Society & Natural Resources: An International Journal
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/usnr20

Resource Use and Ecosystem Services in a Forest Park Landscape

Joel Hartter [a]
[a] Department of Geography, University of New Hampshire, Durham, New Hamsphire, USA
Version of record first published: 28 Jan 2010.

To cite this article: Joel Hartter (2010): Resource Use and Ecosystem Services in a Forest Park Landscape, Society & Natural Resources: An International Journal, 23:3, 207-223

To link to this article: http://dx.doi.org/10.1080/08941920903360372

Society and Natural Resources, 23:207–223

ISSN: 0894-1920 print/1521-0723 online
DOI: 10.1080/08941920903360372

Routledge
Taylor & Francis Group

Resource Use and Ecosystem Services in a Forest Park Landscape

JOEL HARTTER

Department of Geography, University of New Hampshire, Durham, New Hamsphire, USA

Dependence upon forest fragments and wetlands by local people outside Kibale National Park in western Uganda illustrates the challenge for rural communities in meeting resource needs, while also controlling overuse and degradation. Using a new geographically stratified, random sampling technique to select study sites, 130 households outside Kibale were interviewed to understand how local uses (e.g., firewood, water) and importance of such fragments (e.g., ecosystem services) depend on household location, size of fragment, and demographic characteristics. While a large majority of households derived material benefits from both wetland and forest fragments, only a minority perceived fragments as providing ecosystem services. Households that derived benefits from fragments tended to live farther from the park, though benefits were largely unrelated to the size of the nearest fragment. An understanding of the importance of these areas is critical for conservationists and park managers when developing cooperative management agreements or outreach programs.

Keywords forest fragments, Kibale National Park, protected areas, wetlands

Landscapes around parks in tropical areas are critically important to local populations because growing population densities in many of these places create increased pressure on land and resources. In many cases in Sub-Saharan Africa where the majority of the population is rural and heavily dependent on the land to support their livelihoods, park neighbors are excluded from settlement, access, resource extraction, and most forms of consumptive land use in the park, which in turn affects farmers' land use and livelihood options (Brockington et al. 2006; Wilkie et al. 2006). Unprotected landscapes outside park boundaries represent reservoirs of land, economic opportunity, and resources for local communities. In settled agricultural landscapes, resource needs are satisfied in two ways: either land is used

Received 30 November 2007; accepted 3 May 2009.

This research was supported by the National Science Foundation (number 0352008), the University of Florida (UF) Center for African Studies David L. Niddrie Memorial Scholarship, and a Working Forests in the Tropics Field Research Grant. Permissions were granted by the UF Institutional Review Board, Uganda Wildlife Authority, Uganda National Council for Science and Technology, and local council leaders. Helpful comments on this article were provided by A. Goldman, C. Chapman, S. Ryan, and three anonymous reviewers. I also thank S. Ledermann, Agaba E., and Mwesigwe P. for their hard work in data collection.

Address correspondence to Joel Hartter, Department of Geography, University of New Hampshire, 102 Huddleston Hall, 73 Main Street, Durham, NH 03824, USA. E-mail: joel.hartter@unh.edu

more intensively (i.e., reduced fallow time) or additional land is acquired. Around forest parks in particular, where access to park resources is severely limited or prohibited, neighbors convert uncolonized areas (e.g., forests, wetlands) to woodlots, pasture, or cropland or they rely on remaining natural areas to supply resources before using their own land more intensively (Barbier 1993; Chapman et al. 2003).

Ecosystem goods and services provided by natural ecosystems are essential for sustaining livelihoods (Costanza et al. 1997; Daily et al. 1997). In Uganda, wetlands (3.1 million ha) and forests (4.9 million ha) fill critical social and ecological roles (Banana and Gombya-Ssembajjwe 1998; NEMA 2001).[1] Forests and wetlands provide wood-based goods (e.g., firewood, building poles, timber), and nontimber goods (e.g., food, medicines) (Banana and Gombya-Ssembajjwe 1998; Schuyt 2005) and services (e.g., domestic water conservation, soil moisture retention, flood abatement, contribution to soil fertility, carbon storage, maintenance of biodiversity) (Daily et al. 1997; Bush et al. 2004; Schuyt 2005).

Although the Ugandan government recognizes the contribution of forests and wetlands to human livelihoods and the need for their conservation (Bikangaga et al. 2007), conversion of these areas continues at unprecedented rates (NEMA 2001). Only small fragments of unprotected forest and wetlands remain, and those that are left are becoming increasingly isolated by encroaching agriculture (NEMA 1997).

Resource consumption and perceived value may vary by ethnicity, wealth, location, and gender (Rocheleau and Edmunds 1997; Byron and Arnold 1999; Goebel et al. 2000; Kagoro-Rugunda 2004). Perceptions and preferences of ecosystem services likewise can be site specific, based on local geographic and cultural characteristics, moral convictions, life experiences, and on use and non-use of particular areas (Daily 1997; Costanza 2000). Ethnicity is important because it defines cultural landscapes through settlement shapes and patterns and influences where, how, why, and what crops people farm and what trees they grow (Stone 1996; Hill 1997). Outside Bardia National Park in Nepal, Baral and Heinen (2007) found that resource use and ethnicity were related; some resources were collected for certain social and cultural functions. Stone (1996) and Leach (1994) acknowledge that social structure and gender differentiation affect land and forest resource use. While they both may find forests and wetlands useful, women and men value and use natural ecosystems differently (Rocheleau and Edmunds 1997; Goebel et al. 2000), and often the use of specific resources is defined culturally through defined gender roles (Goebel et al. 2000). Women tend to spend more time collecting resources for the family than their male counterparts in many rural African communities because of their responsibilities in food production and firewood and water collection (Rocheleau 1991), so their perceptions and use of forests may be different from those of men (Leach, 1994; Mehta and Kellert 1998).

Wealth can also be important in shaping resource use (Scherr 2000), which may in turn shape perceptions of importance. Baral and Heinen (2007) found that resource dependency outside the park was negatively correlated with landholdings and wealth. Poorer farmers' capacity to grow trees and access to certain resources may be limited, leading to the use and non-use of forests and wetlands in particular ways. As forest resources decline, wealthier landholders are less constrained because they tend to have more land and the financial capability to augment their energy needs by growing firewood or purchasing firewood or charcoal (Nabanoga 2005). Compared to poorer landholders, wealthier landholders may find certain goods or services less important because of their ability to absorb and mitigate risks

(Smith et al. 2000). For example, they can purchase what is not available on their land and are more able to absorb lost crops to wildlife, or may be further removed from the day-to-day operations and decision making.

Distance from forests and wetlands (park lands and outside remnants) is an important determinant of resource use and availability (Adams 1993; Byron and Arnold 1999). Those residing farther from four national forests protected by the Uganda Forestry Department extracted fewer resources and derived less total household income from those forests than those closer (Bush et al. 2004). The decrease in forest resources relates to the increased land clearance for agriculture and resource extraction, thereby affecting goods and services provided by wetlands and forests (Nabanoga 2005). In the case of Kibale National Park (Kibale), the established park border represents a barrier to resource extraction. This means that those residing closest to the park have a smaller selection of resource pools since they are not permitted to collect resources inside the park, while those farther from the park potentially have a larger selection of resource pools to choose from. Therefore, households closer to the park may perceive fewer goods and services provided by unprotected wetlands and forest fragments. It is expected that larger fragments are more useful because they can accommodate more households and can maintain a more abundant and diverse set of resources.

The objective of this study was to gain a better understanding of local importance and uses of wetlands and forest fragments within the landscape surrounding Kibale, a forest park amidst dense agricultural settlement. I hypothesize that use of these areas depended on location, size for wetland or forest fragment, and demographic characteristics. Two questions are addressed: (1) What ecosystem goods and services are associated with wetlands and forest fragments[2] around Kibale? (2) How do these goods and services vary by distance to the park boundary, distance to fragment, size of fragment, gender, wealth, and ethnicity? Understanding perceptions and use of these goods and services at the local scale will inform conservationists, park managers, and community leaders wishing to address management of resources outside the park.

Study Region

Ecological System

The Kibale National Park region (Figure 1) in western Uganda is illustrative of agricultural expansion and intensification surrounding many tropical protected areas. Kibale Forest was demarcated in 1932 as a Crown Forest Reserve and elevated to national park status in 1993, leading to the eviction of a few thousand settlers (Struhsaker 1997). This transitional forest (between lowland rainforest and montane forest) ranges, in an elevation of 1110–1590 m, covers 795 km^2 (Struhsaker 1997). The average annual rainfall for the region is 1719 mm.

The landscape outside the park is a patchwork of small farms (most <5 ha in size), tea estates, and a collection of forest fragments and wetlands, effectively isolating the park. About 40% of the land within 5 km of the park boundary is under cultivation or pasture, and tea is found bordering much of the northwest portion of Kibale (Hartter 2007). Forest fragments and wetlands extending from the park's boundaries and isolated within the agricultural matrix vary in size, shape, and resource types and amount. The fragments range in size from 0.5 ha up to 200 ha

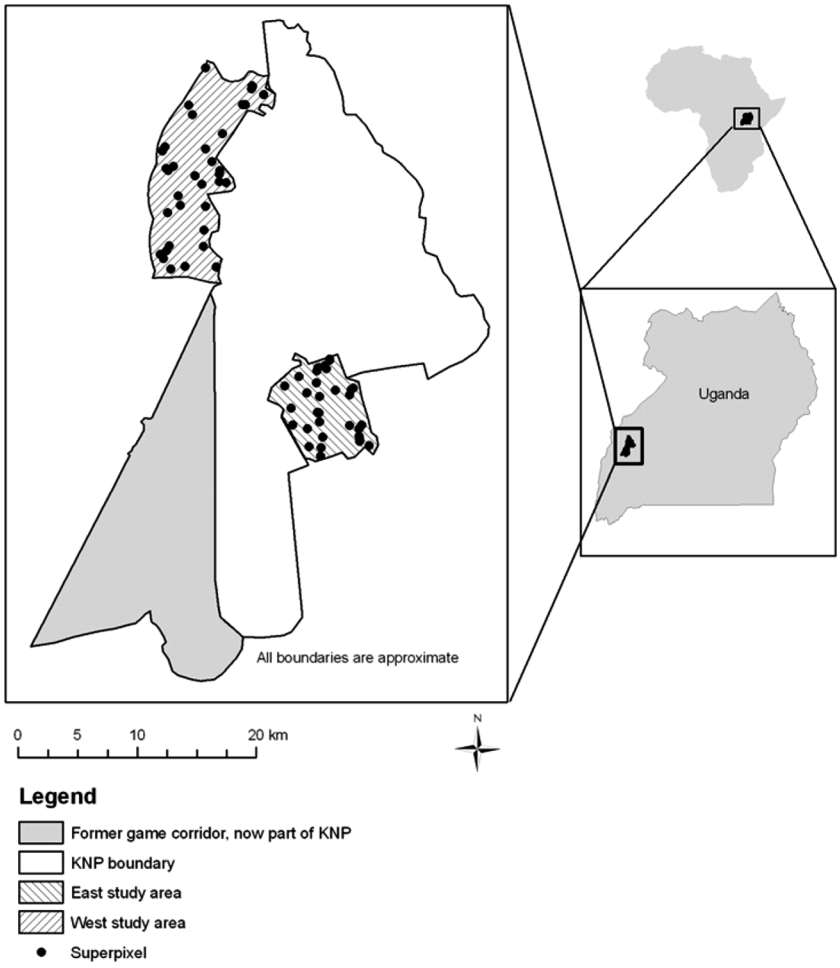

Figure 1. Kibale National Park and surrounding landscape in western Uganda.

for forests and up to 400 ha for wetlands. Since nearly all of these natural areas occur in bottomland areas, many of the forest fragments and wetlands are combined.

Social System

In Kabarole District, where the western portion of Kibale lies, the vast majority of the population sustains their livelihoods through agricultural-based activities. Agriculturalists in the area belong to primarily two ethnic groups: the Batoro (west side of Kibale) and the Bakiga (east side of Kibale) (see Figure 1). The Batoro are the largest ethnic group in the area (~52% of population). But immigrant Bakiga, who came to the region from southwestern Uganda beginning in the 1950s (Naughton-Treves 1998), and individuals of other ethnic groups have greatly contributed to population growth and the demand for agricultural land and resources (NEMA 2001). This region is one of the most densely populated areas on the African continent (Lepp and Holland 2006), and the population around Kibale more than

tripled between 1959 and 1990 (Naughton-Treves 1998). Population (2006) in the study areas is estimated at 262 individuals/km^2 on the west side of the park and 335 individuals/km^2 on the east side of the park (Hartter 2007).

Methods

The two research areas within 5 km of the park boundary on the east and west sides of Kibale differ to some extent in altitude, ethnic composition, and settlement and land use history. A set of 95 random geographic coordinates within these areas was selected, and those points became the centers of 9-ha areas (circles with radius of 170 m) termed "superpixels" (Goldman et al. 2008; Hartter and Southworth 2009). Land cover, use, and holdership were surveyed for each superpixel, and interview respondents were selected from among landholders in each of the superpixels for which there were landholders ($n = 68$, 36 on the west and 32 on the east sides of the park) (see Figure 1).

Between May and August 2006, 130 semi-structured household interviews were conducted in the east (56 km^2) and west study areas (110 km^2). The number of respondents selected per superpixel was proportional to the number of landholders controlling land within the study area, and at least one interview was conducted in each superpixel. Therefore, superpixels with more landholders (and correspondingly smaller individual landholdings) had a higher sampling intensity than those with fewer landholders. Since each superpixel comprised only 9 ha, there was only a small potential sample pool of households connected with each one. Houses were selected based on proximity to the center of the superpixel. The closest house was selected for the first interview, the next closest for the second interview, and so on. Interviews were conducted in one of the main local languages, Rutoro or Rukiga, using an interpreter, or in English. Respondents were asked general questions about household composition, employment, and land use, and then were asked to freely list any benefits[3] they and/or their families associated with the forests and wetlands outside of Kibale and how they used them, as well as perceptions of resource availability. Responses were then coded into categories of ecosystem goods and services.

Universal Transverse Mercator (UTM) X and Y coordinates from each respondent's house and entry point to each wetland and forest fragment used by households were collected. These coordinates were combined with the location of the entry points and the Kibale boundary polygon provided by Uganda Wildlife Authority to calculate the straight line distance. An independent-samples *t*-test was used to test whether the mean distances from a respondent's house to the park boundary and fragment (wetland or forest) differed between those who found forests and wetlands useful and those who did not.

A dendogram produced from agglomerative cluster analysis (Ward's method) using wealth indicators from each respondent (number of animals goats and cows per household, head of household gender, total amount of land held, and a five-category classification of house construction materials) was used to cluster respondents into three classes ("more poor," "less poor," and "well off") (Aldenderfer and Blashfield 1984). A *k*-means cluster analysis was used to segment wetland and forest fragment size into two categories (0–5 acres[4] and >5 acres) because sizes could only be estimated in the field due to limited access and permission.

Relationships between responses and independent variables (ethnicity, respondent gender, wealth, fragment size) were examined using Fisher's exact test

(for 2×2 tables) and chi-square (for all other tables) tests for independence (Agresti 2007). Given the reliance on recalled information in data analyses, and since the focus of this research was in correlations of responses not causal relationships, and since the presence of type I errors is not a main concern to the results, a significance value of .1 was used for all statistical tests.

Results

Ecosystem Goods

Most respondents perceived forest fragments and wetlands to be useful and as providing different ecosystem goods (Tables 1 and 2). Since park neighbors are prohibited from resource collection inside Kibale, most respondents, regardless of demographic category, turn to the wetlands and forest fragments to fulfill their needs. However, a larger proportion of respondents used wetlands than forest fragments. Forest fragments and wetlands were most useful as sources of firewood, indigenous medicines, handcraft materials (grasses, thatching, reeds), and water for household consumption.[5] Households also collected building materials and ties (*ebigoya*, vines used to tie fences and poles together when constructing houses).

In general, demographic variables were not strong indicators of forest fragment and wetland use. More male respondents reported collection of building poles in forest fragments than their female counterparts, which is consistent with locally defined gender roles. Traditionally only men will cut and carry the poles from the forests. Other ecosystem goods were not strongly related to a particular gender except firewood from wetlands. It is unclear why more male respondents report collection of firewood from wetlands than female respondents and why this is different than for forest fragments.

Overall size of and mean distance to the closest fragment were not strongly related to use (Tables 2, 3a, and 3b). Larger forest fragments were more useful for ecosystem goods in general and firewood, but not other goods (Table 2). Surprisingly, distance from the forest fragment and wetland did not prove to be a good predictor of use. Mean distances of those who found forest fragments and wetlands useful did not significantly differ from those who did not except for firewood from wetlands (Tables 3a and 3b).

Mean distance to the park boundary provided the most significant relationships to ecosystem goods (Tables 3a and 3b). Households that reported forest fragments useful for ecosystem goods in general lived farther from the park boundary than those that did not use fragments. Furthermore, those households that collected goods from wetlands (firewood, medicines, handcraft materials, water) and forest fragments (firewood, medicines, building poles, craft materials) were located farther from the park boundary than those that did not collect a particular good from these areas.

Respondents were also asked about their primary sources of firewood. Since multiple individuals within the household collected from multiple sources, and some collected from the multiple locations in a single trip, forest fragments and wetlands were aggregated together as "natural areas." Respondents relied on "natural areas" as primary sources for firewood (37%, $n = 130$). Other primary sources for firewood reported were woodlots (e.g., a planted forest usually consisting of eucalyptus [*Eucalyptus* spp.], musizi [*Maesopsis eminii*], silk oak [*Grevillea robusta*], and other species grown predominantly for fuel and/or sustenance) (31%), branches and

Table 1. Do households benefit from wetlands?: Five most mentioned ecosystem goods and ecosystem services

					Primary ecosystem goods					
		n	"Wetlands are useful"	Ecosystem goods	Firewood	Medicines	Water	Crafts	Ties	Ecosystem services
All respondents		130	92%	91%	51%	49%	65%	76%	38%	32%
Ethnicity	Batoro	72	94%	94%	49%	46%	67%	76%	40%	22%
	Bakiga	46	87%	85%	54%	52%	63%	74%	30%	48%
	Other[a]	12	100%	92%	50%	58%	67%	83%	50%	25%
	p value		.190	.719	.830	.641	.917	.791	.366	.012*
Respondent gender	Male	63	92%	89%	59%	48%	65%	75%	38%	46%
	Female	67	93%	93%	43%	51%	66%	78%	37%	18%
	p value		1.000	1.000	.083*	.729	1.000	.837	1.000	.001*
Wealth class	Below Average	58	90%	90%	48%	50%	74%	74%	31%	21%
	Average	59	93%	92%	56%	44%	56%	80%	39%	37%
	Above Average	13	100%	92%	38%	69%	69%	69%	62%	58%
	p value		.422	.143	.458	.256	.112	.646	.117	.029*
Size of fragment[b]	0–5 acres	89	90%	95%	48%	52%	63%	74%	38%	29%
	>5 acres	41	98%	91%	56%	44%	71%	81%	37%	37%
	p value		.127	.481	.409	.409	.384	.431	.860	.401

Note. Other benefits of wetlands mentioned by respondents ($n = 130$) were: timber (2%), building poles (32%), grazing animals (24%), planting crops (26%), planting trees (19%), fish (or fish ponds) (12%), sand (31%), food (22%), thatch (3%), clay (5%), reeds for houses (7%), and other uses (ceiling panels, bamboo, dyes, beekeeping, 3%). Asterisk indicates response and wetland benefit not independent ($p < .1$).

[a]"Other" includes Banyoro, Banyankole, Bakonjo, Bafumbira, Bamba, Baganda.

[b]Not all respondents had an accessible wetland within 2 km of their house (the locally defined threshold for resource collection).

Table 2. Do households benefit from forest fragments?: Five most mentioned benefits and ecosystem services

					Primary ecosystem goods					
		n	"Forest fragments are useful"	Ecosystem goods	Firewood	Medicines	Poles	Crafts	Water	Ecosystem services
All respondents		130	78%	78%	69%	49%	46%	45%	38%	8%
Ethnicity	Batoro	72	78%	80%	72%	43%	44%	39%	39%	3%
	Bakiga	46	78%	78%	67%	61%	50%	57%	39%	20%
	Other[a]	12	58%	58%	58%	42%	42%	33%	33%	0%
	p value		.314	.261	.593	.145	.796	.122	.929	.003*
Respondent gender	Male	63	78%	78%	70%	52%	56%	46%	40%	10%
	Female	67	75%	76%	69%	46%	37%	43%	37%	8%
	p value		.674	.838	1.000	.599	.053*	.860	.857	.759
Wealth class	Below Average	58	76%	78%	69%	48%	45%	50%	43%	10%
	Average	59	78%	78%	69%	49%	46%	41%	36%	7%
	Above average	13	69%	69%	69%	54%	54%	38%	31%	8%
	p value		.798	.785	.998	.936	.838	.535	.589	.782
Size of fragment[b]	0–5 acres	76	76%	78%	70%	53%	50%	47%	38%	11%
	>5 acres	43	93%	93%	86%	54%	51%	51%	47%	7%
	p value		.022*	.031*	.046*	.928	.903	.691	.374	.521

Note. Other benefits included: timber (9%), grazing animals (13%), planting crops (19%), planting trees (15%), fish ponds (4%), sand (20%), ties (35%), food (23%), thatch (2%), and other uses (dyes, beekeeping, stones, 2%). Asterisk indicates response and wetland benefit not independent ($p < .1$).

[a]"Other" includes Banyoro, Banyankole, Bakonjo, Bafumbira, Bamba, Baganda.

[b]Not all respondents had an accessible forest fragment within 2 km of their house (the locally defined threshold for resource collection).

Table 3. Do households benefit from local forest fragments and wetlands outside the park?

3a. Benefits of forest fragments (FF) and distance to park

	Ecosystem goods and/or services	Ecosystem goods	Firewood	Medicines	Poles	Crafts	Water	Ecosystems services
FF provide:	2111 m	2097 m	2170 m	2309 m	2284 m	2454 m	2158 m	2008 m
FF do not provide:	1405 m	1428 m	1431 m	1588 m	1651 m	1531 m	1808 m	1936 m
p value	.013*	.020*	.008*	.010*	.026*	.001*	.254	.887
Benefits of forest fragments and distance to nearest forest fragment								
FF provide:	300 m	300 m	297 m	309 m	309 m	313 m	334 m	245 m
FF do not provide:	295 m	294 m	309 m	29 0 m	289 m	288 m	278 m	305 m
p value	.913	.905	.631	.631	.604	.538	.196	.337

3b. Benefits of wetlands and distance to park

	Ecosystem goods and/or services	Ecosystem goods	Firewood	Medicines	Crafts	Water	Ties	Ecosystems services
Wetlands provide:	2002 m	1495 m	2301 m	2307 m	2113 m	2115 m	2085 m	2097 m
Wetlands do not provide:	1227 m	1707 m	1573 m	1589 m	1399 m	1618 m	1857 m	1871 m
p value	.034*	.770	.009*	.010*	.015*	.074*	.431	.484
Benefits of wetlands and distance to nearest wetland								
Wetlands provide:	289 m	288 m	316 m	299 m	297 m	294 m	285 m	290 m
Wetlands do not provide:	234 m	259 m	251 m	271 m	244 m	267 m	284 m	282 m
p value	.357	.718	.040*	.390	.178	.431	.978	.830

Note. Households responded whether or not forest fragments and wetlands provided benefits and which benefits (ecosystem goods or services) they provided. Unpaired *t*-tests were used to determine relationship between response and mean distances to park and nearest forest fragment/wetland from household. Asterisk indicates mean distance significantly different ($p < .1$).

woody material from fallow- or bush-lands (21%), purchased firewood or charcoal (10%), and clippings from tea estates (2%).

Ecosystem Services

More respondents reported that ecosystem services are provided by wetlands than forests (see Tables 1 and 2). Most often mentioned services were rainfall (quantity and/or timing) (23% and 14%, $n = 130$) for wetlands and forests, respectively, and air quality (9% for both, $n = 130$). Other services mentioned were maintenance or improvement of local climate (moderation of temperature and moisture), improved soil fertility, windbreaks, water level maintenance, and water filtration. A much smaller proportion of respondents cited these services from forest fragments (8%, $n = 130$) than from wetlands (32%, $n = 130$). A larger proportion of Bakiga respondents reported ecosystem services as a benefit from wetlands and forest fragments. More male and wealthier respondents cited ecosystem services from wetlands than female and less wealthy respondents. Perceived ecosystem services were neither related to size of and distance to fragment nor related to distance to park.

Discussion

The following is a discussion of the findings, which fall naturally into the categories of goods, services, and the implications of these findings for conservation practices.

Ecosystem Goods

In the landscape surrounding Kibale, forest and wetland fragments serve as important pools of ecosystem goods to most households. People gather resources from forests and wetlands or they convert these areas to other land uses (e.g., plant trees for woodlots or drain swamps and cut forests for pasture or to plant crops), a common trend throughout Uganda (NEMA 2001). Contrary to other park landscapes where most people are reliant on resources and general trends can be identified using key predictors, such as wealth and gender, for resource use (e.g., Baral and Heinen 2007), the Kibale landscape appears different. The specific benefits (ecosystem goods) may vary from household to household due to individual needs, availability and access, cultural traditions, personal preferences, and means of household income (Stone 1996; Hill 1997). In addition, while gender roles are important in defining roles for specific resource extraction and use (Rocheleau and Edmunds 1997), both men and women find forests and wetlands useful to their household. Thus, forests and wetlands, regardless of size, continue to be used for resources as well as converted to plant crops by all wealth, ethnic, and gender categories.

Population density plays a role in both the existence and the use of forest fragments and wetlands. The Batoro and Bakiga in the Kibale landscape generally spend their lives near their natal home/village. As families grow and eventually the older children move to establish their own farms, more land outside Kibale is converted and allocated to farming. While out-migration is rare, immigrants (e.g., Bakiga) came to the area seeking land. Together, in-migration, natural growth rates, and limited available land for agriculture have increased population density outside the park by 76% between 1980 and 2002 (UBOS 2002).

A larger proportion of respondents farther from the park found forest fragments and wetlands useful for ecosystem goods, which reflects a landscape layout similar to other protected-area landscapes (Bush et al. 2004): Areas with fewer resources provide fewer goods. This finding may also indicate that those closer to the park boundary are harvesting resources in Kibale to supplement their needs. Mugisha (2002) found that the landscape surrounding Kibale National Park showed dramatic land cover change from 1955 to 2000, with smallholder agriculture expanding by approximately 137%, while there was a loss of wetlands (−19%) and forests (−20%). Approximately 25% of the land within 1 km of the park was allocated to farming in the study areas (east and west) in 1984 and 34% in 2003 (Hartter 2007).

Though commonalities exist across social/demographic lines, differences may exist that are largely spatially determined. Forest fragments and wetlands persist at higher density farther from the park for a number of reasons. First, newcomers were allocated large plots farther from the Forest Reserve boundaries in the 1950s and 1960s, but with increasing immigration, allocations became smaller and nearer to the park. As the population increased, and parcel size decreased, households were forced into more intensive land use, and remaining unclaimed forests and wetlands were converted to agriculture (Agaba E. personal communication).[6] Second, land closest to the park boundary was and continues to be vulnerable to crop raiding by wild animals from the park (Naughton-Treves 1997). This led many farmers directly adjacent to the park to cut trees next to the forest, both to clearly demarcate their land from the park and to separate themselves from potential risks. Recent newcomers were also allocated this land. A third reason is that prior to Kibale's elevation to national park status in 1993, park neighbors could collect firewood, poles, and other resources with relative ease and without fear of punitive measures. Since resources within the Forest Reserve were plentiful and accessible, those closer to the park boundary could devote more of their land to agriculture. Fourth, much of the land adjacent to the park boundary is planted with tea. Therefore, there are now fewer sources for naturally occurring ecosystem goods closer to the park, and those that remain are generally overexploited and degraded (Hartter 2007). The resulting landscape configuration of access and allocation means that people located farther from the park potentially have a larger selection of forests and wetlands, while those closer to the park are much more restricted in the availability of resource pools since collection inside Kibale is prohibited. Therefore, households closer to the park tend to gain fewer goods from fragments than those farther from the boundary.

The types of ecosystem goods collected from the forest fragments and wetlands were not strongly dictated by size of or distance to nearest fragments. Each wetland and forest fragment has its own anthropological history, species composition, and quality, providing a unique interaction of ecosystem goods and services. People rely on a suite of forest fragments and wetlands to meet their needs, but they predominantly rely on one or two wetlands and/or forest fragments. Usefulness of a fragment, according to respondents, is probably dictated more by accessibility and availability of a specific good than by size or proximity (Hartter and Ryan in press). If need be, people will travel greater distances (up to 2 km was reported by respondents) for a particular good from a particular location.

While this research does document the importance of these unprotected areas in a forest park landscape, it is limited in ability to understand the relationship of household use of particular ecosystem goods to resource availability and size and location of forest fragments and wetlands. Future analyses should focus on the

spatial extent and pattern of forest fragments and wetlands outside Kibale; the role of land tenure in determining usufruct access to particular fragments; and a temporal inventory of ecosystem goods for each fragment. Future research should also expand to include other geographic areas around the park and address adaptive mechanisms for resource shortages and the complexity of and factors governing use and access to unprotected forest fragments and wetlands.

Ecosystem Services

Social and ecological systems are tightly linked in the landscape surrounding Kibale; thus, one would expect the heavy reliance on ecosystem goods. Most respondents reported ecosystem goods more often because they are physical objects and identifiable, but surprisingly, many households perceived ecosystem services from forest fragments and wetlands despite small size, isolation, degradation, and continued conversion. Often local communities report benefits of neighboring forests, but these tend to be from larger forested areas (Chomitz and Kumari 1998), as opposed to the largely isolated and interstitial fragments, such as those that surround Kibale. In addition, many studies have documented the local perceptions of wetland importance in maintaining water levels and quality (Barbier 1993; Schuyt 2005) and erosion control, nutrient cycling, or wildlife habitat (Costanza 1997; Chapman et al. 2003). In the Kibale landscape, these ecosystem services were downplayed or not mentioned at all, while benefits of rainfall and air quality were emphasized. The widespread perception of timely and adequate rainfall and air quality may come from and be reinforced by a combination of education programs, community conservation and development group and park outreach programs, radio broadcasts in partnership with the National Environment Management Authority (NEMA), a foreign volunteer,[7] secondhand information, and local lore. The scientific accuracy of these climate perceptions is unclear, although rainfall records indicate some increase in annual rainfall in recent years (T. Struhsaker and C. Chapman unpublished data).[8] Respondents in our survey areas corroborate other social research around the park: Mugisha (2002), with a broad sample of respondents living near several Ugandan parks, and Solomon (2007), who studied groups living near the southern boundary of Kibale, both found similar perceptions that forest parks improve rainfall and air quality.

In addition, these results suggest ethnicity is related to perceptions of ecosystem services provided by forests and wetlands. Large groups of immigrants often bring with them their knowledge and practices of land and resource uses, and their value system (Nesheim et al. 2006). The Bakiga who were lured by economic opportunity and land emigrated from densely populated southwestern Uganda (Kabale), where resources were increasingly becoming scarcer as forests and wetlands were used and converted to the Kibale region. Despite the presence of more forests and wetlands in the Kibale landscape compared to Kabale, perhaps they brought with them a lasting sense of resource scarcity and therefore a heightened awareness of ecosystem services (Holt 2005).

These results may also reflect the impact of a community conservation program on local perception of ecosystem services that exists on the east side of the park. In the east study region, which has been predominately settled by Bakiga, the Kibale Association for Rural and Environmental Development (KAFRED) has worked to manage the ~420-ha Magombe Swamp. KAFRED is very active in its

environmental outreach efforts on the east side of Kibale, and many Bakiga respondents cited education programs by KAFRED as a major contributor to their understanding of the environment (Lepp and Holland 2006). While the Kibale and Semuliki Conservation and Development Project (now defunct and absorbed by KAFRED) and the foreign volunteer were active on the west side of the park in the past, these efforts have stalled and park outreach programs are limited there. KAFRED, a large continuous natural area within an intensively farmed landscape, remains an example of community-based natural resource management success. Though fewer fragments exist on the east side than the west, the environmental awareness and higher number of people reporting ecosystem services on the east side may be attributed to the sense of resource scarcity (Holt 2005) and the active environmental education and outreach programs through KAFRED, ultimately leading to more Bakiga finding importance in forest fragments and wetlands than Batoro.

Though both provide ecosystem goods and services, wetlands and forests are perceived differently in terms of their ecosystem services, and more people claim derived services from the wetlands than the forests. One explanation is that wetlands can be combined with woodlands (called "swamp forests") and thus one location can provide resources that would otherwise be gathered separately. Another possible explanation is that there exists some degree of protection of wetlands by Ugandan law (NEMA 1997). Permanently inundated wetlands therefore cannot be privately held, but instead are held by the government and managed by local councils (Bakema and Iyango 2001). These areas shall then be managed with the size of the wetland taken into account and so that the community may enjoy access to the wetland (Richardson 1993). Monitoring and sanctioning mechanisms by NEMA, the district environmental officer, and village chairpersons help to provide more effective management of communal areas (Johnson and Nelson 2004). Widespread sensitization through community meetings and radio programs has also made people more aware of the ecosystem services from wetlands. Such a movement for forests (other than those in protected areas) does not exist, which may explain why more households perceived ecosystem services from wetlands than forests.

Access to education programs and environmental discourse has been demonstrated as an important determinant in environmental perception (Hunter et al. 2007). Males and those classified as well off (not exclusively males) reported more ecosystem services from the wetlands. Males typically stay in school longer, have more opportunities for socialization and off-farm work and therefore are more exposed to extension services, engage other farmers, or have access to or participate in other learning programs.

Conservation Implications

Despite forest and wetland ecosystem goods and services, population increase and land shortage have led to intense pressure on the remaining resources outside Kibale (Lepp and Holland 2006). Landholders recognize that resources are becoming scarce and that their current consumptive use is having deleterious consequences. Use of forest fragments and wetlands is vital, and simultaneously, contact with the resource is so common, that users are very aware of the fragments' condition and of the ways in which their use affects them. Many say there is little they can do; most believe that forest fragments and wetlands will be unable to support future needs and withstand pressures for land. Since resource use within Kibale is restricted, heavy reliance on

remaining forest fragments and wetlands places them in jeopardy of eradication (Chapman et al. 2007). The fragments farther from Kibale may currently be displacing that pressure. However, once remnant forests and wetlands surrounding Kibale are destroyed or degraded beyond use, then pressure on Kibale may increase as it has with other protected areas (Chhetri et al. 2003).

These findings illustrate the importance of wetlands and forests, and by building on this knowledge, conservationists, community members, and park managers can work to develop cooperative management agreements or appropriately designed outreach programs to provide accurate information to communities outside Kibale. Encouraging recognition of finite resources by local communities and stressing their importance may help to foster a stronger sense of conservation and may lead to improved management of resource pools (Johnson and Nelson 2004).

The heavy pressure placed on wetlands and forest fragments in the Kibale landscape due to resource extraction and land conversion may be emblematic of the problem facing forest parks across the world. Forest loss and fragmentation has been called the single greatest threat to global biological diversity, and has detrimental impacts on ecosystem services and biodiversity (Turner and Corlett 1996). Parks depend on these areas, especially those closest or adjacent to the park, to serve as buffers (Schonewald-Cox and Bayless 1986). Without them, pressure may increase on Kibale and fragments farther from the park will probably succumb to the same fate. As fragmentation increases, more edge is created and the interior of forest fragments is opened, becoming more accessible to wood extraction and other consumptive uses. This perpetuates the cycle of fragmentation and degradation. Habitats and food supplies for wildlife are shrinking and remaining patches are becoming increasingly isolated. This eventually forces wildlife to cross between patches through the agricultural matrix, leading to increased human–wildlife conflict (Hill 1997).

Conversion of wetlands to grazing or cropland and extraction of firewood, timber, and other resources from wetlands and forest fragments provide invaluable land and resources to sustain local livelihoods. At the same time, these practices diminish the abundance of resources and the ability to provide ecosystem services that many people find important. The population outside forest parks faces two daunting challenges: achieving balance by maintaining forest fragments and wetlands in a good condition in order that they can supply ecosystem goods and services, and meeting the current needs of people and ensuring long-term supplies for the growing population. At the same time, conservationists must work with local communities to explore options to meeting resource needs of a growing population and successful biodiversity conservation.

Notes

1. Ecosystem goods and services are benefits that people "derive, directly or indirectly, from ecosystem functions" (Costanza et al. 1997, 253).
2. Those forests that exist as a remnant of a larger forest of endemic species and a forest not purposely planted.
3. When asked in general about "benefits" from the forests and wetlands, respondents could list as many benefits as they wanted. The benefits were based on respondents' perception of how their particular household directly benefited from the presence of forests or wetlands. Collectively, these benefits are known as ecosystem goods and services.
4. Landholdings in western Uganda are defined locally in acres.
5. Respondents considered water for livestock as a separate use.

6. Agaba Erimosi, local farmer, informal discussion July 26, 2006.
7. This volunteer came to the area in the early 1990s and began a grass-roots environmental education program that took her village to village, mostly on the west side of the park. She gained most of her knowledge from personal experience, interaction with foreign researchers stationed at Kibale, and other limited training. It is difficult to get accurate accounts of the information that she spread, though many respondents mentioned her name. Whether or not she explicitly told people that rainfall was a direct result of increased forest in the area, this idea has permeated the culture and left a lasting impression.
8. Thomas Struhsaker, Duke University, and Colin Chapman, McGill University, have recorded weather data in Kibale National Park continuously since 1970.

References

Adams, W. M. 1993. Indigenous use of wetlands and sustainable development in West Africa. *Geogr. J.* 159(2):209–218.

Agresti, A. 2007. *An introduction to categorical analysis*. Hoboken, NJ: John Wiley & Sons.

Aldenderfer, M. S., and R. K. Blashfield. 1984. *Cluster analysis*. Sage University Paper 4. Beverly Hills, CA: Sage.

Bakema, R. J., and L. Iyango. 2001. *Engaging local users in the management of wetland resources: The case of the National Wetlands Programme, Uganda*. Nairobi, Kenya: IUCN Eastern Africa Regional Office.

Banana, A. Y., and W. Gombya-Ssembajjwe. 1998. Successful forest management: The importance of security of tenure and rule enforcement in Ugandan forests. In *Forest resources and institutions*, eds. C. Gibson, M. McKean, and E. Ostrom, Forests, Trees and People Programme, Working Paper 3. No pages listed. Rome, Italy: FAO. http://www.fao.org/docrep/006/x2104e/X2104E00.HTM#TopOfPage

Baral, N., and J. T. Heinen. 2007. Resources use, conservation attitudes, management intervention and park-people relations in the Western Terai landscape of Nepal. *Environ. Conserv.* 34(1):64–72.

Barbier, E. B. 1993. Sustainable use of wetlands valuing tropical wetland benefits: Economic methodologies and applications. *Geogr. J.* 159(1): 22–32.

Bikangaga, S., M. P. Picchi, S. Focardi, and C. Rossi. 2007. Perceived benefits of littoral wetlands in Uganda: A focus on the Nabugabo wetlands. *Wetland Ecol. Manage.* 15:529–535.

Brockington, D., J. Igoe, and K. Schmidt-Soltau. 2006. Conservation, human rights, and poverty reduction. *Conserv. Biol.* 20(1):150–252.

Bush, G. K., S. Nampindo, C. Aguti, and A. J. Plumptre. 2004. *Valuing Uganda's forests: A livelihood and ecosystems approach*. Wildlife Conservation Society. Kampala, Uganda: Unpublished report to National Forest Authority.

Byron, N., and M. Arnold. 1999. What futures for the people of the tropical forests? *World Dev.* 27(5):789–805.

Chapman, C. A., L. Naughton-Treves, M. J. Lawes, M. D. Wasserman, and T. R. Gillespie. 2007. Population declines of *colobus* in western Uganda and conservation value of forest fragments. *Int. J. Primatol.* 28:513–528.

Chapman, L. J., C. A. Chapman, T. L. Crisman, and L. S. Kaufman. 2003. The conservation and management of African inland waters. In *Conservation, ecology, and management of African fresh waters*, eds. T. L. Crisman, L. J. Chapman, C. A. Chapman, and L. S. Kaufman, 476–488. Gainesville: University Press of Florida.

Chhetri, P., A. Mugisha, and S. White. 2003. Community resource use in Kibale and Mt. Elgon National Parks, Uganda. *Parks* 13(1):28–49.

Chomitz, K. M., and K. Kumari. 1998. The domestic benefits of tropical forests: A critical review. *World Bank Res. Observer* 14(1):13–35.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387:253–260.

Costanza, R. 2000. Social goals and the valuation of ecosystem services. *Ecosystems* 3:4–10.
Daily, G., ed. 1997. *Nature's services: societal dependence on natural ecosystems*. Washington, DC: Island Press.
Daily, G. C., S. Alexander, P. R. Ehrlich, L. Goulder, J. Lubchenco, P. A. Matson, H. A. Mooney, S. Postel, S. H. Schneider, D. Tilman, and G. M. Woodwell. 1997. Ecosystem services: benefits supplied to human societies by natural ecosystems. *Issues Ecol.* 1(2):1–18.
Goebel, A., B. Campbell, B. Mukamuri, and M. Veeman. 2000. People, value, and woodlands: A field report of emergent themes in interdisciplinary research in Zimbabwe. *Agric. Hum. Values* 17:385–396.
Goldman, A., J. Hartter, J. Southworth, and M. Binford. 2008. The human landscape around the island park: Impacts and responses to Kibale National Park. In *Science and conservation in African forests: The benefits of longterm research*, eds. R. Wrangham and E. Ross, 129–144. Cambridge, UK: Cambridge University Press.
Hartter, J. 2007. *Landscape change around Kibale National Park, Uganda: Impacts on land cover, land use, and livelihoods*. Doctoral dissertation. Gainesville: University of Florida, Department of Geography.
Hartter, J., and J. Southworth. 2009. Dwindling resources and fragmentation of landscapes around parks: Wetlands and forest fragments around Kibale National Park, Uganda. *Landscape Ecol.* 24(5):643–656.
Hartter, J., and S. J. Ryan. In press. Top-down or bottom-up? Decentralization, natural resource management, and usufruct rights in the forests and wetlands of western Uganda. *Land Use Policy*. Online December 2009. http://dx.doi.org/10.1016/j.landusepol.2009.11.001
Hill, C. 1997. Crop-raiding by wild vertebrates: The farmer's perspective in an agricultural community in western Uganda. *Int. J .Pest Manage.* 43(1):77–84.
Holt, F. L. 2005. The catch-22 of conservation: Indigenous peoples, biologists, and cultural change. *Hum. Ecol.* 33(2):199–215.
Hunter, L., S. Strife, and W. Twine. 2007. *Environmental perceptions of rural South African residents: The complex nature of a post-material concern*. Boulder, CO: Institute of Behavior Science Working Paper ES2007-0001.
Johnson, K. A., and K. C. Nelson. 2004. Common property and conservation: The potential for effective communal forest management within a national park in Mexico. *Hum. Ecol.* 32(6):703–733.
Kagoro-Rugunda, G. 2004. Crop raiding around Lake Mburo National Park, Uganda. *Afr. J. Ecol.* 42:32–41.
Leach, M. 1994. *Rainforest relations. Gender and resource use among the Mende of Gola, Sierra Leone*. Edinburgh, Scotland: Edinburgh University Press.
Lepp, A., and S. Holland. 2006. A comparison of attitudes toward state-led conservation and community-based conservation in the village of Bigodi, Uganda. *Society Nat. Resources* 19:609–623.
Mehta, J. N., and S. R. Kellert. 1998. Local attitudes toward community-based conservation policy and programmes in Nepal: A case study in the Makalu-Barun Conservation Area. *Environ. Conserv.* 25(4):320–333.
Mugisha, A. 2002. *Evaluation of community-based conservation approaches: Management of protected areas in Uganda*. Doctoral dissertation. Gainesville: University of Florida, Department of Wildlife Ecology and Conservation.
Nabanoga, K. G. N. 2005. *Transgressing boundaries: gendered spaces, species, and indigenous forest management in Uganda*. Doctoral thesis. Wageningen, The Netherlands: Wageningen University, Department of Social Sciences.
National Environment Management Authority. 1997. *State of environment report for Uganda 1996*. Kampala, Uganda.
National Environment Management Authority. 2001. *State of environment report for Uganda 2000/2001*. Kampala, Uganda.

Naughton-Treves, L. 1997. Farming the forest edge: Vulnerable places and people around Kibale National Park, Uganda. *Geogr. Rev.* 87:27–46.

Naughton-Treves, L. 1998. Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. *Conserv. Biol.* 12(1):156–168.

Nesheim, I., S. S. Dhillion, and K. A. Stølen. 2006. What happens to traditional knowledge and use of natural resources when people migrate? *Hum. Ecol.* 34(1):99–131.

Richardson, B. 1993. Environmental management in Uganda: The importance of property law and local government in wetlands conservation. *J. Afr. Law* 37(2):109–143.

Rocheleau, D. 1991. Gender, ecology and the science of survival: Stories and lessons from Kenya. *Agric. Hum. Values* 8:156–165.

Rocheleau, D., and D. Edmunds. 1997. Women, men and trees: Gender, power and property in forest and agrarian landscapes. *World Dev.* 25(8):1351–1371.

Scherr, S. J. 2000. A downward spiral? Research evidence on the relationship between poverty and resource degradation. *Food Policy* 25:479–498.

Schonewald-Cox, C. M., and J. W. Bayless. 1986. The boundary model: A geographic analysis of design and conservation of nature reserves. *Biol. Conserv.* 8:305–322.

Schuyt, K. D. 2005. Economic consequences of wetland degradation for local populations in Africa. *Ecol. Econ.* 53:177–190.

Smith, K., C. B. Barrett, and P. W. Box. 2000. Participatory risk mapping for targeting research and assistance: With an example from East African pastoralists. *World Dev.* 28(11):1945–1959.

Solomon, J. 2007. *An evaluation of collaborative resource management and the measurement of illegal resource use in a Ugandan national park*. Doctoral dissertation. Gainesville: University of Florida, Department of Wildlife Ecology and Conservation.

Stone, G. D. 1996. *Settlement ecology: The social and spatial organization of Kofyar agriculture*. Tucson: The University of Arizona Press.

Struhsaker, T. 1997. *Ecology of an African rain forest: Logging in Kibale and the conflict between conservation and exploitation*. Gainesville: University Press of Florida.

Turner, I., and R. Corlett. 1996. The conservation value of small, isolated fragments of lowland tropical rain forest. *Tree* 11(8):330–333.

Uganda Bureau of Statistics. 2005. *The 2002 Uganda population and housing census, main report*. Kampala, Uganda: Uganda Bureau of Statistics.

Wilkie, D. S., G. A. Morelli, J. Demmer, M. Starkey, P. Telfer, and M. Steil. 2006. Parks and people: Assessing the human welfare effects of establishing protected areas for biodiversity conservation. *Conserv. Biol.* 20(1):247–249.