

Tradeoffs between income, biodiversity, and ecosystem functioning during tropical rainforest conversion and agroforestry intensification

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Abstract

Losses of biodiversity and ecosystem functioning due to rainforest destruction and agricultural intensification are prime concerns for science and society alike. Potentially, ecosystems show nonlinear responses to land-use intensification that would open management options with limited ecological losses but satisfying economic gains. However, multidisciplinary studies to quantify ecological losses and socioeconomic tradeoffs under different management options are rare. Here, we evaluate opposing land use strategies in cacao agroforestry in Sulawesi, Indonesia, by using data on species richness of nine plant and animal taxa, six related ecosystem functions, and on socioeconomic drivers of agroforestry expansion. Expansion of cacao cultivation by 230% in the last two decades was triggered not only by economic market mechanisms, but also by rarely considered cultural factors. Transformation from near-primary forest to agroforestry had little effect on overall species richness, but reduced plant biomass and carbon storage by $\approx 75\%$ and species richness of forest-using species by $\approx 60\%$. In contrast, increased land use intensity in cacao agroforestry, coupled with a reduction in shade tree cover from 80% to 40%, caused only minor quantitative changes in biodiversity and maintained high levels of ecosystem functioning while doubling farmers' net income. However, unshaded systems further increased income by $\approx 40\%$, implying that current economic incentives and cultural preferences for new intensification practices put shaded systems at risk. We conclude that low-shade agroforestry provides the best available compromise between economic forces and ecological needs. Certification schemes for shade-grown crops may provide a market-based mechanism to slow down current intensification trends.