Testimony of William H. Schlesinger
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Committee on Natural Resources
Subcommittee on Energy and Mineral Resources
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Good afternoon. I am William Schlesinger, currently Dean of the Nicholas School of the Environment and Earth Sciences at Duke University. (N.B. in late May, I will become President of the Institute of Ecosystem Studies in Millbrook, N.Y.) I have spent the past 30 years conducting scientific investigations of the global carbon cycle, especially on the carbon content of trees and soils and how they may affect the content of carbon dioxide (CO_2) in Earth's atmosphere.

We are here today to talk about carbon sequestration. Trees, like all plants, take carbon dioxide from the atmosphere in the process of photosynthesis, and they store some of what they take up in wood, which is about 50% carbon by weight. Carbon storage in trees is one form of carbon sequestration.

Some of the carbon that trees take up is allocated to leaves, small branches and fine roots that do not live for long. When these plant parts die and fall to the ground, they decompose, returning carbon dioxide to the atmosphere. If any of these materials escapes decomposition, it accumulates in the soil as soil organic matter or humus. That storage is another form of carbon sequestration.

Today, I will refer to carbon sequestration using units of grams of carbon-per-square-meter-per-year ($gC/m^2/yr$) for individual forests or soils. For comparison, a graphite pencil lead contains about 1 gram of carbon. In contrast, when we talk about the annual rate of storage of carbon in trees and soils for the entire United States, we will use units of teragrams (TgC/yr). This is equivalent to a million metric tons.

Each year the U.S. emits more than 1600 TgC to the atmosphere as carbon dioxide by burning coal, oil and natural gas. This is a huge mass. For perspective, a long train of coal—100 rail cars of 100 tons each, carries 1/100th of a teragram of carbon, which is converted to carbon dioxide and added to the atmosphere when it is burned.

The potential for carbon sequestration in forests and agricultural soils must be measured against our nation's annual emissions of 1600 TgC/yr.

Young growing forests can accumulate more than 500 gC/m^2yr, but a landscape that includes a mix of old, young and disturbed sites stores much less (Clark et al. 2004). In the southeastern U.S., where young pine plantations cover large areas of the coastal plain, average carbon accumulation is 100 $g/m^2/yr$ (Binford et al. 2006). To accumulate 10% of the nation's emissions of carbon dioxide in wood, it would take an area of planted forests about the size of the state of Texas. No small order.

Why do I refer to young, planted forests? Because eventually all forests mature to what is known as a steady-state, where growth matches death, and there is no further sequestration of carbon. Even then, some trees in the forest are growing, but others are dying and the total biomass per acre does not show an increase in carbon content. Only in young forests can we expect significant carbon sequestration.

It is tempting to suggest that we should cut down such old, mature forests that no longer provide carbon sequestration and replace them with young forests that do so. This would be a mistake. When an old forest is cut, much of the carbon that it contains is released back to the atmosphere as CO_2. Net sequestration is thus the difference between carbon stored in the planted forest minus the carbon released from the previous forest, and the value is often neutral, or even negative. Nearly twenty years ago, Mark Harmon and his colleagues (1990) showed that timber harvest results in a net release of carbon dioxide to the atmosphere. Long-lived timber products—houses, furniture, coffins—do not store large amounts of carbon—about 6 TgC/yr for the U.S. (Woodbury et al. 2007). (Remember our emissions are closer to 1600 TgC/yr). Old growth forests retain large stores of carbon, and we should make every effort to retain them.

This means that if we wish to store more carbon in forests—that is carbon sequestration—we need to do so by planting forests in areas that were previously harvested (reforestation) or by encouraging successful forest growth in areas that have never contained forests (afforestation). We can expect those forests to accumulate carbon dioxide from the atmosphere for a number of decades, perhaps even at rates somewhat higher than today's growth rates due to rising concentrations of carbon dioxide in the atmosphere (DeLucia et al. 1999). We would need to allow those forests to grow to maturity, and to maintain them as mature forests or use them as a substitute for fossil fuels if we are to see any benefit from the carbon they have sequestered.

In forests, there is also carbon beneath our feet. A typical forest soil contains about 10,000 gC/m^2, but it accumulates new carbon at a rate of only about 2.5 $gC/m^2/yr$ (Schlesinger 1990). When forests are cut and replanted immediately, there is little loss of soil carbon, but where forests have been converted to agricultural fields for significant periods of time, there are often large losses of soil organic matter, which contributes carbon dioxide to the atmosphere. Replanting forests on those areas can be expected to restore soil carbon and offer another form of carbon sequestration. Typically the rates of carbon storage in soils abandoned from agriculture are 30 to 40 $gC/m^2/yr$ (Post and Kwon 2000)—less than 1/10 of the rate of carbon storage in wood. Nevertheless, as native vegetation has returned to lands enrolled in the Conservation Reserve Program (CRP), it has undoubtedly resulted in some carbon sequestration in soils during the past few decades.

In recent years, rather outlandish claims have been made for the potential for better management of agricultural lands to result in significant carbon sequestration in soils (Lal 2004). These should be examined carefully. In many cases, irrigation and a greater use of nitrogen fertilizer result in additional carbon dioxide emissions to the atmosphere (Schlesinger 2000). Conversion of cultivated lands to no-till agricultural practice offers rather limited benefits in terms of carbon storage (Baker et al. 2007), and these can be erased by a single act of cultivation at a later time (Six et al. 2004). West and Post (2002) found average rates of carbon sequestration were 57 gC/m^2/yr with conversion to no-till, but Kern and Johnson (1993) estimated that the conversion of all U.S. farmland to no-till would store only 1% of U.S. carbon emissions in soils. Only the abandonment of agriculture in favor of planted or natural regeneration of forest is likely to produced significant carbon sequestration (Jackson and Schlesinger 2004).

So, my take-home message today is not an optimistic one. Growing forests store carbon in wood and soil, but we should not sacrifice old-growth forest to increase the nation's carbon sequestration, and carbon sequestration in forests is not likely to offer much overall benefit to the problem of global climate change.

If credit is given to those who choose not to cut existing forests, an increasing global demand for forest products will simply shift deforestation to other areas. Frequent audits of carbon sequestration projects will be needed to determine current carbon uptake, insurance will be necessary to protect past carbon sequestration from destruction by fire or windstorms, and payments will be necessary if the forest is eventually cut. All these efforts will be costly to administer, diminishing the value of the rather modest carbon credits expected from forestry (Schlesinger 2006).

Abandoning agricultural lands might offer some soil carbon sequestration, but large-scale agricultural abandonment seems unlikely at a time when there is so much enthusiasm for biofuels to power the nation's future energy needs. For me, the only realistic way for the United States to contribute meaningfully to reduced concentrations of carbon dioxide in the atmosphere will be to curtail emissions, from a combination of conservation, efficiency and non-fossil sources of energy production.

Thank you.

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