Lessons about parks and poverty from a decade of forest loss and economic growth around Kibale National Park, Uganda

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We use field data linked to satellite image analysis to examine the relationship between biodiversity loss, deforestation, and poverty around Kibale National Park (KNP) in western Uganda, 1996–2006. Over this decade, KNP generally maintained forest cover, tree species, and primate populations, whereas neighboring communal forest patches were reduced by half and showed substantial declines in tree species and primate populations. However, a bad decade for forest outside the park proved a prosperous one for most local residents. Panel data for 252 households show substantial improvement in welfare indicators (e.g., safer water, more durable roof material), with the greatest increases found among those with highest initial assets. A combination of regression analysis and matching estimators shows that although the poor tend to be located on the park perimeter, proximity to the park has no measureable effect on growth of productive assets. The risk for land loss among the poor was inversely correlated with proximity to the park, initial farm size, and decline in adjacent 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. Rather, Kibale appears to provide protection against desperation sales and farm loss among those most vulnerable.

conservation | tropical forest | protected areas | economic development

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). Testing these contradictory predictions is difficult, given local variation in livelihoods and level of park restrictions on resource use. Although several studies have revealed the disproportionate presence of the poor at park edges, the underlying causal mechanism is unclear (6–8).

To illuminate the local socioeconomic consequences of lost or limited access to forests, we analyze longitudinal data from Kibale National Park (KNP) in western Uganda. Like most tropical parks, KNP is increasingly isolated by deforestation beyond its boundaries because of population growth, urban markets, and agricultural expansion (9). Although generally successful in protecting forest and generating tourism revenue (10), KNP and other African parks have drawn criticism for exacerbating land and resource shortages and worsening poverty (3, 11). During the past decade, land from some Ugandan forest reserves was excised to allow agricultural expansion, and many political leaders reportedly perceive the country "cannot afford the luxury of protecting nature's ecological processes" (12). Similar recent excisions have been observed at parks and reserves elsewhere in the tropics (13).

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" (14). We test whether proximity to a forest park is a key geographic characteristic promoting the emergence or continuation of a poverty trap. In addition, we compare local citizens' use of forest in KNP vs. adjacent communal forest patches where commercial extraction is allowed. We also compare forest use by the poorest households with that of their more affluent counterparts. This analysis reveals the welfare impact of two distinct forms of lost access to forest: (*i*) loss attributable to conservation-oriented restrictions on forest use and (*ii*) loss attributable to deforestation.

We combine forest data from satellite imagery and field transects with panel data on the economic assets and welfare of 252 households lying 0–5 km from KNP during 1996–2006, the decade beginning 3 y after the park's creation. KNP generally maintained forest cover, tree species, and primate populations, whereas communal forest patches were reduced by half and showed substantial declines in tree species and primate populations. We then compare patterns of deforestation with changes in local welfare. A combination of regression analysis and matching estimators shows that although the poor tend to be located on the park perimeter, proximity to the park has no measureable effect on growth of productive assets. Indeed, distance from the park is inversely correlated with the propensity of households to fall into extreme poverty. Therefore, there is no evidence that the park is a poverty trap. Instead, the data suggest low-intensity subsistence use of forest in the park prevents the extreme impoverishment of poor households. Further evidence of this dependency comes from beyond KNP's boundary; poor households neighboring forest patches that were severely reduced or cleared altogether were more likely to sell or abandon their land, a strategy of last resort in agricultural communities, such as those found in rural Uganda (15).

Study Site

KNP (795 km^2) is located in a biodiverse area known for extraordinary primate density and diversity (16) (Fig. 1). Established as a colonial timber reserve in 1932, Kibale's management goal later shifted to biodiversity conservation (16). After Kibale became a park in 1993 (*SI Text S1*) timber extraction, hunting, charcoal production, and agriculture were curtailed, although local people have continued to draw nontimber forest products (NTFPs) from the park, including >89 plant species for fuelwood, construction, or medicinal purposes (16–18). During our

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Fig. 1. Study area: Kibale National Park and neighboring forest patches, Uganda.

study, only the harvesting of fish, honey, and thatch was officially allowed in the park, although other NTFP use was common, a pattern seen within other Ugandan reserves (12, 19, 20).

KNP now holds the last substantial tract of premontane forest in East Africa (21). Small patches [range: 3–350 ha, average = 32 ha] of formerly contiguous extensive forest are still found outside the park amid smallholder agriculture and tea plantations. Local use of forest patches is shaped both by customary tenure and more recent legal norms. Traditionally, local communities (formerly "clans") collectively managed forest patches, allowing their members to draw 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. Since Uganda's independence (1962), the state has aimed to regulate forest use through national decrees and to govern land access via legally codified property rights (20). During the study, forest access rules and land tenure were unclear outside of KNP, as around other reserves (12, 20), except in the case of eucalyptus woodlots, an exotic species locally recognized as a private resource. Most local residents did not own legal title to land, yet they recognized property boundaries and engaged in land transactions. Commercial forest use (e.g., timber harvest) required licenses, a rule poorly enforced during the study (17). Rapid population growth has further intensified forest use. By 2006, population density near KNP's edge reached 300 people per square kilometer (22).

Results

Forest Use and Cover Change. The area in communal forest patches declined by half during 1995–2006 (average %Δ = −13.5 ha, SD = 12.4; average Δ = −50.8%, SD = 24.4%; n = 24 patches) concomitant with an average loss of 39% of canopy tree species per patch (SD = 27%, n = 24, 61 total species). The patches did gain some tree species (7.5% of the total species surveyed in 1996); however, these were primarily early colonizing species. Primate numbers declined markedly in patches. The black-and-white colobus (*Colobus guereza*) population dropped from 81 to 21 individuals, and the endangered red colobus (*Procolobus rufomitratus*) population dropped from 126 to 16 individuals. Tree species and primate populations showed no similar decline in the park edge forests, where deforestation was significantly slower (average Δ over study period = −3.6%, SD = 7.2, Welch ANOVA; area deforested: n = 32, t = 3.6, P = 0.0015; % deforested: t = 5.8, $P < 0.0001$). The red colobus population was stable in the park, whereas the black-and-white colobus population showed a slight increase (21).

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 diameter at breast height (DBH), patch mean = 14.2 cm DBH; n = 164 trees extracted from park, n = 743 trees extracted from patches; maximum size: t = 3.493, P = 0.001; park average = 15.6, patch average = 36.9). The contrast was even more pronounced for hardwoods (paired t = 4.9, $P < 0.0002$; average patch maximum = 86 cm DBH, average park maximum = 17 cm DBH; n = 15 species). These high-value species offer special advantage for commercial activities (e.g., timber), but large hardwood trees are costly to extract. In general, forest extraction in the park was confined to NTFPs. By contrast, charcoal production, pit-sawing for timber, 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 more durable roofs, have more cattle and goats, own eucalyptus woodlots, and use 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% of households, n = 241) and cases of "land abandonment" (i.e., when households sold off all their land or relinquished it entirely to a creditor) (10% of households, n = 247).

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 in which households move to the city and obtain higher paying jobs. We base this assumption on interviews, which revealed the reason for land abandonment for 14 of the 24 cases. Local residents consider selling land an unfortunate strategy for coping with emergency cash needs (15). Selling or relinquishing one's land entirely is so dire that most respondents were reluctant to discuss these cases. Illness and/or death of an adult household member featured prominently in 12 of these 14 cases. Unmanageable debt and crop loss to elephants were also mentioned in 4 cases. The members of 3 of the 14 households became laborers on other people's farms, and 8 left the region to search for land in Kasese, a poorer district. Another 3 households moved to urban centers. Beyond the 14 tracked cases, another 6 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 across space (*SI Text S2*). In terms of land sales, for the households that remain in the sample, we can compare differences in mean asset changes for households that sell land as opposed to households that do not. In all cases, asset growth for households selling land was less than for households that did not sell land, although the differences were not always significant (Table S1).

Are the Wealth Outcomes of Better-Off Households Improving Faster Than Those of the Poor? We do not have a direct measure of wealth vs. poverty; however, as a proxy, we define "poor" as all house-

Table 1. Welfare indicators and productive assets over time for households neighboring KNP, Uganda, and adjacent forest patches, 1996–2006

Outcome	1996	2006	Δ1996–2006	Test of difference[a]
Rely on least safe water source	0.23	0.04	−0.19	6.43***
Rely on safest water source	0.13	0.43	+0.3	10.07***
No. cattle[b]	1.76	3.31	+1.55	3.02***
No. goats[b]	2.39	4.04	+1.65	4.45***
No. employees[b]	0.21	0.63	+0.42	4.64***
Wood lots[c]	0.21	0.44	+0.23	5.17***
Grass roof[c]	0.14	0.05	−0.09	3.29***
Farm size, ha[b]	3.43	3.52	+0.09	0.78
Small farm, ≤1 ha[c]	0.24	0.27	+0.03	0.49
Female-headed household[c]	0.11	0.14	+0.03	0.96
Farm abandonment[c]	NA	0.01	NA	
Land sales[c]	NA	0.25	NA	

[a]Test of difference is a *t* test for continuous variables and a χ^2 test for binary variables. Significance: ***$P < 0.01$.
[b]Average per household, sample size range 176–248.
[c]Proportion of all households, sample size range 176–248.

Table 2. Asset change among land-poor and land-rich households around KNP, Uganda, 1996–2006

Changes in wealth indicators, 1996–2006	Households with ≤1 ha of land in 1996 (n = 52)	Households with >4 ha of land in 1996 (n = 53)	Test of difference[a]
Safety rank of water source (1–3, 3 = safest)	+0.54	+0.57	0.21
No. cattle	+0.43	+5.61	2.43***
No. goats	+0.81	+3.2	1.51
No. employees	+0.10	+1.22	3.09***
Farm size, ha	+0.002	+0.45	0.88
Farm size, % change	−0.244	+2.8	1.15
Land transactions (proportion of households)			
Farm abandoned[b]	0.26	0.02	3.94**
Sales of farmland	0.38	0.19	2.20**

[a]Test of difference is a *t* test for continuous variables and a χ^2 test for binary variables. Significance: **$P < 0.05$; ***$P < 0.01$.
[b]Land sold off entirely or relinquished to creditor.

holds with ≤1 ha of land (lower 20% of distribution) and households with >4 ha (top 20%) as "better off." Landholding size is recognized locally and elsewhere in rural Uganda as a key endowment shaping wealth (12, 20), and it has special significance for forest use. At Kibale, those with more land were more likely to engage in more profitable commercial activities (e.g., pit-sawing timber, tea cultivation) than those with small farms (Table S2).

Although the overall wealth of the population seems to be improving, the wealth outcomes of the better-off households are increasing faster than those of the poor (Table 2). This is at least partially because the main determinant of increase in the key productive assets (employees, cattle, 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 percentage of change for farm size. We find the rate of growth of farm size is higher among the better off than the poor (2.8% vs. −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 the better off, 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 vs. large landholders (Table 2). Land sales are also significantly higher in the land-poor group (Table 2; findings are robust to using the top and bottom 10% of the sample). Together, these results indicate that, on average, citizens enjoyed increasing prosperity but that the assets of better-off households increased faster than those of the poor. Increasing inequality is further reflected in the 9.5% rise of the Gini coefficient (a measure of inequality) of farm size from 0.42 in 1996 to 0.46 in 2006.

Is KNP a Poverty Trap? If one were only to consider our data at 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 >1 km from the park are wealthier because they have more cattle, have larger farms and woodlots, and hire more laborers. Households near (<1 km) the park are more likely to fall into the land-poor category. The two groups do not differ in terms of the 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 3). Farm size change also increases with distance from the park; however, so do farm abandonment and land sales. The latter result is unexpected, given that we already determined that the poor live closer to the park and would seem to be 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. We infer that access to NTFPs, potentially from the park, helps the very poor avoid selling all or part of their smallholding during such crises.

We first examine the poverty trap possibility using ordinary least squares regressions of change in assets as a function of the baseline of that asset, poverty (i.e., farm size ≤1 ha), distance to the park, and interaction between distance and poverty (Table S3, these results are robust to the inclusion of distance to a main road). The most important determinant of asset change, both in magnitude and significance, proved to be the baseline value of that asset: Increases of one unit in cattle, goats, and employees in 1996 all increased the change in the asset by more than 0.5, which implies an increase of one cow/goat/employee in 2006 for every two cows/goats/employees in 1996.

Distance to the 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 of 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 better off vs. the poor. However, being a smallholder farther from the park has a significant effect on the probability of farm abandonment. In particular, a 1-SD increase in distance from the park increases the probability of poor farmers abandoning their farm by 13%. It does not change the probability of farm abandonment by the nonpoor. Land values do not account for this difference (*SI Text S2*).

To explore wealth dynamics as a function of distance to the park further, we modify the specification above to interact initial wealth levels with distance to the park. These estimations (Table S3) do not reveal any correlation between distance to the park interacting with baseline assets and asset accumulation. There is no support for the hypothesis of park impoverishment of surrounding households. However, it is an imperfect estimation. An

Table 3. Household welfare indicators by distance from KNP, Uganda, 1996–2006 (0–5 km)

Outcome	Near park[a] (<1.1 km) (n = 120)[b]	Far from park (≥1.1 km) (n = 128)	Test of difference[c]
Baseline variables (1996)			
Rely on least safe water source	0.35	0.13	4.17***
Rely on most safe water source	0.03	0.21	4.42***
Grass roof[d]	0.18	0.11	1.59
No. cattle[e]	0.45	2.83	2.21**
No. goats[e]	2.55	2.27	0.63
No. employees[e]	0.12	0.29	1.74*
Farm size, ha[e]	2.84	3.51	1.74*
Small farms, <1 ha[d]	0.29	0.17	2.22***
Female-headed household[d]	0.10	0.13	0.61
Changes (1996–2006)			
Rank of water source (1–3, 3 = safest)[e]	+0.41	+0.71	3.72***
Grass roofs[d]	−0.04	−0.06	0.26
No. cattle[e]	+0.52	+2.21	1.82*
No. goats[e]	+0.84	+2.05	1.79*
No. employees[e]	+0.31	+0.51	1.14
Farm size, ha[e]	+0.04	+0.14	0.43
Land transactions (1996–2006)			
Land sales (0/1)[d]	0.13	0.36	3.96**
Farm loss (0/1)[d]	0.03	0.15	3.10**

[a]Near vs. far partition explained in *SI Text S5*.
[b]Sample sizes range from 181 to 248 but remain proportional between groups near and far from the park.
[c]Test of difference is a t test for continuous variables and a χ^2 test for binary variables. Significance: *$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.
[d]Proportion of all households.
[e]Average per household.

ideal estimation would compare the same households, were they living close to or far from the park, an impossible condition.

To examine this counterfactual result further, we use a matching estimator, which predicts the "missing" outcome for each household that is near the park using one similar household from the group of households far from the park (*SI Text S3*). Matching is conducted with replacement and SE adjusted accordingly. If there are two equally appropriate matches for a household, both are used. We further adjust for bias in the estimator (23) and use heteroscedasticity robust SE. The limitation of this estimator is that it is based on observable characteristics. If there are unobservable characteristics correlated with distance to the park, the difference in means between households close and far can reflect these unobservable characteristics. The assumption required for validity of the matching estimator is that the expected trend in welfare indicators for households far from the park equals the expected trend of households near the park, were those households "not assigned" to live so far away. We match households based on baseline assets, farm size in 1996, if the household was headed by a woman in 1996, and if the household had a grass roof in 1996. "Near" is defined as <1 km (*SI Text S4*). We conduct robustness checks using only "closest" matches, as defined by the best 90% of the matches (Table 4), and further robustness checks varying our definition of near the park (Table S4).

The results of the estimations (Table 4) are qualitatively similar to those of the regression estimates. 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 the park is extremely important for the poor. The likelihood of land sales is 22.8% lower near the park than far from it in our estimate using 90% best matches. For land-poor households, this number is 58.2%, and for non–land-poor households, it is 14.2%. The relationship between park proximity and land abandonment is also very important, particularly for the poor. Households near 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 separate estimates for the non–land-poor households are small and insignificant. The matching estimator improves the comparison of households considerably from the full sample used in previous analyses, where we observe significant differences in baseline characteristics (e.g., Table 3). The matched subsample has few significant differences in covariates in the baseline (Table S5).

Our estimation strategy cannot control for the possibility that, at some point in history, the families that lived near the park may have had different assets and livelihood strategies, which were then passed on to the households that we observe today. 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) (24).

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 better-off vs. poor households (Table S2) suggests the possibility that wealthier households have access to productive assets inaccessible to the poor, possibly as a result of credit constraints.

Although poor households near and far from the park appear similar, their use of forest is quite different. To understand these differences, which underlie the treatment effect estimated in Table 4, we next use the matching estimator 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 bananas and banana gin (Table S6). Banana gin is sold in urban markets and requires bananas as an input, laborers, the purchase of a license, and a steady supply of slow-burning wood to manufacture. The disproportionate presence of stills at the park edge 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 of poverty (farm ≤1 ha) with patch size in 1996. The impact of being poor on welfare outcomes varied significantly according to forest patch size in 1996. The first part of Table 5 shows the marginal effect of being poor, given that the household is located adjacent to a small forest patch (3 ha, the smallest in the sample) or a large one (102 ha, the largest in the sample). Poor households that lived by larger patches in 1996 had significantly more growth in cattle and goatherds. 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 is also correlated with welfare outcomes, although the direction of causality cannot be identified using the data at hand. The marginal effects of poverty shown in the second part of Table 5 indicate that the deepening poverty of some individuals is associated with deforestation. In particular, a 1-SD increase in deforestation is correlated to large increases in the probability of land sales and land abandonment.

Table 4. Difference in welfare indicators between <1 km and >1 km from KNP, Uganda: Matching estimations

	Dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
	Δgoats (no.)	Δcattle (no.)	Δemployees (no.)	Δfarm size (ha)	Land sales during study period? (y/n)	Abandon land? (y/n)
Matched sample						
Average effect	−0.700 (0.432)	0.729 (0.522)	0.0135 (0.129)	−0.118 (0.256)	−0.127* (0.0654)	−0.0592** (0.0300)
Observations	157	157	157	157	173	173
Best 90% matches						
Average effect	−0.165 (0.361)	−0.088 (0.325)	0.009 (0.130)	0.063 (0.217)	−0.228*** (0.061)	−0.156*** (0.024)
Observations	159	159	159	159	181	181

Significance: *$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

Higher deforestation is also associated with an increased probability of land sales among the nonpoor, but the effect is smaller. In addition, a 1-SD increase in deforestation results in an increase in the probability of farm abandonment of 15.2% among the poor, with no measureable effect on the nonpoor. These results support the assertion that lost access to communal 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 an insurance mechanism during crisis times (25). Given that there is likely to be reverse causality between the outcomes and patch deforestation, these results should be taken as merely descriptive rather than causal.

Discussion and Conclusions

Over the decade of study, forest cover, tree species richness, and primate populations declined rapidly outside KNP. A 2010 survey revealed that most of the patches have since been entirely cleared (26). The increasing isolation of Kibale matches observations from parks elsewhere in Uganda and other tropical sites of rapid agricultural expansion (9, 12). Nearly 18% of Uganda's tropical high forests were cleared during the 1990s (26). Once covering ~20% of the country, closed-canopy forest has been reduced to <3% of Uganda, mainly within protected areas (26).

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.

Most households in the study improved their production capacity and also enjoy safer water and more durable roof material, a trend matching economic growth in the broader region (15, 27, 28). However, we also observed widening inequality in productive assets and signs of deepening poverty for some households, a pattern observed elsewhere in Uganda, most notably among female-headed households and those suffering health crises (15, 29). This is consistent with the literature on poverty traps, which shows considerable path dependence of assets (30, 31). Households fortunate enough to have larger landholdings and more livestock in 1996 enjoyed greater growth in these assets than those that started with less wealth. Differentiated access to forest also proved an important predictor of welfare outcomes.

As expected (25), wealthier households were more likely to engage in more profitable commercial forest use, including pitsawing timber and distilling banana gin for urban markets. These activities were unsustainable, yet wealthier households appeared to be minimally affected by resulting forest loss, perhaps because they had alternative incomes, including cultivating tea and raising cattle. Meanwhile, the very poor drew on forests (in both patches and park) primarily for NTFPs and appeared more vulnerable to the negative consequences of forest depletion. At other locations in Uganda, where all surrounding forest was cleared, the land poor were more likely to risk illicit harvest of NTFPs from reserves and parks (12, 20). Together, these facts suggest that the poor and wealthy have differential access to capital, which may be the source of the poverty-trap dynamics observed in assets.

The greatest poverty risk, land abandonment, was associated with smallholding size at the start of the study 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 higher in neighboring patches than in the park, it would be inappropriate to discard common property as a management strategy based on these results. Around KNP, uncertainty regarding the rules and rights to forest access acts against natural forest.

Table 5. Change in household welfare vs. initial forest patch size and extent deforestation, 1996–2006

	Dependent variable						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Δcattle (no.)	Δgoats (no.)	Δemployees (no.)	Δfarm size (ha)	Abandon land? (y/n)	Land sales during study period? (y/n)	Safe water source 2006
Relationship between initial patch size and welfare: Marginal effect of poverty							
Patch size = 3	−0.667 (0.531)	−1.97** (0.778)	−0.248* (0.131)	0.325 (0.335)	0.301*** (0.089)	0.253*** (0.092)	−0.179 (0.310)
Patch size = 102	1.91* (1.13)	2.78** (1.43)	−0.462 (0.548)	−0.312 (0.608)	−0.025 (0.091)	0.321** (0.161)	−0.247 (0.308)
Relationship between patch deforestation and welfare: Marginal effects of increase of 1 SD in deforestation							
On nonpoor	0.155 (0.208)	0.126 (0.315)	0.082 (0.078)	−0.088 (0.142)	0.014 (0.016)	0.102*** (0.030)	0.146** (0.064)
On poor	0.470 (0.345)	0.849** (0.388)	0.008 (0.064)	−0.005 (0.089)	0.152** (0.064)	0.170** (0.070)	0.203** (0.096)

Significance: *$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

Several respondents explained that they preferred eucalyptus woodlots to natural forest because of the clear status of eucalyptus as a private resource. Comparing the conservation outcomes of parks vs. communal property regimes must be considered in light of markedly different levels of state support and public understanding of rules (32, 33).

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 the welfare of the poor than national parks, particularly in regions of land scarcity and where forest conversion to agriculture is especially rapid. Allowing local citizens to extract limited amounts of NTFPs from parks may help prevent some very poor households from sinking deeper into poverty, but this access is unlikely to lift a significant portion of the rural poor from poverty.

Methods

We studied a ∼90-km^2 area of similar forest and soil type lying <5 km of KNP (Fig. 1) and there monitored socioeconomic and ecological changes in and around all forest patches (n = 24, 3–102 ha; some patches were subdivided into smaller territories, each claimed by a different village). We collected similar data for eight villages immediately bordering the park. We surveyed every household neighboring the 24 patches and eight park edges in 1996 and in late 2005/early 2006 (n = 252). Interviews and data on forest and land use in both patches and park edges were collected intermittently between 1996 and 2006. In May/June 1995, 2000, 2003, and 2010, we conducted a census of all primates in forest patches. Red and black-and-white colobus monkeys are the only primates resident in single patches. Because they are conspicuous and the patches are small we are confident of census accuracy.

Change in closed-canopy forest cover was assessed using Landsat enhanced thematic mapper (ETM) images from 1995 and 2001 and a 2005 Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) image. We calculated classification error estimates of 2.0–7.1% for 5 forest patches and five park sites (average = 4.8%). Because of the heterogeneous quality of vegetation cover, we used on-screen digitization of the 24 forest patches linked to field survey data for the same year as the image [global positioning system (GPS) points every 100 m of perimeter]. If clouds in an image occluded a patch, we measured forest cover more intensively. By 2005, several small patches (<10 ha) 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 the park in the study area (n = 8). There, we assessed forest cover change within a rectangular buffer extending 500 m into the park (n = 8, average = 42.1 ha, range: 20–88 ha). The park forest edges were surveyed in the field every 50–100 m. We counted all individual crowns for each tree species visible in the canopy of each patch at the start and end of the study.

We tallied evidence of charcoal production, timber extraction, gin distillation, and agricultural clearing for every household in 1996 and 2005/2006 as well as at an intermediate point. We also randomly selected established paths (3 per patch or park edge site) and registered evidence of recent extraction by species and tree size along 100 m <2.5 m to either side of path midline.

We surveyed the same 252 homesteads in 1996 and late 2005/early 2006 to assess basic economic assets and locally recognized indicators of wealth and poverty. We also recorded land use and land sales. Of the initial 252 households, 24 sold off or relinquished all their land and left the area by 2005. We attempted to find and interview those who left, or we spoke with their former neighbors.

In-depth interviews with 133 individuals (>2 per patch or park site) over the study yielded insights on livelihoods and forest use as well as land prices. The dataset does not contain income. Interviewees were reluctant or unable to quantify this but agreed that landholding size strongly affects income and is the best wealth indicator.

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