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▶CARBON SINKS

Soaking Up Carbon in Forests and Fields

The climate treaty left open the rules for using managed forests, rangelands, and croplands to help meet Kyoto targets. How should it be done?

Is it fair for global bookkeepers to let countries subtract carbon sequestered by their farmland and forests from the carbon they spew by burning fossil fuels? If so, how do you measure how many tons of carbon an Iowa cornfield has socked away? Those questions will be high on the agenda as negotiators meet later this month to nail down the details of the Kyoto Protocol (see p. 920). Forests and other land sinks, as they are called, could offset a sizable chunk of the extra CO_2 that humans pump into the atmosphere and protect biodiversity as well. But sinks are controversial, both because of uncertainties about how to measure the carbon they absorb and because some countries view sink proposals—particularly the United States'—as a distraction to avoid cutting fossil fuel emissions.

The Kyoto Protocol includes land sinks because they're a big part of the global carbon equation. Carbon dioxide taken up by plants and soils through photosynthesis balances a whopping 2.3 of the 7.9 petagrams of the carbon belched into the atmosphere annually by human activity. (Conversely, cutting and burning forests adds 1.6 petagrams.) That's why the Kyoto Protocol stipulates that countries will be credited for planting new forests and docked for cutting down existing ones.

Still to be decided, however, is exactly how to define these forests, as well as whether to include other lands managed since 1990 to absorb carbon, for example by sustainably harvesting timber and using no-till methods on farmlands. Carbon sinks are no panacea—forests and fields would absorb less and less carbon as decades pass—but "it could make a heck of a difference" in the short term, says soil scientist Neil Sampson, a consultant in Alexandria, Virginia, who helped write a recent report on sinks from the Intergovernmental Panel on Climate Change (IPCC) (*Science*, 12 May, p. 942). Letting U.S. farmers make money from sequestering carbon could also win much-needed support for the treaty from Midwestern conservatives in the U.S. Senate.

But crediting countries for such sinks would require massive surveys. For forests, it's fairly straightforward: Most industrialized countries already track the growth of their forests for timber-harvesting purposes. They typically use a combination of remote sensing, modeling, and on-the-ground measurements, such as carbon analysis of trees, leaf litter, and soil. Even many environmental groups who have some qualms about sinks are fairly comfortable with forest sink accounting, as long as there are provisions to prevent unintended ecological harm, such as mowing down old-growth forest to create tree plantations. "There are some questions about how good the inventory systems are, but in my view they can be overcome," says Daniel Lashof, a senior scientist with the Natural Resources Defense Council in Washington, D.C.

Carbon crop. Canadian researchers have studied the cost of measuring carbon in farmland managed so as to sop up CO_2.

With farmlands and rangelands, however, monitoring is more uncertain because no system is in place. For example, the National Resource Inventory at the U.S. Department of Agriculture tracks nitrogen content and soil erosion on farmlands but doesn't routinely measure carbon. Measuring the carbon added by, say, no-till practices could be horrendously difficult, says ecologist Mac Post of Oak Ridge National Laboratory (ORNL) in Tennessee. For one, the amount of carbon absorbed would be tiny—overall, an annual change of 50 grams per 7 kilograms of soil—and it would vary with crop type, weather, and even from furrow to ridge within a field.

Improving these numbers by sampling each farmer's field just wouldn't be practical: "You'd probably produce more CO_2 than you gained," says biogeochemist Ben Ellert of Agriculture and Agri-Food Canada (AAFC). However, a pilot project in Saskatchewan has convinced some experts that a statistical approach can bring down the costs of measuring carbon uptake. The 3-year project, supported by energy utilities interested in buying carbon credits from farmers, combined statistical sampling with modeling on 150 farms. It concluded that carbon absorbed by changes in land use could be measured for a relatively low 10 to 15 cents per hectare, according to Brian McConkey of AAFC. And better technologies are on the way, says ecologist Keith Paustian of Colorado State University, Fort Collins: A group at Los Alamos National Laboratory in New Mexico, for example, has invented a sensor for detecting carbon just by sticking the tool in the soil, eliminating the need to cart samples to a lab.

Even if monitoring sinks is doable, a host of policy questions remain. Protecting a forest in one part of a country, for instance, may lead to logging elsewhere. Another concern is the impermanence of projects: A credited forest might eventually be destroyed by a hurricane, for example. One solution laid out by the IPCC sinks report and now endorsed by many groups is to count the carbon going in and out of *all* of a country's lands, no matter the type, instead of giving credit for specific activities. "Looking at the whole landscape will bring us closer to what the atmosphere is actually seeing," says biophysicist Darren Goetze, a global change consultant in Ottawa.

Still, the uncertainties over measurement are one reason why some want to hold off on giving credit for sinks until the second phase of the treaty, after 2012. Including sinks also faces fierce opposition from the European Union, which rejects the idea because it would allow countries to avoid reducing their fossil-fuel emissions.

Even some sink proponents see the U.S. position as too greedy. It seeks credit for part of the 310 million metric tons of carbon per year that U.S. forests and fields will absorb between 1990 and 2012—even without any new intervention. That adds up to half of the U.S. target emissions cuts. Most other countries, arguing that only deliberately created sinks should count, won't be willing to accept these credits, says geochemist Gregg Marland of ORNL.

Whether or not countries get credit for their sinks, many scientists look forward to a global effort to monitor the carbon sucked up by the world's green spaces. As Paustian says, "Irrespective of carbon trading, we need to understand the role of the carbon sink" to improve global models and predict how much the world may warm in the future.

—JOCELYN KAISER

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