kruger concluded by noting that inventories are very resource intensive, both in terms of cost and the number of people involved. In theory, if there were no resource constraints, much more information would be beneficial. However, countries will generally have to prioritize their efforts to achieve an effective balance between scientific completeness and practicality.

In the discussion following Ms. Kruger's presentation, William Hohenstein raised the concern that the five-year greenhouse gas inventory conducted by the U.S. Department of Agriculture is not frequent enough. He noted that more frequent inventory data could provide a better perspective on progress from emissions programs. Eric Sundquist encouraged better use of subnational data to inform the national inventories, which generally exist as single-point estimates. Kruger responded that they are aware of the value of disaggregating the data, although she noted that this level of analysis is partly constrained by available resources.

DEVELOPING THE CAPABILITY TO QUANTIFY SPECIFIC PROCESSES IN THE U.S. CLIMATE CHANGE SCIENCE PROGRAM

Bryan Hannegan, from the Council on Environmental Quality, summarized activities of the U.S. Climate Change Science Program related to carbon budgets and quantifying specific processes. He noted that the Bush administration had just released the strategic plan for the science program, which consists of a near-term climate change research initiative, includes the carbon cycle as one of its major elements, and proposes longer-term fundamental and applied research.

In the near-term initiative, a new $103 million program over the next two years includes clarifying the important processes for carbon fluxes. Hannegan noted that a $10 million National Science Foundation initiative has been proposed for 2005 to focus on understanding the impacts of historical and current trends on a variety of scales. The National Oceanic and Atmospheric Administration will apply resources in areas such as tower- and aircraft- based measurements, vertical profile studies, and maps of CO_2 sources and sinks in the United States President Bush also has asked that an improved accounting system for voluntary emissions reporting be developed. One issue to be resolved will be how to separate indirect and direct effects. Hannegan commented that findings from the near-term work will feed directly into the policy process in a two-to five-year time frame.

Hannegan encouraged scientists to explain the following questions to policy makers:

- What gaps exist in the current understanding of greenhouse gases?
- What measurements and what modeling capacity are required to quantify the North American carbon budget?
- What basic research and what resources are needed in the near term to complete our understanding?
- What specific activities are necessary to answer the policy questions with regard to greenhouse gases?

The administration wants to know the implications for emissions inventories in the context of the voluntary emissions program being pursued. Hannegan said he hoped the workshop could inform policy makers as they grapple with the mechanics of accounting and try to identify specific practices and expected outcomes, so that people are accurately rewarded for sequestering carbon and engaging in practices that will lead to sequestration.

To conclude, Hannegan stressed that policy makers want to be informed by scientists about what is not known or understood and what steps should be taken to fill in these knowledge gaps. Too often, he stated, people advocate what they know, and policy makers are left to determine what information is missing and what research needs to be completed.