Harnessing Carbon Payments to Protect Biodiversity

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The rapid destruction of tropical forests produces ~20% of anthropogenic carbon emissions and poses one of the greatest perils to global biodiversity (*1*). A highly anticipated carbon-payment mechanism termed REDD (reduced emissions from deforestation and degradation) is increasing incentives to protect threatened forests (*2*). REDD funding could soon dwarf all other spending for tropical conservation (*3*).

Although designed to limit harmful climate change, REDD could provide additional benefits, such as the conservation of biodiversity. Yet without specific provisions for biodiversity, REDD is likely to protect forests that are most cost-effective for reducing carbon emissions (*3*). Here, we critically assess how well such forests protect biodiversity.

We modeled business-as-usual deforestation for the decade from 2006 to 2015 for 68 developing countries (http://unfccc.int) that suffered net forest loss between 1990 and 2005 (table S1). We used a decision-theory framework (*4*) to optimally schedule the allocation of REDD funds to protect forests from deforestation. Our modeling incorporated data on forest extent and carbon content, current protected areas, business-as-usual deforestation rates, deforestation ceilings, and agricultural opportunity costs (table S1) (*5*). Two funding scenarios were explored, effecting 20 and 40% reductions in business-as-usual deforestation rates. We quantified the return on investment for biodiversity from protecting forests by using the species-area relationship with data on the number of country-endemic, forest-dwelling mammal, bird, and amphibian species in each country (table S2) (*5*).

Our analyses suggest deforestation in developing countries could release 9.0 billion tons of carbon into the atmosphere over 10 years. If expected deforestation could be reduced by 20%, funding for cost-effective REDD would be expended in just eight countries (Fig. 1A and table S3). Funds would go almost entirely to South America, primarily Brazil (74%), where agricultural opportunity costs are relatively low. No funds would be allotted to Asia, which has sizeable revenues from oil palm, rubber, rice, and maize that increase the opportunity costs of REDD (table S1). This funding pattern appears robust to model and parameter uncertainty (*5*), although countries such as Indonesia could conceivably receive increased funding if we accounted for emissions from peat degradation (*6*). Reducing deforestation by 40% distributes funds across 20 countries, but most are still concentrated in South America (fig. S1A and table S3).

Importantly, if REDD focuses solely on cost-effectively reducing carbon emissions, its benefits for biodiversity are low, protecting only slightly more vertebrate species than if funds were allocated at random among forest-losing countries (Fig. 1A and fig. S1A). However, if the same REDD funds were targeted to protect biodiversity, almost four times the number of species would be protected (Fig. 1B and fig. S1B). In this case spending would tend to shift toward Southeast Asian and Indian Ocean nations. This is because species extinctions are most effectively minimized by protecting biodiversity "hot spots"—areas with high species richness and endemism and relatively little remaining forest (*7*)—such as the Philippines, Madagascar, and Indonesia.

There is a trade-off between protecting biodiversity and reducing emissions, but that trade-off is highly nonlinear (fig. S2). This means that, through careful targeting of REDD funds, allocation solutions can be found that come close to maximizing both objectives simultaneously. We discover that the biodiversity benefits of REDD can be doubled while incurring just a 4 to 8% reduction in carbon benefits, depending on the amount of REDD funds expended (fig. S2). Our compromise scheme is broadly similar to that which maximizes emissions reductions but diverts some funding to nations that are jointly valuable for carbon and biodiversity (Fig. 1C and fig. S1C).

Our approach sharply increased the biodiversity benefits of REDD by explicitly incorporating biodiversity values into carbon payments (*5*). A timely opportunity exists to include such provisions within REDD schemes being negotiated under the United Nations Framework Convention on Climate Change. Additionally, private conservation groups could promote biodiversity by using some of their budgets to subsidize REDD programs in high-biodiversity countries, making them more cost-competitive for REDD funding. Lastly, some purchasers of REDD carbon credits, such as certain corporations or nations, might pay a premium to save imperiled ecosystems or areas with high-profile species.

Modest adjustments in REDD strategies could dramatically improve their capacity to conserve imperiled biodiversity. Without such a targeted approach, the biodiversity benefits of REDD will be far more limited than is otherwise possible.

References and Notes

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Supporting Online Material
www.sciencemag.org/cgi/content/full/326/5958/1368/DC1
Materials and Methods
Figs. S1 and S2
Tables S1 to S4
References

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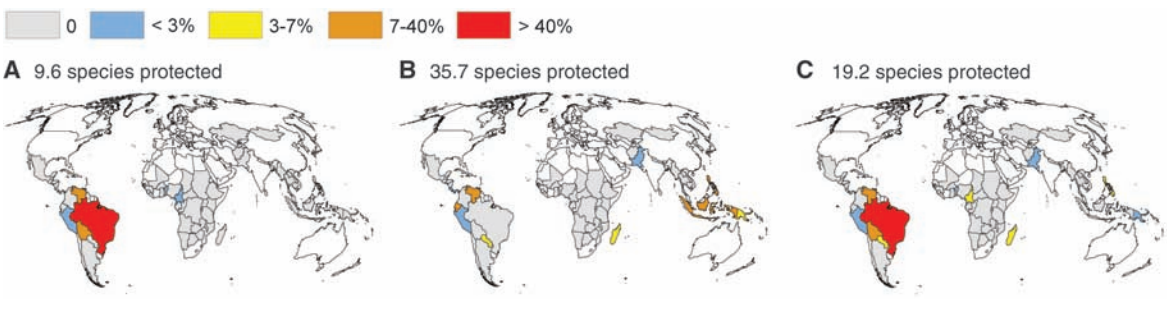

Fig. 1. Proportions of REDD funds allocated to forest-losing countries to (**A**) minimize carbon emissions, (**B**) minimize loss of forest vertebrates, and (**C**) minimize carbon emissions while simultaneously doubling benefits to biodiversity. These three scenarios would reduce deforestation by up to 20%. Shown above each map is the expected number of averted forest mammal, bird, and amphibian extinctions (a random allocation of funds protects 8.4 species on average). Countries in white are not losing net forest cover and so are excluded from the analysis.