
Wild coffee management and plant diversity in the montane rainforest of southwestern Ethiopia

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Abstract

Coffea arabica occurs naturally in the montane rainforests of Ethiopia, but large areas of these unique forests have been converted to other land-uses. In the remaining forest, wild coffee is managed and harvested with increasing intensity because of rising coffee prices in the world market. This study evaluated the impact of coffee management on wild coffee populations and the forest vegetation as a basis for conservation planning in southwestern Ethiopia. Vegetation surveys and yield assessments were carried out in unmanaged natural forest and in managed semi-forest coffee (SFC) systems. Analyses show that wild coffee density and coffee yields were low in natural forest (max. 15 kg ha⁻¹ year⁻¹). In SFC systems, 30% of the canopy trees and most undergrowth vegetation were removed. This stimulated wild coffee growth and strongly enhanced yields (max. 54 kg ha⁻¹ year⁻¹), but severely disturbed forest structure. Species richness increased by 26% because of an increase in species of ruderal and secondary vegetation; however, species richness and abundance of typical forest species declined. Conservation of the natural forest therefore requires the control of wild coffee management. Wild coffee certification is discussed as one tool to reconcile conservation measures and the interests of local farmers.

Key words: certification, *Coffea arabica*, coffee yield, conservation, forest disturbance, ordination

Résumé

Coffea arabica pousse naturellement dans les forêts pluviales de montagne en Ethiopie, mais de grandes superficies de

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ces forêts uniques ont été transformées pour d'autres usages. Dans la forêt restante, le café sauvage est géré et récolté de façon de plus en plus intense en raison de l'augmentation du prix du café au niveau mondial. Cette étude a évalué l'impact de la gestion des populations sauvages de café, ainsi que la végétation forestière, afin d'établir une base pour la planification de la conservation dans le sud-ouest de l'Ethiopie. Des études de végétation et des évaluations des récoltes ont été réalisées dans une forêt naturelle non gérée et dans des systèmes semi forestiers où les caféiers sont gérés. Les analyses révèlent que la densité des caféiers sauvages et les récoltes de café sont faibles dans la forêt naturelle (max 15 kg ha⁻¹an⁻¹). Dans les systèmes semi forestiers, 30% des arbres de la canopée et la plus grande partie de la végétation en sous-bois ont été enlevés. Cela stimule la croissance des caféiers et augmente fortement les récoltes (max 54 kg ha⁻¹an⁻¹), mais cela perturbe gravement la structure forestière. La richesse en espèces a augmenté de 26% à cause de l'augmentation des espèces dans la végétation rudérale et secondaire; cependant, la richesse et l'abondance des espèces typiquement forestières ont décliné. La conservation de la forêt naturelle exige dès lors le contrôle de la gestion du café sauvage. On discute de la certification du café sauvage comme moyen de réconcilier les mesures de conservation et les intérêts des fermiers locaux.

Introduction

Arabica coffee (*Coffea arabica* L., Rubiaceae) has its centre of origin in southwestern and southeastern Ethiopia where it occurs naturally in the undergrowth of Afromontane rainforests between 1000 and 2000 m above sea level.

The gene pool of these wild coffee populations is of national and international importance, because it has high potential for the breeding of new coffee varieties (Meyer, 1965; Hein & Gatzweiler, 2006).

In the past three decades, however, large parts of the Ethiopian rainforests with wild coffee have been modified or destroyed by conversion to agricultural land, new settlements and timber extraction (Reusing, 2000). This ongoing destruction of the original habitat of *Coffea arabica* threatens not only the wild coffee populations, and thus coffee genetic diversity, but also endangers the exceptional floristic diversity of these forests. They are therefore recognized as part of the Eastern Afromontane Biodiversity Hotspot (Mittermeier *et al.*, 2004).

Indigenous communities have been utilizing wild coffee for centuries, and the art of brewing coffee is a central element of the Ethiopian culture. Furthermore, coffee is Ethiopia's most important export crop contributing 41% of the country's foreign currency income (FAO & WFP, 2006). Besides home-garden coffee and coffee plantations, almost 70% of the coffee production area in Ethiopia still consists of montane rainforest with wild coffee (Teketay, 1999).

The harvesting of wild coffee inside the forest is carried out at different use intensities; local farmers may simply pick wild coffee fruits while occasionally removing some of the undergrowth vegetation to facilitate coffee collection. The forest retains a virtually undisturbed vegetation structure and can be considered as natural or unmanaged forest. There are also more intensively managed forest parts where farmers systematically remove some of the shading canopy trees and undergrowth vegetation that competes with wild coffee. These forest areas have a disturbed forest structure and are known as semi-forest coffee (SFC) systems.

The rising coffee prices in the international market (International Coffee Organization, 2008) are a strong incentive for farmers to raise wild coffee yields by managing the coffee forests more intensively. In addition to the high land use pressure mentioned above, the expansion of SFC systems is likely to enhance the modification and loss of the natural rainforest vegetation in southwestern Ethiopia. This is also a danger in the study region, where <10% of the land cover can still be considered as natural forest (Schmitt, 2006).

This study therefore had the objective to assess the effects of wild coffee management on the forest vegetation and to quantify its benefits in terms of wild coffee yields. Specifically, it compared vegetation structure, floristic

diversity and wild coffee yields in natural forest and SFC systems in the Bonga region in southwestern Ethiopia. Based on the results, recommendations for the use and conservation of the wild coffee forests will be given with a particular focus on wild coffee certification.

Material and methods

Study area

The Bonga region forms part of the mountainous highlands west of the Great Rift Valley and is situated on undulating and dissected mountain ranges between 1500 and 2400 m around the town of Bonga (Kaffa zone, southwestern Ethiopia) (Fig. 1). The region has a warm tropical rainy climate; the rainfall is unimodal with low rainfall from November to February and the wettest months between May and September (Liljequist, 1986). Common soil types are nitisols, cambisols and regosols with soil acidity varying between pH (H₂O) 4.1 and 6.3.

The original Afromontane rainforest vegetation covers <10% of the study region, while almost half of the land cover is disturbed forest including SFC systems. In addition, the region is made up of agricultural fields, grassland and built-up areas. The main town Bonga has ca. 16,000 inhabitants but the largest part of the population lives in the countryside with population densities varying between 33 and 103 inhabitants per km² (CSA, 2002). Subsistence agriculture is the major occupation and coffee the most important cash crop (Asres, 1996; Urlich, 2005).

Vegetation survey

Preliminary field investigations at Bonga in March 2003 identified four forest fragments of 600–1700 ha where areas with natural forest vegetation were still present. They were covered by vegetation surveys between May 2003 and January 2005 using a total number of 85 study plots (20 × 20 m) laid out in natural forest (n = 62) and SFC systems (n = 23) (Fig. 1). Plots were located every 300 m along transects spaced up to 1 km apart depending on forest fragment size. This systematic sampling design was complemented by random sampling in SFC systems. At Kayakela, areas of natural forest and SFC systems had the same extent and were sampled with an equal number of study plots to allow for a direct comparison of these two forest types.

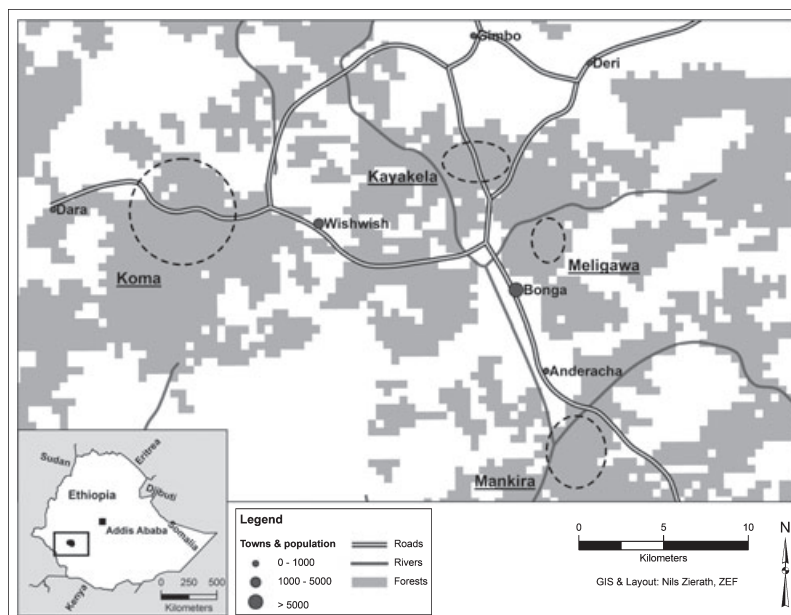


Fig 1 Location of the Bonga region in southwestern Ethiopia with the studied forest fragments Koma, Mankira, Kayakela and Meligawa

Vascular plant species were identified according to the Flora of Ethiopia and Eritrea, the Flora of Tropical East Africa, and according to reference specimen at the National Herbarium of Ethiopia in Addis Ababa and the Herbarium of the Royal Botanic Gardens, Kew (U.K.). Species of the herb layer and epiphytes that could be observed from the ground or had fallen down were recorded as presence–absence data. For woody plants and climbers, height was measured if height ≥ 0.5 m and diameter at breast height (dbh) if dbh ≥ 2 cm.

Percentage cover of herb layer (<0.5 m), shrub layer (0.5–5 m), lower canopy (5–15 m) and upper canopy (>15 m) were recorded for each study plot. The parameter ‘cover index (CI)’ was developed as indicator of forest disturbance: $CI_{\text{study plot}} = [\% \text{-cover (herb layer)} + \% \text{-cover (shrub layer)}]$. If CI of study plots was <105, herb and shrub layer were little developed because of deep shade under closed canopy, which was the case in undisturbed forest. CI larger than 105 indicated dense herb and shrub layers of disturbed forest with reduced canopy cover (Schmitt, 2006). In addition, ‘number of coppiced plants per plot’ was recorded as indicator of human management intensity.

Estimation of coffee yield

The number of fruits per coffee tree was counted or estimated in 35 study plots surveyed during the ripening period

of coffee (June–December). Estimates were made as follows: low yield = ca. 30 fruits per tree and high yield = ca. 200 fruits per tree. The number of fruits per plot was converted to clean coffee (cc) yield per hectare (kg cc ha^{-1}) taking 0.33 g as average weight for a clean berry.

Data analysis

Differences in coffee density and coffee yields between natural forest and SFC systems were tested with one-way ANOVA (SPSS 15.0 for Windows; SPSS Inc., Chicago, IL, USA). Species composition was analysed with ordination techniques using CANOCO, version 4.52 and CanoDraw, version 4.12 (Ter Braak & Šmilauer, 2002). Indirect (unconstrained) gradient analysis was employed to display study plots within the multidimensional ordination space based on similarities in species composition. In indirect analysis, the ordination axes are theoretical gradients and the environmental data are subsequently used to interpret the ordination. Initial tests with detrended correspondence analysis indicated linear rather than a unimodal response of the data. A linear model, i.e. principal component analysis, was therefore selected. Abundance data were log transformed to account for the large differences in species abundances. Ordination diagrams were most coherent if species data table was standardized by samples and centred by species.

Results

Wild coffee populations and wild coffee yield

Wild coffee density was generally low in natural forest with undisturbed vegetation structure and deeply shaded understory (Table 1). In the more inaccessible natural forest areas, farmers casually collected coffee fruits. In the less remote forest parts, they systematically harvested coffee and removed some of the competing undergrowth vegetation, but the overall management impact on the forest vegetation was low (CI <105). Similar to coffee density, coffee yields (cc kg ha⁻¹) were altogether small.

In contrast, SFC systems had disturbed forest structure (CI > 105) because farmers removed 30% of the canopy tree individuals and most of the undergrowth vegetation except for the coffee plants. The SFC systems were usually located close to villages or footpaths, and management interventions were carried out one to several times per year. The removal of shading and competing vegetation stimulated coffee growth. As a result, coffee density, abundance of big coffee trees as well as coffee yields (cc kg ha⁻¹) were much higher in SFC systems than in natural forest (Table 1). Some farmers enrich SFC systems by planting wild coffee seedlings (wildings) from the surrounding forest; however, the common practice of planting wildlings at unequal spacing made it impossible to distinguish spontaneously established coffee from transplanted coffee in the field. Only few farmers said that they had planted seedlings of improved coffee cultivars distributed by government extension workers and nongovernmental organizations.

Floristic diversity and vegetation structure

At Kayakela, plant species richness in natural forest and SFC systems could be compared directly because these forest types were studied with the same number of plots (Table 2). In SFC systems, total species richness increased by 26% because of a strong increase in species richness of the herb layer and climbers. This was mainly related to encroachment of ruderal species, e.g. the grass *Pseudochinolaena polystachya* (Kunth) Stapf and herbs from the Asteraceae, Malvaceae and Lamiaceae families. In contrast, characteristic forest species such as ferns disappeared.

The species richness of small tree species (plants with single trunk that reach maximum height of 15 m) was little affected by coffee management intensity (Table 2), but their individual numbers were much higher in SFC plots than in natural forest plots because of a strong increase in coffee abundance. For tree species (plants with single trunk that have the ability to grow larger than 15 m) species richness was similar in natural forest and in SFC systems, although Table 2 suggests a change in species composition. If only mature trees in the upper canopy (individuals taller than 15 m) were considered, individual number and species richness were reduced in SFC plots compared with natural forest.

The strong impact of SFC management on plant diversity as shown for Kayakela was further confirmed by the ordination of study plots from all forest fragments. SFC plots differed in species composition from natural forest plots because the majority assembled in the upper right quadrant of the ordination diagram (Fig. 2). Species arrows pointing into direction of the upper right quadrant indicate species

Table 1 Coffee populations and forest structure in natural forest and semi-forest coffee (SFC) systems; density = number of individuals per study plot

	Natural forest			SFC systems		
	Aver.	Min.	Max.	Aver.	Min.	Max.
Management intensity	Low			High		
Forest structure ^a	Undisturbed			Disturbed		
Planting of coffee seedlings	No			Possibly		
Density of coppiced plants ^b	5	0	28	20	2	90
Coffee density (height ≥0.5 cm) ^b	156	0	1098	740	68	1901
Density of big coffee trees (>1.5 m; dbh >3 cm) ^b	3	0	27	21	2	56
Clean coffee yields (kg ha ⁻¹ year ⁻¹) ^b	2	0	15	31	3	54

^aUndisturbed: cover index <105; disturbed: cover index ≥105 (see Materials and methods).

^bSignificant difference between natural forest and SFC systems at $P = 0.000$ (one-way ANOVA).

Table 2 Species richness and number of individuals in natural forest and semi-forest coffee (SFC) systems at Kayakela

Growth form (for definition see text)	Total species richness (22 plots)	Natural forest (11 plots)		SFC systems (11 plots)	
		Species richness	No. individuals	Species richness	No. individuals
Herb layer	59	27	Presence–absence data	55	Presence–absence data
Epiphytes	23	21		18	
Climbers	33	23	806	31	1497
Shrubs	15	11	715	14	788
Small trees	20	20	7545	19	21,683
Trees	38	33	558	33	573
Upper canopy	21	18	103	13	74

with high abundance in disturbed SFC plots ('SFC species'). In contrast, species with arrow heads pointing to the opposite direction were associated with undisturbed forest parts ('forest species').

'Semi-forest coffee species' can occur in natural forest and many 'forest species' persist in SFC plots, but there was a strong change in the abundance of these species in the respective forest types. Regarding trees, for example, eight 'SFC species' (Table 3) constituted 18% of all plant individuals in natural forest, but 34% of all individuals in SFC plots (Fig. 3). Besides, 'forest species'

experienced a strong change in species population structure in SFC plots as coffee management removed mature individuals and mainly saplings remained (height <5 m, dbh <2 cm).

Discussion

Impact of coffee management on wild coffee populations

Coffee is considered as wild as long as it grows and regenerates spontaneously in its natural habitat and is

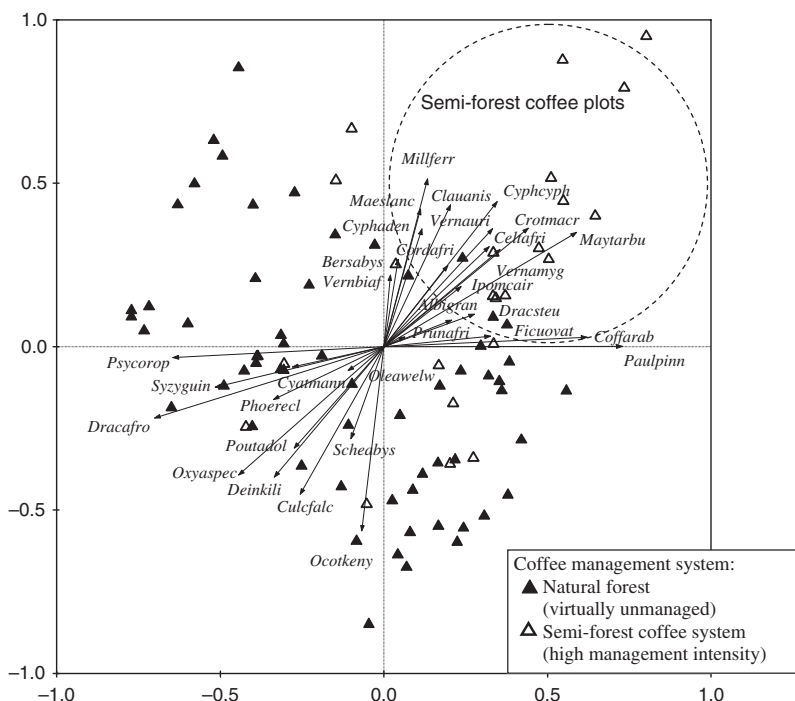


Fig 2 Ordination of study plots from all forest fragments according to abundance data of woody plants and climbers (principal component analysis, PCA); based on 136 species with more than one individual; selected species are shown; species are abbreviated with the first four letters of generic names followed by the first four letters of species names (full names in Table 3)

Table 3 Full names of species shown in Fig. 2

Species	Family	Growth form
'Forest species' (selection)		
<i>Culcasia falcifolia</i> Engl.	Araceae	Herbaceous climber
<i>Cyathea manniana</i> Hook. f.	Cyathaceae	Small tree
<i>Deinbollia kilimandscharica</i> Taub.	Sapindaceae	Small tree
<i>Dracaena afromontana</i> Mildbr.	Agavaceae	Small tree
<i>Ocotea kenyensis</i> (Chiov.) Robyns & Wilczek	Lauraceae	Tree
<i>Olea welwitschii</i> (Knohl.) Gilg & Schellenb.	Oleaceae	Tree
<i>Oxyanthus speciosus</i> DC.	Rubiaceae	Small tree
<i>Phoenix reclinata</i> Jacq.	Arecaceae	Tree
<i>Pouteria adolfi-friederici</i> (Engl.) Baehni	Sapotaceae	Tree
<i>Psychotria orophila</i> Petit	Rubiaceae	Small tree
<i>Schefflera abyssinica</i> (Hochst. ex A. Rich.) Harms	Araliaceae	Tree
<i>Syzygium guineense</i> ssp. <i>afromontanum</i> F. White	Myrtaceae	Tree
'SFC species' (selection)		
<i>Albizia grandibracteata</i> Taub.	Fabaceae	Tree
<i>Bersama abyssinica</i> Fresen.	Meliantaceae	Tree
<i>Celtis africana</i> Burm. f.	Ulmaceae	Tree
<i>Clausena anisata</i> (Willd.) Benth.	Rutaceae	Small tree
<i>Coffea arabica</i> L.	Rubiaceae	Small tree
<i>Cordia africana</i> Lam.	Boraginaceae	Tree
<i>Croton macrostachys</i> Del.	Euphorbiaceae	Tree
<i>Cyphostemma adenocaula</i> (Steud. ex A. Rich.) Descoings ex Wild & Drummond	Vitaceae	Herbaceous climber
<i>Cyphostemma cyphopetalum</i> (Fresen.) Descoings ex Wild & Drummond	Vitaceae	Herbaceous climber
<i>Dracaena steudneri</i> Engl.	Agavaceae	Small tree
<i>Ficus ovata</i> Vahl	Moraceae	Tree
<i>Ipomoea cairica</i> (L.) Sweet.	Convolvulaceae	Herbaceous climber
<i>Maesa lanceolata</i> Forssk.	Myrsinaceae	Small tree
<i>Maytenus arbutifolia</i> (A. Rich.) Wilczek	Celastraceae	Shrub
<i>Milletia ferruginea</i> (Cuf.) Gillett (endemic)	Fabaceae	Tree
<i>Paullinia pinnata</i> L.	Sapindaceae	Woody climber
<i>Prunus africana</i> (Hook. f.) Kalkm.	Rosaceae	Tree
<i>Vernonia amygdalina</i> Del.	Asteraceae	Shrub
<i>Vernonia auriculifera</i> Hiern	Asteraceae	Shrub
<i>Vernonia biafrae</i> Oliv. & Hiern	Asteraceae	Herbaceous climber

genetically different from known cultivars (Wiersum, 1997; DFSC & IPGRI, 2001). Although management intensity is high in SFC systems, coffee regeneration is predominantly spontaneous, and the coffee in SFC systems is therefore regarded as wild. Over-exploitation of the wild coffee populations is not seen as a danger in the Bonga region, because coffee management in fact increases coffee abundance. The introduction of improved coffee cultivars in SFC systems could, however, threaten the genetic diversity of wild coffee. Coffee is self-pollinating, but pollination by bees is also important and can cause interbreeding with cultivars and subsequent

erosion of the original genetic make-up of wild coffee (Roubik, 2002; Klein, Steffan-Dewenter & Tschardt, 2003).

There is a high variability in wild coffee yields from different natural forest areas because of small-scale differences in the amount of shade and competing vegetation (Table 1). The results for this study confirm that wild coffee yields from natural forest can be below 30 kg ha⁻¹ a⁻¹ (Teketay, 1999) with high annual variations. For instance, local farmers reported bad yields from natural forest with 0–7 kg cc ha⁻¹ a⁻¹ and good yields with 4–29 kg cc ha⁻¹ a⁻¹ (Urich, 2005).

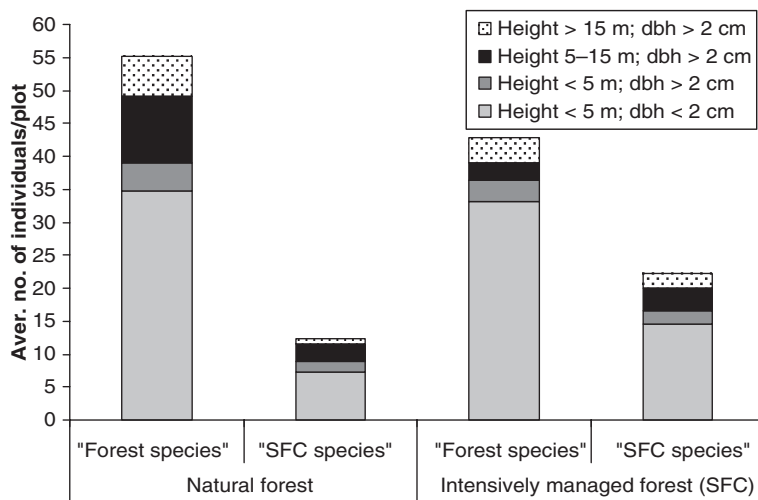


Fig 3 Population structure of tree species in natural forest and semi-forest coffee (SFC) systems; data from all forest fragments; 'forest species': 37 species associated with natural forest, 'SFC species': eight species associated with SFC systems (see Table 3)

Coffee yields from SFC systems are also highly variable because SFC systems are not uniformly managed. The yields are high when compared with natural forest (Table 1), but low when compared with conventional Ethiopian coffee plantations with average yields of 750 to over 1200 kg cc ha⁻¹ a⁻¹ (Teketay, 1999; Agrisystems Ltd, 2001). High yields from coffee plantations are probably related to a further reduction in shading vegetation compared with SFC systems. Furthermore, the coffee trees are high-yielding varieties, fertilized, spaced adequately, pruned and coppiced when yields start getting less. Rural farmers who manage SFC systems usually do not have the means to buy fertilizer. With very few exceptions, they are also reluctant to carry out pruning and to remove old coffee trees with declining productivity.

Impact of semi-forest coffee management on plant diversity

High light penetration in SFC systems caused an increase in ruderal and pioneer species, which was most pronounced for the herb layer and climber species (Table 2). Most climbers establish better in rather open and sunny sites such as SFC systems than in dense and shaded natural forest (Putz, 1984; Brokaw, 1985). The regeneration of both woody climbers and shrubs was promoted by coppicing in SFC systems because they have strong ability to reproduce vegetatively (Ewel & Bigelow, 1996).

Although the species richness of small tree species was little affected by wild coffee management (Table 2), management interventions led to changes in species abundance: *Clausena anisata* and *Maesa lanceolata*, for example, were associated with SFC systems. They are

characterized as early successional species (Chapman & Chapman, 1999; Chapman *et al.*, 2002; Mwima & Mcneilage, 2003). In contrast, tree ferns (*Cyathea manniana*) and *Psychotria orophila* were more abundant in natural forest parts (Fig. 2, Table 3). Tree ferns deserve particular attention because they are only known from few locations in Ethiopia, and require well-shaded and moist conditions (Birdlife International, 2008).

The management interventions in SFC systems also had strong impact on tree species composition, especially in the upper canopy as shown by both the analyses for Kayakela (Table 2) and the overall analyses (Fig. 3). This was related to the fact that many tree species have quite specialized regeneration requirements. Increased light penetration in disturbed forest favoured the 'SFC species' *Albizia grandibracteata*, *Bersama abyssinica*, *Celtis africana*, *Cordia africana*, *Croton macrostachys*, *Ficus ovata*, *Milletia ferruginea* and *Prunus africana*. They are pioneer or secondary species typical for forest edges, secondary vegetation or disturbed sites that have the ability to grow quickly into mature trees in gaps as created by coffee management (Friis, 1992; Chapman & Chapman, 1999; West, Midgley & Bond, 2000; Chapman *et al.*, 2002). In contrast, climax species, e.g. *Pouteria adolfi-friederici*, grow more slowly and are not as competitive as pioneer species in open sites. Selective cutting of trees used for construction and fuel wood also contributes to the changes in tree species composition and to the reduction in tree species richness in the upper canopy in particular. *Milletia ferruginea*, for example, was abundant in many SFC plots because farmers selectively retain this species as shade tree for coffee because of its leaf and crown structure.

Forest conservation planning

The severe impact of SFC systems on the natural forest vegetation was also observed for other coffee forest regions in southwestern and southeastern Ethiopia (Senbeta & Denich, 2006; Woldemariam, 2003). Conservation of the original plant diversity of the Ethiopian forests with wild coffee therefore necessitates the retention of natural forest parts without SFC management.

Wild coffee production, however, is the main source of income for farmers in coffee forest areas. As prices of coffee have been rising in the international coffee market since 2002 (International Coffee Organization, 2008), farmers are highly motivated to increase low coffee yields from the natural forest by managing wild coffee more intensively. Forest conservation concepts will only be successful if they create adequate incentives for the participation of local farmers in conservation measures.

Designating protected forest parts, on one hand, and forest areas for SFC management, on the other, could harmonize farmers' interests and conservation efforts. The remaining natural forest parts should fall under protection, while already existing SFC systems and other disturbed forest areas could be used for intensive wild coffee production. Farmers can be encouraged to participate in conservation measures through support in improving wild coffee management practices in SFC systems, e.g. by training on pruning techniques for coffee trees. This could increase coffee yields and is likely to reduce motivation to manage wild coffee in rather remote protected areas. As mentioned above, improved coffee cultivars should not be introduced, because interbreeding can erode the original genetic make-up of wild coffee.

Wild coffee certification as a tool for forest conservation

The intensification of wild coffee management in protected natural forest could also be discouraged by compensating farmers for low coffee yields from this forest by higher prices. Stimulated by the high international demand for wild coffee, certification concepts are currently being developed, which enable forest users to achieve premium prices for wild coffee from natural forest and SFC systems (Wiersum *et al.*, 2008). Their aim is to control forest management and unlimited wild coffee collection in the remaining natural forest parts as a contribution to wild coffee forest conservation in southwestern Ethiopia.

However, care needs to be taken to set adequate production ceilings and to ensure their control, because commercialization of nontimber forest products will automatically result in intensification of production (Moussouris & Regato, 1999). The production ceiling for wild coffee from natural forest should not exceed 15 kg cc ha⁻¹ a⁻¹, because higher yields can only be achieved through the creation of SFC systems (Table 1).

Existing certification schemes such as organic certification (SIPPO *et al.*, 2002; IFOAM, 2008) and certification by the Sustainable Agriculture Network (SAN, 2005) and Utz Certified (UTZ Certified, 2008) are already applied to coffee production in Ethiopia. However, these certification schemes consider coffee production within the context of agriculture and their environmental criteria are designed to guarantee the sustainable management of coffee plantations. Therefore, they cannot ensure that wild coffee management does not jeopardize the natural forest habitat. From a conservation point of view, standards developed for wild collection, e.g. organic wild collection (IMO & SIPPO, 2005) and the International Standards for Sustainable Wild Collection of Medicinal and Aromatic Plants (Medicinal Plant Specialist Group, 2007), seem to be more appropriate for the unique case of wild coffee certification because they would not support any coffee management activities inside the natural forest. If they are also appropriate for the particular socio-economic context of the Ethiopian wild coffee forests merits further investigation.

Acknowledgements

This study was financed by the German Federal Ministry for Education and Research (BMBF) through the project 'Conservation and use of wild populations of *Coffea arabica* in the montane rainforests of Ethiopia (CoCE)' (project number 01LM0201).

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doi: 10.1111/j.1365-2028.2009.01084.x