Recarbonizing the Earth

The case for reducing emissions of greenhouse gases is more compelling than ever.

But it's also past time to begin drawing carbon out of the air.

by Richard J. Blaustein


Brian Burger

Forests: Clearcuts, slash piles, and logging roads, British Columbia, Canada.

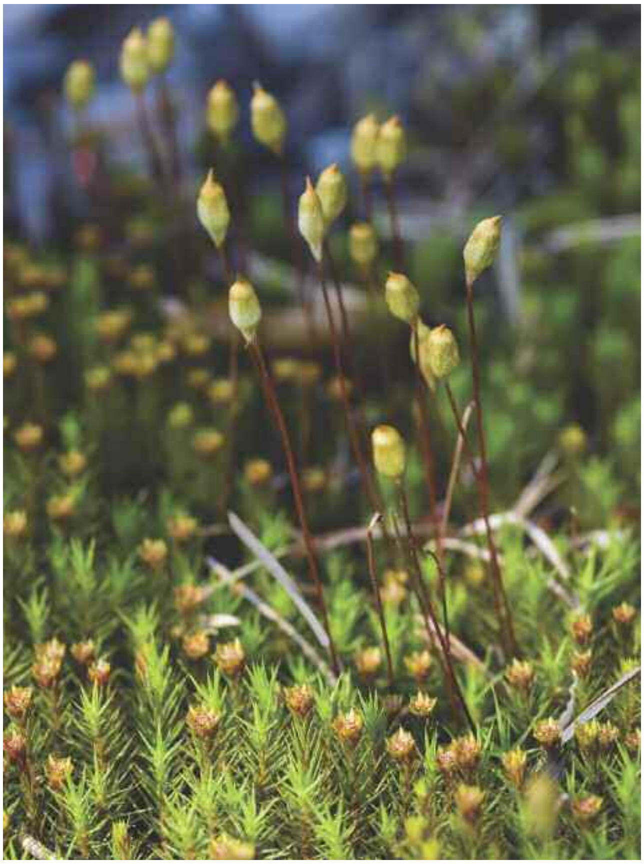
About the time this article is published, the nations of the world will be gathered in Copenhagen to discuss ways to reduce emissions of carbon dioxide and other greenhouse gases (GHGs). In the run-up to Copenhagen, the general expectation had been that this meeting would at last chart an effective international climate-change policy to succeed the Kyoto Protocol. But expectations have moderated as 2009 progressed, and the common wisdom now is that the most likely outcome is a framework understanding with an extended working-out period to follow.

In many ways, this is all too familiar: year after year of presentations and negotiations while GHG emissions continue to rise and the scientific evidence paints an ever-more dire picture. Severe changes in the biosphere, such as the dramatic retreat of Alpine glaciers, are already occurring with atmospheric GHG concentrations at the current level of about 388 parts per million (ppm); they continue to rise about 2 ppm per year. The momentum built into the processes driving climate change virtually guarantees worse to come, even with significant cuts in emissions. To prevent the severest outcomes, it looks like we'll have to augment whatever progress on energy emissions and forest incentives comes out of Copenhagen with new ecosystem-based initiatives to pull carbon out of the atmosphere—an effort that, in effect, will amount to recarbonizing the Earth.

What GHG level should we aim for? The science is still evolving, but many important policy positions and discussions peg the acceptable upper bound at about 450 ppm, which would theoretically limit further temperature increases to an additional 1.25 degrees Centigrade above current levels (and about 2 degrees C above pre-Industrial temperatures). However, NASA's top climate scientist, James Hansen, has been outspoken in advocating a maximum of about 350 ppm. "Humanity's task of moderating human-caused global climate change is urgent," Hansen and several colleagues wrote in a widely cited 2008 paper. "[T]here is a danger that human-made forcings could drive the climate system beyond tipping points such that change proceeds out of our control." Most critically, the Antarctic and Greenland ice sheets could melt and northern permafrost zones might warm and release their methane, triggering cascading ecological catastrophes.

Other assessments broadly support Hansen's target. For instance, climate activist and biologist Tim Flannery of Australia's Macquarie University points out that the findings of the Intergovernmental Panel on Climate Change (IPCC) support the essence of the Hansen et al. 2008 paper: "We are tracking the worse-case scenario of the IPCC's Third Assessment Report.… This indicates that catastrophic climate change will be unavoidable if emissions continue to grow.… Key indicators of this include…the rate of warming…and the rate of sea-level rise…"

"We are seeing abrupt changes, [such as] coral bleaching in the oceans and the pine bark beetle conifer mortality on the land," says biologist and Heinz Center Biodiversity Chair Thomas Lovejoy. "That is with only three-quarter degree of warming. At 450 ppm it is two degrees of warming.… [I]t



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Saturated lands: Wetland plants in a bog in Karelia, northwestern Russia.

seems a real mistake to go beyond 350 ppm." Flannery, Lovejoy, and United Nations Environment Programme (UNEP) Executive Director Achim Steiner called last year for bolstering ecosystems to lower GHG concentrations. Alongside "the imperative to redesign the energy base of human societies," they write that "the potential to remove CO_2 from the atmosphere by restoring biodiversity and carbon is clearly of major consequence." In short, this is a call for planetary engineering, and Lovejoy believes the only guaranteed safe way to do this is "biological…because all life is built of carbon."

Potential

Soil scientist Rattan Lal, director of Ohio State University's Carbon Management and Sequestration Center, has written extensively on natural ecosystem responses that would lower greenhouse gas levels. According to Lal, about 478 gigatons (1 gigaton equals 1 billion tons) of carbon have been released from land uses since the beginning of agriculture, while fossil fuels have released around 292 gigatons of carbon from 1750 to the present. Therefore, Lal argues, "recarbonization of the planet has a technical maximum potential of sequestering 478 gigatons of carbon. Even if 40 percent to 50 percent of this can be sequestered in trees, soils, and wetlands, an average of 200 gigatons is equivalent to an atmospheric drawdown of about 50 ppm over the next 40 to 50 years, or more by the end of the twenty-first century."

Lal looks to the 120-gigaton annual global photosynthesis cycle for opportunities to extract atmospheric carbon and convert it into some form of biomass. "It's low-hanging fruit" with enormous potential, he says. Lal estimates that with the right land management practices the annual sequestration potentials for cropland would be 0.6 to1.2 gigatons, for grazing lands 0.5 to 1.7 gigatons, and for degraded lands 0.6 to 1.7 gigatons—a huge sequestration total over the course of a few decades. Similarly, Hansen and his colleagues argue that an end to deforestation by 2030, matched with substantial reforestation, would "achieve a maximum potential sequestration rate of 1.6 gigatons [of carbon] per year."

A key attraction of these practices is their co-benefits. Among these, Lal cites higher agricultural yields, improved water quality, richer and more dependable grazing lands, decreased pollution (including reduction of coastal dead zones), protection of biodiversity, and new income streams for farmers through carbon credits or ecosystem services payments. However, instigating these changes turns on political will, effective outreach, altering habits, and new policies. For example, for developing-country agriculture, "[u]nder the prevailing socioeconomic and policy environments," Lal writes, carbon-enriching practices such as "no-till farming, agroforestry, diversified mixed farming systems, [and] precision farming…do not meet social and economic needs that determine farmer behavior. Therefore, there is a need for a radical change in mindset at all levels of the societal hierarchy."

With all ecosystem focuses, policymakers, scientists, and advocates will need to work together to create outreach efforts and policies that maximize economic and multiple environmental benefits, not just carbon drawdown. However, on a large scale, payments for ecosystem services, carbon markets, and other ideas will only succeed if they insure the rights and livelihoods of local and indigenous peoples who live in forests and on agricultural and other lands. Without attending to equity considerations, polarization and resentment will surely ensue and undercut diverse ecosystem-based efforts to lower GHG levels (see "Vision Quest: Who Will Control the Future of the Amazon" and "Seeing REDD," both in the November/December 2009 *World Watch*).

Possibilities

Several different land categories, including forests, saturated lands, rangelands, and croplands, are considered candidates for carbon enhancement and show varying degrees of promise and activity:

Forests. Forest options include afforestation (establishing forests in previously unforested areas), reforestation, and avoiding deforestation. A noticeable shift is under way both in terms of major programs—such as large-scale forestry projects in China and UNEP's "Billion Tree Campaign"—and in international discussions.

This year there has been intense focus on deforestation, which accounts for the largest portion of the approximately 20 percent of greenhouse gas emissions related to land uses. (In 2005 the UN Food and Agriculture Organization reported that the globe was losing about 13 million hectares—an area roughly the size of Greece or Nicaragua—of forest every year.) While afforestation and reforestation are currently included in the system created under the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, avoided deforestation is not. Kyoto Protocol discussions debated (but did not resolve) how addressing deforestation, primarily in developing countries, would be linked to wealthy countries' commitments on fossil fuel emissions.

However, advocacy and discussion have continued on avoiding deforestation, now mostly in the context of a program called Reducing Deforestation and Forest Degradation (REDD). In what many consider a breakthrough, at the UNFCCC's December 2007 discussions in Bali, Indonesia, the conference's deforestation decision called for "urgent action" on REDD. In fact, since Bali a consensus has emerged that tentatively favors an eventual incentives approach, which might eventually include REDD in a carbon market, promote a global program of direct foreign assistance, or both. At the same time, in pre-Copenhagen 2009 UNFCCC discussions, the advocates for greater equity and rights have voiced strong concerns about the adequacy of expected REDD provisions.

However, other developments point to an advancing discourse on how to match co-benefits and rights with forest carbon policies and investments. For example, a new effort was launched in 2009 to produce a set of guidelines called "REDD + Social and Environmental Standards" (REDD + SE), which aims to help governments formulate equitable REDD programs. Moreover, even with a desultory Copenhagen outcome, the discourse and the change in politics have been substantial enough to suggest that a forest program—afforestation, reforestation, and avoided deforestation—will loom large in the climate change agenda these next few years.

Saturated lands. Receiving less attention, but critical to mitigating land-use emissions, are peatlands, wetlands, and other saturated lands replete with stable organic carbon. According to biologist Hans Joosten of Greifswald University in Germany, continuing drainage of peatlands releases around 2 gigatons of CO_2 per year, or about 25 percent of all land-use emissions. Peatland conversion occurs often in the tropics, but also in Eastern Europe and the former Soviet Union.

Joosten points out that the way to mitigate peatland emissions is to stop ongoing drainage and "re-wet" already drained peatlands. He believes that restoring peatlands will produce many co-benefits, including improvements in regional hydrology, reductions in nutrient runoff, revitalization of rural economies with new livelihood opportunities, ecotourism, and the prevention of dangerous peatland fires, which in the Chernobyl region of Belarus, for example, "lead to re-emission of radioactive substances." Joosten also hopes for some international incentives to support peatland conservation, similar to those talked about for REDD.

Rangelands and grasslands. A different type of carbon management, rather than capturing carbon in vegetation or avoiding its release, involves modifying or enhancing soils themselves with carbon amendments. Ranchers, farmers, and land managers all over the world look to carbon in the soil for productive lands. Justin Derner, a rangeland scientist with the U.S. Department of Agriculture's Agricultural Research Service (ARS), explains that "carbon is the fundamental building block for healthy rangeland soils." According to ARS pastureland expert Alan Franzleubbers, "soil organic matter is typically composed of 58 percent carbon and 5 percent nitrogen…. Soil organic matter is a sink for carbon, derived from plant uptake of CO_2 from the atmosphere and decomposition and transformation of plant residues into soil organic matter." Grassland and cropland soils can quickly take up considerable amounts of carbon.

USDA ARS

Grasslands: This permanent grass cover established under a conservation reserve program in northern Minnesota sequesters large amounts of carbon throughout the dark soil layer.

The world's 3.3 billion hectares of grazing lands offer enormous potential for sequestration. For example, according to Derner it is estimated that in the United States 90 percent of privately managed rangelands can be significantly better managed and attain much higher levels of soil carbon, by such means as increased plant cover, light-to-moderate livestock loads, and low-disturbance addition of legumes. Ron Follett, who leads the Soil Plant Nutrient Research Unit at ARS, says these plantings and other measures are low-cost technology that land managers already know how to use.

Lynn Betts, USDA NRCS

Croplands: This Iowa farm incorporates terraces, conservation tillage, and green buffers around riparian areas.

Soil carbon enhancement outreach and policy linkages are starting to come into view. For example, Follett points to the Environmental Service Markets Program initiated by the U.S. 2008 Farm Bill as key to preparing American farmers and ranchers for future carbon and ecosystem service markets. There are uncertainties to be worked out—"The question remains about how such benefits of environmental services might best be measured," he says—but the energized scientific and policy scrutiny of soil carbon in the American heartland raises possibilities within and beyond America's borders.

Similarly, in the developing world there is a strengthening focus on the benefits of increasing soil carbon. Recarbonizing developing-world rangelands and grasslands will lead to healthier livestock, less erosion, cleaner water, and better nutrient cycles, among other benefits, as well as better livelihoods. Moreover, for rangelands and pasturelands in the developing world, climate-change adaptation strongly overlaps with mitigation. "For example, if we are assisting pastoralists in the Horn of Africa to be prepared for potentially more arid climatic conditions," explains Namibia-based environmental scientist and UN consultant Julianne Zeidler, "a more directed utilization of limited range resources…will diminish potential degradation or desertification and will limit carbon releases."

Croplands. For croplands worldwide, there are also many opportunities to increase carbon content and yield co-benefits. High-carbon crop systems, livestock management that produces less greenhouse gases, and restoring vegetation in degraded areas are among the strategies on tap. Soil scientist and World Bank advisor Erich Fernandez adds that "[i]n the tropics, the use of a variety of conservation tillage, mulching, agroforestry systems, and improved manure management and composting with crop residues is resulting in significant carbon replenishment of carbon depleted soils." However, Fernandez also warns against neglecting the local picture: "Farmers don't farm to produce carbon—they strive to produce food and fuel crops and building materials for household consumption and for sale." For Fernandez, future agriculture policies must focus on developing farmers' production goals, which will turn on better environmental practices.

Sarah Scherr, an economist and president of the nonprofit group Ecoagriculture Partners, also calls for new focuses, such as expanding agricultural research beyond the traditional concentration on seeds and yields. "[I]n this century, the production of ecosystem services like carbon sequestration, watershed protection, and wildlife habitat will have to be just as important," says Scherr. "We haven't invested very much in research on how to achieve production and livelihood goals, while at the same time producing ecosystem services—particularly how to develop carbon-rich, low-emissions agricultural systems."

Fire management. Then there is managing wildfires, responsible for emissions of perhaps 1 or 2 gigatons per year of carbon, depending on climate patterns and the estimation methods. This area will be difficult to address, as fire policy is often a primary responsibility of local governments. However, with growing dissemination of best practices, such as scheduling prescribed fires in cool seasons instead of hot ones, a real difference could be made in this area too. For example, a 2008 study of Australian indigenous lands and climate mitigation measures by Australia's Commonwealth Scientific and Industrial Research Organization concluded that with better fire management GHG emissions from fires on Australian indigenous lands would decrease from an estimate 7.6 million tons of CO_{2eq} (carbon dioxide equivalent) per year to 5 million tons CO_{2eq} per year. The paper points out that this reduction could be incentivized by linkage to the offset market. Thus, even with fire management, it may be possible to link practices at the local level with national or global carbon programs.

Biochar. Lastly—and getting a lot of attention in 2009—there is biochar, the soil amendment famous for its association with fertile indigenous lands (*terra preta*, or "black earth" in Portuguese) in the Amazon. Biochar is charred organic matter from low-oxygen heating and has an extremely slow rate of carbon decomposition. It is therefore a "recalcitrant" that increases the terrestrial carbon balance in a durable way. As a soil amendment biochar tends to increase growth of photosynthesizing biomass, thereby facilitating sequestration.

Biochar is usually formed for more than one reason, as the biochar heating process (pyrolysis, for example) can also produce gas usable for energy. Biochar expert and Cornell University soil scientist Johannes Lehmann points out that "biochar will create the greatest sustainability value where a waste biomass stream is co-located with energy needs and the need for soil improvement." This could be where biomass is "an environmental liability, such as with some green wastes or animal manure" at agricultural sites, or "where soils are severely degraded," including in unproductive dry lands.

There has been some backlash against biochar. For example, a March 2009 *Guardian* column by British journalist and activist George Monbiot was particularly harsh in questioning biochar's effectiveness and its impact on health and landscapes. And a 2009 UNEP paper, "The Natural Fix? The Role of Ecosystems in Climate Mitigation," was cautious about biochar. Until environmental, agricultural, and economic questions are worked out, it said, "large-scale biochar deployment is inadvisable."

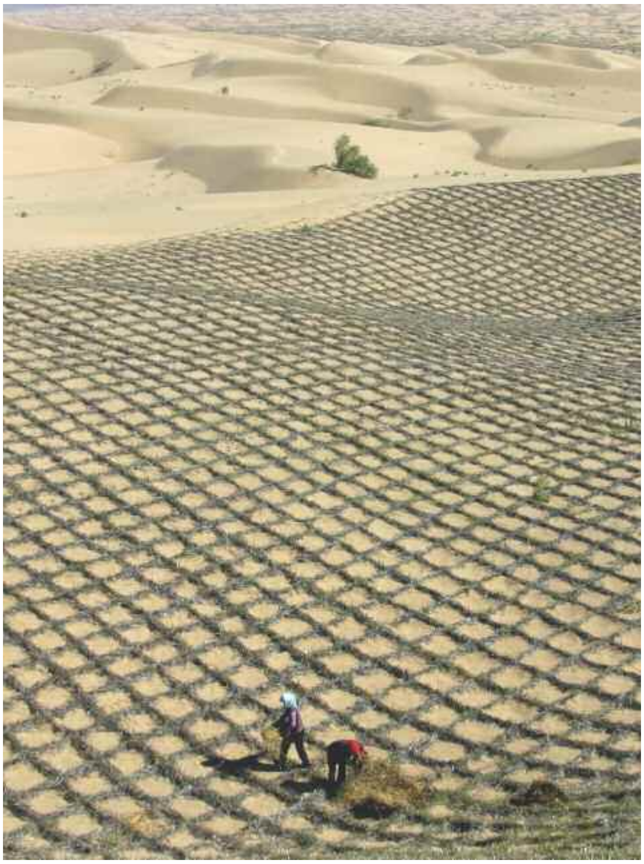
Nonetheless, in recarbonization scenarios biochar is typically included. "There is no single technology which can be applied to all soils, climate land uses, and social and environmental conditions," Rattan Lal contends. "Biochar, similar to no-till and agro-forestry, has some niches where it may be applicable. These niches are those which have sources of biomass which is not used for other purposes." Johannes Lehmann adds that "biochar systems should be seen as another tool in our tool box to mitigate climate change and global soil degradation. It may well turn out to be an important one. We can not afford to overlook any sustainable option for climate change mitigation."

Paradigms

An adequate climate change response with a big natural sequestration component poses a huge challenge in terms of choices, rights, and flexibility of measures. "It is, of course, a big land issue," Thomas Lovejoy says, "the biggest of all time—as the same land base has to supply food, biofuels, biodiversity conservation, and carbon sequestration."

Nonetheless, there are paradigms of large-scale land management which offer guidance. For example, Sarah Scherr gives the example of the United States' response to the Dust Bowl of the 1930s: "Millions of hectares were restored and protected with soil conservation measures and planting of windbreaks." Scherr also highlights current undertakings in India and China that are rehabilitating millions of hectares of degraded lands. "These programs could be scaled up ten-fold if carbon finance for local organizations, technical assistance, and planting materials were available to communities."

Incentives, too, are key. For example, Alan Franzleubbers maintains that farmers, with the right incentives, would adopt carbon sequestering approaches, "not only in response to financial interest but also based on a stewardship ethic and the desire to improve the world. Farmers…are drawn in different directions due to various social and economic policies and incentives." If science, government, and industry would forge a clear framework for agriculture, he says, "enormous potential exists to improve conservation practices in the U.S.A."



Reuters/Stringer Shanghai

Degraded lands: Farmers plant grass to stabilize sand dunes at the edge of the Mu Us Desert in Lingwu, China.

In addition to incentives, the notion of a public-service benefit might appeal to many. According to independent geologist Allison Burchell, who examines geological-based linkages for sequestration, such as with restored mines, "an enhanced natural terrestrial sequestration program may buy us time in the race against climate change. It offers hope and opportunity for both research and public participation—green jobs, green education, AmeriCorps, volunteers for America—to engage collaboratively to determine the combination of applications that may enhance the [carbon] baseline of a restoration area."

Time is critical. "This is the ultimate moment of reconciliation between humanity and the living planet," Lovejoy asserts. "We can either recognize the need to manage the planet as a biophysical system and reap the benefits, or we can continue to degrade the biological underpinnings of the planet." Perhaps what is most encouraging is that what we need to do is clear and has many co-benefits. "We are talking about strengthening Earth's life force," Tim Flannery explains. "What we have done is weaken the life force, and we need to strengthen the capacity of the Earth to take care of us."

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