MINI-REVIEW

Cacao boom and bust: sustainability of agroforests and opportunities for biodiversity conservation

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Abstract

Cacao cultivation holds a sweet promise, not only for chocolate consumers and cacao farmers but also for conservationists who argue that diverse cacao agroforests may be used to sustain both livelihoods of smallholders and ecological benefits such as the conservation of biodiversity within human-dominated tropical landscapes. However, regional boom-and-bust cycles are the rule in global cacao production: after initial forest conversion to cacao agroforests, sustaining production is difficult due to dwindling yields as trees age and pest and disease pressure increases. The failure to revitalize plantations often leads to a shift of cacao production to other regions. Shade removal dynamics within these cycles substantially reduce most of the biodiversity benefits. We investigate the conservation implications of these processes. Using examples from the current cacao crisis in Indonesia, we show that until now commitments to sustainability by the cacao-chocolate sector have not been successful, which endangers remaining forests. Conservation can be combined with smallholder cacao production, but if this is to be achieved, greater quantitative and qualitative efforts to halt cacao cycles are needed on the part of the industry by making use of existing opportunities to combine sustainability, carbon storage, and biodiversity conservation.

Introduction

The protection of pristine areas will not be sufficient to halt the biodiversity crisis in the tropics (Bawa *et al.* 2004). This has spurred interest in forms of agriculture that can both contribute to livelihoods of people and help offset the impact humans exert on the ecosystem outside of strictly protected areas. Few have received more attention than agroforestry systems (Schroth *et al.* 2004). The most common agroforestry crops, coffee and cacao, cover 17.7 million ha in the tropics (in 2007, FAOSTAT 2009), account for the largest legal international trade volume beside petroleum (Donald 2004), and can be grown in conditions that more closely mimic natural forest than other cropping systems (Schroth & Harvey 2007). Recent reviews of the growing literature on biodiversity in agroforests highlight a great potential for conservation. Biodiversity benefits are conditional on adequate management, as modern, intensified plantations deliver few advantages in terms of conservation when compared to traditional, shaded cultivation (Bhagwat *et al.* 2008). Bird-friendly® coffee certification in Latin America (Philpott *et al.* 2007; Smithsonian Migratory Bird Center 2009), in which a premium is paid on coffee originating from plantations that comply with a set of rules geared to enforce the maintenance of a diverse vegetation structure, is an often-cited example on how effectively to combine agricultural production, the support of human livelihoods and nature conservation. This label receives much attention not so much for its market share (which covers just around 5% of the American certified coffee market, Smithsonian Migratory Bird Center 2009) but for the scientific base of its recommendations. In general, certified coffee, partly from certification schemes incorporating some shade-related guidelines, now covers a small but steadily increasing market share, estimated to be around 4% of the world exports (Giovannucci *et al.* 2008). Emulating these success stories in other important agroforestry crops such as cacao (e.g., Cassano *et al.* 2009) is tempting, especially since organic and/or fair-trade premium chocolate is increasingly popular with western consumers, with excellent prospects in terms of market growth (Doherty & Tranchell 2005; Monotti 2008).

The cacao tree *Theobroma cacao* L. is an understory forest species which evolved in the Amazon (Motamayor *et al.* 2008), but is currently grown by smallholders, i.e., small farmers relying mainly by family labor, in many countries of the humid tropics. It is the main cash crop of several West African countries as well as parts of the Indonesian archipelago, especially the island of Sulawesi, where the largest expansion of the past 20 years has taken place. Cocoa beans are exported primarily to Europe and North America to be processed to produce cocoa and chocolate. Cacao trees can be established under thinned forest or under planted shade, but most new cacao plantations are planted into thinned forest (see also Ruf 1995; Ruf & Zadi 1998; Rice & Greenberg 2000; Gockowski & Sonwa 2008; Sonwa & Weise 2008). Shaded cacao can be species-rich, much more so than unshaded cacao or other forms of agricultural land use, even though species composition may differ considerably between shaded cacao and forest as was shown for beetles by Bos *et al.* (2007). Loss of shade trees and reduction of shade tree species richness can reduce the species richness of birds in cacao (Clough *et al.* 2009).

While the integration of farm or household-scale agroeconomical issues with ecological studies are starting to appear (Dahlquist *et al.* 2007; Franzen & Mulder 2007; Steffan-Dewenter *et al.* 2007), there are comparatively few studies integrating the often volatile global economical patterns into the "agroforestry and conservation" discussion. Instability in world prices and fluctuation in the area under cultivation characterize many cash crops, but even by that standard the history of cacao stands out due to the high number of rises and downfalls of geographical centers of production (Clarence-Smith 1996), patterns appropriately termed "cacao boom-and-bust cycles" by Ruf (1995). The danger of these cycles for tropical forests has been highlighted by Rice & Greenberg (2000) and Ruf & Schroth (2004). Here, we review how these cycles function and explore the consequences for land use in current "cacao frontier" regions and the potential of cacao cultivation for biological conservation, drawing largely from our own experience with the ongoing cacao production slump in Sulawesi, Indonesia.

Cacao booms and deforestation

The map of cocoa-producing areas is reminiscent of the map of the world's tropical biodiversity hotspots (Figure 1). This is not a coincidence—cacao not only requires tropical climates to thrive but also plantation establishment is easiest and cheapest within one of the most threatened habitats: tropical forest. Young cacao plants need shade to avoid severe physiological stress arising from direct exposure to the sun, fertile soils, and a protection from competing weeds. Accordingly, the majority of new cacao plantations (around 50% in Sulawesi, Rice & Greenberg 2000) are planted into thinned forest, where shade, fertile soils, and a low weed pressure occur (Ruf & Zadi 1998). Other methods, such as planting beneath planted shade are technically available but much more costly (Wood & Lass 2001; Petithuguenin *et al.* 2004). This is especially true for smallholders who contribute the largest share of the world's cocoa production (90% both in Sulawesi and worldwide, Panlibuton & Meyer 2004). Thus initially, the integration of production in a forest-like environment enables both the maintenance of biodiversity far above that of other agricultural land uses and the improvement of rural livelihoods (Rice & Greenberg

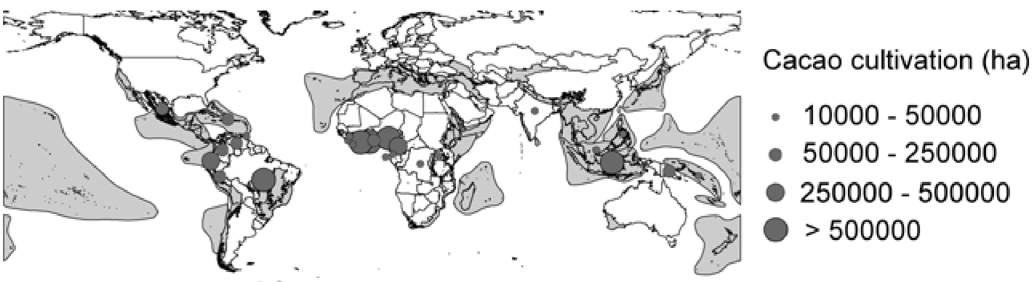

Figure 1 World map of biodiversity hotspots (Conservation International 2005; The Guinean Forests of West Africa hotspot is obscured) with area of cacao production per country (production data 2007, FAOSTAT 2009); Biodiversity hotspots are shaded in light grey.

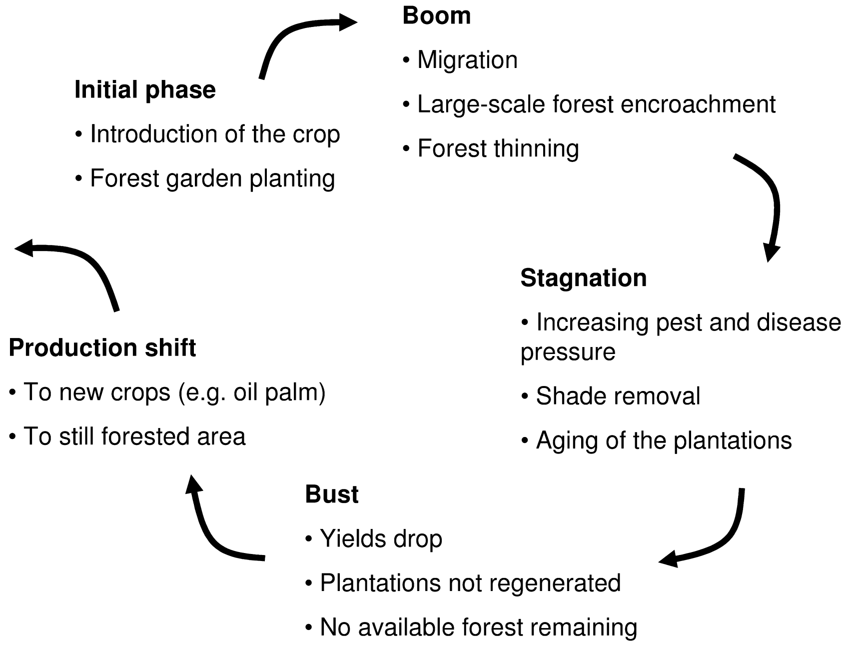

Figure 2 Model of the cacao boom-and-bust cycle; the duration of the cacao cycle may be as short as 20–25 years.

2000), but often at the expense of forested areas including natural forest, secondary forests, and diverse agroforests (e.g., of shaded coffee). As the first harvests are sold, the success of the first farmers leads to adoption by neighboring farmers (Ruf & Yoddang 2004) and finally to migration into the "cacao pioneer front," which is typical for the Sulawesi cacao boom (Weber *et al.* 2007) and for other cacao-producing regions such as West Africa (Gockowski & Sonwa 2008). The increase in area under cacao cultivation is accomplished at the cost of conversion of natural forest to agroforests, either by migrants or by changes in land tenure due to the influx of migrants (Weber *et al.* 2007) (Figure 2). Cacao booms are often initiated by farmers without government incentives as shown by the recent boom in Sulawesi which has taken place largely in a context of "hands-off policy" on behalf of government agencies (Akiyama & Nishio 1996). Expansion of cacao has thus caused widespread encroachment into several biodiversity hotspots (Myers *et al.* 2000) such as the West African Guinea Forest (for the last 50–100 years), Sabah and Sarawak (30 years ago), and finally Sulawesi (for the past 20 years).

Shade tree removal for higher yields

As the cacao trees mature several processes lead to a major change in the agroforestry systems. First, the cacao trees form a closed canopy and are less dependent on the shade trees, which can then be removed without immediate deleterious effects. Yield increases with shade removal in the short-term: agronomists at the West Africa Cocoa Research Institute reported large increases in yield when shade was removed in a large trial in Ghana (Cunningham & Lamb 1958). Several other studies supported these results (see Johns 1999). Planters were thus advised to intensify by combining shade removal and fertilization. This was despite later reports from the WACRI experiment in Ghana showing that the unshaded plantations suffered from an increase in attack by pests and tree death rate, thus severely questioning the initial recommendations to remove shade in mature plantations (Vernon 1967). The dangers of full-sun cultivation had been reported before (Johns 1999), but researchers might have wrongly assumed that pests could be appropriately controlled with pesticides which had by then become available. Indeed, reduced shade not only increases yields but also physiological stress, the susceptibility to certain pests and diseases and consequently, the amounts of inputs required (especially fertilizer and insecticides) (Vernon 1967). In the light of this experience, the no-shade strategy was finally considered unviable, at least for smallholder farmers (Wood & Lass 2001). While it is difficult to get reliable country-wide data for cacao shade cover, it appears that despite these insights, a large part of the cacao is grown under full-sun or light shade conditions, representing up to 70% of cacao cultivated in Sulawesi and Ghana (Juhrbandt *et al.* unpublished results; Gockowski & Sonwa 2008). Moreover, in Sulawesi there is a trend toward accelerated shade removal (Belsky & Siebert 2003; Steffan-Dewenter *et al.* 2007; Juhrbandt *et al.* unpublished results).

Cacao is subject to region-specific pest and disease problems in all areas of the world in which it has been introduced (see Flood *et al.* 2004 for an overview). The oomycete *Phytophthora* species causing black pod disease, the cacao pod borer *Conopomorpha cramerella* (Snellen), and numerous species of mirids (Heteroptera: Miridae), some of which transmit viral diseases, are but some examples of the pool of species causing damage through herbivory or disease. More importantly, cacao does not escape the species–area relationship: the larger the area cultivated with cacao, the larger the number of species that feed on the crop (Strong 1974). As cacao cultivation becomes established in a region, adaptation, spread, or importation of pest or disease agents (e.g., cacao pod borer, Ruf 1995), possibly exacerbated by the high percentage of cacao cover in the landscape, results in lower relative yields and a higher incentive to use insecticides and fungicides in the established cacao plantations.

In addition to the idea that no shade is good for productivity *per se*, farmers sometimes perceive that shade is responsible for the phytosanitary problems by increasing the humidity and thus susceptibility to disease infection, and that shade trees act as a source for pests and diseases (Y. Clough, unpublished data). Thus the remaining shade trees are often poisoned or cut down. Observations in Sulawesi have shown that the attractiveness of full-sun cacao, and the hope of maintaining high cash-crop returns, might even drive the farmer to poison otherwise productive fruit trees (langsat *Lansium domesticum* Correa, candle nut *Aleurites moluccana* (l.) Willd; Y. Clough, unpublished data). A review by Schroth *et al.* (2000) showed that response to shade of cacao pests and diseases depends on the species. However, a major disease in Southeast Asia is *Phytophthora palmivora* Butler, for which losses correlate positively with overall shade (Schroth *et al.* 2000). Plantation microclimate, determined by cacao self-shading and shade tree cover, can be managed to avoid high humidity by controlling the cacao canopy through pruning, but many farmers are reluctant to conduct heavy pruning. In addition, initial mismanagement such as inappropriate planting distance and insufficient pruning in the first few years is widespread among the unexperienced frontier cacao farmers and makes corrective management extremely difficult if not impossible.

In such a context, cacao management intensification by shade removal is generally associated with higher short-term yields. Thus, while shaded agroforests can play an important role in combining high species richness and agricultural productivity (Steffan-Dewenter *et al.* 2007), partly offsetting the loss of secondary and primary forest, this compensation is endangered by the attractiveness of high returns under full-sun cacao, with deleterious long-term effects on cacao sustainability unlikely to play a role in "frontier" regions where experience with cacao is limited.

Cacao bust: the frontier moves on

The ecological instability of unshaded or low-shade plantations and the increasing crop losses to pests and diseases collide with a generational change in the farming community—the returns on cacao plummet just as the next generation of farmers is ready to open plantations of their own (Ruf 1995). Cutting back the old, unproductive plantations, and replanting—with resistant varieties if available—is costly and knowledge intensive (Petithuguenin 1995). In Central Sulawesi, Indonesia, less than 6% of smallholder farmers mention large-scale replanting as an option, possibly due to the lack of resources and experience in mastering such a transition (J. Juhrbandt, unpublished data). The consequence at this stage has often been abandonment of cacao, with a shift to a new potential (forested) production area, as has been seen repeatedly in West Africa for the better part of last century (Léonard & Oswald 1995). Cacao producers may shift to an entirely new crop, as was the case in Malaysia, where large estate plantations lived through the transition of shade to full-sun, and then when riddled by the cacao pod borer and increasing labor costs, were converted to oil palm plantations (Basri Wahid *et al.* 2006).

Fluctuations in world price might also play a role in the abandonment of cacao, especially for large plantations, but they are generally not the main cause of cacao cycles (Ruf 1995). Smallholders, such as those currently producing much of the Indonesian cacao, are better able to cope with slumps in world price than plantation estate owners and managers (Ruf *et al.* 1995), yet the current phytosanitary problems (in Indonesia: cacao pod borer *Conopomorpha cramerella* (Snellen), black pod disease *P. palmivora*, and vascular streak dieback *Oncobasidium theobromae* Talbot & Keane) are currently endangering the whole sector (Panlibuton & Meyer 2004). It might seem surprising that the Indonesian cacao sector did not learn from the Malaysian experience, and is currently struggling with similar problems. This is largely due to the "grass-roots" nature of the cacao boom and the lack of training and experience of the "frontier" farmers. Government cacao-related research and extension did not keep pace with the increase in cacao production (Panlibuton & Meyer 2004), and the main source of information for a farmer has been shown to be neighboring farmers, with little influence of official sources or NGOs (Abbate 2007).

The implications for conservation of boom-and-bust cycles are twofold. During each cacao boom, large tracts

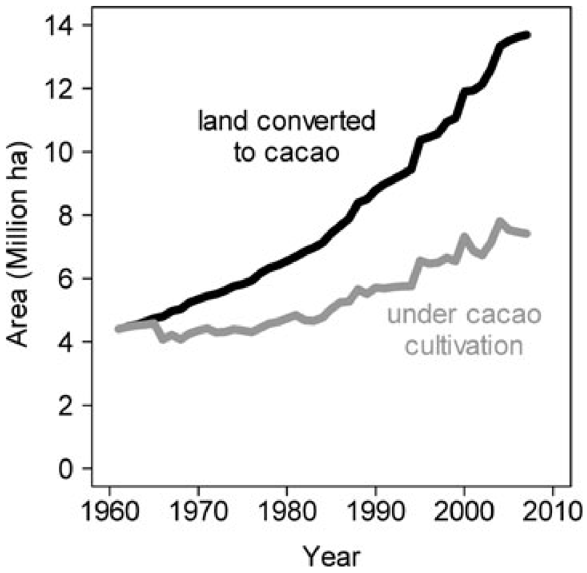

Figure 3 Shifts in cacao-producing regions within and between countries suggest a much larger conversion of (mostly forested) land for cacao than appears from the net increase in area under production (FAOSTAT 2009).

of forest are converted to agroforestry systems. These habitats are then converted to cacao monocultures about 15 to 20 years after establishment, by which time the attractiveness of this land use for wildlife is substantially diminished (e.g., Steffan-Dewenter *et al.* 2007). Case studies show that as the cacao boom turns into cacao bust, shifting to new crops means the establishment of intensive single-strata agricultural land-use forms such as full-sun coffee in Brazil (Hardner 1999) and oil palm in Malaysia (Basri Wahid *et al.* 2006). As other pioneer fronts are opened to meet the demands of the cocoa sector, more forested land is subjected to this cycle either within the region or in another country or continent. FAOSTAT data (starting 1961) show that the area cultivated worldwide with cacao has increased by 3 million ha (from 4.4 to 7.4 ha) in the last 50 years. If we assume replanting to be marginal, the turnover due to shifts in producing countries (e.g., simultaneous decrease in country A due to crop switching paralleled by an increase in cultivation area in country B) represents an additional 6.3 million ha (Figure 3). Turnover also occurs within countries, and existing case studies from Ivory Coast (Léonard & Oswald 1995) and Nigeria (Oduwole 1995) suggest that this is common, at least in western Africa, but within-country data are difficult to obtain. Because within-country production shifts are not instantaneous, with time lags between busts and new booms, these are partly covered by the between-year turnover at the national level calculated above. Given that most of these 6.3 million ha have been converted to cacao from secondary or even near-primary forest, these data support both the reality of cacao cycles and hints at the exploitational character of the cocoa-chocolate sector in terms of natural resources. The fact that in certain areas cocoa production has been going on for over a 100 years, such as in the traditional *cabruca* cacao agroforests of Brazil (Johns 1999) where native species richness remains high (Cassano *et al.* 2009), should not obscure the large impact of moving cacao pioneer fronts, especially in less traditional growing areas such as Southeast Asia.

Initiatives for sustainability: opportunities for biodiversity conservation

In Indonesia, the current slump in production (Figure 4) due to cacao tree aging and increased losses to pests and diseases has raised the specter of large-scale cacao abandonment (Panlibuton & Meyer 2004). This has prompted the Government of Indonesia to initiate a rehabilitation of the sector by replanting 450,000 ha with varieties resistant to pests and diseases: the national aim is to boost national cocoa bean production to 1 million tons per year by 2013 (Antara 2008). This is an important development especially since the government has never previously intervened in the cacao sector. Given the buffering effect of decentralization on national policies and the scarcity of knowledge diffusion pathways in many cacao-growing

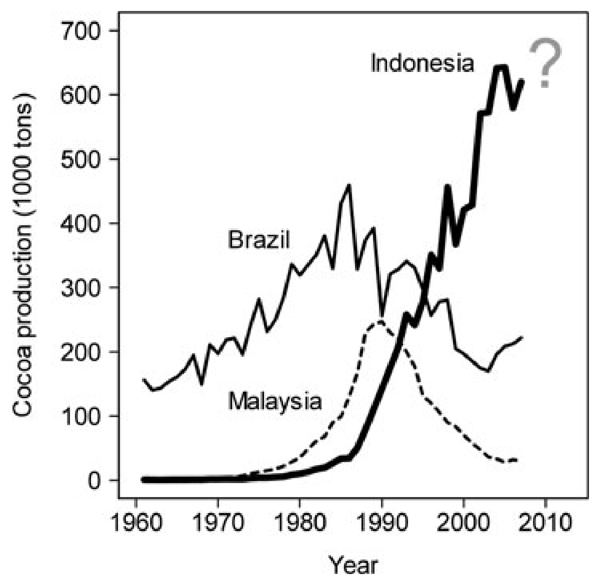

Figure 4 Exponential growth and stagnation of cocoa production in Indonesia against the boom and bust cycles in Brazil and Malaysia: will Indonesia witness the next cacao bust? (FAOSTAT 2009).

regions, it is uncertain how successful this program will be.

Cacao busts are also a problem for the cocoa processors. Indeed, a sustainable cocoa production would deliver a more stable, predictable crop, both in quantity and quality, which is exactly what the industry needs (Lass 2004). Several regional industry–research–farmer partnerships are trying to tackle cacao sustainability. Neilson (2007) describes initiatives to halt the cacao pod borer on Sulawesi, Indonesia, funded by both U.S. development agencies and the American private sector, and highlight that these programs represent a new form of involvement of the industry down to the bottom of the supply chain (see also Shapiro & Rosenquist 2004). While such initiatives have been successful in improving management locally, less than 10% of the 400,000 smallholders have been reached (Panlibuton & Meyer 2004). In addition, halting cacao cycles may require involvement before the problems occur, ideally in the early stages of cacao booms to prevent initial mismanagement.

Even if sustainability can be achieved, how agroforests can be used for biodiversity conservation will depend on whether biodiversity-friendly management strategies, and especially the maintenance of a diverse shade tree cover, will have a place in a modern, sustainable cocoa production. This is by no means certain given that shade removal is attractive because it enables short-term production increases. The role of shade is also ambiguous in other respects (Beer *et al.* 1998). Appropriate degree of shading, or the degree of shading tolerated by farmers, depends on soil, climate and the predominant pest and disease problems as well as choices related to farm economics (Beer *et al.* 1998; Johns 1999), making broadly applicable shade recommendations difficult. Clearly, more long-term studies on the optimal management of shade are needed across smallholder cacao growing regions.

A multi-stakeholder conference on sustainable cacao that took place in Panama in 1998 ended in a Consensus Statement that the industry would try to foster sustainable practices, defined in several points including "[being] *based on cocoa grown under a diverse shade canopy in a manner that sustains as much biological diversity as is consistent with economically viable yields of cocoa and other products for farmers"* (Smithsonian Institution 1998). However, almost 10 years later, in a report of activities aimed at supporting sustainability in cacao (WCF 2007), only the Sustainable Tree Crop Programme (STCP), a multi-stakeholder program focusing on West Africa, explicitly addresses shade tree cover diversification in its training programs conducted in cooperation with Rainforest Alliance, with the aim to reach certification of shaded cacao (Gilmour 2004). Overall, this suggests that the cacao sector is far from having reacted appropriately to its ecological commitments on a broad enough scale.

Further opportunities to increase the attractiveness of maintaining shade trees on a large scale may lie in ecosystem services related to shade. For example, agroforests have been recognized as an option to sequester carbon (Verchot *et al.* 2007; Nair *et al.* 2009). The potential of shaded cacao for carbon storage, and especially the differential sequestration between shaded and unshaded cacao has received little attention, and it is questionable whether the certification of shaded cacao in the framework of Clean Development Mechanism (CDM) projects is feasible given the current bureaucratic hurdles (Basu 2009). However, new opportunities are arising, for example, through the implementation of the Reducing Emissions from Deforestation and Degradation concept (REDD; Miles & Kapos 2008). Planting shade trees, or even reforesting nonforested land with cacao agroforests (Ruf & Zadi 1998) yields benefits in term of carbon storage, that, if remunerated through carbon payments and actively promoted by the cacao industry, could be widely adopted and spin-off benefits in terms of cacao sustainability and biodiversity conservation (Stigter & Abdoellah 2008).

A diverse shade tree cover may deliver ecosystem services benefiting yield and yield stability, such as climatic buffering, the provision of habitat for beneficial organisms (e.g., insectivorous birds, Clough *et al.* 2009). There are indications of this in the ecological literature, but more research is needed to reach the sound scientific basis needed to put forward and demonstrate these arguments to the cacao industry and farming community.

Conclusions

The long-term viability of cacao cultivation in many producing regions, including countries that were experiencing a cacao boom only 10 years ago, is endangered by increases in pest and disease pressure as the area planted with cacao and the age of the plantations increase, which, in conjunction with socioeconomic factors, increases the likelihood of abandonment of cacao and crop switching. The shifting of cacao production fronts is undeniably the largest environmental problem associated with the cacao sector as this adds pressure on dwindling forest resources. This has rightly led to strong skepticism about the value of integrating such commodity production systems into conservation projects (Niesten *et al.* 2004). A new cacao crisis is currently affecting Indonesia, and it still is uncertain whether current efforts to revitalize the cacao production after the current production slump will be successful. The "grass-roots" nature of cacao booms make predictions difficult, but a failure to sustain production in current cacao-growing areas Sulawesi likely means a shift to the forest margins of other parts of the country—the secretary-general of the Indonesian cacao producers' association (ASKINDO) was quoted as saying that he expects "cocoa production from new growing areas, such as West Sumatra and Papua, to cover any further declines from Sulawesi in 2009" (Reuters 14/1/2009).

Paying cacao farmers to keep, plant, and diversify their shade trees, through premium producer prices and, in future, remuneration for carbon storage in shaded agroforests, constitutes an interesting solution for a part of the growing area, and as such cacao agroforestry can be viewed as a tool for conservation. However, cacao consumption will remain exploitative in terms of forest resources unless cacao cycles are halted. Ten years ago, appeals to tackle this issue through multi-stakeholder, interdisciplinary approaches (Smithsonian Institution 1998; Rice & Greenberg 2000) led to commitments by the industry and to several private–public partnerships aimed at fostering cacao sustainability, with only limited success. Involvement of the industry needs to be expanded to the appropriate scale, i.e., reaching hundreds of thousands of smallholders, which will need traceable commitments and, most of all, implementation in a timely enough manner to enable cacao-growing regions to reach sustainability before problems become irreversible. An important focus should be on ideas such as reforestation with cacao agroforests to access carbon payments that represent opportunities to combine several goals such as sustainability, carbon storage, and biodiversity conservation.

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