Allen, K. E. 2015. Trade-offs in nature tourism: contrasting parcel-level decisions with landscape conservation planning. *Ecology and Society* **20**(1): 21. http://dx.doi.org/10.5751/ES-07058-200121

Research, part of a Special Feature on Ecosystem Service Trade-offs across Global Contexts and Scales

Trade-offs in nature tourism: contrasting parcel-level decisions with landscape conservation planning

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ABSTRACT. A challenge for landscape planning is to understand how trade-offs are differently negotiated across privately held parcels and how economic incentives for conservation affect these trade-offs. I used the efficiency frontier framework to explore the trade-offs associated with the nature tourism industry, an economic incentive for conservation, in Monteverde, Costa Rica. I modeled regional changes in forest cover from 1985 through 2009, dates that coincide with the boom in the nature tourism industry. Interview data were used to understand the social context of these forest cover changes and the negotiation of trade-offs from the perspective of individual parcel owners. The results suggest that nature tourism can provide a win-win conservation scenario on individual parcels in which livelihood opportunities coincide with forest regrowth. However, nature tourism has the potential to introduce market feedback that can both complicate livelihood sustainability and hinder multiple ecosystem service provisioning.

Key Words: *ecosystem services; efficiency frontier; nature tourism; trade-offs*

INTRODUCTION

Landscape planning has moved to the forefront of conservation initiatives under the recognition that patch size and connectivity are essential to ecosystem functioning (Turner et al. 2001, Noss 2002). Conservation initiatives have accordingly shifted focus from protecting individual reserves to promoting sustainability across mixed-use landscapes, with human well-being being evaluated in conjunction with conservation benefits (Phillips 2003). Government planners concerned with sustainability are charged with implementing policies, often via economic incentives, that promote both ecosystem function and livelihoods. However, in a landscape dominated by private landowners, the sum of individual decisions responding to economic incentives may not be optimal from a conservation planning perspective. I explore how the nature tourism industry variably impacts parcel owners in the region surrounding and including Monteverde, Costa Rica. In doing so, I provide a case study for the efficiency frontier framework outlined in this Special Feature.

The efficiency frontier framework is a tool for landscape conservation planning and for thinking about how win-win scenarios, i.e., those that benefit both livelihoods and conservation, can be maximized given the productivity and ecosystem service potential of the land (Polasky et al. 2008). In landscape planning, the efficiency frontier with respect to the outcomes of livelihoods and conservation defines the set of land allocations from which there are no alternate distributions that would simultaneously improve both outcomes (see Cavender-Bares et al. 2015). For example, with respect to livelihoods and biodiversity conservation, it would be impossible to improve both of these elements compared with an “efficient” land allocation without having more land. Comparing current land allocations with the efficiency frontier allows for the identification of potential win-win scenarios.

Economic incentives for conservation can alter the nature of trade-offs between ecosystem service provisioning and income production so that these outcomes can be simultaneously realized within a given parcel, thus contributing to an efficiently allocated landscape via promoting conservation on low-productivity and high-biodiversity lands (Pagiola et al. 2002, Jack et al. 2008, Nelson et al. 2009). However, economic incentives directed at private landowners are often unable to encourage ecosystem service provisioning across parcels (Parkhurst et al. 2002). Independent land use management for livelihood benefits, in the context of these incentives, can fall short of conservation goals and have negative impacts on human well-being. Further, directing economic incentives toward the provision of a single ecosystem service may undermine the multifunctionality of ecosystems (Hector and Bagchi 2007, Gamfeldt et al. 2008, Zavaleta et al. 2010). Therefore, analyzing the impacts of economic incentives on ecosystem function and the resulting ecosystem service benefits requires an understanding of how trade-offs are negotiated within parcels and across the landscape (Carpenter et al. 2006, 2009).

Nature tourism has long been a pillar of economic incentives for conservation. Based on travel to protected areas, nature tourism offers livelihood opportunities for local residents and generates revenue for parks (Aylward et al. 1996). Nature tourism, when properly designed and implemented, can also contribute to ecosystem service provisioning and livelihood benefits across the landscape via promoting sustainable hotels, restaurants, and private reserves (Wunder 2000, Krüger 2005, Gordillo Jordan et al. 2008, Honey 2008, Stronza and Durham 2008, Almeyda et al. 2010, Almeyda Zambrano et al. 2010). Costa Rica integrated nature tourism into development policy in the 1970s, where it has since been used to promote conservation (Boza 1993, Evans 1999, Castro et al. 2000). Nature tourism defines Costa Rica’s niche in the tourism market, and almost two decades ago, tourism became Costa Rica’s largest industry (Castro et al. 2000, Brockett and Gottfried 2002). The Costa Rican landscape has changed as national policy has simultaneously deemphasized agricultural production, and the late 1980s witnessed the first shift toward increased forest regrowth throughout the nation (Daniels 2010). Although national patterns of forest regrowth seem evident, there is much uncertainty as to the endurance of these nascent forests and the effectiveness of the nature tourism industry in promoting ecosystem services and economic benefits across the landscape (Castro et al. 2000, Stem et al. 2003).

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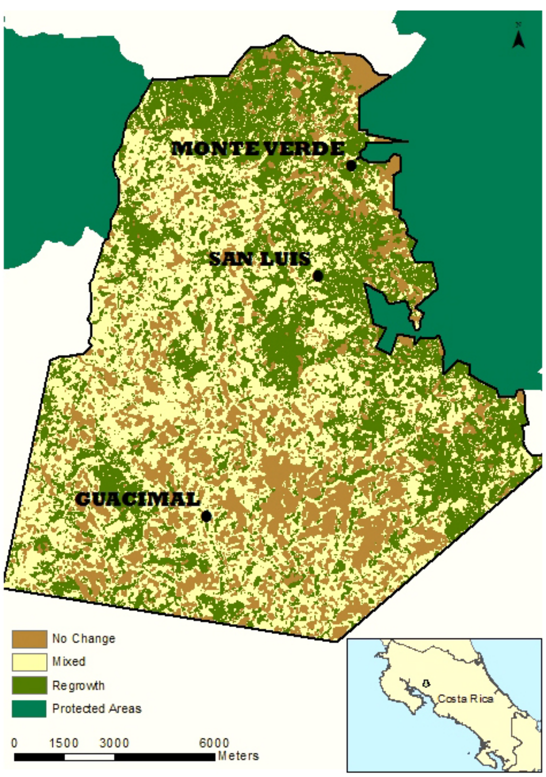
I used a logistic regression on a biomass change map (1985-2009) to model regional changes in forest cover during the boom of the nature tourism industry in Costa Rica. I combined this model with interview data to elucidate the social context of these forest cover changes and examine how trade-offs are perceived and negotiated by landowners in the study area. Through the efficiency frontier framework, I show how trade-offs between ecosystem service benefits and income production are negotiated differently across parcels that are variably impacted by nature tourism and suggest the possible implications of these trade-offs for landscape conservation planning.

Study area

The study area is in the northern portion of the Bellbird Biological Corridor (CBPC, Corredor Biológico Pájaro Campana). The CBPC is 1 of 37 corridors in Costa Rica that form planning regions for landscape conservation management and sustainable development initiatives (SINAC 2009). The northern section is a mixed-use, mountainous region that includes the towns of Monteverde, San Luis, and Guacimal (see Fig. 1). Monteverde is a popular nature tourism destination and is located at the base of the Monteverde Cloud Forest Preserve (MVCFP) in the northern summit of the CBPC. Since the initiation of the MVCFP in 1973, nature tourism has supplied both operational funds for the park and an employment base for the community (Aylward et al. 1996). The MVCFP, adjacent protected areas, and the nature tourism industry in Monteverde have grown since its inception (Burlingame 2000), and tourism is now the dominant economic activity in the town (*personal observation*).

Fig. 1. Map of the study area depicting forest regrowth between 1985 and 2009. Classes indicate no change, regrowth, and mixed. Location of study area within Costa Rica is shown.



Just south of Monteverde, the economy of San Luis is based primarily on dairy and coffee production, but relies heavily on tourism for marketing of food products, farm tours, and off-farm employment (*personal observation*). Further down the CBPC, the economy of Guacimal is primarily based on cattle ranching and dairy production, with little tourism presence in the immediate zone. Although there is only a short distance between these towns, travel is difficult on the gravel roads and public transportation is limited. Hence, the towns analyzed represent diverse livelihood strategies within a relatively small region proximal to protected areas. Across the broader CBPC, which stretches all the way to the coast, policy makers are attempting to promote sustainable development, and nature tourism is considered a key ingredient of this plan (CBPC officials 2013, *personal communication*; http://www.cpbc.org). The CBPC, therefore, is representative of a regional-scale conservation initiative that targets private land conservation using a limited arsenal of economic incentives, among vastly different socioeconomic regions.

DATA AND METHODS

To evaluate the spatial variability of nature tourism impacts within the northern section of the CBPC, I examined both landscape trends of forest regrowth and parcel-level experiences of these environmental changes. First, I mapped conversion of agriculture to forest through a biomass change map. Second, I used logistic regression to analyze forest regrowth across the landscape. Third, I used interview data to provide insight into the parcel-level trade-offs associated with these landscape changes. Although the first two methods reveal landscape-level forest growth trends, the third method places these changes within the context of decision making undertaken by landowners.

Biomass change map

I obtained satellite images for three time periods: 1985, 1997, and 2009/2010. I used three dates so that I could assess the overall trajectory and consistency of conversion of pasture to forest. The first time period represents the beginning of the nature tourism boom in Monteverde, a time that coincides with national economic restructuring that eliminated government subsidies for agricultural production (Edelman 1992, Aylward et al. 1996, Daniels 2010). The 1985 and 1997 images were obtained from Landsat Thematic Mapper (TM) data, at 900 m^2 resolution during the months of March and February, respectively (available at http://glovis.usgs.gov/). The final image spans a two-year time frame from 2009 to 2010, subsequently referred to as the 2009 image, and is composed from a mosaic of 7 images taken using a RapidEye sensor at 25 m^2 resolution on the following dates: September 2009 (two images), March 2009 (one image), January 2010 (three images), and February 2010 (one image).

I constructed a Normalized Difference Vegetation Index (NDVI) change map to identify areas that have shown net forest regrowth across the corridor (Fig. 1). The NDVI is a good proxy for total biomass (Sellers 1985) and can be used to identify biomass change across various dates (Sader and Winne 1992, Wilson and Sader 2002). High NDVI values indicate the presence of leafy vegetation and can be used for differentiating agriculture, particularly pasture, the most common agricultural use in the region, from forest growth (Sader et al. 1989, 1994, Vieira et al. 2003, Soudani et al. 2012). I constructed NDVI maps for the 1985 and 1997 images using ERDAS Imagine 2011 (Intergraph, Huntsville,

Table 1. Independent variables used in the logistic regression to explain probability of forest regrowth between 1985-2009.

Variable	Description	Units	Proxy for
SLOPE	The slope of the land at the specific random point, as represented in a Digital Elevation Model (DEM)	Degrees	Steepness of terrain / agricultural quality
ROAD	Euclidean distance from point to nearest road	-1/(meters$^{1/2}$)	Accessibility / distance from markets
RIVER	Euclidean distance from point to nearest river	Meters	Riparian Buffer zones
SL	Identifies whether random point falls within a 3 km buffer from the center of San Luis	Binary variable 0 = not within buffer 1 = within buffer	Mixed agricultural / nature tourism region
GUA	Identifies whether point falls within a 3 km buffer from the center of Guacimal	Binary variable 0 = not within buffer 1 = within buffer	Agricultural region
MVPA	Identifies whether point falls within a 3 km buffer from the center of Monteverde and the boundary of a protected area	Binary variable 0 = not within buffer 1 = within buffer	Nature tourism region
PA	Identifies whether point falls within a 2 km buffer from the boundary of one of the two protected areas in the study area	Binary variable 0 = not within buffer 1 = within buffer	Conservation region

Alabama, USA; http://www.intergraph.com/). For Landsat TM images, the NDVI is calculated by using the near infrared (band 4) and red band (band 3) in the following formula:

$$NDVI = \frac{Band\ 4 - Band\ 3}{(Band\ 4 + Band\ 3)} \quad (1)$$

In the RapidEye sensor, band 5 is the near infrared band. Therefore, the NDVI is calculated as in the above formula, with band 5 substituted for band 4. I resampled the 2009 NDVI image to 900 m² resolution using bilinear interpolation in ERDAS Imagine 2011 to match it with the Landsat TM data. I then "layer stacked" the NDVIs for the three dates of interest and ran an unsupervised classification using isodata clustering (60 classes) on the resulting image.

In ArcGIS 10.0 (ESRI, Redlands, California, USA; http://www.esri.com/), I used the original true color images to visually examine each of the 60 classes and compare visual changes with NDVI change values. I then simplified these into three classes according to biomass change patterns: regrowth, mixed, and no change (Fig. 1). The regrowth class represents all areas where the land showed net forest regeneration across the three time periods, regardless of the year in which regrowth began. The no-change group represents either permanent forest or permanent agriculture across all time periods. In most cases, no change is equivalent to permanent agriculture, except in the high-altitude regions of Monteverde and San Luis. There was negligible deforestation in the study area because the majority of land in the 1985 image was already used in agriculture. Forty-one percent of pixels could not be confidently placed into either class because of the different seasons included in the 2009 mosaic, the low resolution of the biomass change map, and the presence of mixed-use plots. These were placed into a mixed class to minimize error in the other classes. To reduce heterogeneity within patch types, I ran a 3 cell × 3 cell moving window on the image using ArcGIS 10.0, and burned null data into the final image in the mixed category.

Logistic regression

I used a logistic regression to consider the impact of various landscape characteristics on the probability of forest regrowth. Using ArcGIS 10.0, I created 300 random points in the study area. From these points I defined the dependent variable based on the three categories of land cover change described above: regrowth, no change, and mixed. For the 114 points initially classified as mixed, I individually examined and reclassified each point based on NDVI values and the true color images.

The probability of forest regrowth was predicted to be related to both physical and social landscape factors. I modeled this relationship as:

$$\ln\frac{P_1}{P_0} = \beta_0 + \beta_1 SLOPE + \beta_2 ROAD + B_3 RIVER + \beta_4 SL + \beta_5 GUA + \beta_6 MVPA + \beta_7 PA \quad (2)$$

where P_1 = regrowth, P_0 = no change, and the β's are the coefficients for slope, transformed Euclidean distance from nearest road, Euclidean distance from nearest river, and location within the buffer zone of San Luis, Monteverde protected areas (MVPA), Guacimal, and protected areas (see Table 1). Data for all independent variables were obtained from the Costa Rica Digital Atlas (Ortiz Malavassit and Soto Montoya 2008). The regression was estimated with STATA 11.2 (StataCorp LP, College Station, Texas, USA; http://www.stata.com/). Seven points were eliminated because of missing data and unreliability of the dependent variable in the original map. Variance inflation factors and the correlation matrix were examined for potential problems of multicollinearity, and none were found.

Interview data

The data analyzed here were collected during the months of June and July in 2011 as part of preliminary ethnographic research designed to explore the variable impacts of the nature tourism industry on landowners. I completed semistructured interviews with a subset of landowners who own more than one hectare of land in the study area (n = 13). Because of the exploratory nature of the research and limited time frame for data collection, snowball sampling was used to identify landowners. Beginning with a core of three landowners identified in San Luis and Monteverde, I asked for recommendations of other landowners who lived in neighboring communities who would be willing to participate in the interview.

Most interviews took place within the buffer zones of San Luis and Monteverde: seven farms were in the region between Monteverde and San Luis, two farms were in San Luis, two farms were north of Monteverde, and two farms were in Guacimal (Fig. 1). The average farm size reported by landowners was 21.7 hectares. Of the 13 people interviewed, 12 resided on farms. Two interviewees were citizens of the United States who had immigrated to the zone 18 and 31 years ago. All other interviewees were Costa Rican nationals who had lived in the region for more than 30 years. Interviews with Costa Ricans were done in Spanish, and all translations were by the author. All individuals interviewed received some portion of income from tourism, either directly through offering farm tours or indirectly through employment in the service industry and selling agricultural goods to hotels. Landowners were asked about livelihoods, conservation activities, land use histories, and their impressions of land use and cultural changes in the region associated with nature tourism (Table 2). Interviews lasted approximately one hour each and were audio recorded, and responses were subsequently analyzed.

Table 2. The following questions were analyzed for all people interviewed. Responses are consolidated in Tables 3 and 4.

Semistructured Interview Questions
1. How has land use changed in the last 20 years in this community?
2. What are the benefits of these changes? Impacts?
3. Do these changes seem beneficial or detrimental to the local environment?
4. Do you keep any portion of your land permanently forested? (Why or why not?)
5. Do you consider your current land use ecologically sustainable? (If so, how?)
6. Are you aware of any conservation value that your landholdings may have?
7. Have you ever worked in conservation? In tourism?
8. Do you think that the tourism industry benefits people and the environment in the region?

RESULTS

Forest regeneration

The results of the logistic regression and interviews indicate that there is a spatially variable relationship between nature tourism and forest regeneration. In the logistic regression, three variables were found to be significant at the $p < 0.01$ level: ROAD, RIVER, and protected areas (Table 3). MVPA was significant at $p < 0.05$, and SLOPE was significant at $p < 0.1$. The variable MVPA showed the largest impact on the odds of an individual point showing forest regrowth, meaning that being within 3 km of Monteverde and a protected area increased the odds of forest regrowth by a factor of 3.82. This was followed in magnitude by the effect of protected areas, with location within the 2-km buffer of protected areas increasing the odds of forest regrowth by a factor of 3.01. The coefficient of the variable ROAD indicates that the odds of forest regeneration increased in areas further from roads. In contrast, the odds of forest regeneration increased in areas closer to rivers. There was also a relationship between increased slope and increased forest regeneration. There was not a statistically significant relationship between proximity to San Luis or Guacimal and the odds of forest regrowth. I explored interaction effects between distance to protected area and presence within the buffer of each town and found that the inclusion of interaction effects did not improve the overall fit of the model, nor did it change the understanding of the relationships represented here. The model has a pseudo r^2 of 0.1526 and a relatively good prediction success at 67.58%, an improvement over the null model of 14%.

Table 3. Logistic regression analysis of independent variables predicting likelihood of forest regrowth. Variable descriptions are provided in Table 1.

Variable	Coefficient	Std Error	Odds Ratio	P-Value
SLOPE	0.025	0.014	1.025	0.069*
ROAD	11.875	2.861	6.96e-06	0.000***
RIVER	-0.002	0.001	0.998	0.004***
SL	0.269	0.376	1.309	0.475
GUA	-0.079	0.354	0.924	0.824
MVPA	1.340	0.554	3.819	0.015**
PA	1.104	0.339	3.015	0.001***
CONSTANT	0.861	0.387	2.365	0.026

*p < 0.1, **p < 0.05, ***p < 0.01

Interview data provided context for the results of the logistic regression by indicating potential drivers of forest regrowth in the region. Landowners reported an average of 38% of total area allotted to afforestation, with a range of 0% to 92%. Landowner reasons for permitting forest regeneration fell into two categories: agricultural optimization and conservation value (Table 4). The agricultural optimization category includes reasons specifically considered by interviewees to be better for farm production and income optimization, whereas the conservation value category lists reasons not associated with income benefits. The response frequency indicates the number of people who listed the given factor as influencing their decision to allow forest regrowth on lands. Although some informants associated conservation benefits with forest regeneration, the most salient reasons for allowing forest regrowth involved agricultural optimization. Interviewees explained that previous generations frequently cleared land that was not good for agriculture, particularly land located on steep, rocky slopes. Further, the entire study area is subject to strong winds during approximately five months out of the year, and these winds are thought to lower agricultural production. Thus, reforested areas often provide critical windbreaks for farmers.

Table 4. Reasons for allowing forest regrowth (afforestation) and planting trees (reforestation) on farms. "Response frequency" indicates the number of people interviewed who mentioned the item in their responses.

Reason	Response Frequency
Agricultural optimization	
Too steep; "not good for anything else"	5
Windbreaks	5
Water and soil conservation	4
Direct tourism potential	3
Conservation value	
Wildlife	4
Connectivity / proximity to other conserved areas	3

Trade-offs in tourism

In addition to exploring the relationship between tourism and forest regeneration, interview data also provided insight into the general environmental and cultural trade-offs associated with the tourism industry that are not visible via satellite data. Landowners were asked about whether nature tourism has benefited the economy, the community, and the environment of the region (Table 2). Responses were mixed. Table 5 provides a list of commonly cited trade-offs associated with nature tourism growth. As in Table 4, response frequency indicates the number of individuals who discussed each category in their responses.

In terms of ecological impacts, nine interviewees stated that tourism has allowed for more forest regeneration because of partial and complete farm abandonment. Increased tourism and related off-farm employment opportunities were listed as the reasons for this landscape change. Forest regeneration was associated with benefits such as increased precipitation and wildlife habitat.

Respondents also identified negative ecological impacts of tourism, such as increased garbage and pollution (Table 5). In these instances, people expressed concern with lack of government planning, increased garbage accumulation, and lack of a town water treatment facility. Three individuals spoke extensively about the water pollution that has accompanied increased population and visitation to the zone. One discussed frustration with an inability to ensure adequate gray and black wastewater disposal in Monteverde. Two others claimed that polluted water was running downstream and into their property. One interviewee stated:

> *In the meetings in Monteverde and other places they talk about ecosystems and conservation projects, and yet no one looks at the pollution that is being dumped into the rivers. ... It makes me mad when I go to the farm and see that the cattle are drinking that water, and the water is disgusting. It's terrible! So if people in Monteverde are promoting on a national level that we are willing to conserve, we should stop this pollution.*

Table 5. Tourism trade-offs. These themes arose in response to the question, "Does nature tourism benefit people and the environment in the region?" Responses are grouped by category and frequency, where the frequency indicates the number of people who mentioned the theme. Direction of impact indicates whether the respondent considered the result to be positive or negative.

Category	Response Frequency	Direction of Impact
Ecological Impact		
Forest Regeneration	9	+
Increased Precipitation	4	+
Pollution (Water and Air)	5	-
Increased Garbage	4	-
Economic Impact		
More Employment	10	+
Infrastructure Development	4	+
Rising Cost of Living and Increased Debt	5	-
Community Impact		
Awareness of Physical Beauty / Conservation Value	4	+
Low Ratio - Infrastructure Development: Town Growth	7	-
Loss of Agricultural Knowledge and Lands	6	-
Rising Crime	2	-

Farm owners tended to indicate that nature tourism has brought more employment to the region. Even farm owners in Guacimal, a 30-minute drive from Monteverde, indicated that some residents take advantage of tourism opportunities by establishing businesses along the main road or commuting to Monteverde for daily work. Accompanying these changes, nature tourism has brought increased infrastructure, such as road improvements, increased educational access, and opportunities for women (Table 5). However, informants frequently voiced concern over rising cost of living and increased debt.

Almost half of the people interviewed expressed concern about the loss of agricultural knowledge and land. One stated that lands are being sold to foreigners who have different value systems regarding private landholdings. Several others spoke of land abandonment and land sales. In a similar vein, informants expressed concern that agricultural knowledge is being lost as the younger generation moves almost exclusively into the service industry. One informant stated:

> *A lot of agricultural knowledge has been lost. I learned from a young age how to clear a field and plant corn, and how to plant and take care of a banana tree or an orange*

> *tree ... and that has been mostly lost. For me, this is sad because it isn't just about earning money; it's about a culture, and a culture that carries a very close relation to the earth and a way of life.*

DISCUSSION

Forest regeneration

The logistic regression model revealed two trends in forest regrowth. First, lands closer to Monteverde and protected areas were more likely to experience forest regrowth between 1985 and 2009 than other lands in the study area. Secondly, land on steeper slopes, away from roads, and closer to rivers were more likely to return to forest during the time period studied. The first trend likely relates to the growing investment of conservation organizations in the region, as well as the increasing profitability of the nature tourism industry during the time period studied. These two factors are intertwined, because nature tourism is ultimately a product of conservation and related science tourism in Costa Rica (Campbell 2002). The first nature tourists in Costa Rica were the foreign conservation organizations and scientists who came to study the exotic biota of regions such as Monteverde, and the national government capitalized on this trend by marketing Costa Rica as a green tourism destination (Evans 1999). Hence, because conservation organizations in Monteverde and elsewhere were purchasing lands throughout the 1980s and 1990s for inclusion in a growing system of private and public preserves (Janzen 1986, Vivanco 2006), nature tourism may have been rapidly out-competing agriculture as the most profitable land use.

The second trend revealed by the logistic regression relates to the intensification of agriculture. The regression showed differential forest regrowth on steeply sloped lands, land further from roads, and land closer to rivers. The first two variables represent an abandonment of marginal agricultural land. Most of the initial clearing of the area occurred after the 1941 law that granted titles to landholders for maintaining land in productive capacity, a policy that ended with the first forestry law in 1969 (Brockett and Gottfried 2002). Political changes invoked by Costa Rican international debt default in the 1980s subsequently deemphasized agricultural production. Similar to other Latin American countries that defaulted on international debt in that decade, Costa Rica was encouraged by international lending agencies to make structural changes that included reduction of government subsidies for agriculture and increased market liberalization (Edelman 1999). Further, in 1996, a revised forestry law prohibited deforestation on lands with secondary regrowth and instituted a new financial mechanism to incentivize private land conservation: the national program known as Payments for Environmental Services (Brockett and Gottfried 2002). The combined message of these changes in national policy was clear: the Costa Rican economic pillars of coffee and bananas were giving way to tourism and conservation.

The microscale interview data reveal part of the impact of these national policy changes on local land use decisions. Small-scale farmers have found themselves turning away from reliance on agriculture and supplementing their incomes with work in the tourism industry, either through off-farm employment or offering educational farm tours on-site. Farmers closer to Monteverde have seen increased opportunities to sell lands to conservation organizations and to convert land use from agricultural production to tourism. It appears, therefore, that nature tourism does contribute, both directly and indirectly, to forest regrowth.

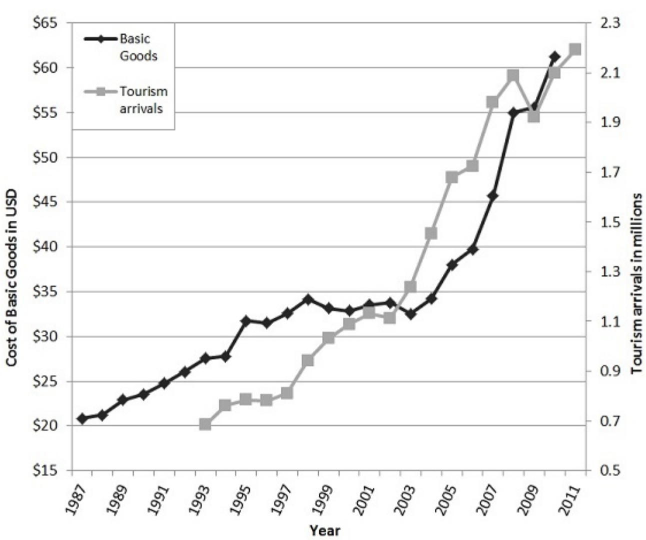
The intensification of land use that has occurred during the time period studied has been at least partially driven by a desire to guard against erosion and to protect water sources. This trend is revealed both in interview data and in the logistic regression variable RIVER. The variable RIVER indicates that more forest regrowth occurred close to rivers. The national forestry laws (1969, 1973, 1979, 1996) have prohibited deforestation along steep slopes and rivers, but they have proven difficult to enforce because of lack of infrastructure (Brockett and Gottfried 2002). Several landowners interviewed indicated that they allow forest regrowth to protect steep slopes from erosion and to protect water sources. Other research has found similar concerns among farmers in Costa Rica (Schelhas and Pfeffer 2005, Vivanco 2006, Newcomer 2007). Therefore, it is likely that forest regrowth has been encouraged by national policy, but undertaken because farm owners' values have shifted regarding forest uses.

Nature tourism and multiple ecosystem service provisioning

The data analyzed here seem to indicate that nature tourism can have a positive impact on ecosystem service provisioning related to forest cover in private parcels. However, the interview data reported, as well as subsequent follow-up interviews and ethnography throughout the study area, point to water contamination associated with the nature tourism industry in Monteverde. Monteverde and the adjacent town of Santa Elena, with roughly 5000 permanent inhabitants (http://www.inec.go.cr), have approximately 50 hotels and 45 restaurants, in addition to park facilities, zip line tours, and other tourist attractions. This growth occurred during the boom years of the tourism industry (see Fig. 2), and growth in infrastructure did not follow suit. To date, Monteverde and Santa Elena lack a sewage treatment facility, and most gray water is dumped directly into gutters and river ways. Septic tanks often overflow into surrounding areas and, perhaps more disturbingly, are commonly believed to be frequently emptied into the roads and rivers further down the mountain as a means for private companies to avoid paying a sewage treatment facility to receive the waste. The association between water contamination and tourism is not unique to Monteverde. In 2008, eight of the most popular beaches in Costa Rica lost their "blue flag" status, which is a national certification program for clean beaches, because of water contamination from runoff of nearby hotels (Ávalos 2008). Although it seems possible for nature tourism to protect the water supply, it would require investment in infrastructure and careful planning that does not always accompany the rapid growth that ensues when a new destination is "discovered."

Other impacts associated with the growth in nature tourism must be considered when evaluating the extent to which nature tourism is benefiting both local people and the environment, i.e., a win-win situation. As noted in Table 5, several informants indicated that they felt that the cost of living had increased since tourism boomed in Monteverde. Although this assertion is difficult to quantify with existing data, it seems plausible. Figure 2 compares the cost of basic goods, converted to US dollars to account for fluctuations in cost of imports, with the increases in tourism visitation. It appears that from 1993 to 2010, food costs and tourism had similar trajectories. Logically, this makes sense. Current visitation rates raise the population of the country by more than 40%. However, at the same time that visitation has increased the demand for food in the country, fewer people have been producing food. Further, rural zones in Costa Rica such as Monteverde had a subsistence economy before the influx of nature tourism. Now, there is increased cash flow through the economy and decreased reliance on subsistence agriculture. These patterns, although they would need to be confirmed with an empirical study, lend credence to the informant who said, "I believe, economically speaking, there is more today than yesterday, more benefits for local people, more employment, but there are also more expenses."

Fig. 2. The number of tourist arrivals per year to Costa Rica and the cost of basic goods have followed similar trajectories in recent years. Tourism data are reported as millions of visitors per year. The cost of a basic "basket" of goods indicates, on average for the given year, how much money was necessary per person per month to fulfill basic food needs. The cost has been converted to US dollars using the annual average conversion rate for the corresponding year. Tourism data were not available prior to 1993. Note: Figure is constructed using the "Canasta Básica Alimentaria, base 1995" data available from the Instituto Nacional de Estadística y Censos (INEC), Costa Rica (http://www.inec.go.cr). Data is based on the "Encuesta Nacional de Ingresos y Gastos de los Hogares 1987-1988" y la "Encuesta de Nutición, Evaluación Dietética de 1978," adjusted yearly for price changes in the cost of the identified basic goods. The exchange rate was averaged using data available from the Banco Central de Costa Rica (http://www.bccr.fi.cr). Tourism data is from the "Anuario Estadístico del Turismo, ICT" published via INEC.



Finally, when attempting to characterize the trade-offs associated with nature tourism, it is important to consider cultural impacts. Although it is difficult to quantify the impact of the intangible loss of cultural knowledge, it is a factor that is important to recognize when considering the conservation value of nature tourism. Throughout the study area, farm abandonment is on the rise as more youth move exclusively into the service industry. This pattern may bode well for forest cover, but it indicates a loss of social-ecological knowledge. Given the fluctuations that Costa Rica has experienced in tourism since 2007, farming knowledge may still have an important role to play in the well-being of future generations. Although this is merely speculation now, such trade-offs need to be considered as part of the package with nature tourism. By looking at only one ecosystem service and one aspect of human well-being, the income generated, we may be ignoring a broader picture that has critical implications for long-term sustainability.

Individual parcel versus landscape trade-offs

The efficiency frontier framework is designed to aid policy makers in conceptualizing the trade-offs between ecosystem service provisioning and income productivity across a landscape. An efficiently allocated landscape will be somewhere on the efficiency frontier for that landscape, where the allocation of lands between two outcomes is such that no alternate allocation could improve both outcomes. In practice, this should result in a landscape where ideal lands for ecosystem services will be conserved, whereas those better suited for production will be maximized for their income potential. I have borrowed from this framework in Figure 3 to highlight the distinct parcel-level trade-offs that are negotiated within the study area. This exercise serves to illustrate how, in a privately owned landscape, economic incentives for conservation such as nature tourism will not affect all landowners in a target conservation area equally. By considering differences in individual parcel owner negotiation of the trade-offs between ecosystem protection and income, it is possible to begin to conceptualize the role of feedback loops across parcels and scales of conservation interest.

Fig. 3. This figure illustrates theoretical parcel-level trade-offs between landowner income and forest cover. The regions of the curves that maximize both income and forest cover can be said to be on the efficiency frontier (solid lines). Point A represents the maximum "win-win" situation for forest cover / income on land close to nature tourism centers, while Point B demonstrates the forest cover associated with the equivalent income on land far from tourism centers. Points C and D suggest that when land is managed for income maximization, which may be promoted via feedback mechanisms between land managers, forest cover will decline as a result.

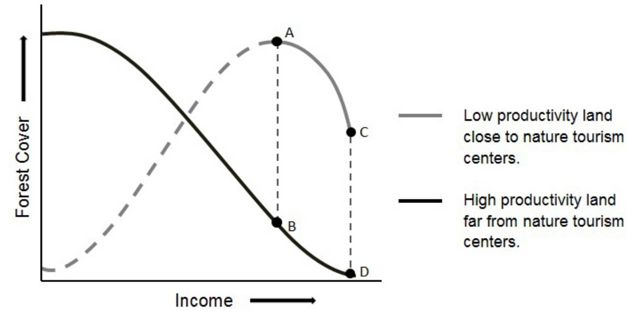


Figure 3 uses the efficiency frontier framework to theorize about how landowners who own land with tourism potential and those who own land that is more profitably employed in agriculture have different trade-offs associated with their land. Although this figure is a sketch of hypothetical trade-offs and related efficiency frontiers based on the understanding of the study area presented in this paper, it follows the framework presented by Cavender-Bares et al. (2105) in demonstrating how the concave relationship between a livelihood provisioning service and an ecosystem service varies in accordance with the production and biodiversity value of the land. For the individual landowner who owns productive agricultural land far from a tourism center, there is nearly a direct trade-off between forest cover and income (black line). For farmers owning mountainous lands close to Monteverde (gray line), a win-win situation exists in which income increases with forest cover on land up to a point, after which some moderate decrease in forest cover, e.g., building a hotel on land, increases income. The solid portion of the gray line and the entire black line represent the efficiency frontier where the combination of income and forest cover is being maximized. As illustrated in Figure 3, nature tourism can foster a situation in which efficiently allocated lands conserve forest while generating income for local residents.

The real challenge for understanding nature tourism as a conservation tool comes from the assessment of cross-parcel dynamics and hidden trade-offs. As Carrier and Macleod (2005) point out, a nature tourism operation cannot exist in a bubble. The question becomes, therefore, not whether the individual parcel is used sustainably or environmentally efficiently, but rather what are the landscape impacts of these parcel-level trends? Points A, B, C, and D (Fig. 3) illustrate a possible relationship between land use decisions across parcels. One relationship suggested by the data is that the rising cost of living continually pushes landholders to manage for income potential. For example, a landowner working in agricultural production may be pressured by the rising cost of living to increase agricultural output to generate income equivalent to that produced under a win-win nature tourism scenario (points A and B). Likewise, a landowner working in the nature tourism industry who manages his/her land at point A may invest in higher impact tourism, increasing the sizes of hotels and restaurants to encourage higher rates of visitation and shifting land management to point C. Higher tourism rates can further increase the cost of living, pushing agricultural land management to point D. The assumption here, which would need to be investigated with further research, is that rather than landowners seeking a given balance between income and forest cover, they may be incentivized by income. This relationship is analogous to that discussed by Mastrangelo and Laterra (2015) regarding agricultural intensification in the Argentine Chaco.

Finally, efficiency frontiers and the related trade-offs faced by landowners may vary based on the ecosystem services in question. The data presented here suggest that nature tourism, as it is currently operating in the study area, is particularly detrimental to the water supply. Small-scale agriculture, such as that typical of the study area, seems to provide a small degree of protection for water sources. When maximizing income, agriculture shifts toward industrial agriculture, a land use that has detrimental impacts on water quality and quantity. Likewise, when tourism is managed for maximum income production, and tourism booms cause massive increases in visitation to an area, water quality suffers. Therefore, the same win-win conservation scenario for income/forest cover in nature tourism may possibly produce a win-lose scenario for income/water quality. Although these findings are only preliminary, they carry an important suggestion: if nature tourism is to contribute to long-term conservation in the area, more research needs to go into understanding the extent to which tourism provides multiple ecosystem services that have benefits across the landscape.

CONCLUSION

Understanding nature tourism as a tool for conservation involves challenges: identifying the cultural, economic, and ecological trade-offs associated with nature tourism and evaluating cross-parcel feedback sources between land uses. The data presented here suggest that nature tourism is able to contribute to forest regrowth through providing an economic incentive for forest cover. However, interview data suggest that there are cross-parcel dynamics and unforeseen trade-offs that may hinder social-ecological sustainability and provisioning of multiple ecosystem services. Identifying trade-offs and cross-parcel interactions is critical to understanding the functioning of nature tourism as a sustainable development strategy. Because much of conservation is focused on providing economic incentives for private conservation, it will become increasingly important to evaluate the cross-parcel feedback sources related to economic factors. The efficiency frontier is one tool for thinking about those sources of feedback and how economic incentives have differing effects across parcels. Costa Rica continues to be a world leader in sustainable development. However, further research is necessary to understand the multiple trade-offs associated with economic incentives for private land conservation and how these trade-offs are negotiated across the landscape.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/7058

Acknowledgments:

I thank the University of Georgia (UGA) Costa Rica and the Compañía Nacional de Fuerza y Luz for providing the RapidEye imagery, and Ryan Malloy for running the Normalized Difference Vegetation Index on the 2009/10 mosaic. This research was funded in part by the UGA Latin American and Caribbean Studies Institute. I am grateful to the numerous people who provided assistance in analysis and comments on the manuscript: Ted Gragson, Nathan Nibbelink, Julie Velásquez Runk, Rebecca Moore, Jeff Hepinstall, Steve Holloway, and Peter Brosius. I also thank the reviewers for providing helpful comments and suggestions that greatly improved the manuscript.

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