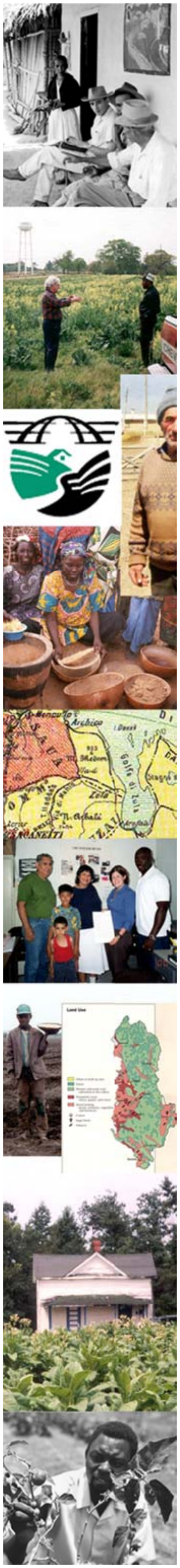


This work was funded with the generous support of the American people through the Leader with Associates Cooperative Agreement No.EPP-A-00-06-00014-00 for implementation of the TransLinks project. The contents of this report are the responsibility of the author and do not necessarily reflect the views of the United States government.

Land Tenure Center

PARKS AND POVERTY:

LESSONS FROM A DECADE OF FOREST LOSS AND ECONOMIC GROWTH AROUND KIBALE NATIONAL PARK, UGANDA

Lisa Naughton-Treves: University of Wisconsin-Madison
Jennifer Alix-Garcia: University of Wisconsin-Madison
Colin A. Chapman: McGill University

♦♦♦♦♦♦♦♦

Provided by the **Land Tenure Center.** Comments encouraged:
Land Tenure Center, Nelson Institute of Environmental Studies,
University of Wisconsin, Madison, WI 53706 USA
kdbrown@wisc.edu; tel: +608-262-8029; fax: +608-262-0014
http://www.ies.wisc.edu/ltc

CLASSIFICATION:

Social Science

SUB-CLASSIFICATION:

Sustainability Science

SPECIAL ISSUES:

Biodiversity Conservation and Poverty Traps

TITLE:

Parks and Poverty: Lessons from a decade of forest loss and economic growth around Kibale National Park, Uganda

AUTHORS:

Lisa Naughton-Treves[1]

Jennifer Alix-Garcia[2]

Colin A. Chapman[3]

1 Dept of Geography, Univ of Wisconsin, Madison, 53706, 608-238-6873, lnaughto@wisc.edu
2 Agricultural and Applied Economics, UW, Madison, 53706, 608-262-4499, alixgarcia@wisc.edu
3 Dept of Anthropology, McGill Univ, Montreal, and WCS, Bronx, NY, 10460, 514-398-1242, Colin.Chapman@McGill.ca

ABSTRACT

Field data linked to Landsat ETM and ASTER image analysis reveals the patterns and biodiversity impacts of deforestation in western Uganda between 1995 and 2006. Communal forest patches were reduced by nearly half during this period and we observed marked declines in species richness of both canopy level trees and primates. Deforestation was significantly slower within Kibale National Park where commercial forest extraction and agricultural clearing were prohibited. Yet a bad decade for the forest proved a prosperous one for most local residents. Longitudinal data for 252 households show substantial improvements in welfare indicators, with the greatest increases found among those with the highest initial assets; as a result wealth inequalities increased over time. Nearly a quarter of households sold land, an economic strategy of last resort in rural Uganda, and 10% lost their land altogether. The risk of land loss amongst the poor was inversely correlated with proximity to the park, initial farm size, and decline in communal forests. We conclude the current disproportionate presence of poor households at the edge of the park does not signal that the park is a poverty trap.

\body

INTRODUCTION

National parks are often blamed for creating or exacerbating poverty in the tropics because they prevent local access to resources, a hardship made worse during times of crisis (1-3). Others counter that parks are placed where households are already poor and may actually provide income-generating opportunities (4, 5). These contradictory predictions are difficult to test given the diverse livelihood strategies of people living next to tropical forests and the variability in park restrictions on resource use. To illuminate the local socioeconomic consequences of lost or limited access to forests, we analyze longitudinal data from Kibale National Park in western Uganda (KNP). Like many tropical parks, KNP is increasingly isolated by deforestation beyond its boundaries due to population growth, urban markets, and agricultural expansion (6, 7). Although generally successful in protecting forest and generating tourism revenue (8), KNP and other Ugandan parks have drawn criticism for exacerbating land and resource shortages (3, 9, 10).

This paper examines the relationship between forest use, biodiversity loss and poverty. In particular, it considers whether park restrictions on forest use induce a *poverty trap* in the sense that the "characteristics of a household's area of residence … entail that the household's consumption cannot rise over time, while an otherwise identical household living in a better endowed area enjoys a rising standard of living" (11):330. Thus we test whether proximity to a forest park is a key geographic characteristic promoting the conditions of a poverty trap. We compare local citizens' use of forest in KNP versus adjacent communal forest patches where commercial extraction is allowed. We also compare forest use by the poorest households to that of more affluent counterparts. Thus we reveal the welfare impact of two distinct forms of lost access to forest: loss due to conservation-oriented restrictions on forest use versus loss due to deforestation from logging and/or agriculture (12).

We combine forest data from satellite imagery and field transects with panel data on the economic assets and welfare of 252 households 0-5 km from KNP during 1996-2006, three years after the park's creation. KNP generally maintained forest cover, tree species and primate populations, whereas communal forest patches were reduced by half and experienced marked declines in tree species and primate populations. We then compared patterns of deforestation with changes in local welfare. A combination of regression analysis and matching estimators show that although the poor tend to be located on the park perimeter, the park has little causal effect on growth of productive assets. Indeed, distance from the park is inversely correlated with the propensity of households to fall into extreme poverty. As a result there is no evidence that the park is a poverty trap. Instead the data suggest low-intensity subsistence use of park forest prevents extreme impoverishment of poor households. Further evidence of this dependency comes from beyond KNP's boundary; poor households neighboring forest patches that are severely reduced or cleared altogether are more likely to sell or abandon their land, a strategy of last resort in rural Uganda.

STUDY SITE

Kibale National Park (795 km^2) is located in a biodiversity hotspot with extraordinary primate and other mammalian diversity (Fig. 1) (13). Established as a colonial timber reserve in 1932, Kibale's management goal later shifted to biodiversity conservation (13). After Kibale became a park in 1993 timber extraction, hunting, charcoal production, and agriculture were curtailed, although local people have continued to draw water and non-timber forest products (NTFPs) from the park's edges (13, 14). KNP now holds the last substantial tract of premontane forest in East Africa. Small patches (3 to 350 ha, average 32 ha) of formerly contiguous extensive forest are still found in lowlands or hillsides outside the park within a mosaic of grasslands, smallholder agriculture, and tea plantations (15). Local use of forest patches is shaped both by customary tenure and more recent legal norms (14). Traditionally, local communities (formerly "clans") collectively managed forest patches, allowing their members to draw forest resources for subsistence (e.g., thatch, firewood) throughout the community's patch. Individual members could also clear forest for crops or pasture within private territories inscribed within the communal forest patch (16). Since Uganda's independence (1962) the state has claimed ownership of all land and attempted to regulate forest use through various national decrees. During the study period forest access and land tenure was confused (17) except in the case of eucalyptus woodlots, an exotic species recognized as a private resource. Most local residents did not own legal title to land yet they recognized property boundaries and some engaged in land transactions. Commercial forest use (timber extraction, gin distillation, and charcoal production) required licenses, a rule poorly enforced outside the park (14). Rapid population growth has further intensified forest use. By 2006 population density near KNP's edge reached 300/km^2 (18, 19).

RESULTS

Forest use and cover change

The area in community forest patches declined by half during 1995-2005 (avg. change = -13.5 ha, SD = 12.4; avg. % change = -50.8%, SD = 24.4%, n=24 patches) concomitant with an average loss of 39% canopy tree species per patch (SD = 27%, n=24 patches, 61 tree species total). The patches did gain some tree species (7.5% of the total species from Time 1) however these were primarily early colonizing species, e.g. *Polyscias fulva*. Primate numbers declined markedly in patches. The black-and-white colobus (*Colobus guereza*) population declined from 81 to 21 individuals and the endangered red colobus (*Procolobus rufomitratus*) from 126 to 16 (Fig 2). Tree species and primate populations showed no similar decline in the park edge forests where deforestation was significantly slower (avg= 3.6%, SD = 7.2, Welch Anova, area deforested: t =3.6, n=32, p =.0015; % deforested: t = 5.8, p<.0001, includes classification error estimates of 2.0-7.1% calculated for 5 patches and 5 park sites, avg= 4.8%). The red colobus population were stable in the park, while the black-and-white population showed a slight increase (20).

People's forest use varied between the park and communal patches. Although the average tree size removed was no different, the maximum size of removed trees was significantly higher in the patches (t=1.070, p=0.291; paired for 41 tree species; park mean 12.3 cm DBH, patch 14.2, n=164 trees extracted from park, n=743 from patches; max size: t=3.493, p=0.001; park mean 15.6. patch mean 36.9). The contrast was even more pronounced for hardwoods (paired t = 4.9, p<.0002, avg patch max =86 cm DBH, avg park max = 17 cm DBH, n=15 species). These slow burning, high-value species offer special advantage for commercial activities but large individuals are costly to extract. In general, forest extraction in the park was confined to NTFPs. By contrast, charcoal production, pit-sawing, and conversion to pasture and crops were observed in every patch (n=24).

How is household welfare changing over time?

By 2006, households were more likely to obtain their drinking water from safe sources, have better roofs, more cattle and goats, own eucalyptus woodlots and employ laborers (Table 1). These changes suggest that both the households' production capacity and their ability to sustain their health have increased. However, there was a slight increase in female-headed households and in farms ≤1 ha. In addition, there were numerous land sales (25% households, n=63) and 'farm abandonment' (10% sold off all their land or relinquished it to debtors, n=24).

We take land abandonment and sales as indicators of duress for these households rather than a sign of "escape" from poverty, as might be the case in situations where households move to the city and obtain higher-paying jobs. Local residents consider selling land an unfortunate strategy for coping with emergency cash needs (39). Selling or relinquishing one's land entirely is so dire, most respondents were reluctant to discuss these cases. We base this assumption on interviews which revealed the reason for land abandonment for 14 of the 24 cases. Illness, HIV especially, but also malaria, and mental illness and/or death of an adult household member featured prominently in 12 of these 14 cases. Unmanageable debt or chronic crop loss due to elephants were also mentioned in four cases. Three of the 14 households became laborers on other people's farms, eight left the region to search for land in Kasese, a poorer District. Another three households moved to urban centers. Beyond the 14 tracked cases, another six households that left the area were deemed "very poor" by their former neighbors, but no specific explanation for their departure was offered. Incidents of land abandonment result in attrition from our sample, but this likely yields an underestimate of differential growth (SI Text 1).

Are the outcomes of the rich improving faster than those of the poor?

We do not have a direct measure of wealth versus poverty, but as a proxy we define as "poor" all households with ≤1ha of land (lower 20% of the land distribution), and households with >4ha (top 20%) as "rich". Landholding size also has special significance for forest use. Those with more land were more likely to engage in commercial forest uses than those with small farms (SI Table 1).

Although the overall wealth of the population seems to be improving, the wealth outcomes of the rich are increasing faster than those of the poor (Table 2). This is because the main determinant of increase in the key productive assets (employees, cattle, goats, and land) is a household's initial level of the asset. Because so many of the households start with zero of the variables in question we can only calculate % change for farm size. We find the rate of growth of farm size is higher amongst the rich than the poor (2.8% versus -0.24 % for the poor). Among those who owned goats in 1996 the increase in goats averaged 1.51 with 0.81 and 3.2 head for the poor and rich, respectively. There were not enough poor households with cattle to even calculate these rates. We also observe that our indicator of extreme distress – land abandonment – is significantly higher for small versus large landholders (Table 2). Land sales are also significantly higher in the land-poor group (Table 2). (Even if we vary cut-off criteria our findings are robust to using the top and bottom 10% of the sample.) These results together indicate that, on average, citizens enjoyed increasing prosperity but the assets of the rich increased faster than those of the poor. Increasing inequality is further reflected in the rise of the Gini coefficient (a measure of inequality) of farm size from 0.42 in 1996 to 0.46 in 2006 – a 9.5% increase.

Is Kibale National Park a poverty trap?

If one were only to consider our data in a single time (1996 or 2006), the evidence would suggest that poverty and distance to the park are indeed inversely correlated (Table 3). On average, households >1km from the park are wealthier – they have more cattle, larger farms and woodlots, and hire more laborers. Households near (<1km) the park are more likely to fall into the land-poor category. The two groups do not differ in terms of number of goats, whether or not the head of the household is female, or whether the house has a grass roof.

When we compare temporal outcomes over space, we find a significantly greater increase in cattle farther from the park and slightly more growth in goatherds and number of employees (Table 4). Farm size change also increases slightly with distance from the park, as does farm abandonment and land sales. The latter result is unexpected given that we have already determined that the poor live closer to the park and would seem more vulnerable to land loss during crises. Evidently the relationship between poverty and proximity to the park is not as straightforward as it appears using cross-sectional relationships.

Results from in-depth interviews further explain the park's impact on household well-being. Many respondents (74%, n=133) stated that poor households use NTFPs to help sustain themselves in times of distress (illness, crop loss to elephants, etc.). We infer that access to NTFPs -- potentially from the park -- allow the very poor to avoid selling all or part of their smallholding during such crises.

We first examine the poverty trap possibility using OLS regressions of change in assets as a function of the baseline of that asset, poverty (farm size ≤1ha), distance to park, and the interaction between distance and poverty (Table 4). The most important determinant of asset change, both in magnitude and significance, proved to be the baseline value of that asset – a one unit increase in cattle, goats, and employees in 1996 all increase the change in the asset by more than 0.5 which implies an increase of 1 cow/goat/employee in Time 2 for every 2 cows/goats/employees at Time 1.

Distance to park does not have a strong effect on any of the outcomes, with the exception of goats and water source quality, where an increase in distance from the park is correlated with significant improvements in both these indicators. This implies that when controlling for the baseline distribution of assets, living close to the park does not by itself have an independent effect on income growth. Interestingly, the analysis shows no significant difference in the effect of distance to the park on asset change among the rich versus the poor. However, being a smallholder farther from the park has a significant effect on the probability of farm abandonment. In particular, a one SD increase in distance from the park increases the probability of poor farmers abandoning their farm by 1%. It does not change the probability of farm abandonment by the non-poor. Land values do not account for this difference. *We found no significant affect of park distance on reported land price (n=27 interviews, 18 <1km KNP, 19>1km KNP, 1ha compared within 4 land use types). The high variability of reported prices suggests a thin land market.

There is no support for the hypothesis of park impoverishment of surrounding households during the study period (Table 4). However, it is an imperfect estimation. An ideal estimation would compare the same households were they living close to and far from the park, an impossible condition. To construct this counterfactual we use a matching estimator, which predicts the "missing" outcome for each household (where "missing" is the "near park" welfare measure for "far" households vice versa for "near" households) using one similar household from the opposing group.[†] Matching is conducted *with replacement* and standard errors adjusted accordingly. If there are two appropriate matches for a household, then both are used. We further adjust for bias in the estimator (21) and use heteroskedastic-robust SE. The limitation of this estimator is that it is based upon observable characteristics. If there are

[†] We match with only the closest nearest neighbor as defined by the minimum Mahalonobis metric between two observations, although the results do not change when matching with more than one. See SI Text 2.

unobservable characteristics correlated with distance to the park, then the difference in means between households close and far can reflect these unobservables. We match households based on: all of their baseline assets, farm size in 1996, if the household was female headed in 1996, and if they had a grass roof in 1996. Thus we show the impact of being near to the park on the whole sample, where “near” is defined as <1 km (SI Text 2). We conduct robustness checks using only “closest” matches as defined by the best 90% of the matches (SI Text 3).

The results of the estimations (SI Table 2) are qualitatively similar to those of Table 4. In general, there is little impact of being close to the park on growth in cattle or goat herds, hiring of employees, or farm size. In terms of avoiding distress sales of land and farm abandonment; however, proximity to park is extremely important, particularly for the poor. The likelihood of land sales is 25.4 percentage points lower near the park than far from it. For land-poor households, this number is 56.1 percentage points and for non-land poor 16.7 percentage points. The impact of being near the park on land abandonment is also very important, particularly for the poor. Households near from the park are 15.6% less likely to abandon their farms on average, and this impact appears to come solely from the effect on poor households. The matching estimator improves the comparison of households considerably from the full sample used in previous analysis where we observe significant differences in baseline characteristics (e.g. Table 4). The matched subsample has few significant differences in covariates in the baseline (SI Table 4).

Our estimation strategy cannot control for the fact that at some point in distant history the families which lived near the park had different assets and livelihood strategies which were then passed on to the households that we observe today. Income growth is a dynamic process and there exists the possibility that the park affected the initial distribution of assets back when it was being established and the current distribution reflects that event. However, this seems unlikely given that 85% of respondents had at least two generations of family residency on their land well before Kibale became a park in 1993 (n=133). No evictions occurred in the study region when KNP was created in 1993 (although a large eviction with high reported social costs occurred 20 km away in the Kibale corridor, a region populated by more recent immigrants) (22).

Despite these potential differences the evidence presented here does not provide even minimal support for the assertion that the park has induced a poverty trap, although the path dependence of assets certainly suggests the possibility that there is some other source of a poverty trap. The differences in forest use by the rich and poor revealed in the previous section suggest the possibility that wealthy have access to productive assets inaccessible to the poor – possibly as a result of credit constraints.

Another possibility is that although poor households near and far from the park appear similar, their use of forest is quite different as a result of being near the park. For this reason, in the following section we apply the matching estimator of the previous section to analyze differences in NTFP use and other livelihood activities. Only two livelihood differences appear – households near the park are slightly more likely to be engaged in the production of banana gin (SI Table 3). Banana gin is sold in urban markets and requires laborers and a steady supply of slow burning wood to manufacture. The disproportionate presence of stills at park edge (vs. patches) may be a function of the fact that logs to fuel stills are available from the forest floor within the park.

Who benefits most from forest patches?

To analyze the effect of baseline patch size on available indicators, we again use a regression framework that controls for baseline assets. However, in this specification we consider the interaction of our indicator for small farms (≤ 1ha) with patch size in 1995. The impact of being poor on welfare outcomes varied significantly according to forest patch size at Time 1 (Table 5). Poor households who lived by larger patches in 1996 had significantly more growth in cattle and goat herds. Meanwhile, poor households located near small patches were significantly more likely to abandon their land, although poor households near large patches were actually more likely to sell their land. There were no significant differences in changes in farm size and employees in poor households after controlling for baseline characteristics.

Forest clearance within patches also influenced welfare outcomes (Table 5). The marginal effects of poverty indicate that the poor are differentially affected by deforestation. In particular, a one SD increase in deforestation leads to large increases in the probability of land sales and land abandonment. Higher deforestation also results in an increased probability of land sales among the non-poor but the effect is significantly smaller. In addition, although a one SD increase in deforestation results in a decrease in farm size of 0.18 hectares among the poor, it has no significant effect on the farm size of the non-poor. These results support the assertion that lost access to common forest resources differentially affects the very poor, much as they are differentially affected by their proximity to the park, who apparently use park resources as insurance mechanism during crisis times (23). Given that there is likely to be reverse causality between the outcomes and patch deforestation, these results should be taken as descriptive.

DISCUSSION AND CONCLUSIONS

Over the decade closed canopy forest fared significantly better within Kibale National Park than in the surrounding communal patches. Our results accord with other studies documenting rapid deforestation around Kibale and other Ugandan parks (19, 24, 25). Unfortunately, like most tropical forest parks, Kibale is becoming increasingly isolated (26). Our field measures of tree species loss and primate population decline outside the park also match previous research (27). A 2010 survey revealed that most of the study patches have been entirely cleared (Chapman, unpub. data). As the largest remnant of premontane forest in East Africa, Kibale's biodiversity value is obvious. We found no evidence that sustaining this biodiversity is creating a poverty trap. Our data suggest that although there is evidence of poverty trap dynamics, the park is not the source of this trap – rather, Kibale appears to provide some protection against desperation sales and farm loss among those most vulnerable. Yet the patterns of economic growth and commercial forest use we observed beyond Kibale's boundary indicate some trade-offs between conservation and development, and confirm models of differentiated forest use and dependency (23).

Most households improved their production capacity and ability to sustain their health, a trend matching economic growth in the broader region (28-30). However, we also observed widening inequality in productive assets, and signs of deepening poverty for some households, a pattern also observed elsewhere in western Uganda, most notably among female-headed households and those suffering health crises (28, 31). This is consistent with the literature on poverty traps, which show considerable path dependence of assets (32, 33). Households fortunate to have larger landholdings and more livestock at Time 1 enjoyed greater growth in these assets than those who started with less wealth (34). Differentiated access to forest also proved an important predictor of welfare outcomes.

As expected, wealthier households were significantly more likely to engage in commercial forest use. These commercial uses were unsustainable yet wealthier households appeared minimally affected by resulting forest loss, perhaps because they had alternative incomes, including: cultivating tea, commercial bananas and eucalyptus, and raising cattle. Meanwhile, the very poor drew on forests (in both patches and park) primarily for NTFPs and appeared more vulnerable to negative consequences of forest depletion (35). The greatest poverty risk, land abandonment, was associated with smallholding size in Time 1, and with living next to a heavily depleted or entirely cleared communal forest patch. There were no increases in productive assets associated with park proximity aside from the lowered incidence of land sales and loss.

Finally, although deforestation was an order of magnitude faster in neighboring patches than in the park, it would be inappropriate to discard common property as a conservation strategy based on these results. Around Kibale, profound uncertainty regarding access rights acts against natural forest. Several respondents explained that they preferred eucalyptus woodlots over natural forest due to the clear status of eucalyptus as a private resource. Comparing the conservation outcomes of parks versus communal property regimes must be considered in light of markedly different levels of support and understanding of rules (36, 37). Until tenure is clarified and conservation incentives are in place, parks will be necessary for biodiversity conservation in this densely settled area.

In sum, our results caution against interpreting the disproportionate presence of very poor households at park edges as evidence that parks create poverty traps. There may be more powerful threats to very poor and marginalized citizens than national parks (e.g., land concentration and scarcity, exhaustion of common pool resources). On the other hand, allowing local populations to extract limited amounts of NTFPs from parks is unlikely to lift rural poor from poverty. Targeted investments in infrastructure, forest governance, health care and social safety nets are essential to achieve economic growth at the least harm to biodiverse forests.

METHODS

We focused on a ~90 km^2 area <5km of KNP, all of similar forest and soil type (Fig 1) and monitored socioeconomic and ecological changes in and around all forest patches (24 patches, 3-102 ha; some large patches were subdivided into smaller territories, each claimed by a different village). We collected similar data for the eight villages immediately bordering the park. We surveyed every household neighboring the 24 patches and 8 park edges, once during 1996 (Time 1) and again in late 2005/early 2006 (Time 2) (n=252 households). Interviews and data on forest use in both patches and park edge sites were collected intermittently between 1995-2005. In May and June of 1995, 2000, 2003, and 2010 we censused all resident primates in the forest patches, with each census requiring 2-4 days. Red and black-and-white colobus are the only primates resident to single patches and thus can be accurately censused (*Pan troglodytes* and *Cercopithecus ascanius* occasionally visit patches). Since the black-and-white and red colobus do not flee observers, are conspicuous, and the forest patches are small, we are confident of the accuracy of the census.

Change in closed-canopy forest cover was assessed using Landsat ETM images from 1995, 2001, and a 2005 ASTER image. Due to the heterogeneous quality of vegetation cover, we employed on-screen digitization of the 24 forest patches linked to field survey data for the same year as the image (GPS points were recorded every 100m of forest perimeter). If a patch was occluded by clouds in an image, we measured forest cover for that year more intensively (min. 1 GPS point per 50m). By 2005, several small patches (<10ha) were no longer visible via satellite and we relied entirely on field measures to determine their area. We selected park border sites wherever villages abutted park in the study area (n=8). There we assessed forest cover change within a rectangular buffer extending 500m into the park (n=8, average 42.1 ha, range: 20-88 ha). Again, park forest edges were surveyed in the field every 50-100m. To assess change in tree species at Time 1 and 2 we counted all individual crowns for each tree species visible in the canopy of each patch.

To measure forest use, we tallied evidence of charcoal production, timber extraction, gin distillation, hunting, and agricultural clearing for every household at Time 1 and 2. Additionally, we randomly selected established paths (3 per patch or park edge site) and registered evidence of recent extraction by species, tree size, and presumed usage up to 100 m of path length, <2.5m to either side of path midline.

We surveyed the same 252 homesteads at Time 1 and 2 to assess basic economic assets (goats (#), eucalyptus woodlot (y/n)), and locally recognized indicators of wealth (cattle (#), farm size (ha), employ occasional or fulltime laborer on farm (y/n)) and poverty (grass roof, obtain water directly from stream, woman-headed household). We also recorded land sales. Of the initial 252 households, 24 had sold off or relinquished all their land and left the area by Time 2. To determine the reason, we attempted to find and interview those who left or we spoke with their former neighbors.

Detailed interviews with 133 individuals (>2 per patch or park site) at Time 1 and 2 yielded insights on livelihoods, forest use and land prices at varying distance from park (0-5 km, 124 price estimates for 4 use types: natural forest, fallow, cultivation, pasture). The data set does not contain income because the interviewees were reluctant or unable to quantify this. But they agreed that landholding size strongly affects income and is the best wealth indicator.

ACKNOWLEDGEMENTS

Funding was provided by US NSF Geography & Regional Science Division (#98-10144), travel grants from Princeton Univ and UW-Madison, Fulbright-IIE Faculty Grant, Canada Research Chairs Program, NSERC Canada and USAID Translinks Leader with Assoc. Coop. Agreement #EPP-A-00-06-00014-00. The Uganda National Council for Science and Technology and the Uganda Wildlife Authority approved this research. R. Rose lead the satellite image analysis. R. Kirby, K. Archabald, D. Kammen, T. Buckingham and E. Olson provided invaluable assistance. Pascal Baguma plus Kibale Fish and Monkey Project staff provided expert assistance with field data collection and its interpretation.

REFERENCES

1. McSweeney K (2005) Natural insurance, forest access, and compounded misfortune: Forest resources in smallholder coping strategies before and after Hurricane Mitch, Northeastern Honduras. *World Development* 33:1453-1471.
2. Adams W, Hutton J (2007) People, parks and poverty: Political ecology and biodiversity conservation. *Conservation and Society* 5:147-183.
3. Cernea M, Schmidt-Soltau K (2006) Poverty Risks and National Parks: Policy Issues in Conservation and Resettlement. *World Development* 34:1808-1830.
4. Sims KRE (2010) Conservation and development: Evidence from Thai protected areas. *Journal of Environmental Economics and Management* In Press, Corrected Proof.
5. Joppa LN, Pfaff A (2009) High and Far: Biases in the Location of Protected Areas. *PLoS ONE* 4:e8273.
6. DeFries RS (2010) Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience* 3:178-181.
7. Chapman CA, Lawes MJ, Eeley HAC (2006) What hope for African primate diversity? *African Journal of Ecology* 44:116-133.
8. Plumptre AJ*, et al.* (2007) The biodiversity of the Albertine Rift. *Biological Conservation* 134:178-194.
9. Laudati AA (2010) The Encroaching Forest: Struggles Over Land and Resources on the Boundary of Bwindi Impenetrable National Park, Uganda. *Society & Natural Resources: An International Journal* 23:776 - 789.
10. Tumusiime D (2006) Dependence on environmental income by households around Rwenzori Mountain National Park, Western Uganda.).
11. Jalan J, Ravallion M (2002) Geographic poverty traps? A micro model of consumption growth in rural China. *Journal of Applied Econometrics* 17:329-346.
12. Turner BL*, et al.* (2001) Deforestation in the southern Yucatan peninsular regin: an integrative approach. *Forest Ecology and Management* 154:353-370.
13. Struhsaker TT (1997) *Ecology of an African rain forest: logging in Kibale and the conflict between conservation and exploitation* (University Press of Florida, Gainesville, FL).
14. Naughton-Treves L, Kammen D, Chapman C (2007) Burning biodiversity: Woody biomass use by commercial and subsistence groups in western Uganda's forests. *Biological Conservation* 134:232-241.
15. Chapman CA, Lambert JE (2000) Habitat alteration and the conservation of African primates: Case study of Kibale National Park, Uganda. *American Journal of Primatology* 50:169-185.
16. Hartter J, Southworth J (2009) Dwindling resources and fragmentation of landscapes around parks: wetlands and forest patches around Kibale National Park, Uganda. *Landscape Ecology* 24:643-656.
17. McAuslan P (2003) *Bringing the law back in: essays in land, law, and development* (Ashgate Publishing Ltd., Farnham).

18. Hartter J (2007) Landscape change around Kibale National Park, Uganda: impacts on land cover, land use, and livelihoods. (University of Florida).
19. Mulley B, Unruh J (2004) The role of off-farm employment in tropical forest conservation: labor, migration, and smallholder attitudes towards land in western Uganda. *Journal of Environment Management* 71:193-205.
20. Chapman CA, Struhsaker TT, Skorupa JP, Snaith TV, Rothman JM (2010) Understanding long-term primate community dynamics: Implications of forest change. . *Ecological Applications* 20:179-191.
21. Abadie A, Imbens GW (2006) Large sample properties of matching estimators for average treatment effects. *Econometrica* 74:235-267.
22. Feeny P (1998) *Accountable Aid* (Oxfam, London).
23. Angelsen A, Wunder S (2003) Exploring the Forest—Poverty Link: Key Concepts, Issues and Research Implications. (CIFOR, Bogor, Indonesia), p 70.
24. Howard PC (1991) *Nature Conservation in Uganda's Tropical Forest Reserves* (IUCN, Gland, Switzerland) p 313 pp.
25. Olupot W, Barigyira R, Chapman CA (2009) The status of anthropogenic threat at the people-park interface of Bwindi Impenetrable National Park, Uganda. *Environmental Conservation* 36:41-50.
26. DeFries R, Hansen A, Newton AC, Hansen MC (2005) Increasing isolation of protected areas in tropical forests over the past twenty years. *Ecological Applications* 15:19-26.
27. Chapman CA, Lambert JE (2000) Habitat alteration and the conservation of African primates: A case study of Kibale National Park, Uganda. *American Journal of Primatology* 50:169-186.
28. Krishna A*, et al.* (2006) Escaping poverty and becoming poor in 36 villages of Central and Western Uganda. *Journal of Development Studies* 42:346-370.
29. Emwanu T, Okwi O, Hoogeveen J, Kristjanson P (2004) Where are the Poor? Mapping patterns of well-being in Uganda: 1992 and 1999. (Uganda Bureau of Statistics and the International Livestock Research Institute (ILRI), Nairobi, Kenya).
30. Fan S, Chan-Kang C (2004) Returns to investment in less-favored areas in developing countries: a synthesis of evidence and implications for Africa. *Food Policy* 29:431-444.
31. Anonymous (2000) *Kabarole District Report* (Kampala), Ministry of Finance, Planning and Economic Development.
32. Lybbert TJ, Barrett CB, Desta S, Coppock DL (2004) Stochastic wealth dynamics and risk management among a poor population. *The Economic Journal* 114:750-777.
33. Carter MR, Barrett CB (2006) The economics of poverty traps and persistent poverty: An asset-based approach. *Journal of Development Studies* 42:178 - 199.
34. Chowdhury RR, Turner BL (2006) Reconciling Agency and Structure in Empirical Analysis: Smallholder Land Use in the Southern Yucaťan, Mexico. *Annals of the American Association of Geographers* 96:302-322.
35. Bush G, Nampindo S, Aguti C, Plumptre A (2004) The Value of Uganda's Forests: A livelihoods and ecosystems approach. *Kampala, Uganda: Wildlife Conservation Society*.
36. Barrett C, Brandon K, Gibson C, Gjertsen H (2001) Conserving tropical biodiversity amid weak institutions. *BioScience* 51:497-502.
37. Ostrom E, Nagendra H (2006) Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory. *PNAS* 103:19224-19231.
38. Abadie A, Imbens, G (2002) Simple and Bias-Corrected Matching Estimators for Average Treatment Effects. *NBER Working Paper No. T0283*.
39. Abadie A, Drukker D, Herr, J, Imbens, G (2004) Implementing matching estimators for average treatment effects in Stata. *The Stata Journal* 4: 290-311.

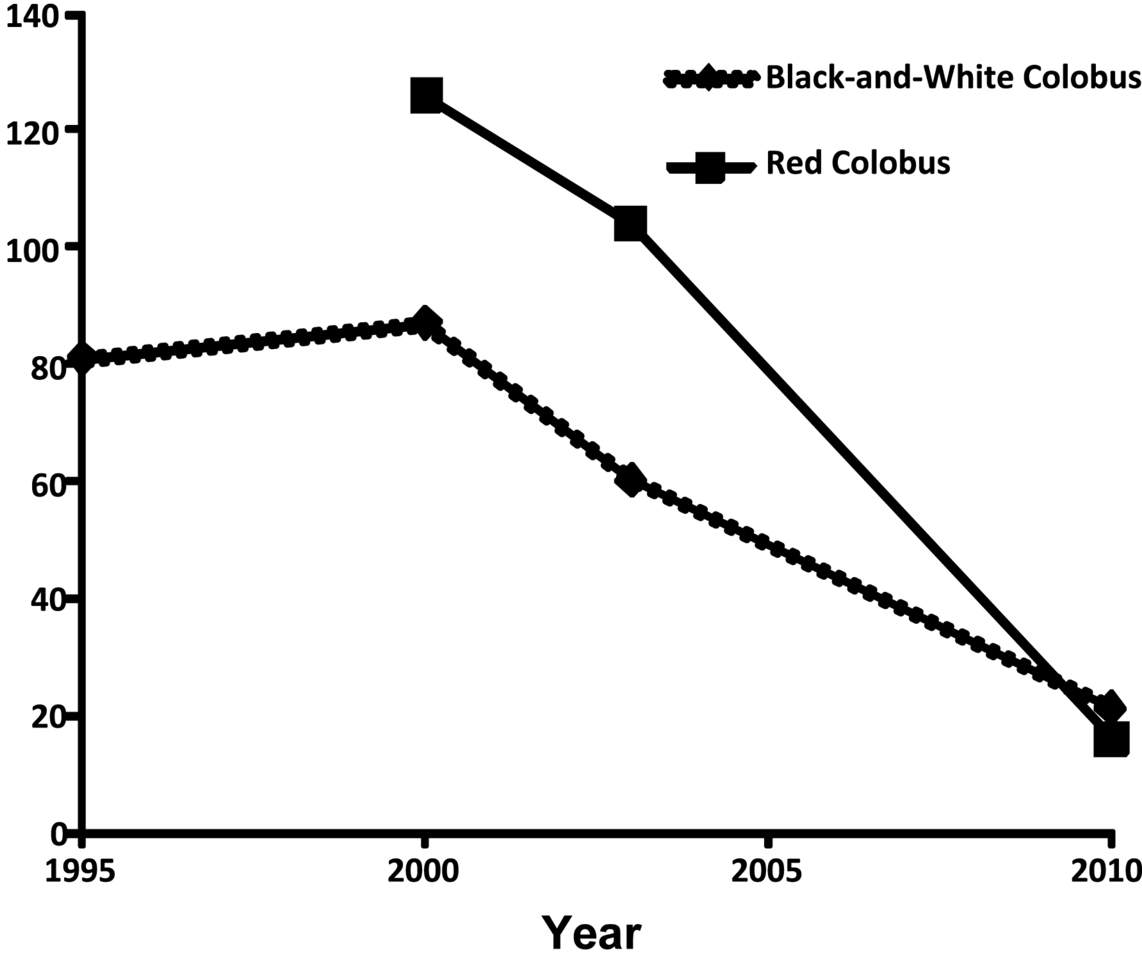
TABLE LEGENDS

Table 1: Welfare indicators and productive assets for households neighboring Kibale National Park, Uganda or adjacent forest patches, 1996-2006.
Table 2: Asset change among land-poor and land-rich households around Kibale National Park, Uganda, 1996-2006
Table 3. Household welfare indicators versus distance from Kibale National Park, Uganda (0-5 km)
Table 4: Impact of distance from Kibale National Park on change in household assets and welfare: Ordinary Least Squares regressions, Δ = change between 1996 and 2006. Columns (1) – (4) are OLS regressions with robust standard errors in parentheses. Columns (4) and (5) show marginal effects of a probit with standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Column (7) shows coefficients from an ordered probit, where increases in coefficients indicate increases in the safety of the water source.
Table 5: Change in household welfare versus initial forest patch size and extent deforestation, 1996-2006. Robust standard errors, clustered on patch, in parentheses *** p<0.01, ** p<0.05, * p<0.1 Marginal effects of poverty are shown in lower panel.

Supporting Information

SI Table 1. The proportion of households engaged in different activities as a function of wealth as indexed by landholding size. The households are directly neighboring Kibale National Park, Uganda or a forest fragment within ≤5 km of the edge. ** Indicates a statistically significant difference among wealth categories with the category being different always being readily apparent from the values presented.
SI Table 2: The effect of being less than 1 km from Kibale National Park, Uganda: matching estimations
SI Table 3: Improvement in covariate comparison with matching (abandon sample)
SI Table 4: Use of non-timber forest products by households less than 1 km from the park, relative to those far from the park Δ indicates a change in the variable between 1996 and 2006. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Uganda
SUDAN
DEMOCRATIC REPUBLIC OF CONGO
UGANDA
KENYA
Kibale National Park
Lake Victoria
Kibale National Park, Uganda
Imagery: Google, 2010
a
b
v
c
e
d
f
g
h
i
j
1
2
3
4
5
6
7
8
w
x
u
k
l
m
n
o
p
q
r
s
t
Kibale National Park
0 1,000 2,000 yards
0 1,000 2,000 meters



140
120
100
80
60
40
20
0
1995
2000
2005
2010
Year
Black-and-White Colobus
Red Colobus

Table 1: Welfare indicators and productive assets for households neighboring Kibale National Park, Uganda or adjacent forest patches, 1996-2006.

Welfare indicator or productive asset	1996	Change by 2006	N (households)
Water from stream or lake (*least safe*)[1]	0.23	-.197	248
Water from shallow well [1]	0.55	-.11	248
Water from borehole or deep well[1] (*most safe*)	0.13	.325	248
# cattle[2]	1.76	1.41	195
# goats[2]	2.39	1.51	204
# employees (includes short & long term)[2]	0.21	0.41	217
Eucalyptus woodlot[1]	.44	.02	217
Farm size (ha)[2]	3.21	.09	204
Farm ≤ 1 ha[1]	0.24	.02	248
Female headed household (0/1)[1]	0.11	0.03	242
Grass roof (0/1)[1]	0.14	-0.10	245
Farm abandonment (0/1)[1]	--	0.01	247
Land sales (0/1)[1]	--	0.25	241

[1] Proportion of households
[2] Average per household

Table 2: Asset change among land-poor and land-rich households around Kibale National Park, Uganda, 1996-2006

Observed outcomes, 1996-2006	Outcome for those with ≤1 ha land in 1996 (n=52)	Outcome for those with >4 ha land in 1996 (n=53)	Test of difference
Safety rank of water source (1-3, 3= safest)[1]	0.54	0.57	0.21
Farm abandoned[2]	0.26	0.02	3.94**
Sales of farmland[2]	0.38	0.19	2.20**
Cattle (#)[1]	0.43	5.61	2.43**
Goats (#)[1]	0.81	3.2	1.51
Employees (#)[1]	0.10	1.22	3.09
Farm size (ha)[1]	0.002	.45	0.88
Farm size (% change)[1]	-.244	2.8	1.15

** Indicates a difference significant at $p < .05$

[1] Average for households
[2] Proportion of households

Table 3: Household welfare indicators by distance from Kibale National Park, Uganda (0-5 km)

Welfare indicator	Near park (<1.1 km) (avg.)	Far from park (≥1.1 km) (avg)	Test of difference	N
<u>*Baseline variables at time 1 (1996):*</u>				
Cattle (#)	0.45	2.83	2.213	193
Goats (#)	2.55	2.27	0.63	202
Employees, temporary or longterm (#)	0.12	0.29	1.74	215
Farm size (ha)	2.84	3.51	1.74	229
Small farms (proportion total farms)	0.29	0.17	2.22	248
Female headed household (proportion)	0.10	0.13	0.61	242
Grass roof (proportion)	0.18	0.11	1.59	245
Rely on least safe water source (directly from stream or lake, proportion)	0.35	0.13	4.17	248
Rely on most safe water source (deep well or borehole, proportion)	0.03	0.21	4.42	248
<u>*Changes over time (1996-2006):*</u>				
Rank of water source (1-3, 3 safest)	0.41	0.71	3.72	224
Farm loss (0/1)	0.03	0.15	3.10	247
Land sales (0/1)	0.13	0.36	3.96	241
Cattle (#)	0.52	2.21	1.82	174
Goats (#)	0.84	2.05	1.79	181
Employees (#)	0.31	0.51	1.14	194
Farm size (ha)	0.04	0.14	0.43	202

.

Table 4: Impact of distance (0-5 km) from Kibale National Park, Uganda on change in household assets and welfare: Ordinary Least Squares regressions

	Dependent variables						
	(1) Δcattle (#)	(2) Δgoats (#)	(3) Δemployees	(4) Δfarm size (ha)	(5) Abandon land? (y/n)	(6) Land sales during study period?	(7) Safe water source (borehole or deep well) 2006
Farm ≤ 1 ha	-0.324 (0.454)	0.267 (0.816)	-0.905 (0.624)	-0.211 (0.528)	-0.110* (0.0626)	-0.0954 (0.193)	-0.00625 (0.110)
Ln (distance to park)	-0.0137 (0.0702)	0.278** (0.128)	-0.0957 (0.0863)	-0.0177 (0.0790)	-0.00144 (0.00918)	0.0230 (0.0155)	0.0743*** (0.0121)
Farm ≤1 ha x ln(dist park)	0.0778 (0.0888)	-0.0486 (0.153)	0.108 (0.0894)	0.0146 (0.0801)	0.0478** (0.0200)	0.0436 (0.0329)	-0.0139 (0.0240)
Cattle 1996	0.594*** (0.177)						
Goat 1996		0.584** (0.239)					
Employees 1996			0.534** (0.226)				
Water source rank 1996							0.269*** (0.0426)
Constant	0.365 (0.352)	-1.632 (1.069)	0.947 (0.616)	0.229 (0.524)			-0.470*** (0.0720)
Observations	176	183	196	204	247	241	206
R-squared	0.538	0.185	0.131	0.006			

Table 5: Change in household welfare versus initial forest patch size and extent deforestation, 1996-2006

	Dependent variable						
	(1) Δcattle (#)	(2) Δgoats (#)	(3) Δemployees	(4) Δfarm size (ha)	(5) Abandon land? (y/n)	(6) Land sales during study period?	(7) Safe water source 2006
Relationship between patch size and welfare – marginal effect of poverty							
Patch size = 3	-.667	-1.97**	-.248*	.325	.301***	.253***	-.179
	(.531)	(.778)	(.131)	(.335)	(.089)	(.092)	(.310)
Patch size = 102	1.91*	2.78**	-.462	-.312	-.025	.321**	-.247
	(1.13)	(1.43)	(.548)	(.608)	(.091)	(.161)	(.308)
Relationship between patch deforestation and welfare – marginal effects of 1 sd increase in deforestation							
On non-poor	.155	.126	.082	-.088	.014	.102***	.146**
	(.208)	(.315)	(.078)	(.142)	(.016)	(.030)	(.064)
On poor	.470	.849**	.008	-.005	.152**	.170**	.203**
	(.345)	(.388)	(.064)	(.089)	(.064)	(.070)	(.096)