

BOGGING DOWN IN THE SINKS

Under the Kyoto Protocol, a country may be able to reduce its obligation to cut carbon emissions by "sinking" some carbon in trees. But greenhouse forestry won't necessarily be good for the forests—and it certainly won't prevent climate change.

by Ashley T. Mattoon

LAST YEAR SAW SOME OF THE WORST FOREST FIRES in history. Indonesia lost 100,000 hectares of virgin tropical rain forest, much of which had probably never burned before. Brazil's burning season swallowed 2 million hectares of forest. Overall, more than 5 million hectares of land went up in flames—an area roughly the size of Costa Rica.

This year again, vast stretches of tropical forest have been reduced to charcoal. Another 3.9 million hectares in Brazil were lost. To the north, fires raged here and there through central America, and up into the highland "cloud forests" of southern Mexico, one of the last places in that country where it was still possible to find the quetzals, jaguars, and other species that have shaped thousands of years of indigenous culture.

During the 1980s, the last time an estimate was made, the fires and other forms of deforestation were releasing around 1.4 billion tons of carbon into the atmosphere annually. Deforestation accounts for roughly one-fifth of humanity's annual emissions of carbon dioxide (CO₂), the primary greenhouse gas. In the oddly nondescript language of climatology, the burning tropical forests have become a *net carbon source*—that is, they are pumping more carbon into the atmosphere than they remove through photosynthesis, the process that pulls CO₂ out of the air to build plant tissues and ultimately, forest soils.

But in the temperate and northern forests, an opposing process seems to be occurring. The regrowth of woodland and various other ecological changes have made these forests a *net carbon sink*.

They are absorbing more carbon than they give off. The size of this sink is uncertain but by a rough estimate, it takes in about 700 million tons more carbon than it releases through burning and decay.

Given the links between forests and climate, it's not surprising that forestry has always loomed in the background of the climate negotiations. The 1992 Framework Convention on Climate Change specifically calls for the "conservation and enhancement" of carbon sinks. That idea proved crucial to the negotiations last December in Kyoto, where the actual mechanics of the treaty were being worked out. The principal task at Kyoto was to get an agreement among the "Annex I parties" (essentially, the industrialized countries) on how much they would reduce their greenhouse gas emissions below their 1990 levels by the time of the "commitment period"—the five years from 2008 through 2012. To measure a country's progress towards the treaty target, its total emissions over those five years will be compared to its 1990 emissions level multiplied by five.

The agreement that emerged called for a collective 5.2 percent reduction of industrialized-country fossil fuel emissions below their 1990 level. (Fossil fuels account for 75–80 percent of humanity's CO₂ emissions.) Fossil fuels contributed some 6 billion tons of carbon to the atmosphere in 1990. The contribution is now in excess of 6.3 billion tons and rising, so the treaty would appear to require substantial reductions in fossil fuel use. But cutting back on coal and oil is a tough sell politically. Planting trees, on the other hand, has nearly universal appeal. That's why



ILLUSTRATION BY JEFF MARTIN

the industrialized country delegates at Kyoto were so interested in the carbon their forests were socking away. Was there some way such a country could use its expanding forests as a "credit," which would partly offset its obligation to cut back on fossil fuels?

RETROACTIVE PROGRESS

The world's forests contain less than 5 percent of the immense lode of carbon—42.8 trillion tons of it at least—that is circulating through the air, soil, water, and the tissues of living things in a process known collectively as the carbon cycle. But of all the cycle's natural links (that is, excluding the fossil fuel input), the forests are among the most susceptible to human influence.

At present, according to one recent overview of the cycle, terrestrial plant growth in general absorbs some 61.9 billion tons of carbon from the air every year. Decay and burning (both natural and human-caused) release 61.6 billion tons. So despite the fires, terrestrial vegetation on the whole still seems to be a net sink. (See chart.)

Our biggest effect on the cycle involves, in a sense, the burning of *fossil forests*. Those fossil fuel emissions—all 6.3 billion tons of them—are additional carbon, which is being injected into the cycle through the combustion of coal and oil. Fossil fuel use is releasing the carbon that ancient forests pulled out of the atmosphere hundreds of millions of years ago.

There is no serious debate over the level of fossil fuel emissions. But at Kyoto, many scientists argued that we do not understand the cycle in its entirety well enough to predict whether the carbon moving into industrialized-country forests will actually stay there. In their view, carbon sinks shouldn't have entered into the treaty until more solid data on them had been collected. But intense pressure to reach some sort of agreement before the conference broke up pushed the sink negotiations ahead anyway. In the scramble to come up with something that everybody could endorse, participants fumbled with their calculators and computer models, and new algorithms came spilling out of convention center doorways every few hours. Kevin Gurney, an atmospheric scientist at Colorado State University who attended the meetings, likened the tangle of resulting proposals to spaghetti. Many of these strands, in Gurney's circumspect way of putting it, had "limited scientific merit."

Whatever the scientific value of the resulting provisions, their diplomatic importance was enormous. The sink concept proved to be a wonderful fudge factor—or "flexibility mechanism," to use the diplomatic euphemism. For example, the United States, the world's largest greenhouse gas emitter, agreed to reduce its emissions to a level 7 percent below its 1990 levels—as long as it could invoke its forest sinks, among other things, when the time comes to

do the accounting. Without recourse to the forests, the United States would likely have adopted a more modest limit.

But the U.S. reaction reveals the basic flaw in this approach: it builds too much weasel room into an agreement that may already be too weak to accomplish its ostensible purpose. (See "Last Tango in Buenos Aires," page 10.) Even a straight emissions cut of 7 percent would really only be a start. Consider this: it will take a global reduction on the order of 60 to 80 percent just to prevent atmospheric CO₂ from more than doubling beyond its preindustrial level by the end of the next century.

Yet precisely because it is such a useful "flexibility mechanism," the sink concept will probably have a long legal life. A growing international cadre of consultants, lawyers, and biologists already makes a living off it. And this sink sector may exert a strong influence not just on the international climate debate, but on the management of the forests themselves.

In a way, the basis of that influence is this rather ungainly equation, which is the Kyoto formula for squeezing a carbon credit out of the forests:

$$\text{Gross industrial emissions} + \text{emissions from LUCF activities} - \text{removals from LUCF activities} = \text{total net emissions.}$$

(In treaty-speak, LUCF basically means forestry. The acronym stands for "land-use change and forestry" but at present the only activities covered involve adding or subtracting trees. The term "removal" refers to the absorption of carbon from the atmosphere.)

To get the most out of their flexibility mechanism, negotiators employed the formula in an accounting procedure called the "gross-net" approach. Only *gross* industrial emissions (the first term in the equation) will be used in calculating emission figures for 1990, the baseline year. But during the commitment period, the full equation will be run to get the *net* emissions figures. So the gross figure will be compared with the net figure to measure progress. Since the two figures aren't really comparable, the accounting is a pretty tenuous exercise. But politically, this approach is extremely convenient. Since forest cover is increasing in most industrialized countries, including forestry will almost always produce a lower emissions figure. Excluding forestry from the baseline figure will make the 1990 emissions look as large as possible; including it for the commitment period will make emissions for those years look as small as possible. Automatic "progress" appears, in the form of a carbon credit.

It's not yet possible to calculate the credits with any degree of precision, but this sink accounting may already have become essential for the treaty's survival. In the United States, at least, the mechanism is now a critical part of selling the treaty to a Congress large-

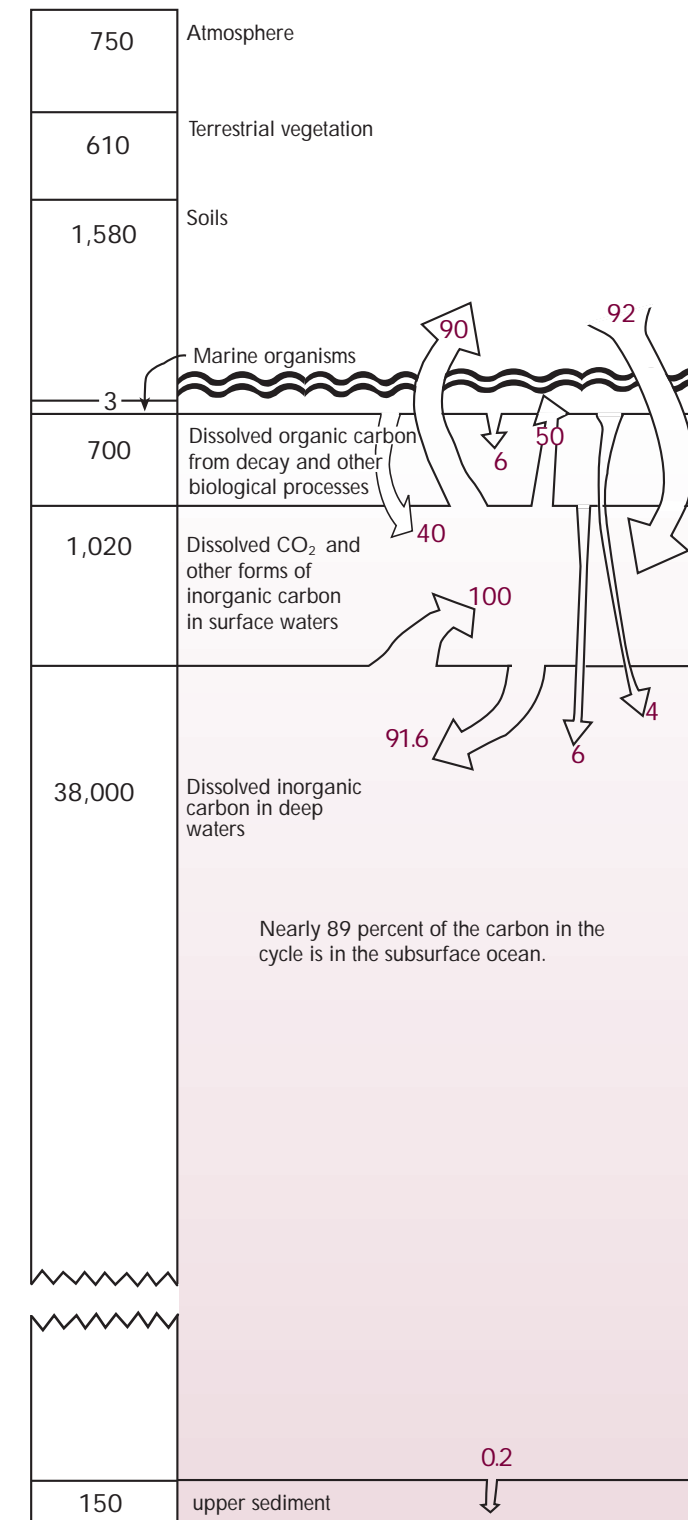
ly hostile to the idea of cutting emissions at all. Janet Yellen, who chairs the president's Council of Economic Advisers, has told Congress that sinks "could comprise a significant portion" of the country's total required emissions reduction.

In a very broad sense, the gross-net approach

allows most industrialized countries to capitalize on a simple artifact of history. Most of these countries cleared their original forests long ago and are now in a regrowth phase. Between 1980 and 1995, forest cover in industrialized countries expanded by 20 million hectares, according to the UN Food and Agri-

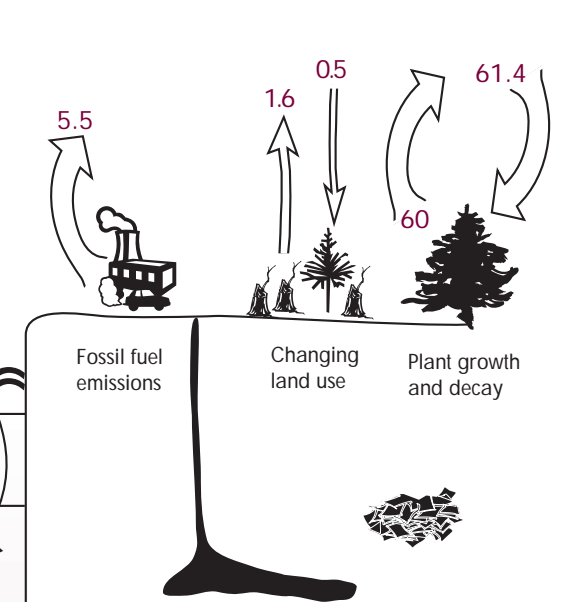
WHERE THE CARBON IS...

(billions of tons)



...AND WHERE IT IS GOING

(billions of tons per year)



At least 300 billion tons of carbon are in oil and gas deposits; another 3 trillion tons are in coal.

These deposits are not naturally a part of the cycle, at least on a time scale than can make any difference to humans.

Note: The numbers given here are not current. Because a full set of current numbers is not available, all of the numbers from the original source have been retained in order to maintain proportions within the diagram.

SOURCE: Schimel et al., "CO₂ in the Carbon Cycle," *Climate Change 1994* (Cambridge, U.K.: Cambridge University Press, 1995).

culture Organization (FAO). But over all, the world is now losing forest cover at a rate without historical precedent: during that same 15-year period, total global forest cover dropped by about 180 million hectares—an area nearly as large as Mexico. Most of these losses are occurring in developing nations, where many original forests were until recently still intact.

But the accounting is also flexible enough to accommodate the one big exception to the historical trend: Australia is one of the few industrialized countries whose forests are releasing more carbon than they are absorbing. In 1990, deforestation in Australia released 122.6 million tons of CO₂ into the atmosphere, an amount equivalent to roughly 45 percent of the country's fossil fuel emissions in that year. So in Australia's case, the gross-net approach tends to tilt the accounting the other way: excluding those deforestation emissions will obviously shrink the baseline year figure, making a carbon credit much harder to extract. Not surprisingly, Australia objected to this procedure, so a provision was shoe-horned into the Kyoto Protocol at the last minute, so that Australia could use "net-net" accounting. Under net-net, Australia will run that full equation for both the baseline year and the commitment period, and the Australian baseline may rise by as much as 30 percent. The basic principle here is a twisted kind of "fairness": if some industrialized countries deserve a carbon credit for their forests, then they all do, no matter what is actually happening to their forests.

It's far less certain what Australia's commitment period figures will look like. The country's deforestation rate is clearly dropping; by 1995, the government was already reporting a 31-percent decline in its deforestation emissions since the base line year. But Australian environmentalists are skeptical of the government's intentions. They point out that even though a national program aims at replanting 250,000 hectares of woodland annually, the country is still losing far more forest than that every year to its logging and ranching industries. The only way for the country to achieve a net vegetation gain, according to the Australian Conservation Foundation, is to make a dramatic cut in the rate at which the land is being cleared. And, says Anna Reynolds, a lobbyist at the Foundation, "there is no work on the part of the federal government to slow landclearing nationally." In the province of Queensland alone, Reynolds says, the clearing is proceeding at a rate equivalent to 60 soccer fields per hour.

THE "KYOTO FOREST"

In order to make the equation on page 30 work, the Kyoto delegates had to agree on the exact meaning of the terms used within it. And there was a good deal of wrangling over how broad that LUCF term

ought to be. New Zealand put forward an initial proposal which argued essentially that everything going on in the forests—all emissions and removals—should be eligible. Under its own definition, New Zealand could invoke its enormous and rapidly-expanding tree-plantation sector to off-set its entire emissions-reduction target. (By 1990, New Zealand's plantations were already accounting for the lion's share of a vegetation sink equivalent to 80 percent of the country's fossil fuel emissions.) Not surprisingly, the proposal had strong support from other industrialized countries with large forests, such as the United States and Canada.

But other countries objected to this approach, noting that what was true of New Zealand would be true to a lesser degree of the industrialized countries as a whole. The total offset could have amounted to roughly 340 million tons of carbon. And this theoretical "reduction" would have resulted largely from activities, such as plantation development, that would presumably have occurred anyway. This approach frustrated many delegates, who saw it as a subversion of the treaty's basic aim. Gylvain Filho Meiro, a Brazilian delegate, pointed out what would happen if the idea were taken to its logical extreme:

"We are discussing credits that will allow emissions to increase.... Do not put here a license to increase emissions. Let us not fool ourselves.... we know that the natural uptake of the oceans is 2 [billion tons]. I am glad that at least we are not trying to take credit for that. There are about 2 [billion tons] uptake by the surface. The implications of taking credit for all of that is a license to increase emissions 30 percent more. This is not in the spirit of the convention."

Eventually, the delegates agreed that the LUCF term would apply only to changes in carbon stock resulting from active management—or mismanagement—of the forests. Specifically, it would cover only reforestation, afforestation, or deforestation, and it would include only activities since 1990. But after Kyoto, the debate shifted to what those three terms should mean. The Intergovernmental Panel on Climate Change (IPCC), the scientific body that advises the parties to the convention, had produced definitions of all three in its *Guidelines for National Greenhouse Gas Inventories*. But these proved too vague. In the ensuing definition debate, the U.S. Forest Service went so far as to set up a computer mailing list, the "RAD-list," to solicit opinions from foresters all over the world on the exact meaning of the terms. The definitions—as many as 20 per term—will be considered in upcoming negotiations.

It's tempting to dismiss the definition debate as just a sideshow, but the way these terms are construed will in some measure determine what becomes of the carbon in the world's forests—and what

becomes of the forests themselves. Take deforestation. Under the definition used by the FAO, which publishes a set of widely-used global forest statistics, deforestation means the loss of 80 to 90 percent of an area's tree cover. If this definition were accepted into the protocol, then an industrialized country could log out three-quarters of a forest canopy without having to account for the consequent carbon emissions, because the area would not technically be deforested.

Under the definition in the IPCC *Guidelines*, an area must be permanently cleared of trees to be counted as deforested. So clearcutting, for example, would not count as deforestation if the clearcuts were left to regenerate. The definition promoted by the Canadian Ministry of Forests makes this point explicit: deforestation is "clearing an area of forest on a non-temporary basis for another use. Clearcutting (even with stump removal), if shortly followed by reforestation for forestry purposes, is not deforesting."

But the problem is that clearing forest results in a massive immediate release of carbon, and it generally takes a century or longer before an ecosystem approaches its previous carbon storage capacity—assuming that the process is allowed to run its course. Under either the IPCC or FAO definition, many activities that would severely reduce a forest's capacity to absorb and hold carbon would not be discouraged—such as selective harvesting, or the construction of logging roads and other forms of fragmentation. These activities obviously result in a direct removal of wood from the area, but their main effects may be more insidious. Soil erosion, landslides, a greater tendency to burn—these are all common results of fragmentation, and all of them tend to reduce a forest's carbon storage capacity.

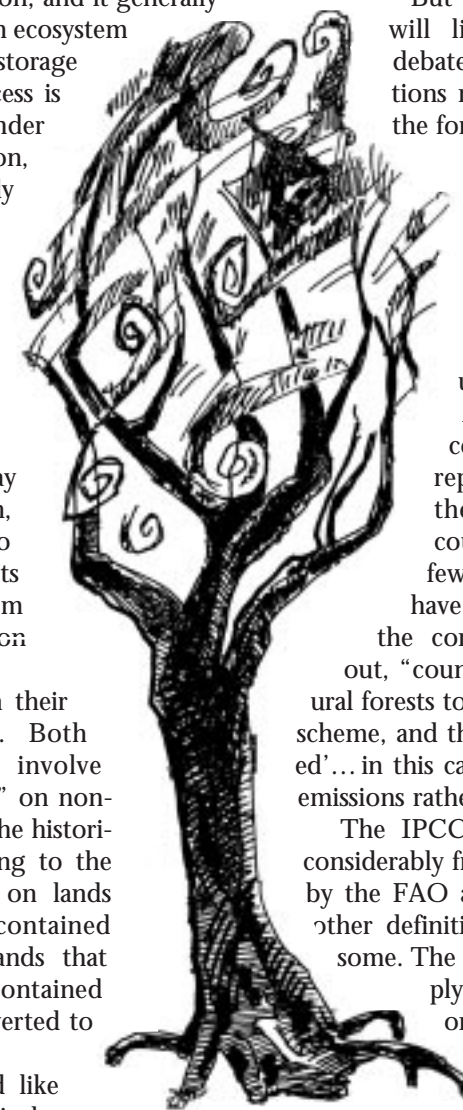
The other two terms contain their share of ambiguities as well. Both afforestation and reforestation involve planting a "forest" or "tree crop" on non-forested lands—the difference is the historical context of planting. According to the IPCC, afforestation is planting on lands that have, "historically, not contained forests." Reforestation covers lands that have "historically, previously contained forests but which have been converted to some other use."

This distinction might sound like little more than a terminological

quibble: if trees have been planted in an area after the beginning of 1990, then that area becomes part of the "Kyoto Forest"—it can be included under the LUCF term—so what difference does it make whether it's "afforested" or "reforested"? But afforestation could mean planting trees where they have *never* grown (at least under modern climatic conditions). So the treaty may encourage the planting of native wetlands, say, or prairies with artificial forests. Such projects are nothing new, of course. This kind of afforestation has already taken place in many countries—among them, Finland, Uruguay, Argentina, South Africa, and the United States. And afforestation may well increase the carbon storage capacity of an area, although certain ecosystem types besides forest can be substantial carbon sinks in their own right—peatlands, for example. As a means of restoring degraded forest, afforestation would obviously be a welcome development. But do we want an agreement that could also encourage the planting of trees at the expense of other natural communities?

But of all three terms, "reforestation" will likely provoke the most heated debate, because it has the biggest implications not just for global climate, but for the forest products industries and for biodiversity in general. Again, you might say it's all in the timing. Suppose, for example, that the IPCC definition—planting on lands that "historically, previously contained forests but which have been converted to some other use"—can refer to *very recent history*. Suppose that the conversion could take place now, as long as replanting follows before or during the commitment period. An area could be logged, for example, spend a few years as grazing land, and then have a pulp plantation installed on it. As the convention secretariat itself pointed out, "countries would be able to convert natural forests to other land uses, begin a plantation scheme, and then declare those lands as 'reforested'... in this case, reforestation would lead to net emissions rather than sinks."

The IPCC definition of reforestation varies considerably from the definitions commonly used by the FAO and foresters in general. But these other definitions could be even more troublesome. The FAO definition, for example, is simply "the establishment of a tree crop on forest land." That would allow the direct replacement of forest by plantation—no intervening form of land use would be required



and no time would need to elapse between the clearing and the replanting. Such a definition probably won't be adopted, given its blatant absurdity, but if it were, it would supply a huge incentive for the destruction of natural forest.

The terminological uncertainty is one of the reasons the forest carbon credit cannot yet be calculated, but for some countries it is likely to be substantial. New Zealand, with its small population and huge plantation sector, is probably the extreme case. The country is currently afforesting nearly 70,000 hectares per year—a rate that is likely to continue well into the next century. A recent report from the New Zealand Forest Research Institute concluded that by the time the commitment period rolls around, this effort will allow for an offset that will cover—not just the entire reduction target—but the entire amount of carbon the country emitted in 1990, the baseline year (roughly 7 million tons).

And the whole sink issue is likely to boil over again, well beyond the bounds of those three terms. That's because the Kyoto Protocol allows "additional activities" to be tacked on to the Kyoto forest definition at a later date. Many countries continue to push for a return to something like the original New Zealand approach—and even for including other types of terrain besides forests. The official position of the United States, as set forth in a recent report to the convention secretariat, is to seek "full and comprehensive treatment of all [human-caused] emissions and sinks" including those occurring in "agriculture, range, and pasture lands."

The protocol could wind up including such "additional activities" as soil conservation, since well-maintained soil contains more carbon than eroded soil. Forest management strategies that increase carbon uptake are another possibility. The production of wood and other biomass fuels is yet another option, since this would presumably reduce dependence on fossil fuels. There is even a chance that some countries may seek credit for making forest products like furniture or paper, since the carbon in these commodities is no longer in the air.

Including such things in the protocol is likely to make the carbon accounting even more complex and hypothetical than it already is. Imagine, for example, all the questions that would arise from trying to include the forest products sector. How will the movement and disposition of such products be tracked? How much of a country's wood products are burned every year? At what rate does wood fiber in a landfill lose carbon to the atmosphere? Before the industry's effects on the atmosphere could be gauged, we would have to find some way of monitoring these and many other aspects of its operation.

CARBON-INTENSIVE FORESTRY

Managing the Kyoto forest is not just about atmospheric carbon—it's also about what will happen to the forests themselves. At least as it's presently structured, the Kyoto Protocol appears to favor plantation development, at the possible expense of natural forests. If a country can install a plantation without triggering any deforestation "debit," then it would garner a certain carbon credit—and no country can claim any credit for maintaining its own natural forest.

The replacement of native, natural forests with tree plantations is already a factor in global forest decline (see "Paper Forests," March/April 1998). According to the FAO, global plantation cover doubled between 1980 and 1995, to reach a total of roughly 180 million hectares—that's substantially more land than is used to grow the global corn crop (about 140 million hectares). It is true that there are many types of plantations, and careful plantation development can benefit both economies and ecosystems (by relieving pressure on natural forests). But the type of plantation that appears to be spreading most rapidly is a chemically dependent, non-native monoculture. New Zealand's 1.6 million-hectare plantation estate, for example, is 90 percent radiata pine, a species of pine native to northwestern Mexico and southern California. Such a planting bears about as much resemblance to New Zealand's native forests as a cornfield does to a native North American prairie. From a strictly ecological point of view, it could be argued that where such plantations are displacing native forest, the result is not reforestation, but deforestation.

Nor is the extension of plantation forestry necessarily good news on the climate front. It is true that some biomass fuel plantations appear to be "carbon-neutral"—that is, they seem to be drawing about as much carbon from the atmosphere as they release when the fuel from them is burned. And such operations are presumably reducing the need for fossil fuels. But most plantation forestry is not operating on that kind of balance. There is a common misperception that rapidly growing plantations, which are cut and replanted at relatively short intervals, are better carbon sinks than the apparently more static natural forests. But while it is true that short-rotation plantations absorb carbon at a faster rate, the *total amount of carbon stored* is generally greater in the natural forest, with its larger trees and far richer soils. (In temperate forests, as much as two-thirds of the carbon is stored in the soil and forest debris, not the trees.) A 60-year-old Douglas fir plantation in Canada, for example, may contain 260 to 275 tons of carbon per hectare (including both trees and soil); a hectare of hemlock-Douglas fir old growth contains more than 600 tons.

Perhaps the fundamental problem with the Kyoto forest is that it is so artificial. In its present form, the protocol will offer the biggest rewards—initially, anyway—to projects that absorb the most carbon during the commitment period. And storing as much carbon as possible as fast as possible is not a prescription for ecologically sensitive management. Nor, over the long term, is it even a prescription for maximizing carbon storage, since rapid rotations and consequent high levels of soil disturbance won't leave as much room for carbon to accumulate on site.

But it looks as if this artificial approach is attracting more and more support. The U.S. government, for example, is proposing to invest in genetic engineering projects for developing crops that absorb more carbon. There are plenty of similar projects in the private sector as well. "Only God and Toyota Can Make a Tree," exclaimed a recent *Business Week* article, which described the car maker's efforts to develop "designer eucalyptus trees" that absorb greenhouse gases faster than "old fashioned trees." But surely, sooner or later, one has to wonder: how much time, energy, and money ought to be invested in manipulating the natural world to cater to our fossil fuel addiction?

OTHER COUNTRIES' FORESTS

Two provisions in the Kyoto Protocol are intended to encourage an international market in carbon emissions credits. The approach is loosely modeled on the U.S. Clean Air Act, which set up a domestic incentive system to promote cleaner power plant technology. That law establishes an air pollution "quota" for U.S. power plants; a plant that produces less pollution than its quota can sell the remainder of its pollution allotment to a plant that is producing more than its quota—and the latter plant would be forced to buy it. The idea is to make clean electricity cheaper and dirty electricity more expensive.

In a roughly similar way, the "joint implementation" provision of the protocol aims to encourage both clean energy projects, such as wind or solar power, and land management strategies that increase carbon sinks. The idea is to allow one industrialized country to claim a credit for investing in such projects in another industrialized country. But the provision doesn't say *which sinks qualify*. So apparently, that limitation to "reforestation, afforestation, and deforestation since 1990"—the current LUCF definition—may not apply here. And that creates another potential contradiction: imagine some activity that would not currently earn a country any credit within its own borders, say a soil conservation project. But if the United States, for example, were to underwrite such a project in Russia, then the United States might be able to claim a carbon credit after all.

The other provision, referred to as the Clean

Development Mechanism (CDM), allows industrialized countries to obtain carbon offsets by investing in "clean technology" projects in developing countries. (See "Can the North and South Get in Step?" page 19.) In its current form, the provision does not mention sinks, and there has been a great deal of debate over whether forestry projects should be allowed under the CDM or not. Given the rate of tropical deforestation and its contribution to global carbon emissions, the argument for including forestry makes an obvious sort of sense. Supporters see huge opportunities here for both forests and local economies. Jonathan Rotter, legal counsel for the Nature Conservancy's Latin America and the Caribbean program, sees CDM forestry as a way to "successfully combine biodiversity protection, climate change prevention, and local community benefits."

Several forestry projects have already been established in anticipation of the CDM provision. The largest is the Noel Kempff Mercado Climate Action Project in Bolivia, a joint venture between the Nature Conservancy, the Bolivian Fundación Amigos de la Naturaleza (Friends of Nature Foundation), the Bolivian government, and three U.S. power companies. The \$10 million project is designed to protect some 648,000 hectares of forest adjoining a large national park, effectively increasing the size of the park to 1.5 million hectares. The goal is to manage the land as forest—and therefore, as a carbon sink—in perpetuity. The project has bought up logging concessions within the forest and is training local communities in sustainable agriculture. Extensive baseline studies of the forest have also been done, and it's estimated that 15 million tons of carbon loss will be avoided over the project's 30-year life. An endowment has been established to protect the forest after the project winds up.

But opponents of this approach—a group that includes most developing countries and many environmental NGOs—argue that such projects would become yet another way for industrialized countries to avoid reducing their domestic emissions. And real-world CDM forestry, according to the critics, may not resemble the well-funded, carefully designed Bolivian project. A horde of problems—the familiar nightmares of tropical forest conservation—awaits such projects on the ground. Many of the countries that would presumably be invited to host such pro-

In a sense, the protocol has the relationship between forests and emissions the wrong way around.

jects have weak legal systems, weak forest management agencies, and growing populations of rural poor who live by subsistence agriculture. Whether from poor people who burn forest because they have little choice, or large corporations who do it because they know they can get away with it, the pressures on intact tropical forest are growing ever more intense. Even when a particular tract of forest appears to have been protected, one always has to wonder how long that will last and whether some other tract is being destroyed instead. For all its importance in its own right, forest conservation is not the best place to look for long-term climate security.

THE TREATY THAT SUNK

Because the Kyoto talks bogged down so badly in the sinks issue, the IPCC has agreed to do a full report on the scientific aspects of the problem. That report is due out in June 2000 and many authorities have high hopes for it: they think the IPCC may be able to come up with cleaner definitions of key terms, and a much better sense of what we do and do not know about the carbon cycle. With the exception of the United States, Canada, and a few other countries, most parties to the treaty would prefer to wait for the report before plunging back into the sinks. But the LUCF provision has already been built into the protocol, so it's not legally possible to conclude the protocol without resolving the sinks issue. The entire process is now stuck—entangled in a struggle that is half scientific and half political, over an issue that cannot be used to advance the treaty's real objective: the reduction of fossil fuel emissions.

To make matters worse, this is an issue that we don't understand very well to begin with. Two great unknowns lie beyond the present legal quagmire. First, we're still not sure where a huge portion of humanity's carbon emissions is actually going. Scientists know roughly how much carbon is released into the atmosphere, how much stays there, and how much is reabsorbed. But exactly where that reabsorbed carbon has sunk is harder to say. Currently some 1.8 billion tons of it per year is disappearing into an enormous "missing sink." There is growing evidence that much of this missing carbon may be somewhere in the mid- to high-latitude forests. If that proves true, then the forest sinks of industrialized countries may become even more politicized than they already are.

The second great unknown is what the forests will do in a warmer world. The forests' current appetite for carbon may be partly the result of increased growth from "carbon fertilization." The extra atmospheric carbon, in other words, is giving plants a slightly richer fuel mixture for photosynthesis, and this is probably being reflected in faster growth. But

recent research suggests that carbon fertilization will likely reach a saturation point, just as ordinary fertilizer does, and at that point the growth rate will level off no matter how much more carbon is available. The extra growth, of course, will eventually mean extra decay, so carbon fertilization will only stretch a forest's storage capacity so far before some new equilibrium is reached. At that point, presumably, we will have packed about as much carbon into the forest as it's likely to hold.

And then there's the problem of climate-related stress. Already, long-term changes in weather patterns appear to be affecting the vast northern forests. In southern Siberia and Alaska, for example, tracts of forests are dying off as various insect forest pests expand their ranges northward. (Insects are often very sensitive to changes in temperature and moisture.) In Alaska, warmer temperatures are inflicting a more direct injury: some stands are drowning, as the trees sink into the melting permafrost. A forest that is a net sink today may one day become a net source.

But what we do understand—about forests, climate, and politics—suggests that the protocol is now badly mired. Sink accounting is likely to become a major loophole which admits vast quantities of fossil carbon into the skies. It is likely to encourage types of forestry that aren't generally very good for forests. And since the carbon captured by forests remains part of an active biological cycle, the protocol is highly *unlikely* to produce any long-term increase in the size of these sinks, beyond what would probably have happened anyway. In a sense, the protocol has got the problem exactly reversed: instead of looking to the forests for a way to avoid facing our fossil fuel addiction, we ought to deal with the addiction, as a way to avoid endangering forests through climatic disruption. After all, many of those recent forest fires were preceded by unusual droughts, and some scientists are reading at least some of the droughts as a form of climate change.

No doubt, the protocol will generate a great deal of additional research into various aspects of forest ecology, and no doubt much of it will be valuable—but not for reducing carbon emissions. "What I keep coming back to is the ultimate objective of keeping CO₂ from accumulating in the atmosphere," said Richard Houghton, a land-use expert at the Woods Hole Research Center in Massachusetts and one of the pioneers in modeling terrestrial carbon sinks. "What can be managed and what can't should be the focus." Managing the world's forests to mitigate climate change is not a realistic or an ecologically healthy ambition. Managing our fossil fuel emissions is.

Ashley T. Mattoon is a staff researcher at the Worldwatch Institute, and coauthor of a chapter on forests in the forthcoming *State of the World 1999*.