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SCIENCE DIRECT
Forest Ecology and Management 232 (2006) 68–74
Forest Ecology and Management
www.elsevier.com/locate/foreco

Effects of wild coffee management on species diversity in the Afromontane rainforests of Ethiopia

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Received 30 November 2005; received in revised form 10 May 2006; accepted 16 May 2006

Abstract

Coffea arabica L. is native to the Afromontane forests of Ethiopia. The local communities living in and around the forests manage the forest in traditional ways for coffee production. The level of management practices ranges from the relatively undisturbed forest coffee (FC), where little or no human inference is observed to the disturbed semi-forest coffee (SFC) system. This study analyzes the effects of wild coffee management on the floristic diversity and vegetation structure in these systems, in the Berhane-Kontir and Harenna forest sites. A total 114 quadrats, of 20 m × 20 m were laid along transects in both forest sites. Species richness was highest in the FC and lowest in the SFC system although the scale varies between the two forests. Shannon diversity and evenness indices exhibit high variation between the two forest systems and the lowest in the SFC system. The type of growth-form dominance also varies between the two forest systems, with up to 50% reduction in the number of species of lianas, small trees and shrubs were observed in the SFC system. In the SFC system in both forests, coffee plants occupy greater than 88% of plant density in the diameter class between 2 and 10 cm compared to less than 23% in the FC system. The ordination analysis also demonstrates the importance of human management influence and shows clear distinction between the FC and SFC plots of both forests. The continuous wild coffee management in the SFC system suppresses tree regeneration, reduces tree density and eventually leads to the disappearance of forest species, while promoting coffee plants. Therefore, conservation strategies of the Afromontane forest with wild coffee populations should focus on the balance between plant diversity and coffee production.

Keywords: Biodiversity; Conservation; Deforestation; Forest coffee; Floristic composition; Management practices

1. Introduction

Ecological and historical studies have demonstrated the dramatic human influences on the forest vegetation of Ethiopia (von Beritenbach, 1963; Hamilton, 1981; Bonnefille and Buchet, 1986; Bonnefille and Hamilton, 1986; McCann, 1997; Friis, 1992; Darbyshire et al., 2003). The main driving forces behind deforestation are the expansion of agricultural land, unrestrained exploitation of forest resources, overgrazing and establishment of new settlements into forested land coupled with increasing population pressure. As a result, forest biodiversity is disappearing rapidly in the forest landscapes of Ethiopia (Teketay, 1992; Woldemariam, 2003; Senbeta et al., 2005).

Coffea arabica L. is native to the Afromontane rainforests of Ethiopia. In the Afromontane rainforests, where wild *C. arabica* occur as understorey plants, local communities, by tradition, manage the forest for coffee production. The traditional coffee management system focuses on the reduction of the density of trees and shrubs in order to improve the productivity of the wild coffee plants. The level of management ranges from little or none in the undisturbed forest coffee to significant in the disturbed semi-forest coffee systems. Although these coffee management systems have been in existence for many years, there is limited information concerning their relative influence on forest biodiversity (Woldemariam, 2003). The problem of coffee forest management, from a biodiversity point of view, has been its tendency to reduce the variation in natural forests, leading to homogenization of the age, size and species composition of the forests. Consequently, reducing species diversity.

In view of the above, understanding coffee management and its effects on the forest biodiversity are necessary for the sustainable management of the forest. Therefore, a comprehensive analysis of the ongoing coffee forest management is helpful in elucidating the extent of its influence on the coffee

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0378-1127/$ – see front matter
doi:10.1016/j.foreco.2006.05.064

forests. The objectives of the study are: (1) to assess the impact of the wild coffee management on the species composition, structure and diversity of the rainforests, (2) to evaluate the influence of wild coffee management on the population structure of coffee and (3) to recommend management options for the forest with wild coffee populations.

2. Materials and methods

2.1. Study sites

The present study was conducted in two Afromontane rainforests, namely the Harenna forest and the Berhane-Kontir forest, located in SE and SW Highlands of Ethiopia, respectively (Fig. 1). A long history of forest exploitation and coffee use is deeply rooted into the socio-cultural activities of the people in these areas (Bonnefille and Hamilton, 1986; Tadesse and Nigatu, 1996; Asres, 1996).

The Harenna forest is located in the Bale Zone of Oromia, at 6°24′N and 39°44′E. It is one of the few remaining rainforest patches in the southeastern highlands, and partly constitutes the sub-section of the Bale Mountains National Park. The Bale Mountains were formed from lava outpourings in the Miocene and Oligocene geological periods (Mohr, 1965, 1971). The Harenna forest lies within the altitudinal ranges of between 1300 and 3000 m a.s.l., although coffee forest occurs only in the lowest-lying areas of the forest between 1300 and 1850 m a.s.l. The pattern of rainfall in the area is bimodal, i.e., March–April (short rain season) and August–October (long rain season). The mean annual rainfall is about 1000 mm and the mean annual temperature is 18 °C (EMSA, 1996). The soil in the coffee forest is acidic to slightly acidic with a pH between 5.3 and 6.6. A detailed description of the soil of Harenna forest is given in Nigatu (1987) and Tadesse and Nigatu (1996).

Although the Harenna forest was demarcated and considered as a National Forest Priority Area in mid-1980s, and partly under Bale Mountains National Park, there has been little conservation efforts. As a result, the forest is shrinking continuously due to agricultural expansion, coffee management, overgrazing and selective cutting or logging of trees. Honey production, cereal crop and coffee farming and livestock rearing are the main livelihoods of the communities living nearby the forest.

Fig. 1. Map of Ethiopia showing location of the study areas (Berhane-Kontir and Harenna).

The Berhane-Kontir forest is situated in Sheko Wereda of Bench-Maji Zone of the SW highlands. It is located at 7°N and 35°E and with altitudinal ranges between 900 and 1810 m a.s.l. The forest occurs on various topographic features from undulating to steep mountain slopes. The Pre-Cambrian basement rocks of different origin (Asres, 1996) dominate the area. Soils of the Berhane-Kontir forest are moderately acidic and with high cation exchange capacity (Murphy, 1968). The area is highly humid and receives rainfall throughout the year except between October and February. Annual rainfall is around 2200 mm and the mean annual temperature is around 22 °C (EMSA, 1996). According to studies (e.g., Senbeta et al., 2005) the indigenous Majenger people are highly dependent on the Berhane-Kontir forest for their livelihoods. In the area, coffee production and processing contribute significant income and employment opportunity to the local people. Although the forest is identified and designated as a National Forest Priority Area in the early 1980s and Forest Coffee Conservation site in 2002, it does not appear to be receiving much attention until very recently.

2.2. Methods

The study was carried out between May and June 2003 and from October 2003 to June 2004 in both Harenna and Berhane-Kontir forests. Prior to vegetation sampling, a reconnaissance survey was carried out at each forest to identify the major forest types harboring coffee. Accordingly, two major forest systems that differ in management were recognized, i.e., the forest coffee (FC) and the semi-forest coffee (SFC) in both forest sites. In the SFC system, selective cutting of competing trees and shrubs has been taking place over the past 20 years (local sources) beside coffee-berry collection. However, in the FC system, management is limited to only seasonal coffee-berry picking. At both sites, one forest system is disconnected by the other and widely distributed over a large area.

In each system, quadrats of 20 m × 20 m were laid down along transects at 300 m distance, and transects were also spaced 300 m apart. A total of 114 quadrats were laid; 55 quadrats from the Berhane-Kontir forest (BKFC, $n = 37$ and BKSFC, $n = 18$) and 59 quadrats from the Harenna forest (HAFC, $n = 24$ and HASFC, $n = 35$). In each quadrat, all vascular plant species were identified and counted; height and diameter of all woody plants (with dbh ≥ 2 cm and ≥ 0.5 m height) were measured. And, coffee saplings and trees were also counted. Plant identification was carried out both in the field and in the herbarium. All species are categorized into six major growth forms. This growth-form classification is based on information from the fieldwork and from the Flora of Ethiopia and Eritrea.

In each plot, slope, altitude, tree canopy cover, aspect and disturbance factors were recorded. The magnitude of disturbance was based on a scale from 0 to 3 (where 0 represents