Protected Area Management and Poverty Alleviation in Costa Rica

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Abstract

This study measures the success of Costa Rican Protected Areas (PAs) in alleviating surrounding levels of poverty based on the degree of land use restrictions they place within their boundaries. The degree of restrictions is measured by which IUCN category a given PA falls under. As a proxy for poverty levels Critical Insufficiencies as defined by El Instituto Nacional de Estadística y Censos (INEC) are used. In general, results indicate no significant differences in poverty levels based on a PA's given IUCN category. However, the study does not control for the heterogeneity of the landscape that is most likely critical in determining whether or not a PA will exacerbate or alleviate surrounding poverty levels. An expanded version of this study that controls for heterogeneity is necessary.

Introduction

Habitat destruction and the loss of large carbon sinks as a result of deforestation, are some of the primary drivers in loss of biodiversity and increase in CO_2 emissions into the atmosphere (Pandit, et al., 2007) (Bala, et al., 2006). Property easements, Payments for Ecosystem Services, and habitat rehabilitations have all been heavily relied upon to conserve biodiversity and combat habitat destruction. However, since the 1980s the establishment of Protected Areas (PAs) has been the primary form of conservation employed by environmental organizations across the globe (Scherl et al., 2004). Protected areas are clearly defined tracts of land established by government agencies, NGOs, or private foundations that restrict land development in order to preserve a crucial facet of a particular ecosystem or unique biophysical feature. They may be aquatic (marine or freshwater), terrestrial, or a combination of the two. The IUCN (International Union for Conservation of Nature), which is the international governing body of PAs, is charged with assessing their quality and function, and categorizes all protected areas based on the degree restriction they place on land development. Categories are numbered I-VI with Category I PAs maintaining the tightest regulations and VI permitting the largest amount of land development. The IUCN list of definitions for each category is provided in the appendix.

Since PAs began to gain prevalence within the environmentalist community, there has much skepticism over both their effects on the surrounding socioeconomic conditions as well has how successful they actually are in achieving their conservation goals. Often the success rate of a particular PA is determined primarily by how success is actually measured. As such, much controversy has arisen over how large a role PAs should play in the global conservationist agenda. Proponents of PAs contend that maintenance of biodiversity requires a spatial level approach and that focusing efforts to save a particular species rather than specific area fails to recognize the complex habitat requirements necessary for the species to survive. In this sense, PAs are the only possible route for preserving biodiversity. Furthermore, advocates of PAs have also been vocal about their ability to create an ecotourism industry as a source of income for local communities. This is especially true when a protected area (usually a wildlife refuge or sanctuary) gains recognition by international groups such as UNESCO. If this happens, communities in close proximity to a refuge or sanctuary may suddenly find themselves right next to a World Heritage Site and a major tourist destination, almost over night

Critics of PAs generally point out two main flaws inherent in their governance. In the case of terrestrial PAs intended to prevent deforestation, critics argue they are mostly established in regions unlikely to be deforested even without protected status. These are areas were other forms of land development are less desirable and the opportunity costs of forgone land development is minimal, thus local opposition to the formation of PAs is very weak. A converse of the first criticism, the second critique states that when PAs are established in areas subject to deforestation, the opportunity costs of the forgone land development (for infrastructure, agriculture, etc…) are excessively high and tend to create poverty traps.

However, conservationists on both sides agree that poverty and environmental degradation go hand in hand. Those living in abject poverty are mostly likely to engage in intensive and unsustainable resource extraction and agricultural production in order to generate the maximum income possible. In the case of agricultural production, the farmer may engage unsustainable farming practices and sacrifice long term productivity for short term monetary gain. As per area production capacity decreaseshe will need to expand his land development to reach the yield levels of previous years until he has exhausted all farmable land available to him. Eventually the farmer will find himself on a plot of land unsuitable for cultivation and perhaps his only source of income gone. Furthermore, they may be inclined to sell their land to large resource extraction industries such as mining and logging companies.

What this points to is a growing need to consider conservation and poverty alleviation jointly, as the negligence of one will always critically undermine the other. In recent years conservationist have begun to understand this, and PAs are increasingly designed to achieve both poverty alleviation and biodiversity conservation. Empirical studies measuring the success of each have generated polarizing results. Studies attempting to reconcile the disparity in results claim that it is the heterogeneity of biophysical features present with PAs that dictate their levels of success. However, no studies have attempted to examine how the management of PAs affects their levels of success in alleviating poverty and preventing deforestation.

This study will attempt to tackle the first component of this two part question which is measuring the success of PAs in in reducing poverty based on the extent of regulations and restrictions placed on land development. It is predicted that PAs with the greatest restrictions on land development will tend to exacerbate poverty levels, while PAs with the most lenient restrictions on land use will tend to reduce poverty levels by still allowing for some land development while also affording the opportunity to establish and ecotourism industry for nearby communities.

A Review of the Literature

In 1989, amidst a growing body of evidence suggesting that large scale environmental organizations were being neglectful and in some cases even abusive of low-income rural community rights, the Coordinating Body of Indigenous Organizations of the Amazon Basin (COICA) issued an appeal to international community outlining the need for indigenous groups to be included in the implementation and management of protected areas near their homes. (Chapin, 2004). COICA went further to say that without an equal partnership between the two stakeholders, the success of conservation programs would always be critically undermined without local buy in, while simultaneously perpetuating the cycle of rural marginalization (Chapin, 2004). Responding favorably (at least in rhetoric), the international community acknowledged that the rapid growth of PAs could potentially hinder economic development through excessive opportunity costs associated with forgoing land development, thus creating new poverty traps (Scherl et al., 2004). With this understanding, conservation projects were to be conducted jointly between local communities, governments, and NGOs and the strategy known as Integrated Conservation and Development Projects (ICDPs) began to take hold (Scherl et al., 2004). Not all new protected areas were explicitly labeled as ICDPs, but the overwhelming majority was still designed with the dual functionality of poverty alleviation and environmental conservation in mind.

At the time IDCPs and "sustainable development" began to gain traction, little was known about the relationship between protected areas and socioeconomic development. An initial assessment conducted by the World Bank found that some of the poorest countries in the world also had the most extensive coverage of protected areas (Scherl et al., 2004). For instance, in 2004 Tanzania was listed as the world's poorest country, with 39.8% of its total land area given protected status, while Zambia ranked as the 7th poorest country, held 41.5% of its total land area under protected status (Scherl et al., 2004). Yet, as of 2004 no causal relationship had been posited between protected status and socioeconomic development within adjacent communities. An earlier study on protected areas in Kenya, offers an explanation for the World Banks's findings by estimating that the opportunity costs forgone by the combined amount of total land dedicated to protected areas was around 203$m per year, while the revenue generated by ecotourism was only around 42$m per year (Norton-Griffiths & Southey, 1995).

However, this study does not take into account the spending that's avoided by maintaining ecosystem services provided by protected areas, such as erosion mitigation and pollination. More importantly, however, it still does not assess the connection between protected areas and poverty alleviation. The study only produces an estimate, it does not empirically assess the opportunity costs of PAs, nor does it intend to demonstrate PAs as a causation for increased levels of poverty. It wouldn't be until the early 2000s, after the effects of PAs on socioeconomic development had sufficient time to set in, that empirical studies would be conducted to directly test both how PAs were influencing poverty levels as well as their success in achieving their conservation goals.

Results of such research typically fall into one of two categories. The first category generally concludes that protected areas are in fact exacerbating poverty levels as many had predicted. Most studies falling within this category also maintain that success of PAs in preventing deforestation could only be considered marginal at best given that most PAs are established in areas unlikely to be deforested. For instance, an AAAS review finds that on average, protected areas exacerbate poverty traps due to the opportunity cost (imposed on local communities) associated with forgoing land development and resource extraction (Adams, 2006).

The International Journal of African Historical Studies presents another example of the adverse effects PAs can have on rural livelihoods. Their case study examines the unintended consequences of the Tanzanian government's policy of shooting poachers on wildlife preserves (Igoe, 2002). On its face the killing of poachers may seem justified, however, in reality many of these poachers are actually farmers trying to protect their livestock from predators. Many, if not most, of these farmer's families have owned their land dating back several generations, long before it was given protected status, and if not for the protected status, they would have been well within their rights to defend their livestock. This is obviously the worst possible effect the establishment of protected areas could have on adjacent communities and is not the norm across countries with large tracts of protected areas, yet it demonstrates some of the immediate and negative impacts PAs can generate.

However other reviews were quick to point out much more common but still very serious consequences of protected areas. Somewhere between 50%-100% of PAs in South America and Asia still contain permanent human inhabitants (Brockington, 2006). As legislation expands and enforcement of these PAs increases, the IUCN warns that millions of refugees may be created (Brockington, 2006). Other critical studies even question the success of PAs in achieving one of their primary goals, preventing deforestation.

Payments for Ecosystem Services (PES) is a program in which NGOs and/or governments pay local land owners to abstain from certain resource extraction practices such as logging, in order to bridge the opportunity cost of forgoing land development while maintaining the function of various ecosystems. In Costa Rica counterfactual matching experiments were conducted to measure the success of PES programs in preventing deforestation. It is observed that less than 1% of land under a PES program would have been deforested if not for the program (Pfaff, 2008). PES programs are different than protected areas, in that land ownership still remains private and highly centralized, however, regulations on logging and other resource extractions are largely the same, thus results found for PES programs are expected to be comparable for PAs with similar biophysical features.

It is clear from these studies, reviews, and observations, that the merits of protected areas as the primary means to achieve both conservation and development should be heavily scrutinized. Yet there also exists strong research advocating the merits of PAs.

This second body of research presents results that are almost a completely contradictory to the first body of evidence, critical of the success of PAs in general. According to this group of work, the formation of PAs, as a whole, have worked to both reduce poverty, and prevent deforestation. Many of these conclusions were reached based on studies and cross-national comparisons between Costa Rica and Thailand, given that each have some the largest and most progressive areas dedicated to the preservation of biodiversity. In these countries it is evident that PAs actually work to reduce baseline poverty as a net result. A study published by PNAS found that in each of the above countries it was true that communities in close proximity to PAs were poorer than the national average, but no causal link could be established between the PAs and the increased poverty levels (Andam et al., 2010). In fact the study found that communities near newly established PAs actually experienced, on average, reduced poverty levels (Andam et al., 2010). Although the study could not explicitly link PAs to poverty reduction, the thought is that protected status generates income through the potential for tourist activities and maintenance of costly ecosystem services.

The same authors of the above study, along with Alexander Pfaff (the Duke University professor critical PES programs' success in preventing deforestation) also conducted another similar study in which protected areas were matched to a counterfactual control group of unprotected areas with similar biophysical and socioeconomic features. Measurements of land deforested in the control group between 1960 and 1997 were taken and it was found that approximately 10% of protected land in Costa Rica would have been deforested, if not for its protected status (Andam et al, 2010). If results of the PES study can be used to predict the deforestation outcomes of PAs and the counterfactual methodology of the two studies are largely the same, then the 10% success rate of PAs compared to Pfaff's earlier results indicating a 1% success rate of PES programs is very intriguing. In other words, Pfaff essentially found two very different results using a very similar study design.

The disparity in findings between both bodies of research is most likely not a result of inadequate research designs on either side. The statistical analyses conducted by both categories lead to valid inferences and predictions. Assuming both categories present scientifically sound findings, another PNAS study, "Conditions Associated with Protected Area Success in Conservation and Poverty Reduction" conducted by Paul J. Ferraro and Katherine Simms could reconcile the contradictory results.

Their study produces the same deforestation results as Pfaff et al, however it also considers deforestation and poverty alleviation jointly and links both variables to differences in the biophysical features of the land. It essentially uses the same counterfactual method as Pfaff and posits that it is primarily the slope of the land which determines a PAs success in achieving its dual purpose. Through a cross-country comparison between Costa Rica and Thailand, they find that PAs with an average terrain slope between 15%-40% experienced the greatest benefits of both poverty alleviation and prevention of deforestation (Ferraro et al., 2010). In these regions, they explain that the agricultural production is rather limited due to the relatively steep slope. In these areas, the opportunity costs of forgoing land development is not so high as to induce a poverty trap, but not so low that the benefits of deforestation (and land development) are non-existent. In other words these areas would still be subject to deforestation and therefore their protected status is still has merit, but local communities do not suffer huge opportunity costs from strict limitations to development. Expanded further, areas where the land is mostly flat have the highest success rate in preventing deforestation, but also tend to exacerbate poverty levels due to excessive opportunity costs (Ferraro et al., 2010). Conversely, regions with an average slope greater than 40%, were found to have the lowest probability of deforestation, and therefore had little success in that regard (Ferraro et al., 2010). However, they did promote the greatest amount of poverty alleviation most likely due to the potential for tourist operations on land otherwise impossible for development. Their study concludes that, landscape heterogeneity must be controlled for when assessing these success rates of PAs in both deforestation and poverty alleviation.

None of the above studies or reviews takes into account the type of protected area in their measurements of success. The degree of land development permitted can have significant impacts on both measures of success (poverty alleviation and deforestation). Take for instance the 203$m aggregate opportunity cost of PAs estimated in the Kenya study. Those estimates would look very different if the regulation of PAs in Kenya was suddenly changed. Ferraro and Simms even acknowledge in their results that "Future analyses should also incorporate an understanding of the differential impacts of protected area types (e.g., wildlife refuges vs. national parks) and other characteristics determining economic opportunities" (Ferraro et al., 2011, p.3). By conducting essentially the same counterfactual methods employed by Ferraro and Simms but also comparing the success of PAs based on category, this study will attempt to quantify their propensity to alleviate poverty levels as a function of their IUCN category. Hopefully, those concerned with the management and implementation of protected areas can be better informed of the potential socioeconomic and environmental side effects that arise from various management designs. The qualitative component of the study should also provide a more nuanced understanding on the effects of PAs than what's possible from the aggregate and low resolution data relied upon by the Ferraro, Simms, and Pfaff.

Materials and Methods

Costa Rica is an ideal place to study the effects of different PA management designs. It has one of the most extensive system of PAs with over 20% of its terrestrial area designated as national parks, wildlife preserves, sanctuaries, and national heritage sites (Worldbank). The study will essentially consist of three separate, but highly related tests.

The first test will assess the general relationship between the proportion of land dedicated to protected areas and surrounding poverty levels. This will be done through a regression of poverty proxies as function of percent land coverage by a protected area. The second test will be a comparison between PAs designated with an IUCN category of either II, IV, or VI and their surrounding poverty levels. This will serve as an overview of PAs success rate in alleviating poverty based strictly on the spectrum of IUCN categorization. The third test will employ matching of protected areas to non-protected areas while controlling for various factors believed to also influence socioeconomic development. Essentially the success of a PA with an IUCN category II, IV, or VI will be measured by the difference between poverty levels surrounding the PA and the poverty levels surrounding its non-protected control match. IUCN categories producing the greatest difference in poverty levels compared to their non-protected match will be considered to have achieved the greatest levels of success in reducing poverty levels.

ESRI ArcMap software is used to compute the approximate percentage of land covered by a PA in each of the 473 districts across Costa Rica. A district level base layer is provided by ESRI's open source online database. Protected area shapefiles are downloaded via the World Database on Protected Areas (WDPA) and then overlayed on the district basemap. Major city point data, and road map line data were also downloaded via ESRI's online data base and then overlayed on the same district base layer. Road density (measured in meters/hectare) and distance (in meters) to the nearest city with a population > 10000 were also calculated for each district. Although Ferraro et al. study, does account for distance to major roads, it does not include a road density control. The inclusion of this control variable may produce a stronger correlation between PA coverage and poverty levels.

Because only limited data exists for exact poverty levels at a district level, 2011 Critical Insufficiency data, by district, was obtained from the Census Institute (El Instituto Nacional de Estadística y Censos) of the Costa Rican government and is considered a proxy for poverty levels. As defined by the Census Institute, Critical Insufficiencies (denoted INS in the results and discussions sections) are a measurement of the percent of population, in each district, living without access to critical features necessary for socioeconomic development. Although an exact list of these features is not provided, the Census Institute generalizes these features as access to basic education, healthcare, and employment (or an equivalent opportunity for adequate income). Although these measurements are only proxies for poverty levels they may, however, produce more substantial results than using actual poverty levels alone. Critical Insufficiencies are a more direct measurement of infrastructure and/or agricultural development. Direct poverty levels only measure relative income and may not take into account the overall quality of livelihoods that are dependent on infrastructure or agricultural development. In this way insufficiency proxies may create a more accurate picture of the socioeconomic condition of each district.

All three tests will employ two sub-tests; one using the percent of the district population living with one or more Critical Insufficiency, and one using the percent of district population living with exactly four Critical Insufficiencies (the highest number of deficiencies listed in the census data). This will account for any relationship that may exist with one extreme, but not the other.

After controlling for other factors with the potential to influence economic development (road density, population, and distance to major cities) a regression is run through STATA for the percentage of each district population living with 1 or more Critical Deficiency against the percent district coverage by a PA. Again, the same regression is run for district populations living with exactly four critical deficiencies.

For the second test, the average deficiency level (for both Critical Deficiencies>=1 and =4) of all districts with >20% of total land area dedicated to PA categories II, IV, or VI is taken and the averages of each category are compared.

By using a data filter in EXCEL, three districts with at least 20% coverage by a PA are first separated based on their IUCN category (II, IV, VI) and then matched to a completely unprotected (0% coverage) district while holding all other economic development factors (population, distance to major city, and road density) mostly constant (slight variations in values are present). The differences in percent of Critical Deficiencies for each PA category and its non-protected match are then compared. Again, the category with the largest difference will be considered the most successful. Should the PA have a higher level of Critical Insufficiencies than its match, it is considered to be exacerbating poverty levels given that all other factors have been held constant. The overall design of this study allows for the observation of possible relationships on a large scale between PAs and poverty levels, yet also provides for a well-controlled small scale analysis between management types and poverty levels of the surrounding area.

Results

Section 1: Overall Relationship between PAs and Critical Insufficiencies

Table 1:

Number of obs = 370
F(4, 365) = 16.65
Prob > F = 0.0000
R-squared =0.1551
Root MSE = 13.4

INS1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
population	-.0003296	.000063	-5.22	0.000	-.0004539	-.0002054
pacoverage	.2457277	.048013	5.12	0.000	.1513109	.3401446
roaddensity	1.50e-06	3.32e-07	4.51	0.000	8.44e-07	2.15e-06
nearestcity	-.000021	.0000289	-0.73	0.468	-.0000778	.0000359

Table 1 displays the relationship between each of the four independent variables (population, percent area coverage of the district by PA, road density, and the nearest city) and the percent of the population living with one or more critical deficiency. The regression for each independent variable is done while holding constant each of the remaining three variables. For every 1% of land covered by a PA, this model predicts an approximately .246 percent increase in proportion of the district population living with 1 or more INS. A P value of 0 indicates that all relationships are statistically significant

Table 2:

Number of obs = 370
F(4, 365) = 5.45
Prob > F = 0.0003
R-squared =0.1009
Root MSE =69.844

INS4	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
population	.0019689	.0004517	4.36	0.000	.0010807	.0028571
pacoverage	.8389077	.3590614	2.34	0.020	.1328189	1.544996
roaddensity	-.0000111	2.49e-06	-4.46	0.000	-.000016	-6.21e-06
nearestcity	-.0000623	.0001063	-0.59	0.558	-.0002713	.0001467

Table 2 displays the relationship between each of the four independent variables (population, percent area coverage by PA, road density, and the nearest city) and the percent of the population living with four critical deficiencies. The regression for each independent variable is done while holding constant each of the remaining three variables. For every 1% of land covered by a PA, the regression predicts an .84 percent increase in the district population living with 4 INS. A P value of .003 indicates that all relationships are statistically significant.

Section 3: Comparing Average % of Insufficiencies based on IUCN Categories

Table 3:

Category II I Avg (n=14)	Category IV Avg (n=7)	Category VI Avg (n=54)	Non-PA Avg
31.62%	30.86%	31.28%	31.41%

Table 3 lists the average percent of the population living with 1 or more INS in a given district with at least 20% of its total land area covered by a category II, IV, and VI PA. Category

II PAs had the highest average at 31.61% while Category IV PAs had the lowest average of 30.86%.

A similar categorical comparison was made for the percent of population in a given district with over 20% of its total land area covered by a PA that is living with exactly four critical deficiencies. However, averages across each of the three categories are all zero. Although sample sizes are small, the average percent of the population across all districts, with or without and PA is also zero. Therefore the sample categorical averages are most likely representative of the entire categorical averages.

Section 4: Controlled Matching and Evaluation PA Categorical Success in Poverty Alleviation

Table 4:

District	Park Name	Park Type	% Area Coverage	Nearest City (m)	Road Density (m/ha)	Population	INS>=1	INS=4
Copey *Candelaria*	Los Santos	VI	93.93486 *0*	364.79 *515.27*	3.46 *7.85*	1802 *1961*	61.6 *26.93*	.09 *0*
Santa Elena *Mansion*	Santa Roas	II	69.18 *0*	14520.00 *1553.96*	2.27 *3.18*	2040 *5715*	49.75 *29.1*	.0025 *0*
Cano Negro *Monte Romo*	Cano Negro	IV	26.14 *0*	1549 *1251.52*	0.93 *0*	1808 *671*	47.29 *48.44*	.001 *0*

Table 4 displays the districts that are dominated by PAs categorized as either II, IV or VI as well as their non-protected district matches. The first district listed in each row is the district that has a significant portion of its land area dedicated to a PA. Listed underneath each district, in italics, is the non-protected district match as well as its values for the corresponding control variables. With the exception of Cano Negro and its non-protected match (Monte Romo) the remaining two districts all had higher percentages of critical insufficiencies for both measures (INS>1 and INS=4). For the INS>1 category, Cano Negro is approximately 1% lower than its non-protected match. However, .001% of the population in Cano Negro is living with exactly four critical deficiencies compared to 0% of its non-protected match.

Discussion

Results from Section 2 indicate that IUCN category IV PAs produce the lowest levels of surrounding poverty with an average of 30.86%, while Category II PAs on average contained the highest levels of poverty at 31.62%. However, Section 3 results are somewhat contradictory. Although the district of Cano Negro, with a significant portion of its area covered by a Category IV PA, outperformed its non-protected match by approximately 1.15%, both the remaining categories had significantly higher poverty levels than their matches for the INS>=1 subtest . As opposed to this study's hypothesis that Category VI PAs would produce the greatest advantage in terms of poverty alleviation, the Copey district with approximately 94% of its area dedicated to a Category VI PA actually had the greatest negative difference between poverty levels with its non-protected match at-34.67 percentage points. All Categories in Section 3 underperformed for the INS=4 subtest compared to their matches. Given that Section 2 result averages are all within 1% of each other as well as the overall district average, and that there is a large disparity in % PA coverage between all categories in Section 3, it is difficult to accurately discern which IUCN PA category performs best at reducing poverty levels.

Results from both Section 1 and Section 3 indicate that districts with a large percentage of total land area dedicated to a PA, regardless of category, have increased levels of poverty. This negative relationship is true for both regressions run in Section 1 while controlling for road density, distance to major cities, and population size. It is especially apparent in Section 3 as Cano Negro had the lowest percentage of land area dedicated to a national park, while also maintaining the lowest INS percentages in both subtests. The Copey district had the highest percent of PA coverage at approximately 94% and correspondingly had the highest INS levels at 61.6% for INS>=1 and .09% for INS=4.

In general, the Section 1 and Section 3 results are consistent with the body of literature purporting that PAs tend exacerbate poverty such as the AAAS review and the original PES study by Pfaff. However, this study does not take into account the heterogeneity of slope and land use capacity that the research by Paul J. Ferraro, Katherine Simms, and Alexander Pfaff, et al. conclude must accounted for when conducting these types of assessments. Again, their study concludes, that the PAs most successful in alleviating poverty levels are those that are established where the average slope of the land is relatively steep (PAs most successful in poverty alleviation and deforestation are in areas where the average slope is 15%>=x=<40%). For example, it could be the case that for Section 3 results, the Cano Negro district has a relatively steep slope and is therefore under optimal conditions for PA success, whereas the Copey district is relatively flat and the opportunity costs of the established PA are extremely high. In other words, it is possible that Section 3 is comparing districts under suboptimal conditions to districts under optimal conditions for PA development. This study does not include land slope data.

It would be worthwhile to expand this study to include the average slope of the land by district and then run the same counterfactual matching comparisons. If slope is accounted for, more distinct differences between the successes of each PA category may arise and a more accurate assessment of this study's initial hypothesis can be made. The PNAS study be Ferraro, Simms, Pfaff, et al. also includes a map of areas they believe most likely for a PA to be successful in both alleviating poverty as well as preventing deforestation. If land cover data is also included, it would also be interesting to observe the success rate of each PA category in both poverty alleviation and deforestation prevention within the areas demarcated for success by the PNAS map.

It would also be beneficial to use a more direct measurement of poverty levels rather than the INS proxies relied on in this study. Since the compilation of this study's results, more direct socioeconomic indicators have been made available by the Cost Rican census institute and should be used in an expanded study. Furthermore, large gaps in the dataset for this study have more than likely skewed some of the results. These gaps arise largely from incomplete attribute and feature class values for the various shapefile layers downloaded via ESRI and DIVA-GIS. A final, but relatively insignificant source of error arises from the fact the ArcMap does not take into account the slope the land or actually boundary distances when computing the percent coverage by a PA for each district. Instead, it relies on the geometries of each polygon and extrapolates total area based on the defined XY coordinate system. However, the variations between actual percent coverage and calculated percent coverage are most likely very slight and the relative proportions between each district are accurate.

Conclusion

Results of this study are, all together, inconclusive. Although they support the first body of literature claiming the PAs exacerbate poverty levels, in light the PNAS study demonstrating the need to account for landscape heterogeneity, no conclusions based on PA category can be drawn. It is most likely the case the results in Section 3 are a product not of the actual PA, but of the landscape features of each district. In other words, the 3 selected districts under protection, were most likely unsuitable for land and economic development to begin with. Therefore the districts could be less developed not because of the opportunity costs forgone by the PA, but because there were no opportunities for land development or access to valuable resources in the first place. The fact that they are poorer than the national district average may be a result of this fact, and their protected status is only a coincidence.

An expanded version of this study accounting for landscape heterogeneity is necessary and it would be interesting, as a preliminary assessment, to see what the average slope of the three districts from Section 3 are. An initial hypothesis is that they are all relatively steep in slope. A raster listed in the appendix comparing the overall slopes between the Copey-Candelaria district match and Cano Negro-Monte Romo match from Results Section 3 supports this hypothesis. In this expanded study more direct measurements of poverty should also be included. When measuring these poverty levels, it should also attempt to quantify the economic benefit of ecosystem services maintained by a PA and perhaps subtract those values from the actual poverty levels. If, under an expanded study similar inconclusive results are found, it may be necessary to do a counterfactual case study of various districts in an attempt to uncover in minute differences in PA management designs not accounted for in a quantitative study such as this one

Appendix

IUCN Category Basic Description

Below is a basic decription of all IUCN categories. A more in depth description and list of category requirements can be found by using the link found at the bottom of the description.

Ia Strict Nature Reserve

- Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphical features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring

Ib Wilderness Area

- Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.

II National Park

- Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.

III Natural Monument or Feature

- Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

IV Habitat/Species Management Area

- Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

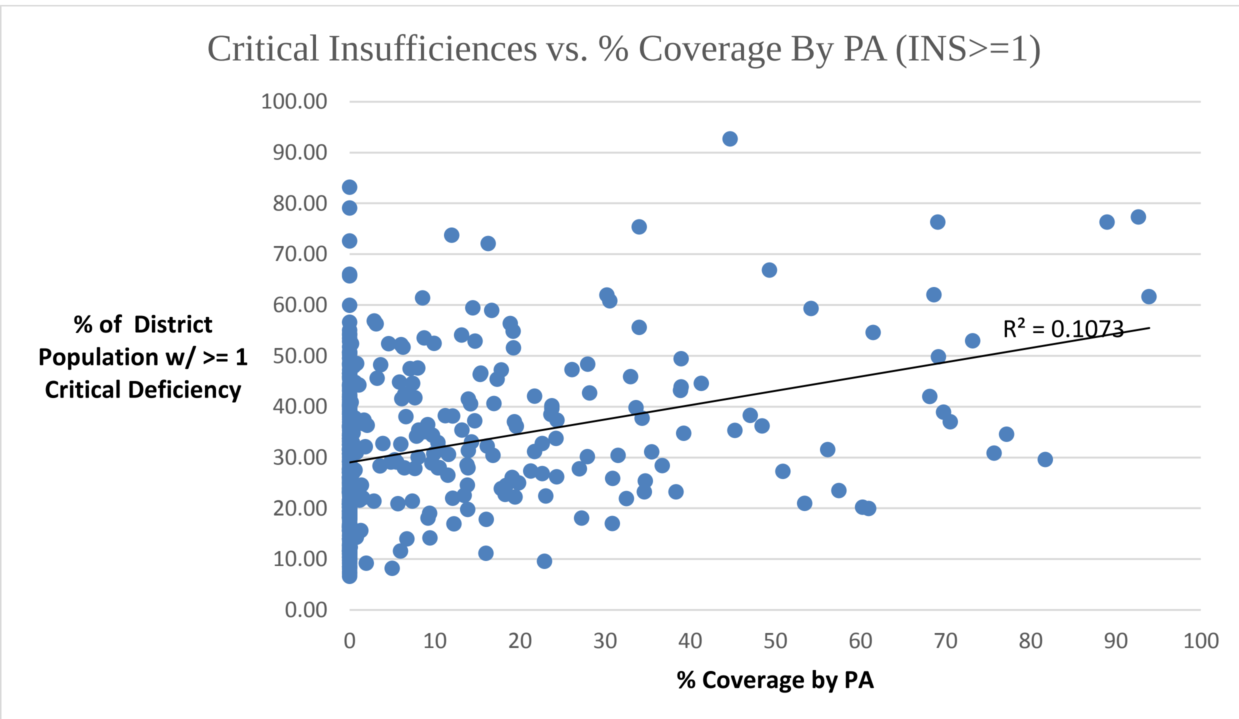
V Protected Landscape/ Seascape

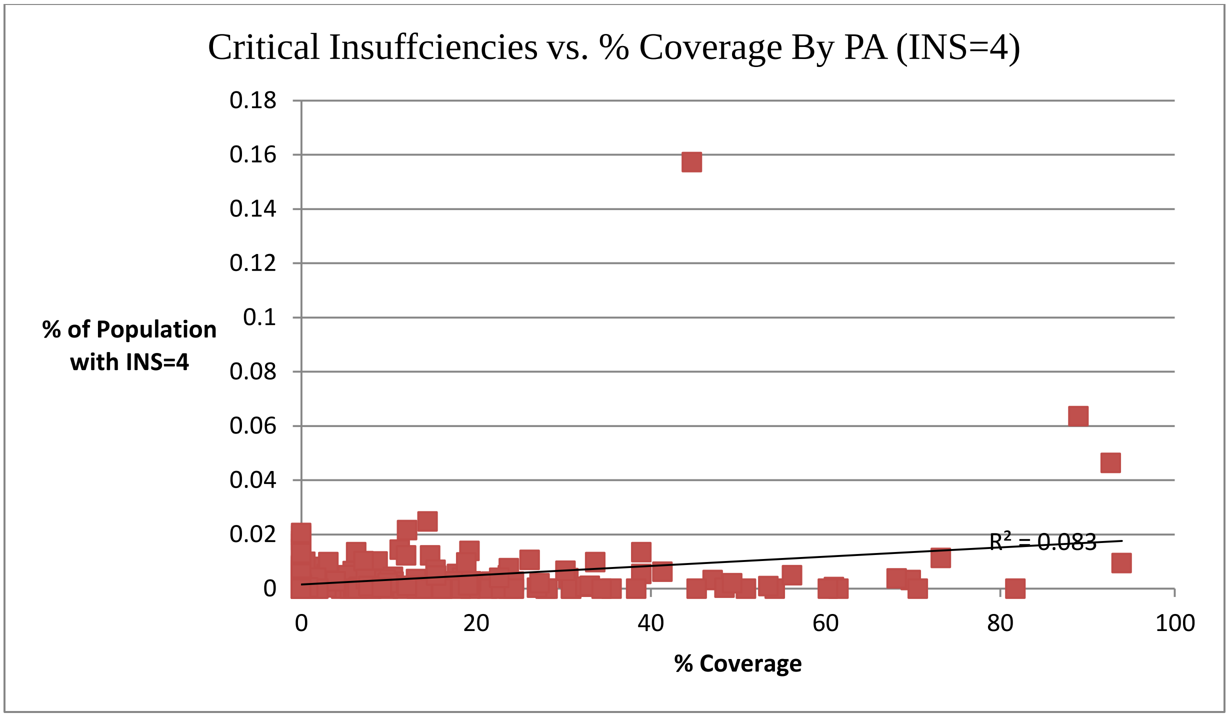
- A protected area where the interaction of people and nature over time has produced an area of distinct charcter with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

VI Protected area with sustainable use of natural resources

- Category VI protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

General Regression Trends of % PA Coverage and INS Levels

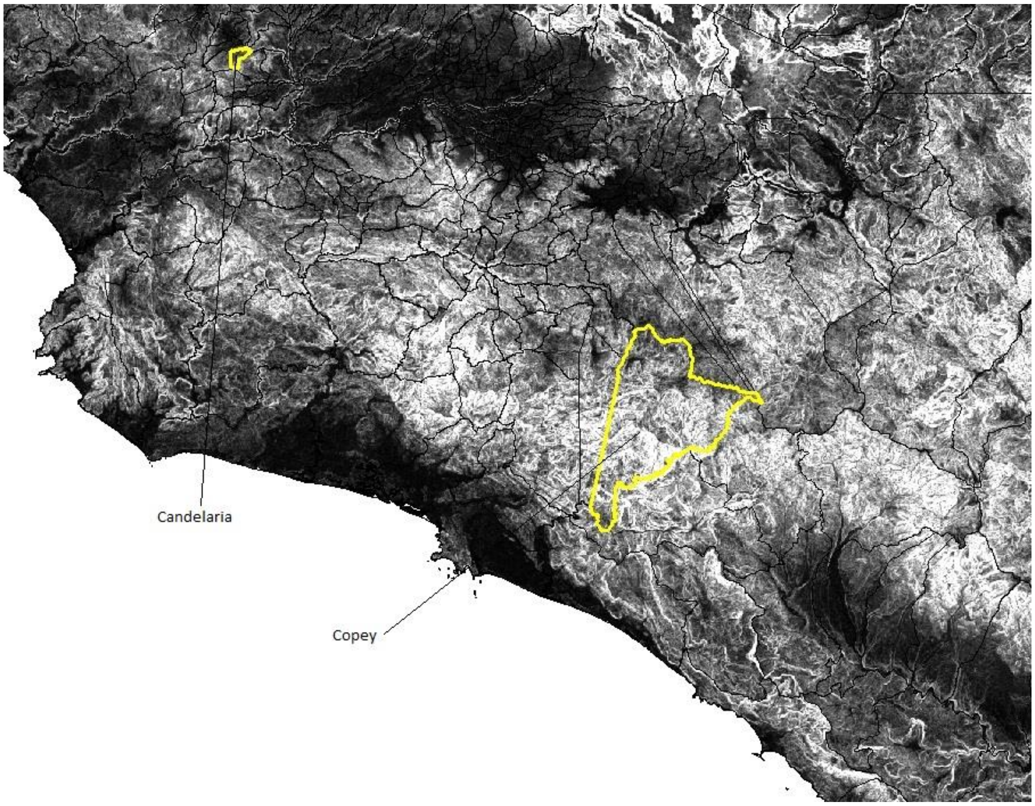


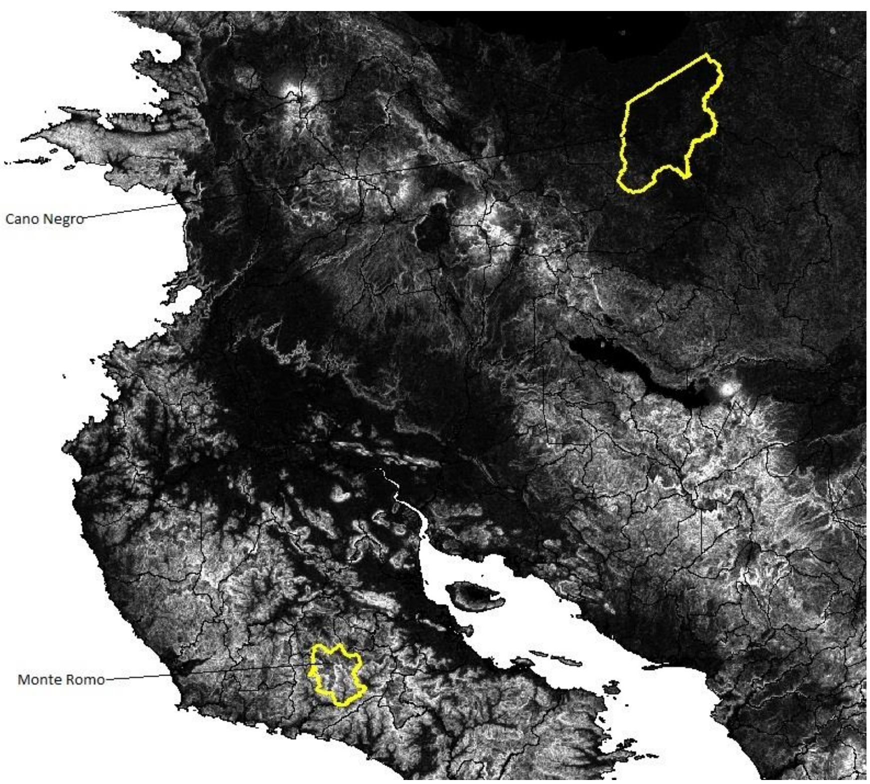


5 Number INS Summary

	INS>=1	INS=4
Min	6.58	0
Q1	20.79783	0
Median	29.11	0.000336
Q3	39.89474	0.002407
Max	92.66	0.157266

Slope Comparison Between District Matches





The rasters displays the % land slope across Costa Rica. Steeper grades are displayed in white, while the flatter areas are displayed in black. Highlighted in yellow are the districts matched in Results Section 3. Overall Copey has a greater proportion of white areas indicating a steeper slope than its Candelaria match. This is consistent with the results indicating a higher percentage of INS >=1 in Copey than in Candelaria. The Cano Negro district is overall flatter than the its match with Monte Romo. This is consistent with the results indicating that Cano Negro has an approximately 1% lower rate of INS>=1 than Monte Romo. However, this is inconsistent with the results indicating Cano Negro has a greater percentage of INS=4 than the Monte Romo match.

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