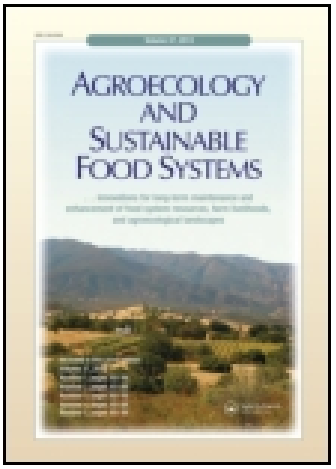

Agroecology and Sustainable Food Systems
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wjsa21

Supporting Rural Livelihoods and Ecosystem Services Conservation in the Pico Duarte Coffee Region of the Dominican Republic

Lee H. Gross[a], Jon D. Erickson[b] & V. Ernesto Méndez[c]
[a] EcoAgriculture Partners, Washington, DC, USA
[b] Gund Institute for Ecological Economics, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, Vermont, USA
[c] Agroecology and Rural Livelihoods Group (ARLG), Plant and Soil Science Department, University of Vermont, Burlington, Vermont, USA
Accepted author version posted online: 18 Jun 2014.Published online: 17 Sep 2014.

To cite this article: Lee H. Gross, Jon D. Erickson & V. Ernesto Méndez (2014) Supporting Rural Livelihoods and Ecosystem Services Conservation in the Pico Duarte Coffee Region of the Dominican Republic, Agroecology and Sustainable Food Systems, 38:9, 1078-1107, DOI: 10.1080/21683565.2014.932883

To link to this article: http://dx.doi.org/10.1080/21683565.2014.932883

Agroecology and Sustainable Food Systems, 38:1078–1107, 2014

ISSN: 2168-3565 print/2168-3573 online
DOI: 10.1080/21683565.2014.932883

Supporting Rural Livelihoods and Ecosystem Services Conservation in the Pico Duarte Coffee Region of the Dominican Republic

LEE H. GROSS,[1] JON D. ERICKSON,[2] and V. ERNESTO MÉNDEZ[3]
[1]*EcoAgriculture Partners, Washington, DC, USA*
[2]*Gund Institute for Ecological Economics, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, Vermont, USA*
[3]*Agroecology and Rural Livelihoods Group (ARLG), Plant and Soil Science Department, University of Vermont, Burlington, Vermont, USA*

Successful conservation strategies have increasingly looked beyond bounded protected areas and toward integrated landscape approaches that conserve biodiversity while maintaining ecosystem services that benefit human communities and food production. More integrated approaches to conservation are particularly timely in agricultural landscapes, where individual farm-level choices can play a significant role in the management of habitat provisioning, nutrient cycling, recreation amenities, carbon sequestration, and the delivery of clean water. This study presents results of an interdisciplinary analysis with shade coffee farmers in the Pico Duarte region of the Dominican Republic. Findings suggest that small farms, as part of a diversified livelihood strategy, maintain a diverse tree canopy, which supports soil conservation and important watershed services. However, high poverty levels and strong economic pressures to convert to high-input, monoculture crops are threatening native tree species biodiversity and the provisioning of ecosystem services (e.g., delivery of clean water and carbon sequestration) to local beneficiaries, as well as to national and international actors. A coordinated effort to support smallholder shade coffee farmers across the landscape through agricultural extension, capacity building, and other market-and-non-market-based

Address correspondence to Lee H. Gross, EcoAgriculture Partners, 1100 17th St. NW, Washington, DC 20001, USA. E-mail: leehgross@gmail.com

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/wjsa.

interventions offer the potential to improve rural livelihoods and ecosystem services conservation over the long-term.

KEYWORDS rural livelihoods, ecosystem services, integrated landscape approaches, coffee, Dominican Republic

INTRODUCTION

Integrated conservation and development efforts recognize the linkages between household-level livelihood strategies and the complex economic-social-environmental relationships of a given area (van Vliet 2010). Livelihood strategies are influenced by local, regional, and global factors across many scales (A. J. Bebbington and Batterbury 2001). For instance, key ecological processes occur across plot, farm, landscape, and regional climate scales in rural landscapes, requiring integrated research methods (Liu et al. 2007; Milder et al 2011). Visible changes and their explanations, in terms of livelihoods and landscapes, also require an analysis of factors over the medium to long-term (Zimmerer 2007). Multiple scalar and temporal influences pose a series of challenges for researchers, decision makers and stakeholders seeking to simultaneously support rural livelihoods and conserve ecosystem services in rural landscapes (Buck et al. 2007; Rapidel et al. 2011).

In shade coffee landscapes, broad social, economic, and political forces influence producers and the management of their coffee systems (Jha et al. 2011). Volatility in the global commodity coffee market, trade liberalization, and falling prices have had a profound impact on the up to 25 million coffee farming families and the landscapes they inhabit worldwide (Bacon et al. 2008). Despite some recovery in prices, such trends have caused great difficulty for many farmers, who are pressured to increase short-term production at the expense of shade trees and/or traditional farming methods. Working against these global market forces are increasingly knowledgeable consumers who are interested in product provenance from healthy, safe, environmentally benign production. For example, this awareness has increased demand for certified coffee, a market-based financial incentive for local farmers to produce more sustainably for the international market (Giovannucci 2003).

To investigate the complex tradeoffs between immediate livelihood needs, higher price premiums for certified coffee, and longer-term resource and environmental conservation across multiple scales, this research incorporated an interdisciplinary, participatory action framework focused on coffee farmer households in the Pico Duarte region of the Dominican Republic. The complex and highly dynamic tropical landscape of this remote, mountainous region provides an ideal case study of the tradeoffs and potential synergies

between rural livelihood development and ecosystem services conservation. A rich literature documents the ecological benefits of bio-diverse shade-grown coffee, generating value to stakeholders from local to global scales (Jha et al. 2011; Philpott, Arendt, et al. 2008). Biodiversity conservation is one of the most tangible benefits of more ecologically complex multistrata coffee systems, but the short-term versus long-term tradeoffs with supporting sustainable livelihoods is less clear (Perfecto et al. 1996; Toledo and Moguel 2012).

This empirical research, which took place between 2009 and 2010, provides important contributions to the growing body of literature on shade coffee and rural livelihoods as it is among the first to use this framework in a Caribbean coffee producing country. We addressed three primary questions: (1) What is the contribution of shade coffee plantations to the conservation of ecosystem services, such as erosion regulation, carbon sequestration and recreational amenities? (2) What social networks and economic factors affect the ecosystem services conservation potential of smallholders and their cooperatives? and (3) How do national and international market forces and actors affect coffee farmer livelihoods and ecosystem services conservation? This article is organized to first consider various conceptual frameworks from the literature available to analyze the multiscale tradeoffs between conservation and development goals. Then, the context of coffee landscapes is developed, including the particular characteristics of the Dominican Republic case. Next, results are presented on aspects of farmer household livelihoods, including income, consumption, food security, education health, and savings, followed by results on coffee farm agrobiodiversity and farmers' perception of ecosystem services benefits. Finally, the discussion and conclusions focus on the potential for field-level data to be integrated into higher levels of the decision-making process, including local agricultural associations, companies purchasing coffee, and national and international development organizations. This integration is examined as a means to support the market and institutional frameworks needed for sustainable landscape management within the Pico Duarte region over the long term.

FRAMEWORKS FOR MULTISCALE INTEGRATION OF CONSERVATION AND DEVELOPMENT

There are numerous conceptual frameworks that address the challenges of integrating conservation and development, which range in focus from household to landscape to political system. One commonly utilized approach among international development organizations draws from the concept of sustainable rural livelihoods, which can be defined as the assets and capabilities people use to secure a living, and their efforts to make it meaningful (Chambers and Conway 1992; Scoones 1998; Carney 1998; Ellis

2000; Bebbington 2001). Emphasis is placed on the sustainability of various household assets or capitals, including natural (e.g., deforestation rate, level of erosion), physical (e.g., rural access to roads, electrification, water supply, housing quality), social (e.g., social organization, corruption, local networks, awareness of boundaries), financial (e.g., remittances, credit associations, employment), and human capital (e.g., quality healthcare and education, skill levels, infant mortality). While widely used by development organizations, a sustainable livelihoods approach has not been central to many conservation projects.

The ecosystem services framework is a more recent approach, which is useful to better explain the links between household activities and the maintenance and impact of ecological function, within the context of integrated conservation and development objectives (Tallis et al. 2008). The maintenance of and access to natural capital stocks and flows, one of the five capital assets identified in the sustainable livelihoods approach, is fundamental to the ecosystem services framework (DeGroot 1992; Costanza et al. 1997; Daily et al. 1997). Mainstreamed in recent years by the Millennium Ecosystem Assessment (2005) ecosystem services are often categorized into four broad areas of provisioning (e.g., food, fiber, and fuel), regulating (e.g., climate, flood, water quality, and disease regulation), supporting (e.g., soil formation), and cultural services (e.g., spiritual, aesthetic, heritage, and recreational and tourism benefits). As in livelihood approaches, ecosystem service flows to humans can be mediated by broader sociopolitical processes and individual livelihood choices to the benefit or detriment of well-being. Understanding these complex interactions requires contextual multiscale analysis.

A third approach focused more on the broad sociopolitical context is political ecology (Bebbington and Batterbury 2001; Zimmerer and Bassett 2003; Zimmerer 2007). Bebbington and Batterbury (2001) stress the significance of "transnational livelihoods" and the "analytical value of grounding political ecologies of globalization in notions of livelihood, scale, place and networks." A significant body of political ecology work focusing on rural livelihoods has analyzed the complexities resulting from the interactions among local people and ecologies, and higher political, economic and social processes at larger geopolitical scales (Robbins 2004; Watts and Peet 2004). As local initiatives become increasingly involved with global actors, the local landscape can be seen, at the same time, as a transnational landscape subject to varying directions and influences.

These three approaches operate along a spectrum from household to landscape to macroeconomic strategies, but have in common a priority of understanding the maintenance of critical social and ecological assets for sustainable development. The maintenance of ecosystem services from natural capital conservation has beneficiaries that also span from household to national and international scales. A key opportunity to integrated

conservation and development is to identify and align land-use practices that provide ecosystem services to multiple beneficiaries at multiple policy scales. However, the monitoring and evaluation frameworks used by most conservation projects focus on assessing single conservation outcomes, such as the status of rare species or the quantity of high conservation value area preserved. These approaches regularly fail to capture the impacts of conservation measures on local livelihoods or the impacts of development activities on conservation outcomes (Reed et al. 2008; Wells and McShane 2004). In most cases, local stakeholders are being asked to provide stewardship on the behalf of external interests without compensation for the opportunity costs of alternative land use. For example, Sayer et al. (2007) developed a set of "conservation indicators" to reflect assets valued primarily by conservation organizations (e.g., rare species and critical habitats) and valued less so by local people. However, local providers of ecosystem services and their rural communities manage resources based on services specific to their livelihood needs (i.e., food, firewood, and water quality) before managing for broader service provisions (i.e., biodiversity and carbon sequestration) (Programa Salvadoreño de Investigación sobre Desarrollo y Medio Ambiente [PRISMA] 2003).

One option to better align global conservation concerns with local livelihood priorities has been to capture non-local values through payment instruments and capacity development from non-local beneficiaries (Wunder 2008; Milder et al. 2010). Successful policies might include packages to meet self-provisioning ecosystem services before moving on to support other producer strategies related to ecosystem services at higher scales. Coordinating such efforts will require simultaneous investments in social capital to strengthen community capacity for decision-making (Kandel and Cuéllar 2011). For instance, coordination can be achieved by investing in the social and technical capacity of small-scale farmers and their organizations to manage low input, diverse agroecological systems across a landscape (Perfecto and Vandermeer 2008; Méndez 2009).

New monitoring and evaluation methods to assess environmental outcomes and changes in individual livelihoods resulting from landscape-scale interventions have been developed (Buck et al. 2006). These methods underscore the importance of participatory processes, such as community focus groups and capacity building, to better incorporate the values of local stakeholders as the primary stewards of their landscape and natural resources. Landscape approaches to a new generation of integrated conservation and development planning place less emphasis on interventions to mitigate threats to the household and more on creating incentives to encourage specific land-management practices that achieve multiple benefits, including ecosystem services conservation, food production and poverty reduction at scale (Scherr and McNeeley 2008).

CASE STUDY IN THE PICO DUARTE REGION OF THE DOMINCAN REPUBLIC

Shade coffee regions have been recognized as landscapes with great potential to support both rural livelihoods and provide ecosystem services (Perfecto et al. 1996; Jha et al. 2011; Perfecto and Vandermeer 2008). On the livelihood side, inter-planted tree, fruit, and crop species in shade coffee systems provide important sources of income and food security to households (Méndez 2008; Bacon 2005). For ecosystem services, shade coffee ecosystems have higher potential than full sun coffee plantations to protect hydrological services, provide more diverse habitat, and conserve soil resources. Balancing the tradeoffs between environmental and agricultural benefits in coffee landscapes is a natural case study to explore better strategies for integrated conservation and development planning. This section provides general background on this potential, and then introduces the Pico Duarte region of the Dominican Republic as a focus of study.

Conservation Potential of Shade Grown Coffee Landscapes

Moguel and Toledo (1998) proposed a useful typology that highlights the tradeoffs between environmental and agricultural benefits for coffee landscapes along a gradient of management intensity, including: (a) rustic (i.e., coffee under intact forest canopy); (b) traditional polyculture (i.e., coffee under a diverse shade canopy); (c) commercial polyculture (i.e., coffee under a moderately diverse shade canopy); (d) shade monoculture (i.e., coffee under one or two shade tree species); and (e) sun monoculture (i.e., coffee under no shade canopy). Recent analysis documents the various ecosystem service provisions offered by these schemes in relationship to both scale of delivery and management by stakeholders (Jha et al. 2011). Sun and shade coffee monoculture systems offer little soil erosion reduction services and organic matter while commercial to traditional polycultures offer a range of services from local to global levels. Shade coffee systems are also important repositories of trees and epiphytes, mammals, birds, reptiles, amphibians, and arthropods, and can offer organisms habitat to travel through forest fragments between protected areas (Perfecto et al. 2009). For example, in the Dominican Republic, bird biodiversity of endemic, native, and migrant species can benefit from shade tree presence in coffee plantations (Wunderle 1999).

Soil preservation has also been noted in shade coffee plantations relative to open regimes. Studies in Indonesia showed significantly greater earthworm and litter layer biomass in multistrata coffee systems versus sun coffee, though simple shade systems were little better than sun coffee (Hairiah et al. 2006). Water quality benefits would also be expected to be higher in a

shade coffee system than in full sun plantations, although concrete ecological evidence on this is hard to measure. Ponette-Gonzalez et al. (2014) recorded 5–11 times less throughfall in shade coffee systems in Veracruz, Mexico, than in surrounding natural forest. Similarly, analysis from the Way Besai Watershed in Indonesia demonstrates that coffee-based agroforestry systems can perform important watershed service functions, similar to those of natural undisturbed forest (Suyanto et al. 2007). Shade coffee plantations have also been suggested to play a greater role in climate change mitigation (Lin et al. 2008; Méndez et al. 2012) and in reducing the impacts of hurricanes (Philpott, Lin, et al. 2008).

The economic value of these ecosystem services can be significant. For example, in the Dominican Republic, the Department of Environment and Natural Resources (SEMARENA) initiated a national payments for ecosystem services (PES) program in 2008. Ecosystem services, such as soil erosion mitigation and carbon sequestration, represent positive externalities of shade coffee production, not yet valued in formal markets. The economic value of water produced by areas in the Dominican Republic under shade coffee polycultures is estimated at US $0.05 (RD $1.91) per cubic meter. Similarly, the potential value of carbon sequestration in shade coffee polycultures was estimated at US $44 million (Instituto Dominicano de Investigaciones Agropecuarias y Forestales [IDIAF] 2006). Perennials such as coffee trees also store carbon while reducing runoff and enhancing water quality (Lin et al. 2008). Financial compensation to landowners for management strategies that conserve ecosystem services could lead to significant support for the Dominican coffee sector and for the sustainability of its water resources (Heindrichs 2008).

Study Area

The complex and dynamic tropical landscape of the Pico Duarte coffee region of the Dominican Republic was chosen for a case study due to its importance for both rural livelihoods and ecosystem services conservation. Located in the Central Cordillera of the Dominican Republic on the island of Hispaniola, the region spans more than 200,000 ha to encompass the upper watershed of the country's largest river, the Yaque del Norte (Figure 1). The river provides a major source of drinking water to downstream cities and irrigation for agriculture. The river also provides power for 2 of the country's 17 hydropower plants, which produce an estimated total output of 400 megawatts (Siegel and Alwang 2003). The headwaters are largely contained in the province of La Vega with an estimated 2010 population of 429,563 people and a density of about 188 people/km^2. The major city of the region is Jarabacoa, population 69,855 (Oficina Nacional de Estadistica de la Republica Dominicana [ONE] 2012), with an economy based primarily on agriculture (i.e., strawberries, coffee-*Coffea arabica*, chayote-*Sechium*

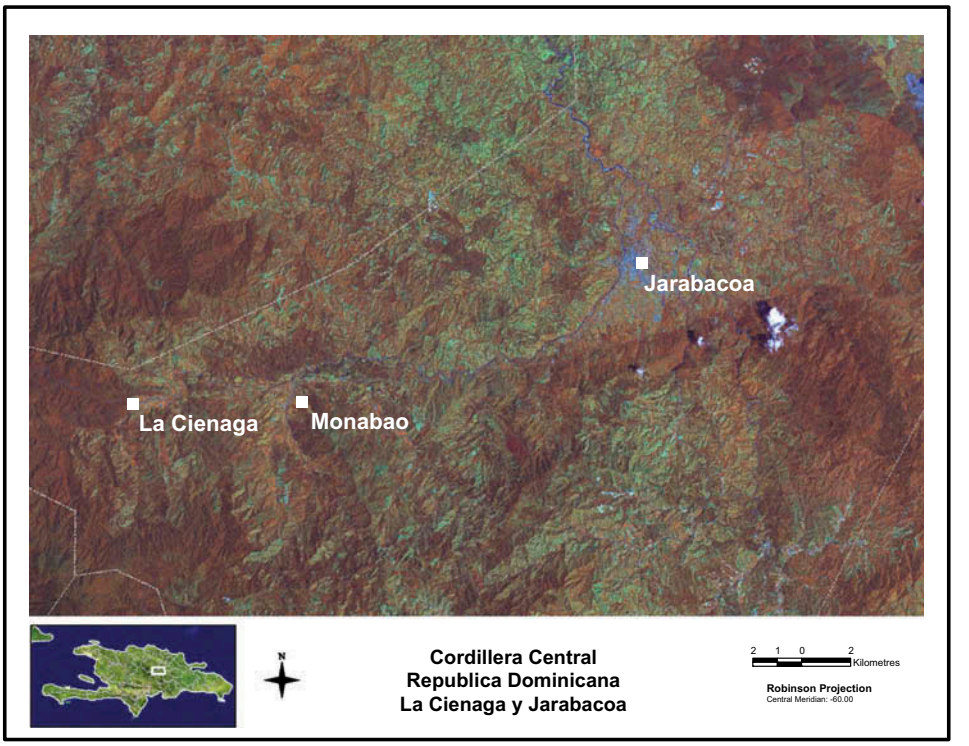

FIGURE 1 Pico Duarte Coffee Region, Central Cordillera, Dominican Republic.

edule), tourism (e.g., rafting, hotels and nightclubs), and real estate of second homes owned by wealthier, urban Dominicans. Since 2000, real estate and tourism have played an increasingly greater role in the local landscape and economy with many large-scale housing developments now occupying once productive cropland (C. Wallace, personal communication, July 15, 2009). The topography is steep and rugged with elevations from 525 m to over 3000 m in the Armando Bermúdez National Park, containing the highest mountains in the Caribbean. The Holdridge ecosystem classification is subtropical moist forest, with modest rainfall (1,000–1,500 mm/year), rich vegetation, and acidic soils (Wunderle and Latta 1998). The area experiences seasonal climatic temperatures unique for the Caribbean, sometimes reaching freezing temperatures in the winter months (January–March) at higher elevations (San-Martin 2007).

Historical agricultural practices by farmers in the region are related to high rates of deforestation, soil erosion and watershed degradation (Geisler et al. 1997). In recent years, much attention has been paid to the management of protected areas for the conservation of biodiversity and ecosystem services, such as water regulation, carbon sequestration, and recreation (Parks in Peril Program 1997). Protected areas represent less than 5% of this working

agricultural landscape. However, shade coffee farms in the region, a historically important land use, have the potential to support both rural livelihoods and conserve ecosystem services (Vandermeer and Perfecto 2007). Similar to other tropical countries, most Dominican shade coffee farmers are smallholders, managing only one to 3 ha of land. Farmers generally depend on family members for labor, lack access to land tenure, and live at or below poverty levels (IDIAF 2006). Falling coffee prices, trade liberalization, and rising input costs have made life more difficult for these small farmers (Taylor et al. 2008). Since 2002, these increased economic pressures have led to significant changes in the landscape. For example, from 1997 to 2006, more than 100 smallholders switched 84 ha of shade coffee land in the Manaboa region to monocultures of chayote squash and beans, and continuous grazing of cattle (Galtier et al. 2007).

The implications for ecosystem degradation, primarily from increased soil erosion, have local, regional, and nationwide impacts. On the farm, food security benefits from interplanted tree and fruit species within shade coffee plots have historically served as an important livelihood strategy. At regional and national levels there is the potential for increasing negative impacts from sediment loads to downstream hydroelectric facilities and reservoirs for drinking water to major cities (Heindrichs 2008). The Dominican Republic has experienced extensive forest conversion, with estimates placing overall original forest loss at greater than 90% (S. C. Latta 2005). Globally, the region's plant biodiversity and high rate of bird endemism has led to recognition as a biodiversity hotspot (S. Latta et al. 2008). While deforestation has stabilized and many protected areas dot the landscape, coffee production provides a means to retain needed canopy cover and connectivity between forested areas, while maintaining agricultural productivity.

Development organizations have addressed these challenges with limited success by supporting small- to medium-sized enterprises that conserve natural resources through specialty coffee markets, ecotourism, and other forms of economic diversification. Persistent poverty remains a significant challenge to conservation efforts. While high rates of poverty are common in much of the rural Dominican countryside, they are most prevalent among coffee farming communities. A study performed by the IDIAF in 2005 concluded that 73% of coffee households live in a constant state of poverty, with 25% living in extreme poverty (IDIAF 2006).

METHODS

To support the next generation of integrated conservation and livelihood strategies in the region, this study was conducted with local support from Finca Alta Gracia (a nonprofit research, education, and demonstration farm), the IDIAF (a quasi-governmental organization that manages production,

research and extension at Finca Alta Gracia), Vermont Coffee Company (a U.S. roaster importing coffee from the area), and La Asociación de Caficultores Jarabacoa ([ASCAJA] a coffee farmer association located in Jarabacoa). Organized in the late 1970s, ASCAJA includes almost 600 farmers in 30 communities, managing almost 18,000 ha of agricultural land in the Pico Duarte region. Baseline information was collected from ASACAJA members through 2 community focus groups, 42 household interviews, and 14 biodiversity transects in order to: (a) document and analyze the livelihood strategies of coffee farmers in the region, (b) examine existing organizational models to better support farmers' identified needs, and (c) analyze the relationship between ecosystem services conservation and farmer livelihoods.

PARTICIPATORY GROUP MEETINGS

Two group meetings were held in order to: (a) introduce the research to the surrounding communities of Finca Alta Gracia; (b) perform a series of livelihood assessments with households to determine local land use history and primary sources of income and consumption; (c) offer growers technical assistance through a professional coffee tasting and evaluation (i.e., cupping) by technicians from IDIAF; and (d) refine household survey questions before broader surveying. The format was based on livelihood exercises performed in forest product dependent communities of Indonesia and Africa (Program on Forests [PROFOR] 2009), with an emphasis on the role of coffee and other agricultural trends in the two communities of Rio Yanque Del Norte. The first activity was a community historical timeline and trends to capture a short history of the two communities regarding important social, economic, and climatic events and the past, present, and future of land use and livelihood strategies. A second activity was a livelihood analysis of household income to explore the extent of currency and subsistence reliance on coffee and other sources (e.g., crops, remittances, and livestock) and their proportion of the total annual livelihood from all sources.

The second participatory group meeting was held after farm surveys were completed and analyzed. The format for the gathering was a presentation by researchers and discussion. Approximately 30 individuals were in attendance including stakeholders from ASCAJA, IDIAF, Finca Alta Gracia, CODOCAFE (the Dominican government coffee agency), and other development organizations. Preliminary findings on household education, income, consumption, food security and land use were presented. This was followed by a roundtable discussion by stakeholders and a community visioning exercise. Community members identified a number of local projects such as small-scale chicken farming, a farmer/tourist's market in the central community of Los Dajaos, increased agroecotourism at Finca Alta Gracia, and an improved water delivery system for the near future.

Household Surveys

In the weeks following the first group meeting, a final survey was constructed, a local research assistant was hired and trained, and surveying of households commenced. In total, 42 household surveys were performed between May and August of 2009 in nine communities within the Pico Duarte watershed. A list of members, farm size and management type was provided by ASCAJA leadership. This list was then stratified by size of producer (i.e., small, medium, and large) and by management type (i.e., conventional, organic, and transitional to organic), and households were chosen at random from each category. Survey variables included: (a) Description of the household (structure, ages, gender, education, occupations, income, health concerns, savings); (b) access to infrastructure and services (e.g., electricity, water, schooling, medical care, etc.); (c) products and benefits from coffee plantation products (e.g., firewood, coffee, fruit, and eco-tourism); (d) income sources; (e) incidence of out-migration (e.g., number of members and destiny); (f) perceptions on the importance of applying agroecological principles and conserving natural resources; and (g) knowledge, perceptions and interest in different coffee certification programs and strategies to diversify their livelihood.

All statistical analysis was performed using SPSS statistical software version 18.0 (SPSS, Inc. Chicago, IL, USA). Yields, price, and gross income were log transformed for normality using Levene and Kolmogorov–mirnov tests. An analysis of variance (ANOVA) was performed to compare yields, price, and gross income between management classes. Pearson's tests were utilized to investigate correlation between species diversity and variables such as farm size, management type, and harvestable species.

In order to analyze and document coffee farmer livelihoods, a descriptive typology was developed to categorize farms by size and management type. First, between-group linkage and Ward's cluster methods were employed to identify typological associations between variables. However, no significant groupings were revealed due to the breadth of data collected and a relatively low sample size. As in other coffee producing countries, farm size provided a good proxy for production type and degree of commercialization (Bacon 2006; Comision Economica para America Latina y el Caribe 2002). In addition, three primary producer types in the Dominican Republic had been identified by IDIAF (2008), including traditional, medium technified, and modern. The combination of farm size and IDIAF's categorization provided a usable typology for analysis (Table 1).

Agrobiodiversity Transects

Following completion of household surveys, shade tree and crop diversity transects were completed in a random sample of 14 of the 42 shade coffee

TABLE 1 Dominican coffee farmer typology (IDIAF 2008)

Traditional producer ($n = 22$)	−Family labor. Contract only for only certain activities (e.g., harvest) −No major capital investments −Principal source of income: activities outside the farm and family −Level of farm technology: *low*
Moderately technified renovated producer ($n = 14$)	−Family labor. Contract for certain activities, including all the harvest −Limited capital investments (e.g., manual pulpers, patio for drying) −Principal source of income: coffee −Level of farm technology: *medium*
Technified or modern capitalistic producers ($n = 6$)	−Contract labor −Significant capital investments (e.g., mechanical pulpers, greenhouses) −Principal source of income: coffee, commercial and industrial activities −Level of farm technology: *high*

farms interviewed to document the different species present. The southeast corner of each farm was sampled within a 20 × 50 m quadrat. All crop and tree species greater than 10 cm in height were identified and counted. The periphery was walked again to determine any discrepancy. Edge effects were reduced through the establishment of each transect at a minimum of 20 m from major roads. Transects were also delineated at a minimum of 20 m from the farmhouse, unless farm size was too small, in order to reduce bias toward crop accessibility. Farmer participation was solicited to help identify species and confirm farm shape/size. The 14 transects included a cross section of 7 small (0.5–2 ha), 4 medium (2–5 ha), and 2 large (5+ ha) farms. Species diversity was calculated using the Shannon diversity index in Estimates 8.2 Software for Macintosh (Colwell 2010). The Shannon diversity index takes both species abundance and evenness into account and is widely used for purposes of biodiversity comparison.

RESULTS

Household Characteristics (Education, Income, Consumption, and Savings)

The mean farmer's age was 57 years with the youngest aged 25 and the oldest aged 78. In total, 135 individuals were documented within households, 81 male and 54 female, with a mean household size of 3.8 individuals. Most of the sons and daughters of the interviewed coffee growers (63%) were being educated through primary school, with no apparent gender bias. Seventy percent of all individuals reported knowing how to read and write.

Twenty three percent of the household heads reported not knowing how to read and write; 16% had no formal education; and 54% had 1 to 6 years of schooling. Five individuals across the entire sample (4%) had received degrees from a university. Two were heads of household and two were from the same household. According to the World Bank, in 2001 about 25% of rural household heads had no schooling at all and about 60% had 1–6 years of schooling. The lack of education and basic reading literacy is seen as a constraint on improving agricultural productivity, particularly in sectors of increased global competition such as coffee and cocoa (Siegel and Alwang 2003).

All farmers interviewed produced coffee. Less than half (42%) of all producers relied on coffee for 25–49% of their income; a quarter relied on coffee for 50–74% of their income; and the remaining producers relied on coffee for either less than 25% (6) or more than 75% (5) of their income. Other primary sources of income (income sources employed by more than 20% of all households) included: animals, chayote squash, government support, other work (day labor) and fruit. A summary of livelihood and income sources is presented in Figure 2. Day labor (other work) and sales of *viveres* (starchy vegetables) provided significant sources of income for smaller producers, while chayote squash and sales of animals (pigs, cattle, and chickens) provided income for medium to large producers with more land.

Organic and transitional farmers reported using most of their savings to pay day labor for the additional farm maintenance needed during the non-harvest season (i.e., weeding, composting, pruning). This resulted in

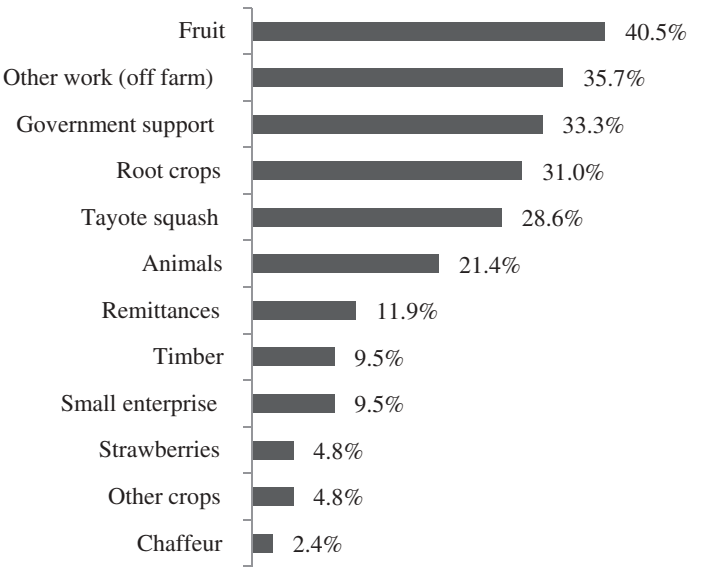

FIGURE 2 Farmer livelihood and income sources other than coffee.

decreased savings for 42% of organic and 52% of transitional producers. For conventional producers, 54% had seen no change in their state of savings, with 18% increasing and 27% decreasing. Despite these figures, conventional farmers' savings were perceived to be the most stable. Organic farmers had the highest percentage of total savings and increase in savings at 20%. However, 70% experienced a decrease in savings or no change at all.

Farmers were asked a series of questions regarding household consumption and food production. The majority (71%) of respondents possessed a *cunuco* or food plot located near their house or coffee plot. In the Dominican Republic cunucos are full of viveres or starchy vegetables (i.e., yuca, potato, banana and plantains) while *jardines* are small ornamental gardens located primarily around the house. Households were asked about the presence of both in relation to household consumption. Despite such a large percentage of respondents with cunucos, the average farm produced only 33% of their basic food necessities, purchasing the remaining two thirds. Families spent between US $111 and $277 a month (mean = US $194) on dietary staples of mostly rice, beans, eggs, and cooking oil. Eighty two percent of households reported having difficulty covering basic food necessities at some point during the year. Of the 42 respondents, 32 (76%) of the total experienced food insecurity on an annual basis, primarily in the months just before the harvest (July–October). At this time of the year, income from the previous year's harvest had usually been spent on basic necessities and the necessary farm investments throughout the year. For other expenses, 79% were unable to cover medical and 57% unable to cover basic education expenses. Seventy eight percent of households reported prolonged sickness, which had kept them from working at some point in the past three years.

Cooperative Dynamics

Most producers (60%) reported that their primary benefit as a member of the local coffee growers' association was access to small loans or *prestamos*, followed by access to markets with organic certification premiums (21%), processing equipment (7%), and gifts of plants from the nursery (7%). For small producers, obtaining major loans from banks was reported as difficult, if not impossible without land tenure as collateral. Coffee farms in the Dominican Republic often serve as collateral for small loans, but these loans come from intermediaries that charge high interest rates. The cooperative itself had been subject to one of these "sharks" and was struggling to pay back a large loan charged for infrastructure investments over the 2005–2008 period. Only one producer specifically mentioned access to higher prices as a primary benefit; however other producers also mentioned this as a secondary benefit. Local knowledge of prices is conveyed mainly through friends and intermediaries, while international prices are communicated by radio and television. The mean membership tenure was

11 years, with the shortest being a member in his first year and the longest was one of the founding members in his 28th year. The cooperative's day-to-day management was delegated to a president, who was a farmer himself, and an administrative staff member, with a board of directors in charge of overall decision making. Interviews with these members suggested that the cooperative's low administrative capacity had affected its ability to provide services to members and to negotiate directly with international buyers for organic certification premiums (Martinez-Torres 2006).

Farm Characteristics (Size, Age, Land Tenure, Coffee Yields, and Price)

Overall this study's results on farmer characteristics were consistent with the typology presented by IDIAF (2008). Small producers ($n = 22$) were classified as those producing from 0 to 2 ha in coffee, or who possessed a total farm size between 0 and 7 ha ($n = 18$). Medium producers ($n = 14$) ranged from 2 to 5 ha in coffee with a total farm size of 7 to 20 ha ($n = 15$). Large producers ($n = 6$) possessed more than 5 ha in coffee with 20 ha or more in total ($n = 9$). The mean farm size was 11.42 ha, with a range 0.5 to 127 ha. The average coffee plot was 2.02 ha with the smallest at 0.5 ha and the largest at 14 ha. Globally, most smallholder coffee farmers manage between 1 and 3 ha (Petchers and Harris 2008). Under these standards, 85% of farmers interviewed can be considered small scale.

The mean time of possession for a farm was 43 years with the newest being 10 years and oldest being 77 years. Only 17% of farmers reported having formal title to their land while 83% did not. The number of farms without title was higher than national figures, which report highly skewed land distribution with less than 50% of the rural population having access to formal land titles (Lopez 2001).

High gross returns were obtained via all production methods with only small differences in price received across management types with varying costs to production. As shown in Table 2, transitional coffee had the highest yields (569.5 kg/ha) and gross returns (US $1,139.00 ha) at the

TABLE 2 Coffee yield, price paid (pergamino), and production cost magnitude

Coffee type	Yield kg/ha	Price $/lb (.45 kg)	Gross $/ha	Prod. Cost
Certified organic ($n = 13$)	407	$1.15	$814.00	++
Conventional ($n = 11$)	511.5	$1.07	$1,094.00	+
In transition to organic ($n = 18$)	569.5	$1.09	$1,139.00	+++
ANOVA	$F = 0.452$, $df = 2$, $P = 0.640$	$F = 0.730$, $df = 2$, $P = 0.488$	$F = 0.052$, $df = 2$, $P = 0.949$	

second highest price (US $1.09/lb). Conventional coffee provided intermediate yields (511.5 kg/ha) and gross returns (US $1,094.00/ha) with the lowest price (US $1.07/lb). Certified organic coffee had the lowest yields (407 kg/ha) with the lowest returns (US $814/ha) at the highest price (US $1.15/lb). However, differences between yields ($F = 0.452$, $df = 2$, $P = 0.640$), price received ($F = 0.730$, $df = 2$, $P = 0.488$), and gross return ($F = 0.052$, $df = 2$, $P = 0.949$) were not statistically significant, nor correlated to management type.

Production cost magnitude was estimated based on the additional units of labor required (i.e., labor days), which contributed to higher costs of production. A study by IDIAF (2006) reported that labor represented 91.8% of the cost of production for traditional producers, followed by 87.1% for medium-technified, and 72.4% for modern producers. No Dominican studies were identified with estimates of labor intensity by management type, but personal communication suggests that herbicide use on conventional farms decreases associated labor costs. Therefore, organic and transitional are seen as having higher production cost magnitudes. The average labor rate in the region ranged from RD $300–$350 or US $8.33–$9.72 per day. On larger farms, Haitian migrant labor is often employed.

On the revenue side, most farmers interviewed identified prices paid for coffee (*pergamino*) in the 2008 harvest as sufficient (40%) or good (64%). Twenty one to thirty one percent of producers felt like prices were not sufficient, bad, or very bad. One producer reported foul dealings with an intermediary, which led to poor relations and very low prices. The data reflects that conventional farmers were the least satisfied with prices. State of transformation was also analyzed to understand how much value was added and returned to the producer by processing. Value added through processing can serve as a means for vertical diversification of household income (Varangis et al. 2003). Drying added the most value at $0.27 per pound, however, most members sent their beans to the processing plant or *beneficio* at ASCAJA, in Jarabacoa, for drying, where US $0.10 was charged for transportation and drying per pound. Drying coffee in the Dominican Republic can be a significant challenge since the harvest coincides with the rainy season. The use of drying tunnels at the ASCAJA beneficio represents a significant benefit to cooperative members to maintain and improve coffee quality. Constraints included harvesting, hulling, and transporting to drying tunnels on the same day. Preliminary analysis of access to infrastructure suggested that all members have access to manual de-pulpers, but lacked small-scale drying tunnels within an appropriate distance for improving drying efficiency the day after harvest.

Agrobiodiversity Transects

All farms possessed Arabica coffee with the two main varieties, *Tipica* and *Caturra*, grown at elevations of 700 m or above. The Dominican Republic

grows almost entirely Arabica coffee with only small amounts of robusta grown for internal consumption. Most producers possessed 75% or more *Tipica* with 25% or less *Caturra*. *Tipica* is a tall, more traditional, older variety, which produces higher quality coffee, with relatively lower yields. *Caturra* is smaller and bushier than *Tipica*, with smaller beans and lower quality, but with higher yields. *Caturra* can be grown in pure stands without shade, enabling easier application of agrichemicals (IDIAF 2006). According to Siegel and Alwang (2003), about 75% of coffee producers had only *Tipica* trees and 64% of land area was under *Tipica*. This survey confirms only minimal increases in *Caturra* or *Tipica* interplanting despite national efforts in recent years to increase mixed production. This represents a positive sign for increasing coffee quality under strict *Tipica* production.

Biodiversity transect data suggest that all management types and farm sizes exhibited similar shade tree and crop species richness and abundance ($F = 0.48$, df $= 1$, $P = 0.830$). Farm age had no significant correlation to species richness ($F = 0.48$ $df = 1$, $P = 0.926$). Transects identified 39 species in the 14 plots for a total abundance of 1849 species. The most abundant species were Guama *(Inga vera)*, Guineo (*Musa paradisiaca*), and Yautia (*Xanthosoma sagittifolium)*. *Inga vera* was the most common shade tree, a native nitrogen fixing legume widely used in coffee plantations throughout the neotropics. *Xanthosoma sagittifolium, Musa paradisiaca*, and chayote squash (*Sechium edule)* were the most abundant crop species used for both sale and consumption. *Pinus occidentalis,* an endemic tree to the Hispaniolan landscape, was also found but in low numbers (30 individuals).

Related to the degree of on-farm biodiversity, farmers were also asked about a variety of non-market benefits related to shade coffee systems. Farmers recognized 14 ecosystem benefits for themselves and their families (Figure 3). A regression was run to determine if there was a

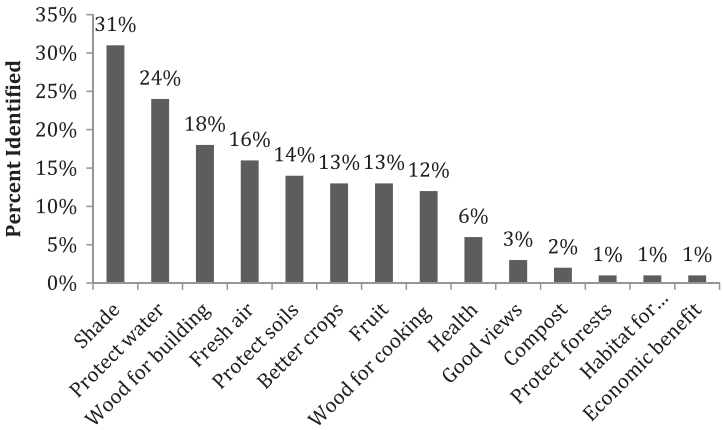

FIGURE 3 Farmers perceptions of ecosystem benefits from shade grown coffee.

relationship between farmers' perception of ecosystem benefits and greater crop biodiversity, however no significant statistical relationship was found ($R^2 = 0.00045$, $df = 1$, $P \leq 4.029$). A better approach would be to evaluate ecosystem benefits economically to be embraced on a practical level as suggested by Heindrichs (2008) in his evaluation of PES program in the Rio Yaque del Norte. However, all farms, independent of management or size, exhibited similar diversity in income sources. A larger sample size is needed to draw any significant conclusions.

DISCUSSION

Our first research question asked, "What is the contribution of shade coffee plantations to the conservation of biodiversity and ecosystem services?" The agrobiodiversity transect results support that 95% of documented coffee farm systems surveyed can be classified as commercial polycultures to traditional polycultures (Moguel and Toledo 1999). Recent analysis documents the various ecosystem service provisions offered by these production schemes in relationship to both scale of delivery and management by stakeholders (Jha et al. 2011). Table 3 summarizes the percentage of land cover under each scheme to examine the conservation potential of small producers and their management schemes on the Pico Duarte landscape. Producers identified a number of ecosystem benefits to themselves and their families from interplanted shade coffee systems ranging from provisions of shade, food, and firewood, to better crops, protection of water quality, and the prevention of soil erosion.

Most coffee producers, independent of size and management type, interplant coffee with shade trees, both fruit and timber, which led to similar species richness. These findings corroborate national surveys that found almost all coffee in the Dominican Republic is interplanted (Siegel and Alwang 2003). This study and Siegel and Alwang (2003) both confirm that the tendency to interplant is weakly related to farm size. Thus, despite different uses of technologies, virtually all producers in the Dominican Republic interplant, but diversified production systems are somewhat more important for smaller producers. These findings differ from studies in Nicaragua and El Salvador where farm size, management, and institutional factors played a greater role in affecting shade tree biodiversity and composition. The total number of tree and crop species at 39 species per 14 (20 × 50m) plots (2.79 species/plot), however, was found to be comparable to these studies at 130 species per 51 plots (2.54 species/plot) in El Salvador and 113 species per 49 plots (2.3 species/plot) in Nicaragua (Méndez et al. 2007).

Our second research question asked, "What social networks and economic factors affect the ecosystem services conservation potential of smallholders and their cooperatives?" Coffee farming households across

TABLE 3 Ecosystem services provisions and coffee systems in the Pico Duarte Region

Coffee system type	Potential ecosystem services offered	References	% of total land area in Pico Duarte region	# of farms in this study ($n = 42$)
Traditional polyculture: some forest trees and some planted timber and fruit trees	Alternative food/ timber sources, pollination, pest control, biodiversity, natural disaster protection, climate regulation	Jha et al. (2010), Philpott, Arendt, et al. (2008), Méndez et al. (2007), Toledo and Moguel (2012)	95%	22
Commercial polyculture: mostly planted canopy trees (timber and fruit trees) and N-fixing legumes, few very a genera	Alternative food/ timber sources, pollination, pest control, biodiversity	Jha et al. (2010), Philpott, Arendt, et al. (2008)		14
Sun coffee: with rare isolated trees or without tree canopy. Some shade monoculture: Canopy dominated with one species or genus of tree (e.g., *Inga spp.*)	Minimal soil erosion control and organic matter incorporation from coffee leaf litter	Philpott, Arendt, et al. (2008)	5%	2

management type and size demonstrated diversity in livelihood and management strategies. In coffee plots, farm diversity of interplanted shade tree and crop species contributed to moderate species richness relative to other shade coffee systems in Mesoamerica (Méndez, Bacon, Olson, Morris, and Shattuck 2010; Philpott, Arendt, et al. 2008). Households possessed a diversity of income and consumption sources with an average of four to six primary sources accounting for 20% or more of total household income. Sales of fruit were a source of income for 40% of producers, followed closely by food crops (31%), and chayote squash (28.6%). Fifty three percent of producers relied on coffee for less than half of their income. This suggests a higher level of income diversification away from coffee compared to other shade coffee households in Nicaragua and El Salvador (Bacon 2005; Méndez, Bacon, Olson, Morris, et al. 2010). Méndez et al. (2007) documented contributions of agrobiodiversity through greater varieties of interplanted food crops, orchids, and tree species that directly support farmer livelihoods.

Despite the ecosystem service benefit of their shade coffee systems, agricultural production is seemingly unable to generate sufficient income for

these small producers. With the cost of production estimated at US $0.44/lb of coffee by IDIAF in 2004, conventional producers' net income falls to around US $250 per household annually, which corroborates the conditions of economic poverty reported in regional statistics. Nonagricultural sources, such as day labor and government support, served as important sources of income to enable small producers to maintain their farms under current management. Larger and medium-technified producers with more land and capital were able to diversify into more lucrative crops such as chayote squash, animals and strawberries, whereas smaller producers were limited by lack of access to land, financial capital and water.

Any local or regional analysis of farmer livelihoods and management decisions should also analyze the underlying sociopolitical influences on land use change. In the Dominican Republic, coffee production is often characterized by a strong dualism. Previous national estimates found that while small producers own 76% of total land area, they account for just 30% of total production. Large producers own only 8% of land area, yet account for 50% of total production (Galtier and Batista 2008). In the Pico Duarte region, this dualism is equally prevalent, but less pronounced. Small producers are estimated to own 50% of the cultivated land and account for 30% of total production. Coffee production among smallholders is significantly lower at approximately 200 kg/ha compared to over 2500 kg/ha among larger, more technified producers (IDIAF 2006). This can be attributed to the fact that smallholders' farms tend to be located on marginal lands at lower altitudes, possess older plants, use fewer inputs, and have less access to capital.

Dualism was equally prevalent in land tenure among the producers interviewed, with only 17% of farmers reporting to have formal title to their land. Rates are higher than national figures, which report highly skewed land distribution with less than 50% of the rural population having access to formal land titles (Lopez 2001). Insecure land tenure inhibited access to credit for producers from commercial banks. Sixty one percent of producers mentioned access to small loans as their primary benefit of being members of the cooperative, followed by increased market access, gifts of plants, and postharvest processing. The lack of land tenure among producers and the resulting lack of access to credit for small producers represents a source of livelihood and landscape vulnerability, which requires greater attention by government. Overall, the lack of access to financial services, particularly among rural populations, in the Dominican Republic results in suboptimal investment in the agricultural sector, lower productivity and growth, and skewed income distribution to larger producers (Siegel and Alwang 2003). However, since coffee is a perennial crop, two farmers surveyed were able to use their farms as a proxy for land ownership. These farmers had received loans from a local bank to be used for farm improvements, including labor for pruning, new trees for replanting, and fertilizers. Therefore, while a lack of formal title does not result in a complete lack of land tenure security, it

does serve as a major inhibitor for most farmers in the size and scope of investments to improve productivity. For example, some of the farmers in transition to organic suggested they were doing so out of a lack of resources for proper agricultural inputs.

In the household, the lack of basic literacy and education among family members remains a constraint to improving both societal well-being and agricultural competiveness. Historically, the Dominican Republic has among the lowest education and health indicators in the Latin American and Caribbean region due to a lack of investment in social development in rural areas (Lopez 2001). Comparatively, the low levels (70%) of literacy and secondary education (63%) among households surveyed in the Pico Duarte compared to national averages of 90% for literacy and 75% for secondary education (World Bank 2009) corroborate these findings. Association members identified numerous benefits of membership, but education and technical opportunities were not mentioned. Food security also remains precarious. Without improved returns or increased diversification into higher value products, households with coffee as the primary source of income are at risk of food insecurity. Future research is needed to understand the tradeoffs between time allocated to cash crops versus food crops and the historic price inflation of basic dietary staples.

Our final research question asked, "How do national and international market forces and actors affect coffee farmer livelihoods and ecosystem services conservation?" The low prices received by producers highlights the Dominican context and, more generally, the commodity nature of coffee. In 2008, the ASCAJA cooperative did not export coffee; therefore, all prices are reflective of the internal Dominican market set primarily by Indusrias Banielejas, C por A. (INDUBAN). INDUBAN controls 95% of the domestic market and about 20–30% of exports. Historically, INDUBAN paid the international price minus a predetermined marketing margin. However, during periods of low prices INDUBAN sets what it refers to as a "good quality" price, which remains constant for many months. Most coffee is purchased at or below this price. Since price is a reflection of quality, which is only partly determined by management, price premiums for certified coffee (i.e., organic, shade and social best practices) are not offered as in the international specialty market. This study confirms that no significant price premiums were associated with management type. High price premiums to producers are needed to demonstrate consumer's willingness to pay for a product that helps conserve biodiversity and promote sustainable land management practices (Giovannucci 2003; Perfecto et al. 2005). Experts agree that the region possesses the agroecological conditions needed for high quality coffee production (IDIAF 2006). However, nationally poor management and postharvest processing techniques have led to poor quality and a bad reputation in the international market, which stifles the export potential of small producers and their cooperatives. Given the region's prime growing

conditions, geographic indication of the Pico Duarte coffee region could serve as a way to "de-commodify" coffee in international supply chains and transfer additional value to smallholders for high-quality coffee (Galtier et al. 2008).

The crop varieties found within the coffee farmers, particularly those of small producers, can allow for the diversification of income sources, which can potentially lead to better management of labor and cash flows, and improve the management of risks due to fluctuating coffee prices or yields (Ellis 1998; Reardon 1997). In this case, coffee farmer's diversification is both a livelihood strategy in response to vulnerabilities, and also a result of engagement by higher-level institutional actors and processes. In household interviews, the influence of historical conservation and development projects on diversification of the farm was documented. Most notable was the Project to Manage the Upper Watershed of the River Yaque del Norte (PROCARYN). With primary funding from the German development organization, PROCARYN was established in 2002 with the primary goal to mitigate soil erosion in the watershed through improved land management practices. As a result of this project, most producers had received gifts of trees (primarily oranges, lemons, avocado, and pine) to be interplanted in their coffee plots. For larger producers, sales of pine resulted in significant sources of income generation on a 10-year harvest cycle. On the other hand, smaller producers reported only marginal financial returns from fruit sales, but production was important to household consumption. Conversely, historical government financing of root crops near protected areas in the Dominican Republic has been seen as a driver of deforestation, resulting in ecosystem degradation (Geisler et al. 1997).

In the Pico Duarte region, this has taken the form of policies that promote the increased production of chayote squash, beans and cattle by the Ministry of Agriculture and Environment. In the participatory meeting, one extension agent mentioned that development stakeholders introduced chayote squash to the region in the mid-1990s as a diversification crop for coffee farmers. The impact of chayote on the region has arguably had perverse ecological effects, moving beyond a crop of diversification to a monoculture crop for many producers. The likelihood that farmers will abandon coffee for monocultures crops remains precarious. Four farmers mentioned they did not wish to continue with coffee and preferred to grow more chayote, while five farmers mentioned they would grow less coffee and more chayote. However, farmers also mentioned a number of ideas for local entrepreneurship, including regional farmer's markets for vegetables crops, egg production, handcrafts and ecotourism.

Overall, the findings suggest that farmers recognize the role of their shade coffee systems in maintaining biodiversity (e.g., conservation of native tree species) and essential ecosystem services such as the delivery of clean water and soil protection. However, producers' ability to maintain farm

diversity is constrained by low prices and livelihood challenges, resulting in poverty (Oficina Nacional de Planificación 2005). These findings highlight the potential tradeoffs between biodiversity conservation and farmer livelihoods in coffee production (Philpott et al. 2007).

CONCLUSION

Findings suggest that increased agricultural extension for smallholder farmers, paired with capacity building for their associations could help to advance conservation and livelihood objectives in the region. At the farm level this would include extension services for farmers in post-harvest processing and for those in transition to better management practices such as organic production. At the cooperative level, capacity-building to improve the financial management and marketing of the ASCAJA cooperative would enable it to better provide essential services to its members, such as access to credit, and overall, improve the quality and marketability of its coffee to a global market. Financial resources tied to the social and conservation benefits have matured internationally and offer an opportunity that could benefit the ASCAJA farmers if they are able to meet the increasing requirements of international buyers. This would enable access to new markets for organic and shade grown coffee certification premiums that reward farmers for good land use practices in the absence of these incentives from the domestic market. For example, Vermont Coffee Company's marketing of high-quality, shade grown organic coffee from Finca Alta Gracia has led to increasing demand and a new premium market for local farmers with similar best practices.

The expansion of PES programs tied to watershed service functions could also play a more significant role to support conservation and livelihood objectives in the region. The Payment for Environmental Services Water Project (*Pago por Servicios Ambientales Hídricos en la Cuenca del Río Yaque del Norte* [PSA-CYN]) was initiated in 2008 with support from the Dominican hydroelectric sector and Ministry of Environment. The program offers a payment mechanism to land owners for the development of forest management plans, protection, and restoration of riparian areas and improved production practices for shade-grown coffee in the five municipalities that encompass the Rio Yaque del Norte's upper watershed (United States Agency for International Development [USAID] 2013). Globally, water supply PES schemes offer promise due to their ease for identifying beneficiaries and providers of service functions (Southgate and Wunder 2009). However, studies have noted the limitations encountered by smallholders to be incorporated into PES projects equitably (van Noordwijk and Leimona

2010). In the Pico Duarte, the lack of formal land titles and access to information by smallholder farmers warrants further attention (Corbera 2007). None of the farmers surveyed for this study were participants in the PSA-CYN program. Early evidence suggest that the program has been hampered by inconsistent appropriations, yet, even in the absence of payments, participating farmers have often maintained their conservation plan due to the co-benefits they receive through improved timber management and coffee production (USAID 2013). Evidence from this research and other studies should be used to improve PES design in the region.

In the case of the Pico Duarte region, farmer cooperatives, coffee companies, researchers, municipal governments and other local community stakeholders could serve as an integrated landscape initiative for collaborative dialogue, planning, management and monitoring of biodiversity and ecosystem services at multiple scales. However, this robust multi-stakeholder platform is still needed. Current initiatives such as the United States Agency for International Development's supported Jarabacoa "coffee and ecotourism clusters" represent two such platforms, given equal representation and power dynamics exist among smaller and larger farmer groups, and other regional stakeholder groups such as the hydroelectricity sector are included.

Farmers' perceived benefits of their shade coffee farms support their willingness to provide services if compensated for the opportunity costs of alternative land uses (Quintero et al. 2009). Future research requires a greater understanding of these tradeoffs for sustainable landscape management. Collectively, through diverse, low input, agroecological management, farmers exhibit great potential to contribute to the protection of native tree species biodiversity and the conservation of ecosystem services across the landscape, particularly watershed service functions. To achieve these means, a greater recognition of the interconnection between sustainable rural livelihoods, ecosystems, and economy is needed among stakeholder groups to help reverse the current trajectory and enhance the resilience of the Pico Duarte region.

ACKNOWLEDGMENTS

The authors would like to thank the farmers of the ASCAJA coffee cooperative of Jarabacoa. Secondly, the authors thank the staff of the Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF) and the many volunteers at Finca Alta Gracia who assisted with fieldwork. They are also grateful to the Vermont Coffee Company, including Paul Ralston, Bill Eichner, and Julia Alvarez. This work was completed as part of L. H. Gross' master's thesis for the Rubenstein School of Environment and Natural Resources at the University of Vermont.

FUNDING

Financial support was provided by a Research Opportunities Grant from the University of Vermont, the Conservation and Research Foundation, and the Gund Institute for Ecological Economics.

REFERENCES

Bacon, C. M. 2005. Confronting the coffee crisis: Can fair trade, organic and specialty coffees reduce small-scale farmer vulnerability in northern Nicaragua. *World Development* 33:497–511.

Bacon, C. M., V. E. Méndez, S. R. Gliessman, D. Goodman, and J. A. Fox, eds. 2008. *Confronting the coffee crisis: Fair trade, sustainable livelihoods and ecosystems in Mexico and Central America*. Cambridge, MA: MIT Press.

Bebbington, A. 1999. Capitals and capabilities: a framework for analysing peasant viability, rural livelihoods and poverty. *World Development* 27:2012–2044.

Bebbington, A. J., and S. P. J. Batterbury. 2001. Transnational livelihoods and landscapes: Political ecologies of globalization. *Ecumene* 8:369–380.

Buck, L. E., T. A. Gavin, N. T. Uphoff, and D. R. Lee. 2007. Scientific assessment of ecoagriculture systems. In *Farming with nature: the science and practice of ecoagriculture*, eds. S. J. Scherr and J. A. McNeely, 20–45. Washington, DC: Island Press.

Buck, L. E., J. A. Milder, T. A. Gavin, and I. Mukherjee. 2006. Understanding ecoagriculture: A framework for measuring landscape performance. Ecoagriculture Discussion Paper no. 2. EcoAgriculture Partners, Washington, DC.

Carney, D., ed. 1998. *Sustainable rural livelihoods: What contribution can we make?* London: Department for International Development.

Chambers, R., and G. Conway. 1992. *Sustainable rural livelihoods: Practical concepts for the 21st century* (Discussion Paper 296). Institute of Development Studies, University of Sussex, UK.

Colwell, R. K. 2010. *Estimates: Statistical estimation of species richness and shared species from samples*. Version 8.2.5, University of Connecticut, Storrs, Connecticut. from://purl.oclc.org/estimates (accessed November 15, 2010).

Comision Economica para America Latina y el Caribe. 2002. *Centroamerica. El impacto de la caidea de los precios del café* (LC/MEX/L.517). Mexico, DF: CEPAL.

Corbera, E., N. Kosoy, and M. Martínez Tuna. 2007. Equity implications of marketing ecosystem services in protected areas and rural communities: Case studies from Meso-America. *Global Environmental Change* 17:365–380.

Costanza, R., R. D'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, et al. 1997. The value of the world's environmental services and natural capital. *Nature* 387:253–260.

Daily, G. C., S. Alexander, P. R. Ehrlich, L. Goulder, J. Lubchenco, P. A. Matson, et al. 1997. Ecosystem services: Benefits supplied to human societies by natural ecosystems. *Ecological Society of America* 2.

Daly, H. E., and J. Farley. 2004. *Ecological economics: Principles and application*. Washington, DC: Island Press.

de Groot, R. 1992. *Functions of nature: evaluation of nature in environmental planning, management and decision making*. Groningen, the Natherlands: Wolters-Noordhoff.

Ellis, F. 1998. Household strategies and rural livelihood diversification. *Journal of Development Studies* 35:1–38.

Ellis, F. 2000. *Rural livelihoods and diversity in developing countries*. Oxford, UK: Oxford University Press.

Galtier, F., and I. Batista. 2008. *Estudio de la cadena de comercializacion del café en la Republica Dominicana*. Santo Domingo, Dominican Republic: Instituto Dominicano de Investigaciones Agropecuarias y Forestales.

Galtier F., G. Belletti, and A. Marescotti. 2008. Are geographical indications a way to "decommodify" the coffee market? 12th Congress of the European Association of Agricultural Economists (EAAE), Wageningen UR, the Netherlands.

Galtier, F., P. del Rosario, J. Camilo, U. Santos, J. Romero, H. Jiménez, et al. 2007. *Caracterización socioeconómica de las empresas cafetaleras en la República Dominicana*. Santo Domingo, Dominican Republic: Instituto Dominicano de Investigaciones Agropecuarias y Forestales.

Geisler, C., R. Warne, and A. Barton. 1997. The wandering commons: a conservation conundrum in the Dominican Republic. *Agriculture and Human Values* 14:325–335.

Giovannucci, D. 2003. *The state of sustainable coffee: A study of twelve major markets*. Cali, Columbia: CINECAFE.

Hairiah, K., H. Sulistyani, D. Suprayogo, Widianto, P. Purnomosidhi, R. H. Widodo, and M. Van Noordwijk. 2006. Litter layer residence time in forest and coffee agroforestry systems in Sumberjaya, West Lampung. *Forest Ecology and Management* 224(1):45–57.

Heindrichs, T. 2008. *Pagos por servicios ambientales en PROCARYN. Programa Gestión de Recursos Naturales Cooperación Técnica Alemana*. Santo Domingo, Dominican Republic: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Instituto Dominicano de Investigaciones Agropecuarias y Forestales. 2006. *Diagnóstico y Plan de la Caficultura Dominicana*. Santo Domingo, Dominican Republic: CODOCAFE.

Jha, S., C. M. Bacon, S. M. Philpott, R. Rice, V. E. Méndez and P. Laderach. 2011. A review of ecosystem services and farmer livelihoods in shade coffee agroecosystems. In *Integrating agriculture, conservation, and ecotourism: Examples from the field*, eds. B. W. Campbell and S. Lopez Ortiz, vol. 1, 141–208 (Issues in Agroecology Series). New York: Springer Academic.

Kandel, S., and N. Cuéllar. 2011. *Compensation for ecosystem services: Directions, potentials and pitfalls for rural communities* (Policy Brief). Salvadoran Research Program on Development and Environment (PRISMA), San Salvador, El Salvador.

Kennedy, L. M., Horn, S. P., and Orvis, K. H. 2006. A 4000-year record of fire and forest history from Valle de Bao, Cordillera Central, Dominican Republic. *Palaeogeography, Palaeoclimatology, Palaeoecology* 231:279–290.

Latta, S., C. Rimmer, A. Keith, J. Wiley, H. Raffaele, K. McFarland, et al. 2008. *Birds of the Dominican Republic and Haiti*. Princeton, NJ: Princeton University Press.

Latta, S. C. 2005. Complementtary areas for conserving avian diversity on Hispaniola. *Animal conservation* 8:69–81.

Lin, B. B., I. Perfecto, and J. Vandermeer. 2008. Synergies between agricultural intensification and climate change could create surprising vulnerabilities for crops. *Bioscience* 58:847–854.

Liu, J., T. Dietz, S. R. Carpenter, M. Alberti, C. Folke, E. Moran, et al. 2007. Complexity of coupled human and natural systems. *Science* 317:1513–1516.

Lopez, R. 2001. Rural poverty in Dominican Republic: Market failures, government failures and new policies. In *Dominican Republic poverty assessment: Poverty in a High-growth economy (1986–2000), Vol. II*. (Report No. 21306-DR). Washington, DC: The World Bank.

Martinez-Torres, M. E. 2006. *Organic coffee: Sustainable development by Mayan Farmers*. Athens, OH: Ohio University Press.

Méndez, V. E. 2008. Farmer livelihoods and biodiversity conservation in a coffee landscape of El Salvador. In *Confronting the coffee crisis: Fair Trade, sustainable livelihoods and ecosystems in Mexico and Central America*, eds. C. M. Bacon, V. E. Mendez, S. R. Gliessman, D. Goodman, and J. A. Fox, 207–236. Cambridge, MA: MIT Press.

Méndez, V. E., C. M. Bacon, M. Olson, K. S. Morris, and A. K. Shattuck. 2010. Agrobiodiversity and shade coffee smallholder livelihoods: A review and synthesis of ten years of research in Central America. *Professional Geographer* 62:357–376.

Méndez, V. E., C. M. Bacon, M. Olson, S. Petchers, D. Herrador, C. Carranza, et al. 2010. Effects of fair trade and organic certifications on small-scale coffee farmer households in Central America and Mexico. *Renewable Agriculture and Food Systems* 25:23–251.

Méndez, V. E., S. Castro-Tanzi, K. Goodall, K. S. Morris, C. M. Bacon, P. Läderach, et al. 2012. Livelihood and environmental tradeoffs of climate mitigation in smallholder coffee agroforestry systems. In *Climate change mitigation and agriculture*, eds. E. K. Wollenberg, A. Nihart, M. Grieg-Gran, and M. L. Tapio-Biström, 370–381. London: Earthscan.

Méndez, V. E., S. R. Gliessman, and G. S. Gilbert. 2007. Tree biodiversity in farmer cooperatives of a she coffee landscape in western El Salvador. *Agriculture, Ecosystems & Environment* 119:145–159.

Méndez, V. E., E. N. Shapiro, and G. S. Gilbert. 2009. Cooperative management and its effects on shade tree diversity, soil properties and ecosystem services of coffee plantations in western El Salvador. *Agroforestry Systems* 76:111–126.

Milder, J. C., L. E. Buck, F. A. DeClerck, and S. J. Scherr. 2011. Landscape approaches to achieving food production, conservation, and the Millennium Development Goals. In *Integrating Ecology and Poverty Reduction*, eds. F. A. DeClerck, J. C. Ingram, and C. Rumbaitis del Rio, ch. 2.1.4. New York: Springer.

Milder, J. C., S. J. Scherr, and C. Bracer. 2010. Trends and future potential of payment for ecosystem services to alleviate rural poverty in developing countries. *Ecology and Society* 15, Article no. 4.

Millennium Ecosystem Assessment. 2005. *Ecosystems and human well-being: Synthesis*. Washington, DC: Island Press.

Moguel, P., and P. M. Toledo. 1999. Biodiversity conservation in traditional coffee systems in Mexico. *Conservation Biology* 13:11–21.

Oficina Nacional de Planificación. 2005. *Mapa de la Pobreza en la República Dominicana*. Santo Domingo, Dominican Republic: ONAPLAN.

Oficina Nacional de Estadistica de la Republica Dominicana. 2012. *Censo 2012 de Población y Vivienda*. Nacional de Estadistica http://www.one.gob.do/Oficina (accessed July 21, 2013).

Parks in Peril Program. 1997. *Initial site work plan*. Madres de Las Aguas Conservation Area. Cordillera Central, Dominican Republic. United States Agency for International Development and the Nature Conservancy, USAID–Washington, DC/TNC–Arlington, VA.

Perfecto, I., R. A. Rice, R. Greenberg, and M. E. van der Voort. 1996. Shade coffee: A disappearing refuge for biodiversity. *BioScience* 46:598–609.

Perfecto, I., and J. Vandermeer. 2008. Biodiversity conservation in tropical agroecosystems: A new paradigm. *Annals of the New York Academy of Science* 1134:173–200.

Perfecto, I., J. Vandermeer, A. Mas, and L. Soto-Pinto. 2005. Biodiversity, yield, and shade coffee certification. *Ecological Economics* 5:435–446.

Perfecto, I., J. H. Vandermeer, and A. L. Wright. 2009. *Nature's matrix: linking agriculture, conservation and food sovereignty*. London: Earthscan.

Petchers, S., and H. Harris. 2008. The roots of the coffee crisis. In *Confronting the coffee crisis: Fair Trade, sustainable livelihoods and ecosystems in Mexico and Central America*, eds. C. M. Bacon, V. E. Méndez, S. R. Gliessman, D. Goodman, and J. A. Fox, 43–66. Cambridge, MA: MIT Press.

Philpott, S. M., W. J. Arendt, I. Ambrecht, P. Bichier, T. V. Dietsch, C. Gordon. 2008. Biodiversity loss in Latin American coffee landscapes: Review of the evidence on ants, birds, and trees. *Conservation Biology* 22:1093–1105.

Philpott, S. M., P. Bichier, R. Rice, and R. Greenberg. 2007. Field testing ecological and economic benefits of coffee certification programs. *Conservation Biology* 21:975–985.

Philpott S. M., B. B. Lin, S. Jha, and S. J. Brines. 2008. A multi-scale assessment of hurricane impacts on agricultural landscapes based on land use and topographic features. *Agriculture, Ecosystems and Environment* 128:12–20.

Ponette-González, A. G., Marín-Spiotta, E., Brauman, K. A., Farley, K. A., Weathers, K. C., and Young, K. R. 2014. Hydrologic connectivity in the high-elevation tropics: Heterogeneous responses to land change. *BioScience* 64(2):92–104.

Program on Forests. 2009. Poverty Forest Linkages Toolkit. Washington, DC: Program on Forests.

Programa Salvadoreño de Investigación sobre Desarrollo y Medio Ambiente. 2003. *Compensation for environmental services and rural communities*. San Salvador: PRISMA.

Quintero, M., S. Wunder, and R. D. Estrada. 2009. For services rendered? Modeling hydrology and livelihoods in Andean payments for environmental services schemes. *Forest Ecology and Management* 256:1871–1880.

Rapidel, B., F. DeClerck, J.-F. Le Coq, and J. Beer, eds. 2011. *Ecosystem services from agriculture and agroforestry*. London: Earthscan.

Reardon, T. 1997. Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Development* 16:735–747.

Reed, M., A. J. Dougill. and T. R. Baker. 2008. Participatory indicator development: What can ecologists and local communities learn from each other? *Ecological Applications* 18:253–1269.

Robbins, P. 2004. *Political ecology*. Malden, MA: Blackwell.

Sayer, J., B. Campbell, L. Petheram, M. Aldrich, M. Ruiz Perez, D. Endamana, et al. 2007. Assessing environment and development outcomes in conservation landscapes. *Biodiversity and Conservation* 16:2677–2694.

Scherr, S. J., and J. A. McNeely. 2008. Biodiversity conservation and agricultural sustainability: towards a new paradigm of 'ecoagriculture' landscapes. *Philosophical Transactions of the Royal Society B* 363:477–494.

Scoones, I. 1998. *Sustainable rural livelihoods: A framework for analysis*. IDS Working Paper 72.

Siegel, P., and P. Alwang. 2003. *Analyses of data from survey of coffee and cocoa producers in the Dominican Republic*. Draft paper prepared for the Commodity Risk Management Group (CRMG), Agriculture and Rural Development Department, The World Bank, Washington, DC.

Southgate, D., and S. Wunder. 2009. Paying for watershed services in Latin America: A review of current initiatives. *Journal of Sustainable Forestry* 28:497–524.

Suyanto, S., N. Khususiyah, and B. Leimona. 2007. Poverty and environmental services: case study in Way Besai watershed, Lampung Province, Indonesia. *Ecology and Society* 12(2):13–21.

Tallis, H., Kareiva, P., Marvier, M., and Chang, A. 2008. An ecosystem services framework to support both practical conservation and economic development. *Proceedings of the National Academy of Sciences, USA*. 105:9457–9464.

Taylor, J. E., A. Yunez-Naude, N. Jesurun-Clements, J. De los Santos, M. Filipski, and J. Paulino. 2008. *Posibles efectos de la liberalizacion comercial en los hogares rurales, a partir de un modelo desagregado para la economia rural, con enfasis en la probreza, el genero y la migracion*. Washington, DC: Inter-American Development Bank.

Toledo, V. M., and P. Moguel. 2012. Coffee and sustainability: The multiple values of traditional shaded coffee. *Journal of Sustainable Agriculture* 36:353–377.

U.S. Agency for International Development. 2013. *Dominican Republic climate change vulnerability assessment report*. Prepared by Tetra Tech, Washington, DC. http://www.usaid.gov/sites/default/files/documents/1862/Dominican%20Republic%20Climate%20Change%20Vulnerability%20Assessment%20Report.pdf

Vandermeer, J., and I. Perfecto. 2007. The agricultural matrix and a future paradigm for conservation. *Conservation Biology* 21:274–277.

van Noordwijk, M., and B. Leimona 2010. Principles for fairness and efficiency in enhancing environmental services in Asia: Payments, compensation, or co-investment? *Ecology and Society* 15(4):17.

van Vliet, N. 2010. Participatory vulnerability assessment in the context of conservation and development projects: a case study of local communities in Southwest Cameroon. *Ecology and Society* 15, Article no. 6.

Varangis, P., P. Siegel, D. Giovannucci, and B. Lewin. 2003. *Dealing with the coffee crisis in Central America: Impacts and strategies*. Washington, DC: World Bank.

Watts, M., and D. Peet, eds. 2004. *Liberation ecologies*, 2nd ed. London: Routledge.

Wells M. P, and T. O. McShane, eds. 2004. *Getting biodiversity projects to work: towards more effective conservation and development*. New York: Columbia University Press.

The World Bank. 2009. http://data.worldbank.org/indicator/SE.PRM.ENRR (accessed February 14, 2013).

Wunder, S. 2008. Payments for environmental services and the poor: concepts and preliminary evidence. *Environment and Development Economics* 13:279–297.

Wunderle, J. M. 1999. Avian distribution in Dominican shade coffee plantations: Area and habitat relationships (Distribución de Aves en Algunas Plantaciónes de Café de Sombra en la República Dominicana: Relaciones Entre Área y Habitat). *Journal of Field Ornithology* 70(1):58–70.

Wunderle, J. M., and S. C. Latta. 1998. Avian resource use in Dominican shade coffee plantations. *Wilson Bulletin* 110:271–281.

Zimmerer, K. S. 2007. Agriculture, livelihoods, and globalization: The analysis of new trajectories (and avoidance of just-so stories) of human-environment change and conservation. *Agriculture and Human Values* 24:9–16.

Zimmerer, K., S., and Basset, T. J. 2003. *Political ecology: An integrative approach to geography and environment-development studies*. New York: Guilford Press.