Albedo credits or carbon credits?

David B. South and David N. Laband[1]

A recent IPCC report, Climate Change 2007: Synthesis Report - Summary for Policymakers (2007a), presents some interesting and counter-intuitive data. The word "forestry" was mentioned eight times, "forests" four times, "deforestation" five times and "afforestation" occurred once. The synthesis report went on to say that of the anthropogenic greenhouse gasses (not including water vapor produced by burning fossil fuels), "forestry" accounts for 17.4 percent of the 49 gigatonnes of carbon dioxide (Gt-CO_2/y) equivalent gas emitted in 2004. This is greater than agriculture (13.5 percent), transport (13.1 percent), and residential and commercial buildings (7.9 percent). The "forestry" emissions were due mainly from deforestation (8.5 Gt-CO2/y), and this amount was ranked third behind "energy supply" (12.7 Gt-CO2/y) and "industry" (9.5 Gt-CO2/y). In a supporting report (2007b), the authors estimate that 93 percent of the warming that has occurred since 1750 is due to human activity (see figure WG1- SMP.2). This guess, produced from unverified computer models, would be even higher were it not for the cooling effects associated with deforestation and from the increase in aerosols in the atmosphere.

Wait a minute… what did we just say? Deforestation has a cooling effect on the planet? Yes, changes in land use, mainly deforestation, has an estimated "radiative forcing" of about -0.2 W m^{-2}, which is a result of deforestation increasing the albedo of the Earth (Betts 2001, IPCC 2007b). This means deforestation allows more energy to be reflected from the surface and this contributed to a net cooling of the Earth by about 0.16 °C according to IPCC (since 1750). The cooling results from a change in the albedo of the Earth's surface. Lighter-colored grasses typically have a higher albedo value than the darker forests (Moore 1976; Gates Ließ 2001). As a result, deforestation would increase the albedo and might produce a net cooling effect (Marland *et al*. 2003; Bonan 2008). For example, in the United States, deforestation (i.e. converting forests to mechanically disturbed areas) has, over a 27-year period, increased the albedo and caused a radiative forcing of -0.12 to -0.25 Wm^{-2} (Barnes and Roy 2008). Since the measurements were made using satellites, this cooling effect from changing the albedo by deforestation is real and not just theoretical.

If deforestation increases the surface albedo, this can contribute to cooling the Earth. But if deforestation results from slash and burn agriculture, won't the release of carbon dioxide have a warming effect that will overwhelm the cooling effect? As far as we know, data do not support an answer in the affirmative (Bonan 2008). Although the cooling effect from deforestation (due to increasing surface albedo) has been measured (Barnes and Roy 2008), any warming effect from carbon dioxide release is theoretical and has not been reliably measured. Therefore, if an empirical approach is not possible, one has to resort to a model for a guess at the answer. According to some global warming models, the answer is the cooling effect, for boreal and temperate zones, is stronger than the theoretical warming effect (Bala *et al*. 2007). In the computer-simulated Earth, the net cooling occurred even when all the trees were converted to carbon dioxide. However, in tropical zones, deforestation might warm the region due to a reduction in evapotranspiration (Costa and Foley 2000).

Authors of the "Forestry" chapter of the IPCC report admit that "there are still knowledge gaps in how forest mitigation activities may alter, for example, surface hydrology and albedo (IPCC 2007c)." However, recently released measurements of the albedo of ecoregions in the USA suggest that afforestation, specifically in the Mississippi Valley, is the land-use change that has the greatest potential for warming the region (Barnes and Roy 2008). A similar effect was reported between natural forests and grasslands in Puerto Rico (van der Molen 2008).

Most forestry policy papers regarding afforestation concentrate on the C-sequestration and generally ignore any potential effect on increasing global temperature. For example, Pacala and Socolo (2004) suggest a massive afforestation program might sequester 12.5 gigatonnes of carbon in 50 years, and this might temporarily lower the carbon-dioxide level in the atmosphere by 12 ppm. Assuming business as usual (ie. + 2 ppm/yr increase), lowering the concentration by 12 ppm might delay reaching a 600 ppm level by six years. Some believe that by combining certain agricultural practices with forestry, the concentration of carbon-dioxide could be lowered by 50 ppm in 150 years (Hansen *et al*. 2008).

It took a century to increase global temperature by 0.74 °C (IPCC 2007d). Therefore, a six-year delay "might" equate to a cooling effect of about 0.044 °C. In contrast, deforesting 0.4 billion ha of boreal forests "might" cool the Earth by 0.2 °C due to changing the albedo (Bala *et al*. 2007). The albedo effect might be five times more powerful than the C-sequestration effect in boreal zones and might be twice as powerful in temperate zones (Bala *et al*. 2007). Perhaps this is why some researchers do not recommend establishing 0.4 billion ha of boreal (Betts 2000) or temperate-zone afforestation (at a cost of perhaps $150 billion) to cool the Earth (Barnes and Roy 2008). On the other hand, would some foresters recommend establishing 0.4 billion ha of afforestation even though it might warm the Earth? Yes, especially if money from selling or buying carbon-credits or managing new afforestation projects increases the foresters' standard of living.

Albedo Credits

It is apparent that some governments and some private organizations are willing to pay forest owners for

[1] *School of Forestry and Wildlife Sciences, Auburn University, Auburn, Alabama, USA*

carbon credits. For example, in Australia, carbon credits for afforestation are sold on the web for $23 per 5.33 trees (ie. one tonne of credit). A lifetime of carbon emissions for one person can be purchased for about $44,000 (U.S.). The exchange of paper from seller to purchaser benefits the dealer, who might take a 30 percent commission. This raises the possibility that dealers and others with a financial interest in carbon credit markets have an economic reason to ignore, or downplay the importance of, papers published by Bala and others (2007) and Barns and Roy (2008).

We believe that a scientifically-grounded case can be made for albedo credits *rather than* carbon credits. Unlike C-sequestration due to afforestation, the cooling effect from increasing the albedo can actually be measured on the Earth's surface. If the albedo effect has a stronger mitigating influence on global temperatures (than paying someone to plant trees in boreal ecosystems), and several journal articles indicate this is true, then governments and organizations should be willing to pay landowners to increase the surface albedo. When calculated on an area basis, the price of the albedo credit might even be greater than the current carbon-credit price paid to landowners to cease harvesting of trees for the production of lumber. That is because they would get more *realized* global cooling per dollar spent on albedo than on carbon sequestration. With albedo credits, landowners earn money by making the land, road or roof surface more reflective. Those who market albedo credits might take a 30 percent cut while those who construct dark-colored roads or roofs, or establish pine plantations on farmland, might be forced by governments to purchase albedo credits. In comparison to estimating the amount of carbon actually sequestered from plantations, albedo verification procedures would be relatively simple, using remote sensing data.

Moreover, for firms that are required to reduce their predicted impact on global warming, albedo credits should be regarded as a straightforward alternative to carbon credits. After all, the main public concern isn't about carbon *per se*, it is about reducing the threat of global warming. If increasing surface albedo reduces global warming cheaper and better than carbon sequestration, then firms that currently opt to purchase carbon credits (because doing so is cheaper than reducing their carbon emissions) should favor the development of albedo credit markets. Such markets would permit them to purchase albedo offsets even more cheaply than they can in the carbon credit markets. But, of course, this means that producers of carbon credits will be opposed to development of albedo credit markets. The value of carbon credits would fall in the presence of an alternative market that has a greater impact on global climate. Everyone loves competition, until it gores their ox.

Notwithstanding the absence of a scientifically-established causal link between CO_2 levels and observed changes in global temperatures, if individuals, groups, or governments want to spend money in order to control the climate, then science may point to efficient mechanisms other than carbon credit markets. According to Hansen (2006), it "would be irresponsible not to consider all ways to minimize climate change." Of course, it seems more and more likely that science plays a minor role when it comes to policy decisions that enrich certain interest groups at the expense of others.

References

Bala, G., K. Cadelra, M. Wickett, T.J. Phillips, D.B. Lobell, C. Delire and A. Mirin. 2007. Combined climate and carbon-cycle effects of large-scale deforestation Proceedings of the National Academy of Sciences 104 (16):6550-6555.

Barnes, C.A., and D.P. Roy. 2008. Radiative forcing over the conterminous United States due to contemporary land cover land use albedo change, *Geophysical Research Letters* 35:L09706, doi:10.1029/2008GL033567.

Betts, R.A. 2000. Offset of the potential carbon sink from boreal forestation by decreases in surface albedo, *Nature* 408(6809):187-190.

Betts, R. 2001. Biogeophysical impacts of land use on present-day climate: near-surface temperature change and radiative forcing. *Atmospheric Science Letters* 1(4):39 -51.

Bonan, G.B. 2008. Forests and climate change: forcings, feedbacks, and the climate benefits of forests. *Science* 320:1444-1449.

Costa M.H. and J. Foley. 2000. Combined effects of deforestation and doubled atmosphere CO_2 concentrations on the climate of Amazonia. *Journal of Climate*. 13:18-34.

Gates, L.D. and S. Ließ. 2001. Impacts of deforestation and afforestation in the Mediterranean region as simulated by the MPI atmospheric GCM. *Global and Planetary Change* 30:309-328.

Hansen, J., M. Sato, R. Ruedy, K. Lo, D.W. Lea and M. Medina Elizade. 2006. *Global*
temperature change. Proceedings of the National Academy of Science. 103(39):14288-14293.

Hansen, J., M. Sato, P. Kharecha, D. Beerling, R. Berner, V. Masson-Delmotte, M. Pagani, M. Raymo, D.L. Royer, J.C. Zachos. 2008. Target atmospheric CO2: where should humanity aim? Godard Institute for Space Studies. http://arxiv.org/pdf/0804.1126v2

International Panel for Climate Change (IPCC). 2007a. Synthesis Report - Summary for Policymakers. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

International Panel for Climate Change (IPCC). 2007b. Working Group I Report "Summary for Policymakers." http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

International Panel for Climate Change (IPCC). 2007c. Working Group III Report "Mitigation of Climate Change" - Chapter 9. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter9.pdf

International Panel for Climate Change (IPCC). 2007d. Working Group I Report "The Physical Science Basis" - Chapter 3. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter3.pdf

Moore, C.J. 1976. A comparative study of radiation balance above forests and grasslands. *Quarterly Journal of the Royal Meteorological Society*. 102:(434) 889-899.

Pacala S. and R. Socolow. 2004. Stabilization wedges: solving the climate problem for the next 50 years with current technologies. *Science* 305:968-972.