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Ecological Economics 54 (2005) 435–446

ECOLOGICAL ECONOMICS

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ANALYSIS

Biodiversity, yield, and shade coffee certification

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Received 10 June 2002; received in revised form 10 September 2004; accepted 25 October 2004
Available online 2 February 2005

Abstract

The current crisis in the coffee market provides an opportunity to explore alternative markets. In Latin America, coffee is traditionally produced under a diverse and dense canopy of shade trees. The structural and floristic diversity contained therein harbors a high biodiversity of associated organisms. The recent trend of reducing this shade cover so as to increase production raises concerns about the potential loss of biodiversity. This concern has given rise to a variety of conservation programs, including shade coffee certification, a market-based conservation strategy. Shade coffee certification programs offer the opportunity to link environmental and economic goals. Although the idea of shade certification is to compensate farmers for the biodiversity conservation service provided by their shaded plantations, the premium offered may not compensate for the low yields of the most shaded plantations. Here we present an approach for guiding the establishment of premium prices for coffee producers based on scientific information that relates shade percentage and levels of species richness with yield. Partial data from two separate studies in Chiapas, Mexico, are combined and used to illustrate this approach. In addition, further theoretical explorations are made by adapting an intercropping model and using coffee yield and biodiversity (as it relates to percent of shade of canopy trees) as the two relevant variables. This model is examined qualitatively from the point of view of optimality (balancing biodiversity preservation with production). Results suggest that price premium for shade certification should be high and go directly to the producers, especially if the intent is to conserve forest-sensitive species.

Keywords: Coffee certification programs; Yield set; Biodiversity; Agroforestry

1. Introduction

The last decade has been devastating for coffee producers all over the world. Coffee prices are at a 30-year low (the lowest in real terms for the past 100 years) and many producers, unable to make a living with coffee, are changing to other crops or abandoning their

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0921-8009/$ - see front matter
doi:10.1016/j.ecolecon.2004.10.009

plantations and migrating to the north (International Coffee Organization, 2003a,b; Gresser and Tickell, 2002). At the base of the crisis is overproduction of coffee due to rapid expansion of production in Vietnam, new plantations in Brazil (International Coffee Organization, 2003c), and the technification of coffee plantations in countries like Colombia and Costa Rica (Perfecto et al., 1996). This crisis opens a window of opportunity to explore the potential for sustainable coffee as a way to improve the economic situation of small producers in Latin America.

Interest in combining conservation and development goals has resulted in more attention being paid to agroecosystems; in particular those that incorporate high levels of planned biodiversity (Vandermeer and Perfecto, 1997). Traditional shaded coffee is one of the diverse agroecosystems that has received considerable attention from conservation organizations in recent years. In these traditional plantations, coffee is grown under a structurally and floristically diverse canopy of shade trees, which provide habitat for a high diversity of associated flora and fauna. These traditional shaded coffee plantations have been shown to contain high levels of associated biodiversity, including birds and arthropods (see reviews: Perfecto et al., 1996; Moguel and Toledo, 1999; Perfecto and Armbrecht, 2003). The trend to reduce or eliminate shade cover in coffee plantations to increase yield has generated concern among conservation organizations because of its potential negative effects on biodiversity (Perfecto and Vandermeer, 1994; Perfecto and Snelling, 1995; Wunderle and Latta, 1996; Perfecto et al., 1997, 2003; Greenberg et al., 1997a,b: Ibarra-Núñez and Garcia-Ballinas, 1998; Armbrecht and Perfecto, 2003; Mas and Dietsch, 2003). Several conservation and research organizations, such as Conservation International, The Smithsonian Migratory Bird Center, and the Rain Forest Alliance have developed programs to help conserve diverse shade cover in coffee plantations in Latin America, and some of these include certification of shade grown coffee (also known as bird-friendly and Rain Forest Alliance Certified, formerly known as Eco-OK). These sustainable coffees command premium prices that have aided certified farmers to withstand the crisis and continue producing coffee (Fleischer, 2002).

2. Ecological and economic importance of coffee in northern Latin America

In northern Latin America[1] coffee farms cover some 3.6 million hectares (Food and Agriculture Organization (FAO), 2002). However, the ecological importance of coffee does not derive as much from the amount of land that is under production, but rather the particular locations where it is grown. In Latin America, coffee is important in countries that have been identified as megadiverse, such as Colombia, Brazil, and Mexico (Mittermeier et al., 1998). *Coffea arabica* is grown primarily in mid elevation mountain ranges and volcanic slopes, where deforestation has been particularly severe. The northern Latin American region has seven of the ten countries with the highest rates of deforestation in the world (Rice and Ward, 1996). In some countries in the region, traditional coffee plantations are among the few remaining “forested” areas, especially in the mid-to high elevation ranges. An extreme example of the ecological importance of coffee can be found in El Salvador, one of the most deforested countries of the Americas. El Salvador has lost more than 90% of its original forests, however 92% of its coffee is shade grown (Rice and Ward, 1996); shaded coffee has been estimated to represent about 80% of El Salvador’s remaining “forested” area (Panayotou et al., 1997). High levels of biodiversity and endemism also characterize some tropical mid-elevation areas. In Mexico, the main coffee-growing areas coincide with areas designated by the national biodiversity agency (CONABIO) as priority areas for conservation, because of the high numbers of endemic species they contain (Moguel and Toledo, 1999).

Coffee is also very important economically for many Latin American countries. In Mexico coffee alone generates 36% of total agricultural export revenue (Nolasco, 1985), and in Peru, coffee is the most important export crop (Greenberg and Rice, 2000). In addition to the generation of valuable foreign exchange, coffee generates cash income for large numbers of small producers throughout Latin America. In Mexico there are 283,000 coffee

[1] Northern Latin America includes Mexico, all of Central America and the Caribbean, Colombia, and Peru.

producers[2] and several million rural people who obtain their principal income from coffee (Nolasco, 1985). Ninety-one percent of Mexican coffee producers farm less than 5 hectares, and 60% of them are indigenous people (Santoyo Cortes et al., 1994). Coffee has been increasingly adopted by small indigenous and *mestizo* producers in the region, with a threefold increase since the 1950s (Rice, 1997, 1999). Furthermore, the majority of the small-scale production in the region is of the traditional sort, where coffee is produced under a multi-species tree canopy (Rice, 1997, 1999; Moguel and Toledo, 1999; Soto-Pinto et al., 2000).

The economic and ecological importance of coffee in Latin America presents an excellent opportunity to develop programs for sustainable development by combining conservation and economic goals in an obvious way, an opportunity recognized by conservation organizations (Philpott and Dietsch, 2003). Recently, several campaigns have been initiated by conservation organizations to promote the production of shaded coffee, primarily in Mexico and Central America, and the consumption in North America, Europe, and Japan (Rice and Ward, 1996; Messer et al., 2000; Giovanuchi, 2003). One of the emerging strategies is shade coffee certification (Greenberg, 1996; Rice and McLean, 1999; Giovanuchi, 2003; Mas and Dietsch, 2004). Shade coffee certification seeks to provide a premium price to producers that maintain shade trees, and thereby contribute to the maintenance of biodiversity in coffee growing regions. Although there are no formal data relating the size of plantations and level of shade, small plantations tend to have higher shade levels than large ones in Chiapas, Mexico (I. Perfecto, personal observation).

3. Shade certification and coffee yield

A potential problem with the shade coffee certification approach is that a variety of shade regimes exist in the coffee agroecosystem (Fig. 1), and it is not clear that all of them are necessarily good for maintaining biodiversity. For example, a common way of producing coffee in Central America is with a low density of monospecific shade trees that are heavily pruned twice a year (Fig. 1D). These plantations are, technically speaking, “shaded plantations.” However, their ability to maintain biodiversity is greatly diminished (Perfecto et al., 1997). Organizations promoting shade coffee are well aware of this problem and have developed criteria to assure that such low-diversity/low density shade plantations will not be certifiable (Mas and Dietsch, 2004; Philpott and Dietsch, 2003). Unfortunately, data currently available do not allow us to say with confidence what levels of shade or what qualitative vegetative structure are the best for maintaining biodiversity in coffee plantations without significantly sacrificing yield. A recent study comparing ants, butterflies, and birds in the same plots along a coffee intensification gradient (forest, traditional polyculture, commercial polyculture, and shaded monoculture;[3] Perfecto et al., 2003), showed that while there is a general decline in associated species richness,[4] the pattern of species loss is different for the three taxa (Fig. 2). This study was a first attempt to fine-tune the relationship between biodiversity and shade cover.[5] Examining multiple taxa within the same experimental plots, it concluded that different taxa exhibit different responses and different sensitivities to habitat modification (Fig. 2).

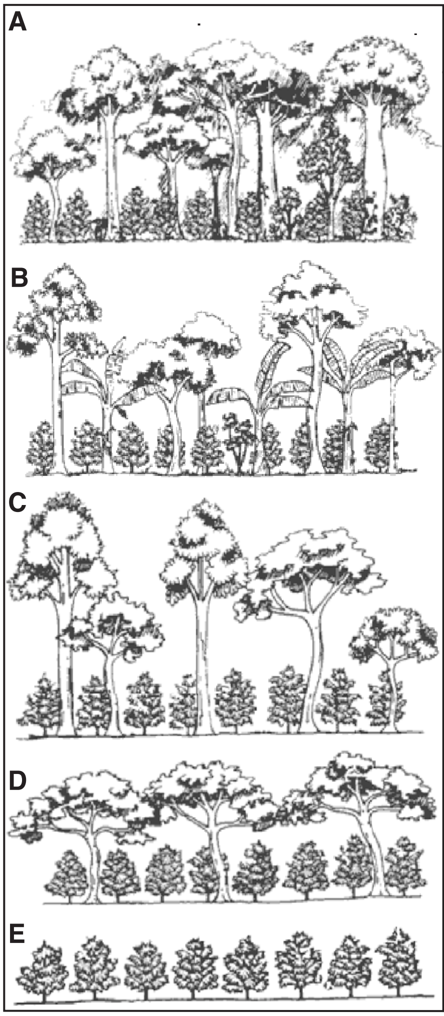
A possible solution to the problem of the diversity of shade systems is to certify only so-called “rustic plantations” (Fig. 1A). These are plantations that have a very dense, tall, and diverse canopy, frequently

[2] This figure includes all producers, from those that have less than 5 hectares to those that have up to 300 hectares, which is the maximum allowable size for a farm owned by an individual in Mexico.

[3] In Perfecto et al. (2003) traditional polyculture is called “restoration,” commercial polyculture is called “diverse shade,” and shaded monoculture is called “intensive.”

[4] Perfecto et al. (2003) used COMNYN to estimate total number of species per habitat (i.e. species richness) based on bootstrapping techniques. Richness estimates are considered a better indicator of biodiversity than diversity indices (Colwell and Coddington, 1994).

[5] Although Perfecto et al. (2003) measured both tree species richness and percentage shade cover, these two components of the shade were confounded and their effect could not be disentangled. In the rest of this article when we talk about shade cover we will be referring at the percentage of shade as measured with a LICOR canopy analyzer or by means of hemispheric photographs. However, the shade could be produced by many or a single species of shade tree.



MANAGEMENT SYSTEM	%SHADE COVER*	SHADE TREE RICHNESS*
RUSTIC	71-100	> 50
TRADITIONAL POLYCULTURE	41-70	21-50
COMMERCIAL POLYCULTURE	31-40	6-20
SHADED MONOCULTURE	10-30	1-5
UNSHADED (SUN) MONOCULTURE	0	0

Modiefied from: Moguel and Toledo, 1999; Rain Forest Allience.
* *Figures for percent shade and tree species richness are approximates based on studies cided by Moguel and Toledo, 1999 and our own reserach (Perfecto et al., 2003).*

Fig. 1. Diagram of the different coffee management systems with the approximate ranges in percent shade cover and shade tree species richness.

composed of the original forest trees. Multiregional data suggest that rustic plantations contain a high degree of associated biodiversity (for a review see Perfecto and Armbrecht, 2003). While this approach may preserve the most biodiversity, plantations with very dense shade canopies may also have very low coffee yield.

The few studies that have examined the effect of overstory shade density on coffee yield have reported contradictory results. Some of these studies show a significant increase in yield (10% to 30%) after shade removal under optimum conditions (Suares de Castro et al., 1961; Ostenderof, 1962; Abruña et al., 1966; Pérez, 1977). Others show no difference between moderate shade and no shade (Muschler, 1997, 1998; Baggio et al., 1997; Hernández et al., 1997), while others show a "hump shaped" relationship (Escalante, 1995; Soto-Pinto et al., 2000; Staver et al., 2001). However, in spite of the inconsistent results of these studies, there is a strong perception among coffee producers that an increase in shade density reduces yield. Furthermore, there is a strong consensus among

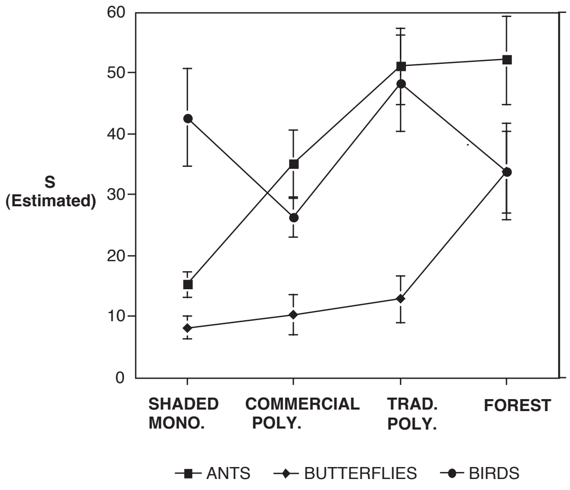


Fig. 2. Species richness of ants, butterflies, and birds in three different coffee management systems and a forest fragment in Tapachula, Chiapas, Mexico (Modified from Perfecto et al., 2003).

both producers and researchers that very dense shade, characteristic of the rustic system results in very low yields. Staver et al. (2001) analyzing the effect of shade on multi-trophic factors that cause yield reduction (i.e. insect pests, diseases, weeds) concluded that yield is maximized between 35 and 65% shade cover. Given this, a certification program that only certifies rustic plantations or plantations with more than 70% shade would have difficulty attracting producers, unless the premium offered is sufficiently high to overcome yield losses. But this high premium would most likely translate into a much higher price at the consumer level and would discourage consumption in consumer countries. Farmers who already produce coffee under moderate or dense shade conditions have little to lose and much to gain from shade certification programs. A recent economic analysis of the financial feasibility of investing in the certification criteria for a "biodiversity-friendly" coffee in El Salvador, indicated that investment was financially viable for all types of plantations investigated (including sun or unshaded plantations) (Gobbi, 2000). However, this study also highlighted the importance of yield for the financial viability of the investment. Of all types of farms, only the traditional shaded plantations were risk free, primarily due to no change in yield associated with the certification criteria. The higher risk was for the sun coffee (unshaded coffee monoculture), since the investments for complying with biodiversity-friendly criteria were higher and yields were assumed to decline due to the increase in shade cover (Gobbi, 2000).

Shade coffee certification programs have emerged primarily from concerns about conservation rather than an integration of conservation and production concerns, and this bias is reflected in the certification criteria that have been developed for the different programs (Mas, 1999; Dietsch et al., 2004). For these programs to be widely adopted by producers, they must incorporate economic goals in addition to the broader environmental goals. The success of shade coffee certification programs depends on the adoption of these approaches by coffee producers and consumers' willingness to pay premium prices for a product that helps conserve biodiversity (i.e. a type of environmental service; Giovanuchi, 2003). We note in passing that premium prices need not come exclusively from elementary market forces (i.e. higher prices for consumers willing to pay for environmental services). The historical record is clear on this point, as summarized in the recent history of coffee (Pendergast, 1999). The famous Brazilian valorization scheme, hatched at the end of the eighteenth century for the purpose of managing the world's supply of coffee, was effective at maintaining fair prices for Brazilian producers. The Brazilian valorization episode was tame compared to the massive international effort to manage coffee prices in response to fears of a German penetration into Central America during World War II; and the UN Coffee Conference of 1962, provided producers with stable coffee prices for almost 30 years, as a bulwark against "Communism." Conservation programs may not have been successfully drafted for managing prices as of yet, but they can easily be seen as a potential force if the political will was extant.

Here we illustrate an approach that can be used to guide decisions about price premiums for shaded coffee, and that seeks to incorporate economic (production) and conservation (biodiversity) goals within the same framework.

4. Biodiversity and yield: an approach to guide coffee farmers and conservation organizations

This approach consists of examining species richness (for various taxa, if available) and coffee yield along a shade gradient. Fig. 3 presents the relationship between species richness for ground ants and butterflies and percentage of canopy openness for a site in southern Chiapas, Mexico (modified from Perfecto et al., 2003). Species richness is presented as a percentage of the number of species found in an adjacent forest plot. This allows us to compare the responses to coffee intensification for each taxa on the same scale. It also allows us to superimpose onto these data percentage yield, as they relate to percentage shade cover. Since we do not have yield data for our study site in southern Chiapas, we use yield data published by Soto-Pinto et al. (2000) for the Chilon region in northeastern Chiapas (Fig. 3). The use of two different data sets is justifiable because this figure is only meant to illustrate an approach for examining diversity-yield relationships and not the relationship for this particular study site. We intentionally focused on ants and butterflies because of their different responses to shade reduction. In this study butterflies appeared to be more sensitive to shade reduction than ants.

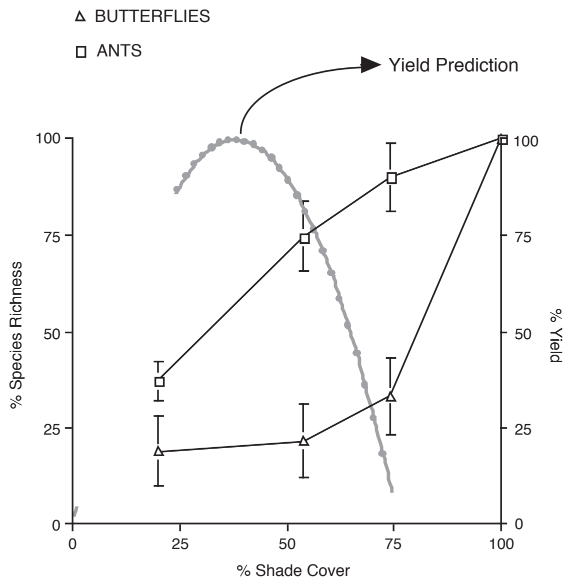


Fig. 3. Relationship between percent species richness of ants and butterflies and the percent of shade cover for 4 management systems (including forest) in the municipality of Tapachula, Chiapas, Mexico (data from Perfecto et al., 2003). The superimposed curve represents the relationship between percent yield and percent shade cover. The percent of species is based on the total number of species found in the forest habitat. The percent yield is based on the maximum yield attained within a range of shade cover in another study conducted in southeastern Chiapas (Soto-Pinto et al., 2000).

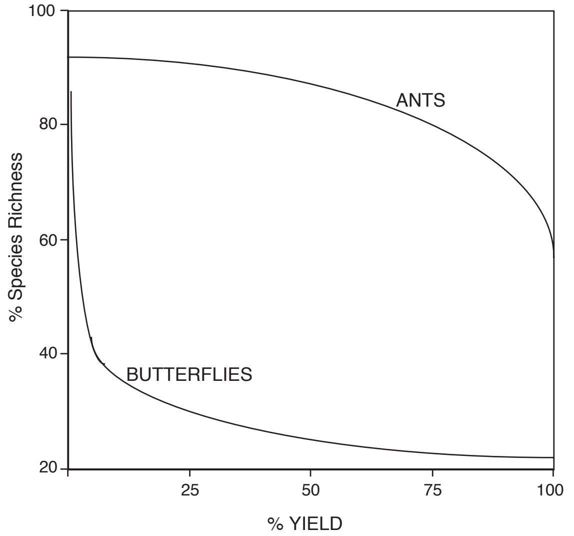


Fig. 4. Indirect relationship between percent species and percent yield through the effect of shade cover on yield and species richness. The percent of species is based on the number of species found in the forest habitat in the Tapachula site (data from Perfecto et al., 2003). The percent yield is based on the maximum yield attained within a range of shade cover in another study conducted in southeastern Chiapas (Soto-Pinto et al., 2000).

Fig. 4 illustrates the relationship between percent yield and percent species richness. This relationship is based on the percent shade cover and its relationship to yield and species richness. So, for example, maintaining 75% of the yield (based on the highest yield that can be achieved within a range of shade levels) results in the maintenance of 23% and 80% of the species richness of butterflies and ants, respectively.[6]

With this approach it is possible to examine how yield and species richness are related in a particular region. This sort of information can guide a farmer's management decisions, in terms of how much shade to have in the plantation, as well as help certification organizations set price premiums for shaded coffee based on how much yield a farm is expected to loose for a given level of shade.

[6] The high sensitivity exhibited by butterflies in this study (Perfecto et al., 2003) was probably due to a particularly extreme dry season (due to El Niño event in 1998) just prior to the time when the data were collected.

5. Further theoretical explorations of the yield–shade–biodiversity interaction

In more general terms, we can treat the question of biodiversity management and its tradeoff with agricultural production as a simple problem of intercropping, where the biodiversity is treated as another crop. We can define the "yield set" (Vandermeer, 1989) as the set of points in S,Y space, where S is number of species of the target taxonomic category and Y is yield of the crop. The yield set is meant to incorporate all possible agricultural designs. However, in the present context, we seek to maximize the benefit in the context of shade, a specific planning variable. Thus $S(C)$ and $Y(C)$ are both functions of shade cover (C), but can be parameterized with respect to shade cover so as to yield a set of points in S,Y space, as illustrated in Fig. 5. The utility of the system can be defined as,

$$U = aS + bY, \quad (1)$$

where a and b are constants that relate the relative value (however defined) of the two variables. We seek to maximize U. Eq. (1) can be rewritten as:

$$S = (U/a) - (b/a)Y \quad (2)$$

which is a straight line in S,Y space. Seeking a maximum value of U is equivalent to locating the maximum intercept on the S axis, which will sometimes be a unique point, as illustrated in Fig. 6.

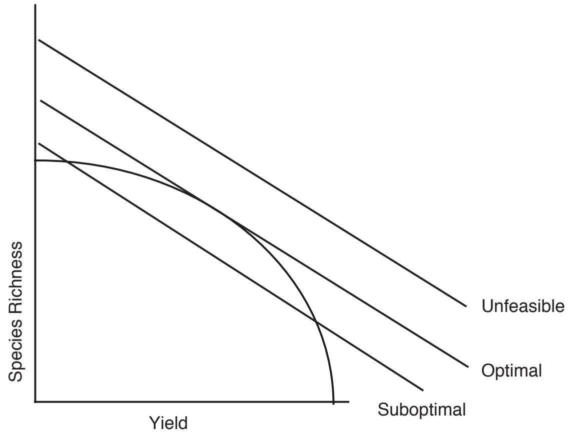


Fig. 6. Maximization of the utility function on the yield set.

With this elementary decision-making machinery, we can examine several interesting qualitative situations. The ratio (b/a) is the ratio of the value of the crop (a) compared to the value of biodiversity (b). As the premium price for biodiversity-friendly crop increases, this ratio decreases. This means that the optimal solution on the yield set moves toward the high diversity (high shade cover) end of the spectrum, as illustrated in Fig. 7. A particularly interesting case arises when the yield set is concave, as illustrated in Fig. 8. Here we see the result that increasing the premium initially has no effect at all on the optimal solution. Utility functions I, II, and III all have the same optimal solution on the yield set, maximum yield–minimum species richness. But utility function IV, which has almost the same slope as III (i.e. very nearly the same premium), suddenly changes the optimum solution to a minimum yield–maximum species richness (i.e. a heavily shaded plantation). There is a critical threshold above which a heavily shaded plantation becomes optimal and below which the very low shade situation remains optimal.

We thus see that the shape of the yield set suggests a differential response to increase prices due to certification. The gradual increase in quality of shade is expected to result from a gradual increase in the premium offered to the farmer, in the case of a convex yield set. But there will be a threshold response in shade quality in the case of a concave set, with no

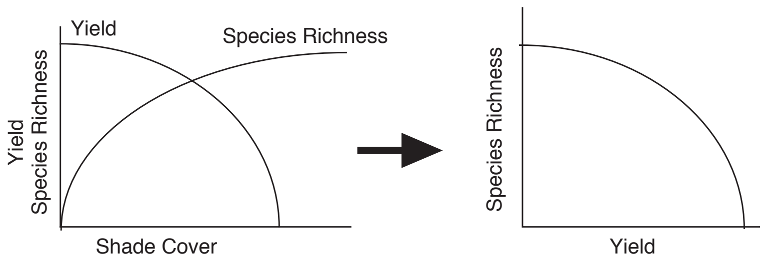


Fig. 5. Construction of the yield set from functions of cover.

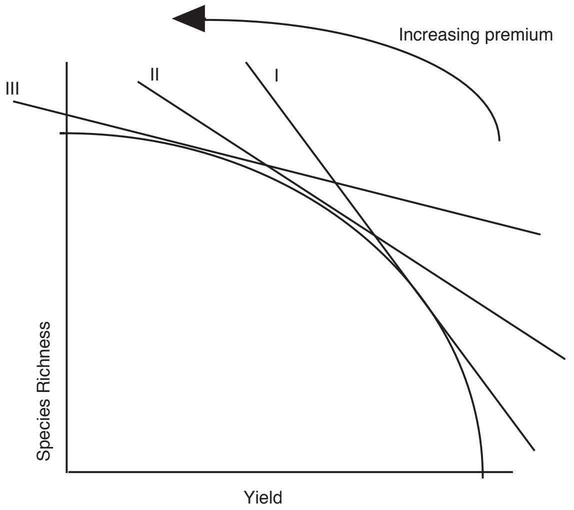


Fig. 7. Increasing premium for shade coffee when the yield set is convex. Note the optimal point moves ever closer to the high diversity end of the spectrum.

discernable advantage to shaded production below some critical threshold value of the premium.

The shape of the yield set will depend on the particular interactions between yield and species richness, as they are mediated by amount of shade cover. Going back to our previous example of ants and butterflies in Chiapas coffee plantations (Fig. 4), we can see that the yield set for ants is convex, while that of the butterflies is concave. Taxa with a very high sensitivity to a reduction in shade will tend to generate concave yield sets, since small changes in yield (due to reduce levels of shade), generate a severe drop in species richness. On the other hand, taxa that are more tolerant of reductions in shade will generate a concave yield set.

6. Discussion

With the current coffee crisis, the potential for combining environmental and economic goals in sustainable coffee has attracted the attention of the conservation and development communities alike. Shade (e.g., Smithsonian Bird Friendly and Rain Forest Alliance Certified) is one of the certification programs that has been developed to promote biodiversity conservation at the same time that it has provided farmers with premiums during times of depressed international prices. However, establishing effective premiums for shade coffee (for the purpose of conserving biodiversity) is more complicated than might be expected due to the fact that (1) the relationship between shade and yield is not linear, and in many cases is best described by a humped-shape curve (Soto-Pinto et al., 2000; Staver et al., 2001), and (2) because different components of biodiversity could differ in their sensitivity to the elimination of shade. Both of these are critical factors for deciding on premiums for certified shade coffee. Here we present an approach to examine the relationship between yield and species richness that suggests that for some organisms that are resistant to shade reduction, the relationship between yield and species richness would be described by a convex set (e.g., Fig. 4 for ants), while some sensitive organisms would exhibit a concave relationship (e.g., Fig. 4 for butterflies). This means that in order to conserve highly sensitive organisms, the farmer will have to be willing to accept the lower yields that will result from a higher density of shade. On the other hand, the richness of more resistant organisms can be maintained at relatively high levels even when shade is reduced significantly (Fig. 4). Although this seems to

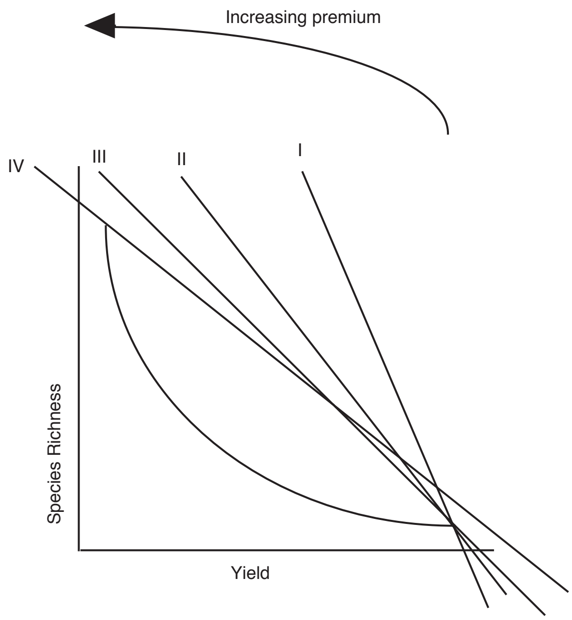


Fig. 8. Increasing premium for shade coffee when the yield set is concave.

be an obvious conclusion and one that has significant implications for the problem of setting premiums for shade coffee, its incorporation into discussions of shade certification criteria has been minimal at best. Further exploration of the relationship between yield and species richness with a simple optimization model adapted from polycultures (Vandermeer, 1989) reveals that the optimum combination of yield and species richness changes gradually for resistant species (with convex yield–diversity relationships) as the premium price increases (Fig. 7). On the other hand, for sensitive species (with concave yield–diversity relationships), increasing premium values will yield the same optimum of high yield–low species richness up to a certain threshold premium value where the optimum shifts dramatically to the other extreme of low yield and high species richness (Fig. 8).

It is important to note that in this study we consider only the total number of species and not their identities. Species richness is only one part of the conservation issue. Changes in species composition in different coffee management systems should also be taken into consideration. In particular, we should be concerned with the ability of the shaded coffee system to maintain forest species and not just species that are characteristic of disturbed habitats. The approach presented here can be modified to substitute the percentage of species richness for the percentage of forest species that remain in the coffee plantations. Other approaches that incorporate species identity are developed elsewhere (Mas and Dietsch, 2003). Another aspect of biodiversity not included in our analysis is the extent to which the conversion of conventional to shaded coffee induces the return of forest species or other species important for biodiversity conservation. To our knowledge there are no studies that have examined this question, and therefore we cannot assess its relevance in the current analysis.

6.1. Shade coffee certification and the producers

The qualitative results presented here suggest that premiums for shade coffee should be higher than for other certification programs that do not affect yield negatively. For example, where small farmers have little access to agrochemicals, the transformation from conventional to organic coffee, usually represents an increase in yield of 15% (in Mexico; Bray et al., 2001) and up to 67% (in Guatemala; Damiani, 2002).[7] This means that in addition to receiving a premium price for the organic coffee, they get the added benefit of a yield increase. However, transforming a farm from conventional (whether unshaded monoculture or shaded monoculture) to shade coffee will most likely result in yield declines. Under these circumstances the premium incentives will have to be high to convince farmers to change to a shaded system that is certifiable. The problem is accentuated when the goal is to conserve forest species that are highly sensitive to disturbance (reduction in shade levels). As shown in Fig. 8, there is a threshold premium at which the optimum solution shifts from a very low shade system with high yields, but low biodiversity benefits, to a densely shaded system with low yield and high biodiversity benefits. Since the particular value of that threshold depends on the particular shade–yield–diversity relationship, it would be different for different farms, locations, and the species that the program seeks to protect. Determining different premium prices for particular regions, not to mention particular farms, is unrealistic. However, this analysis highlights the importance of having relatively high premiums for shade coffee.

It should be clarified that premium prices need not come exclusively from market forces (i.e. higher prices from consumers willing to pay for environmental services). Conservation programs (governmental or non-governmental) could provide funds for a price premium, so farmers receive a fair price without increasing the price to the consumer, as noted with historical examples above.

6.2. Shade coffee certification and the consumers

Unless government or non-governmental institutions provide funds for shade coffee, a high premium will most likely be translated into a higher price for the consumers and can potentially impinge negatively on consumption of shade grown coffee. Premiums for shade coffee typically range from US$ 0.10 to US$

[7] The increase in yield with the conversion to organic is not a universal phenomenon. It depends to a great extent on how coffee is produce conventionally as well as other factors such a soils, climatic conditions, etc. For a counter example of yield declines with organic conversion see Lyngbœk et al., 2001.

0.60 per pound and have shown an upward trend over the last 3 years (Giovanuchi, 2003). Although the export volumes of shade coffee have increased over the last few years, and several high profile distribution deals have been announce in the United States (Starbucks supplying shade grown coffee from farmers in El Triunfo, Mexico, or Ben and Jerry's offering the new "Coffee for a Change" ice cream flavor using shade coffee; Giovanuchi, 2003), it is not clear that this increased consumption can be maintained with very high premiums. A recent empirical study of consumer behavior in the purchasing of shade coffee in the Washington, DC metropolitan area concluded, not surprisingly, that the probability of consuming shade grown coffee increased with income and a positive environmental attitude (Messer, 1999). A model of contingent purchase based on the same study revealed that purchase decreases with the price premium and increases with prior knowledge about shade-grown coffee (Kotchen et al., manuscript). If this pattern holds for other US cities, it means that a much higher premium could impact negatively on the purchasing of shade coffee.

Of the three coffee certification programs (fair trade, organic, and shade-grown), shade coffee has the lowest market share and represents only 10.5% of all exports of certified coffees from Latin America (CIMS (Centro de Inteligencia sobre Mercados Sustentables), 2003).

6.3. Separating agriculture from conservation vs. an integrated approach

One of the surprising results of our model is that for sensitive species, the optimum system jumps from low shade and high yields when premiums for shade coffee are low, to the other extreme of a densely shaded plantation with very low yields when premiums are high. These two options parallel a recent debate concerning the value of coffee for conservation. Rappole et al. (2003a,b) and O'Brien and Kinnaird (2003) argue that the best way to conserve biodiversity is by producing coffee in intensive plantations (with reduced or no shade) and leaving areas of forest intact (Rappole et al., 2003a,b; O'Brien and Kinnaird, 2003). In our model, this may be the optimum option for the farmers when the premium for shade coffee is low. On the other hand, Philpott and Dietsch (2003) and Dietsch et al. (2004) argue that shaded coffee has a significant conservation value, especially if it is combined with organic and fair trade certification and farmers receive a high premium or have a low certification costs (as for fair trade certification). Although our model does not support one side or the other, it does highlight the importance of high premiums for the shade certification programs to be a viable option for farmers. Although Rappole et al. (2003a,b) raise questions about the conservation value of shade coffee, empirical and theoretical studies that focus on the quality of the agricultural matrix support Philpott and Dietsch's perspective that shaded coffee plantations represent a high quality matrix with a high conservation value for forest species (Vandermeer and Carvajal, 2001; Perfecto and Vandermeer, 2002; Armbrecht and Perfecto, 2003). However, premium prices for shaded coffee have to be sufficiently high to provide a large enough incentive for farmers to want to certify their farms as shade-grown coffee. Additionally, shade certification programs can be prohibitively expensive for most coffee growers (Gobbi, 2000). Philpott and Dietsch (2003) suggest linking organic, fair trade and shade coffee certification programs into a single long-term conservation strategy for coffee-growing regions. Our study suggests that for this strategy to be effective the price premiums will have to be high and go directly to the producers rather than to certification agencies. This is indeed what fair-trade certification tries to accomplish, suggesting the possible utility of formalizing the link between fair trade and shade certification.

7. Conclusion

Shade coffee certification has recently emerged as a conservation-oriented marketing strategy. Certification criteria have been developed for the stated goal of conserving habitat for biodiversity. In this article we emphasize the need to integrate environmental and economic goals in the shade coffee movement by examining the relationship between coffee yield and biodiversity. Although the primary motives for establishing shade certification programs are indeed environmental (i.e. the conservation of biodiversity), these programs would not be effective if the farmers perceive that the only way to satisfy the shade criteria would be to accept a large reduction in yield.

In this paper we suggest that shade coffee certification programs take into consideration the relationship between biodiversity and coffee yield, and we propose an approach for examining this relationship. Inclusion of the yield perspective might help identify economic thresholds to motivate farmers, or price tradeoffs that might require additional incentives or alternative conservation strategies. This approach could help guide management decision by both farmers and certification agencies, preferably together.

Acknowledgements

The data on which this paper is based were collected in various coffee farms in Chiapas, Mexico. We wish to thank the members of ISMAM, the Peters and Edelman families from Tapachula, as well as all the small producers from the Chilon region for giving permission to work on their farms. We also thank Dr. Thomas Dietsch for giving permission to use his bird data. We would also like to thank Dr. Guillermo Ibarra-Nuñez and Alvaro Garcia-Ballinas for support in identifying ants and Dr. Roberto de la Masa for helping with the identification of the butterflies. Sean Foley, Robert Rice, and two anonymous reviewers gave valuable comments on earlier versions of the manuscript. This research was partially supported with a grant from the National Science Foundation (# DEB-9981526).

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