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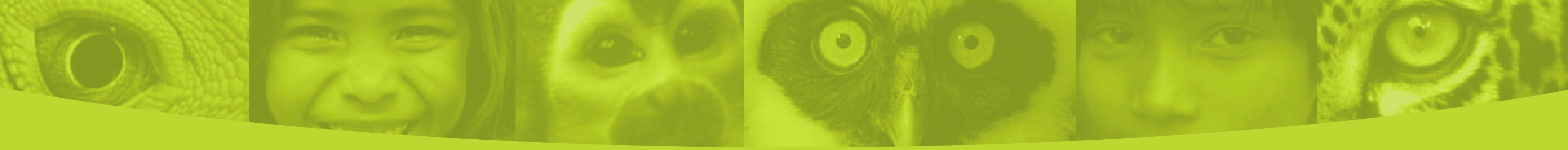

The Value of Protected Areas in Avoiding Climate Change in Amazonia

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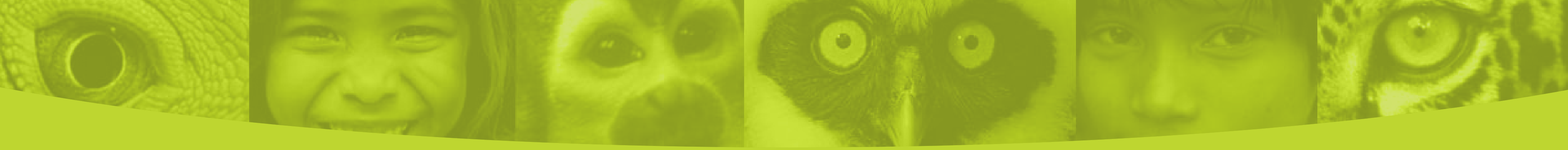
Protected areas are an essential part of strategies to contain deforestation and the consequent release of carbon. Half of the dry weight of the trees is carbon, and this, together with part of the carbon in the soil under the forest, is released as carbon dioxide (CO_2) or as methane (CH_4) when the forest is cleared. Only a relatively small amount is recaptured by the pasture and secondary forests that subsequently occupy the landscape. Amazonia as a whole, including all countries and forest carbon stocks (not only above-ground live biomass, but also the roots, dead trees and soil stocks) has around 100 Gt (gigatons = billion tons) of carbon that could be released. If this enters the atmosphere it would result in a very substantial increase in atmospheric CO_2 concentration and in global temperatures. Since many global climate models do not include this emission, these increases would be in addition to the already catastrophic increases indicated by the models as a result of fossil-fuel emissions under the A2 (= business-as-usual) scenario of the Intergovernmental Panel on Climate Change (IPCC's). This is the multi-model average of 4°C increase by 2100 over pre-industrial temperatures indicated by the IPCC's Fourth Assessment Report (IPCC, 2007). It should also be noted that global mean temperature is dominated by temperatures over the oceans that occupy most of the Earth's surface, and average temperatures over the continents would be substantially higher. In addition, in the case of Amazonia the possibility of a "permanent El Niño" being established could mean even higher temperatures (Cox *et al.*, 2004). If the possibility is taken into account of the global climate reacting to increased atmospheric CO_2 more sharply than the increase corresponding to a 50% probability (*i.e.*, under "high climate sensitivity", or a degree of security corresponding to a 95% probability), then the temperature could shoot up to much higher levels in Amazonia (*e.g.*, Stainforth *et al.*, 2005). The precautionary principle would indicate that these higher potential temperature increases should be considered in policy making, underscoring the importance of immediate actions to reduce global emissions of greenhouse gases, including those from Amazonian deforestation.

Amazonia's stock of carbon could enter the atmosphere in two ways: 1.) emissions from deliberate destruction of the forest by deforestation and by degradation through logging, and 2.) emissions that are not made deliberately, as where forest is degraded due to climate change and by forest fires. Protected areas can play an important role in reducing both types of emissions.

In the case of deliberate emission through deforestation, protected areas can have both short- and long-term effects. On the short term, creation of a reserve can cause a drama-



tic reduction in clearing by *grileiros* (large illegal claimants who occupy public land and obtain titles through fraud and corruption). The existence of a reserve greatly reduces the chance of *grileiros* or other invaders eventually gaining legal title, and therefore reduces the motive for clearing. Some of this activity can simply move to other locations (an effect known as "leakage" in the carbon literature), but some of the reduction is a net gain. In addition, the placement of reserves can act as a barrier inhibiting the advance of deforestation into areas beyond the reserve itself.

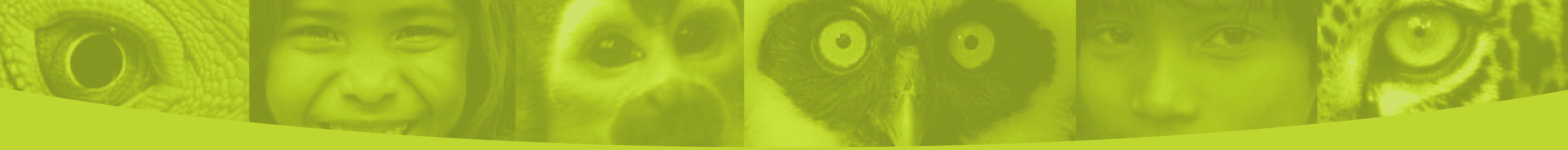
Degradation from climate change and fire can affect the entire forest, including that within protected areas. In addition to their role in slowing global warming by avoiding carbon emissions, reserves contribute to reducing degradation by maintaining the water-cycling functions of the forest. Because about 30% of the rainfall in Amazonia, on average, is water that has been recycled through the forest, and this percentage is substantially higher during the critically important dry season, keeping substantial blocks of forest in reserves maintains the climatic conditions needed to maintain forest in the remainder of the region. Predominant winds in Amazonia blow from east to west, meaning that forests lying to the west of reserves are the ones that benefit from the evapotranspiration of the trees in the reserve. Reserves in eastern Amazonia would have the greatest benefit for maintaining rainfall within the Amazon region, while reserves in western Amazonia would have the most direct benefit in maintaining water-vapor transport to São Paulo and other parts of south-central Brazil (Fearnside, 2004).

The global-warming mitigation value attributed to the deforestation that is averted by reserve creation is heavily dependent on decisions regarding the value of time. Time can be given value in various ways in carbon calculations: by applying to carbon either a discount rate or some alternative time-preference formulation, by setting a time horizon for the calculation, or both. I have argued that the value attributed to reserve creation will depend on whether the reserves are created near the deforestation frontier, where reserves that can be created are smaller and their cost higher but their benefit is almost immediate. If reserves are created far from the frontier, they are large and inexpensive but their carbon benefit will only occur at a future date when the deforestation frontier reaches the area. Tradeoffs therefore exist between reserve proposals in different locations, and between reserve creation and other types of mitigation measures, including avoided deforestation through command-and-control operations, tree planting and reduction of fossil-fuel emissions.

A quantitative example is given in Fearnside *et al.* (2000, pp. 262-264) comparing the carbon benefits of reserve creation with those of slowing the overall deforestation rate, as through enforcement of deforestation regulations with inspection and fines. The discount rate is the critical factor in determining which strategy is most beneficial in combating global warming. At a discount rate of 1%/year, a 50% reduction in deforestation has the same value as converting 5% of the forest area into a protected area, whereas the area that must be converted to a protected area would have to be 22% of the forest to have this effect if the discount rate were 5%/year. The long-term nature of carbon-stock protection afforded by protected areas gives them a strong advantage when the long term is given priority. Reserves have permanence that command and control restraints on deforestation lack, giving them additional value in avoiding climate change (Dutschke, 2007).

This author has argued that some value should be attached to time. While proposals for the appropriate discount rate vary from 0% to market rates of around 12% per annum, a modest value (on the order of 1%/year), or its equivalent through alternative accounting mechanisms, would avoid distortions that militate against forests and against other societal interests at either the high or the low end of the range of possible discounts (Fearnside, 2002a,b). If no value is given to time, future climate change, including glacial cycles that may be millennia in the future, eliminate any value of maintaining forest as a mitigation option. If the future is discounted very sharply, then the benefit of a reserve is also eliminated because the benefit would accrue after the value of the carbon has been discounted to a value near zero. Time preference represents an important difference between carbon and biodiversity considerations, and can result in different strategies being identified as priorities (Fearnside, 1995). A theoretical battle over the value attached to time in carbon calculations is critical to any valuation of forest maintenance as a global-warming mitigation measure (Kirschbaum, 2006; Fearnside, 2008).

The above discussion implies carbon accounting based on "additionality," or emissions reductions relative to a hypothetical (counterfactual) baseline representing what would have been emitted in a reference scenario without creation of the reserve in question. This is the basis of accounting under the Kyoto Protocol's Clean Development Mechanism (UNFCCC, 1997, Article 12). Prior to the December 1997 Kyoto Protocol, this author proposed compensating environmental services of Amazonian forest based on stock maintenance , that is, with payments as an annual percentage of the stock value similar to the interest that is earned on a savings account in a bank (Fearnside, 1997). This form of accounting has recently re-emerged in discussion of the "Amazonas Initiative" proposed by the Amazonas state government. State governments in Brazil becoming are important actors in driving both diplomatic and technical advances towards making the environmental services of Amazonian forests into a force for environmental protection. These efforts complement federal initiatives such as that of the Ministry of the Environment's ARPA program. All of



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these initiatives require improvements in the knowledge base and in the human and physical resources needed for evaluating carbon stocks and properly accounting for and rewarding their maintenance.

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