Applied Geography 31 (2011) 456–462

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Conservation of priority woody species on farmlands: A case study from Nawaikoke sub-county, Uganda

John R.S. Tabuti [a,*], Vincent B. Muwanika [a], Mary Z. Arinaitwe [a], Tamara Ticktin [b]

[a] Makerere University, Institute of Environment and Natural Resources, P.O. Box 7062, Kampala, Uganda
[b] University of Hawaii at Manoa, Botany Department, 3190 Maile Way, Honolulu, HI 96822, USA

Keywords:
Agroforestry
Tree management
Fallows
Tree products

A B S T R A C T

In tropical Africa, woody species provide products and services that millions of people depend on. However, many of these species are also threatened and declining and this can have serious livelihood consequences for communities who depend on them. Identifying which species are most at risk and which ones are being conserved is therefore critical. In this study, we undertook a survey in Nawaikoke Sub-county, Uganda to assess which of 26 most preferred species are managed on farmland, to identify what environmental factors influence their availability, and to describe their conservation statuses. Individuals of these species were enumerated and measured in 320 plots across the eight parishes of Nawaikoke. Seven of the 26 species were not encountered in any plots. The rest were found close to homesteads in homegardens, in crop gardens and in young fallows on well drained soils. Only *Combretum collinum* and *Acacia seyal* were associated with old fallows and poorly drained clay loamy soils. *Mangifera indica*, *Milicia excelsa*, *Ficus natalensis*, *Ficus sycomorus*, *Artocarpus heterophyllus* and *Albizia coriaria* were found in numerous plots in at least six of the eight parishes, and at relatively high densities and we consider them to be at the lowest risk of disappearance from the landscape. Size-class distributions of all preferred species, regardless of their abundance, exhibited little recruitment from juvenile life stages. We conclude that most of the species face some level of threat through destruction of seedlings and saplings and that for these species to persist into the future there is need to work with farmers to encourage them to plant or spare those found growing naturally. There is a high potential for these species to increase in abundance because they grow in a wide diversity of farm niches. For the farmers to become more involved, focus should primarily be on native species that provide shade, fruits and timber. Some of these target species also play ecological roles, increasing their functionality. Lastly, there is need to protect non-crop habitats like fallows and wetlands.

Introduction

Woody species provide products such as fuelwood, timber, medicines and food that millions of people in developing countries depend on (Belcher & Schreckenberg, 2007; Shackleton et al., 2002; Upadhyay, 2005; Vedeld, Angelsen, Bojö, Sjaastad, & Berg, 2007). In Uganda for instance, over 90% of the homesteads depend directly on fuelwood as a source of energy (NEMA, 2005). Woody species also provide important environmental and cultural services, including the provision of shade to crops and people, soil improvement, erosion control and heritage values (Rönnbäck et al., 2007; Varghese & Ticktin, 2008). However, many woody species are threatened and declining (e.g. FAO, 2009).

Worldwide, farmers often selectively manage woody species that are important to them so as to ensure that such species are readily available on their land (Atta-Krah et al., 2004; Augusseau, Nikiéma, & Torquebiau, 2006; Wiersum, 1997). This is an ongoing process that dates back thousands of years and is aimed at facilitating improved access to desired products and services. However, not all useful or preferred tree species are actively managed and those that are not, may be threatened. The loss of diversity of woody species in local communities, especially those that are used and valued by people, poses threats to biological conservation as well as to local livelihoods. Identifying which highly valued species may be at risk is therefore critical.

In Nawaikoke Sub-county Uganda, a rural agricultural community, people depend heavily on gathered products from woody

* Corresponding author. Tel.: +256 414 530 135; fax: +256 414 530 134.
E-mail address: jtabuti@muienr.mak.ac.ug (J.R.S. Tabuti).

0143-6228/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apgeog.2010.10.006

Table 1
The 26 priority woody species of nawaikoke sub-county, uganda[a].

Species	Origin	Major use	Perceived status	Perceived availability
Milicia excelsa (Welw.) C.C. Berg	Native	Timber, House construction	Decreasing	Rare
Mangifera indica L.	Naturalized	Food	Increasing	Very abundant
Maesopsis eminii Engl.	Native[b]	Timber, House construction	Decreasing	Rare
Persea americana Mill.	Naturalized	Food	Decreasing	Rare
Eucalyptus spp.	Exotic	Timber, House construction	Increasing	Rare
Citrus × aurantium L.	Naturalized	Food	Increasing	Abundant
Artocarpus heterophyllus Lam.	Naturalized	Food	Increasing	Abundant
Ficus natalensis Hochst.	Native	Shade	Increasing	Abundant
Terminalia spp.	Native[2]	Shade	Increasing	Very rare
Melia azedarach L.	Naturalized	Timber, House construction	Increasing	Rare
Markhamia lutea (Benth.) K. Schum.	Native	Timber, House construction	Decreasing	Rare
Azadirachta indica A. Juss.	Exotic	Medicinal	Increasing	Rare
Casuarina spp.	Exotic	Shade	Decreasing	Very rare
Albizia coriaria Welw. ex Oliv.	Native	Timber, medicinal, charcoal	Decreasing	Rare
Moringa oleifera Lam.	Exotic	Medicinal	Increasing	Abundant
Sarcocephalus latifolius (Sm.) Bruce	Native	Medicinal	Decreasing	Very rare
Securidaca longipedunculata Fresen.	Native	Medicinal	Decreasing	Rare
Terminalia glaucescens Planch. ex Benth.	Native	Medicinal	Decreasing	Rare
Psorospermum febrifugum Spach	Native	Medicinal	Decreasing	Very rare
Senna siamea (Lam.) H.S. Irwin & Barneby	Naturalized	House construction	Increasing	Abundant
Senna spectabilis (DC.) H.S. Irwin & Barneby	Naturalized	Firewood	Increasing	Abundant
Psydrax parviflora subsp. *parviflora*	Native	Firewood	Decreasing	Rare
Acacia seyal Delile	Native	Medicinal	Increasing	Abundant
Combretum collinum Fresen.	Native	Firewood, charcoal	Decreasing	Abundant
Ficus sycomorus L.	Native	Shade	Increasing	Abundant
Ziziphus pubescens Oliv.	Native	Medicinal	Decreasing	Very rare

[a] Identified in Tabuti et al., 2009.
[b] Native to Uganda but not to Nawaikoke County.

species (Tabuti, Dhillion, & Lye, 2003; Tabuti, Ticktin, Arinaitwe, & Muwanika, 2009). In a previous study, we identified 26 woody species that are most valued by Nawaikoke residents (Tabuti et al., 2009; Table 1). In that study, Nawaikoke residents reported that many of these species are threatened by overexploitation, habitat destruction through expansion of crop agriculture, and reduced fallow sizes and periods. Here, we quantitatively assess the conservation status of these woody species on Nawaikoke farmland. Specifically, our research questions are:

1. Are any of the preferred species managed on farmland?
2. What environmental factors influence where the preferred species are found?
3. What is the conservation status of the preferred species based on their population structure, density and frequency on farmland?
4. Based on the above, which kinds of species are most likely to be managed and protected and which need most attention in terms of conservation and propagation?

Study area and methods

Study area

Nawaikoke Sub-county is located between 33°33′–33°49′ E and 1°00′–1°29′ N, about 200 km north-east from Kampala, the capital city of Uganda (Fig. 1). The sub-county has a land area of 185 km^2 (excluding wetlands) and is made up of eight administrative parishes, which are in turn sub-divided into 6–8 villages. The landscape is relatively flat, at altitudes of 1045–1075 m asl. The total annual rainfall is 1195–1357 mm and is bimodal (UBoS, 2000), raining in March–June and September–November. The soils of Nawaikoke are mostly ferralitic and sandy loams. According to Langdale-Brown, Osmaston, and Wilson (1964), the original vegetation of Nawaikoke consisted of *Cyperus papyrus*, *Combretum-Hyparrhenia rufa* dry savanna swamps, *Combretum-Terminalia-Albizia zygia-Hyparrhenia*

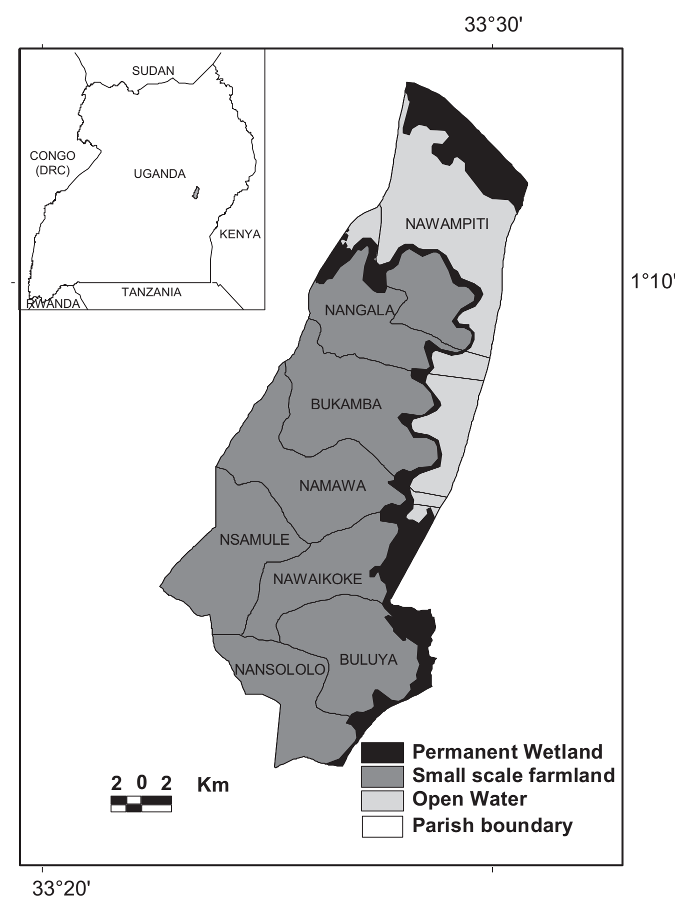

Fig. 1. Map of NawaikokeSub-county showing the study parishes and landuses.

rufa moist savanna and *Sorghastrum* grasslands on sites of impeded drainage. Most of the original vegetation has been replaced with crops and the current landscape consists almost entirely of farmland.

The population density of Nawaikoke is approximately 210 people/km^2 (UBoS: un-published data). Residents are dependant on woody species for the provision of many products especially fuelwood, construction poles, fruits (Tabuti, 2007). The major source of livelihood is subsistence farming, and common crops include cassava, potatoes, cereals (maize, millet), ground nuts and cotton propagated in a mixed cropping pattern.

Data collection methods

To assess the status of the 26 preferred woody species, we established four 1 km m long, line transects in each of the eight parishes of Nawaikoke, with one transect established in each of the cardinal directions. For instance, beginning at a subjectively determined centre of each parish, we moved in the North compass direction and established the first sampling plot 500 m after the edge of the parish. We thereafter established another nine plots at 40 m intervals on opposite sides of that 1 km North transect. We then repeated this procedure in the three other cardinal directions. In this way 40 plots were established in every parish, for a total of 320 plots across the county. We used nested plots of 20 × 50 m for stems larger than 30 cm diameter at breast height (dbh), 20 × 25 m for stems between 15 and 30 cm dbh; 10 × 25 for stems between 5 and 15 cm dbh, and 10 × 12.5 for stems of 1–5 cm dbh.

All stems of the 26 preferred species encountered in the study plots were counted and their diameter at breast height or root collar diameter for very small individuals was measured. A note was made on the number of stumps for every species. However, very few stumps were encountered in the study plots and as a result this data was not included in subsequent analyses. For each plot we also recorded attributes of soil type, drainage and habitat type.

Data analysis methods

We explored the relationships between the species abundances and environmental attributes using canonical correspondence analysis (CCA) (CANOCO for Windows Version 4.55). CCA is a constrained ordination technique that extracts the major gradients in the species data (dependent variables) that can be accounted for by the measured environmental variables (independent variables) (McGarigal, Cushman, & Stafford, 2000). Our environmental variables consisted of a total of nine variables related to habitat (homegarden, young fallow, old fallow, field/compound), soil type (clay loam, sandy loam, loamy), and drainage (seasonally flooded, well drained) that we recorded in the study plots. In the CCA ordination diagram, the axes represent linear combinations of the environmental variables that explain the most variation in the species abundance data. In the ordination diagram the abundance of a given species decreases with distance from its species point; the length of each arrow indicates the importance of the environmental variable it represents, and the angle between arrows indicates correlations among environmental variables (McGarigal et al., 2000). We tested the null hypothesis that species abundances were independent of the measured environmental variables using a Monte Carlo test of significance of all canonical eigenvalues with 9999 permutations.

To determine the conservation status of the target species we calculated their frequency, densities and importance value indices (IVI), and assessed their size class distributions (SCD). The IVI is an aggregate index that measures floristic structure and determines the overall importance of a given species in a given area. It is calculated by summing the relative density, relative frequency and relative coverage of every species (Muthuramkumar & Parthasarathy, 2000). Low IVI values can indicate rare or threatened species. Our target species were the 26 preferred species - therefore our IVI is a relative index and compares the relative importance value of preferred species only. The IVI calculations were based on individuals of all sizes including seedlings.

For size-class distributions, those species with less than 10 individuals encountered in the study plots were omitted. The shape of the SCD can be used to make inferences about the future regenerative potential of species as regenerating populations for which there is continuous recruitment from juveniles attain a reverse J-shaped plot (Lykke, 1998; Newton, 2007).

Results

Twenty seven percent (7/26) of the preferred species were not encountered in any of the survey plots. These were: *Ziziphus pubescens*, *Casuarina* spp., *Maesopsis eminii*, *Psorospermum febrifugum*, *Psydrax parviflora* subsp. *parviflora*, *Sarcocephalus latifolius*, and *Securidaca longipedunculata*. All the other species were found in at least one of the survey plots. Overall, at least one of the preferred species was present in about two-thirds the plots (205 of the 320 plots), for a total to 494 stems across all plots. Some of the plots where none of the preferred species were found had other woody species present.

Environmental factors influencing distribution of preferred tree species on farmland

The CCA showed that there were significant differences in species abundance across the measured environmental variables (i.e. the species-environment relation was significant, $p = 0.03$). The eigenvalue of the first canonical axis was 0.440 and it explained 51.4% of the species-environment relation. The second canonical axis had an eigenvalue of 0.188. Together, the first two axes explained 73.3% of the variance in the species-environment relation.

The species-environment biplot illustrates that most of the variation in the species-environment relation (represented by the first canonical axis) is driven by differences in drainage – well drained versus seasonally flooded and clay loamy soils (Fig. 2). Only two of the 19 species encountered in the survey plots, *Combretum collinum* and *Acacia seyal*, were found in clay loamy or seasonally flooded soils (these two variables were correlated) and in old fallows. *Terminalia glaucescens* was frequently found in young fallows and on sandy loamy soils. Four of the 19 species encountered in plots were found only in homegardens: *Melia azaderach*, *Moringa oleifera*, *Azadirachta indica* and *Eucalyptus* spp. Homegardens tended to have loamy soils. Most of the other species were found throughout fields, young fallows and in homegardens and mostly in well drained soils. *Senna spectabilis*, *Albizia coriara* and *Ficus sycomorus* tended to be found most prevalently in fields and often in sandy loam soil.

Conservation status of preferred woody species

The preferred species showed a wide spectrum in terms of their densities and frequencies in the survey plots (Tables 2 and 3). Six of the preferred species were found in numerous plots in at least six of the eight parishes, and at relatively high densities (*Mangifera indica*, *Milicia excelsa*, *Ficus natalensis*, *Ficus sycamorus*, *Artocarpus heterophyllus* and *Albizia coriaria*; these species had mean densities of about 100 or more individuals per hectare). The first three of these species had IVI values > 50%, the IVI values of the latter three ranged from about 19 to 34% (Table 4). At the other end of the spectrum, six

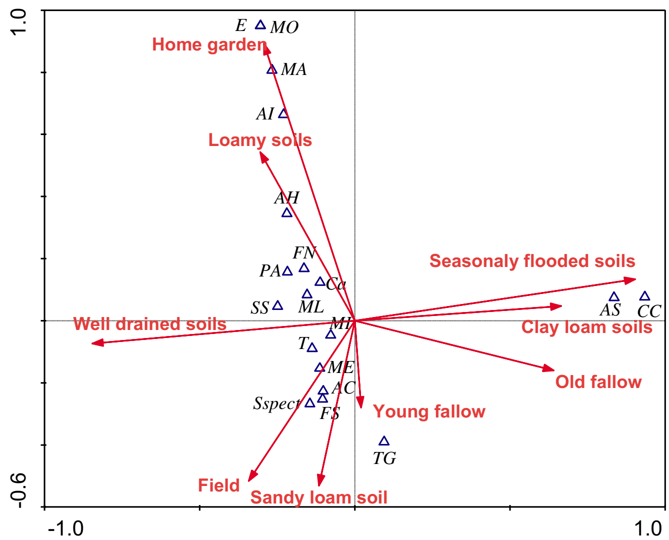

Fig. 2. Ordination diagram from Canonical Correspondence Analysis (CCA) showing the relationship between preferred species abundances and environmental attributes in Nawaikoke sub-county. Key: AC = *A. coriaria*; AI = *A. indica*; AH = *A. heterophyllus*; AS = *A. seyal*; Ca = *Citrus* × *aurantium*; CC = *C. collinum*; E = *Eucalyptus* spp.; FN = *F. natalensis*; FS = *F. sycomorus*; MA = *M. azedarach*; ME = *M. excelsa*; MI = *M. indica*; ML = *M. lutea*; MO = *M. oleifera*; PA = *P. americana*; SS = *S. siamea*; SSP = *S. spectabilis*; TG = *T. glaucescens*; T = *Terminalia* spp.

species (*Moringa oleifera*, *Persea americana*, *Melia azedarach*, *Eucalyptus* spp., *Azadirachta indica* and *Senna siamea)*, were poorly distributed: they were found in two or less parishes, and within these parishes, they were generally found in only one plot. Overall Namawa parish had the highest number of plots with woody species and the highest density of these species (Tables 2 and 3). The relatively higher species diversity and tree density in this parish could be because the parish has a low population density and inhabitants are occupied in fishing (Mr. Sam Kiige – LCIII Chairperson, Nawaikoke; personal communication). The analyses of size class distributions show that there are proportionately many more individuals in the larger size classes than the smaller size classes for all the species (Fig. 3).

Discussion

The results of our ecological survey illustrate that 73% of the preferred species in Nawaikoke occur on farmland in homegardens, crop gardens and young fallows. These are managed through cultivation or by protection when found growing naturally on the farmland (Tabuti et al., 2009). Managing trees near homesteads ensures that farmers have a ready and constant access to desired tree products (Atta-Krah et al., 2004; Augusseau et al., 2006; Wiersum, 1997).

However, only one quarter of the preferred species were found in at least moderate densities and frequencies (means densities of ≥100 stems/ha and in at least 75% of the parishes). These species have probably been able to persist in Nawaikoke's highly disturbed farming landscape for both social and ecological reasons. Four of the six are indigenous species used mostly for shade or timber (*M. excelsa*, *F. natalensis*, *Ficus. sycomorus*, *A. coriaria*), and the remaining two are naturalized species used for food (*M. indica*, *A. heterophyllus*) – all uses that are highly valued by most farmers. Trees used for shade, timber and fruit also tend to be among the most commonly planted or protected on farms elsewhere (Harvey et al., 2005; Leakey, Schreckenberg, & Tchoundjeu, 2003; Martin, Ratsimisetra, Laloe, & Carrière, 2009). In addition these species recruit from coppices and/or regenerate from root suckers and so regenerate easily even if they are cut down (Table 4).

The shade and timber trees that were found in low densities and frequencies (*Terminalia* spp., *Casuarina* spp., *Eucalyptus* spp., *Melia azedarach*), or not found at all (*M. eminii*), are of recent introduction to Nawaikoke (Table 4). These species are exclusively managed by cultivation and are not naturalized to a level where they can regenerate themselves. This means that they require, in addition to land, a further investment of labor, money and skills. For example, although *Casuarina* is highly valued, the seeds are expensive for farmers to purchase and they don't have the silvicultural skills to propagate it well. All those species that were generally found in only one plot per parish were also found only in homegardens, and these were all introduced species.

Several of the species not found in any of the plots surveyed were indigenous species whose major uses are in traditional medicine. These species were rated as highly valuable by traditional medicine practitioners, but were not considered so by the other members of the communities. Most farmers therefore destroy

Table 2
Frequency distribution of 19 of the preferred species in Nawaikoke sub-county parishes. Values refer to the number of plots in which each species was found.

	Parish								
	Bukamba	Buluya	Namawa	Nangala	Nansololo	Nawaikoke	Nawampiti	Nsamule	Total
Mangifera indica	6	9	3	10	5	13	6	6	58
Milicia excelsa	5	3	10	7	3	6	7	5	46
Ficus natalensis	6	6	6	7	11	3		5	44
Ficus sycomorus	2	12	6	1	4	5	4	7	41
Albizia coriaria	2	5	6	4	2	2	5	2	28
Artocarpus heterophyllus	2	5	3	4	8			5	27
Combretum collinum	3		11	2		1	2	4	23
Acacia seyal	3		9	1	1	2	2	1	19
Senna spectabilis	2	1	8	2				1	14
Citrus × *aurantium*	2	4	2		2	2		1	13
Markhamia lutea		3	1	1	3	2		2	12
Terminalia glaucescens	1	1	6					2	10
Terminalia spp.		1			1	1			3
Senna siamea	1				2				3
Moringa oleifera				1	1				2
Persea americana		1				1			2
Melia azedarach			1	1					2
Eucalyptus spp.				1					1
Azadirachta indica		1							1
Total	35	52	72	42	43	38	26	41	349

Table 3
Estimated density (per hectare) of 19 of the preferred species in Nawaikoke sub-county parishes.

	Parish								
	Bukamba	Buluya	Namawa	Nangala	Nansololo	Nawaikoke	Nawampiti	Nsamule	Mean
Ficus natalensis	292	324	320	256	648	256		416	314
Mangifera indica	212	372	112	400	192	640	256	256	305
Ficus sycomorus	64	480	176	32	128	384	160	224	206
Milicia excelsa	160	96	280	256	40	120	224	120	162
Artocarpus heterophyllus	48	232	56	176	472			224	151
Albizia coriaria	64	164	140	112	48	32	168	48	97
Senna spectabilis	64	32	440	48				8	74
Acacia seyal	48		324	32	8	48	64	16	68
Combretum collinum	52		248	20		16	64	64	58
Citrus × *aurantium*	36	128	64		48	32		32	43
Markhamia lutea		56	16	32	100	64		64	42
Terminalia glaucescens	16		104					80	25
Terminalia spp.		16			32	96			18
Senna siamea	32		32		64				16
Persea americana		16				32			6
Melia azedarach			8	32					5
Eucalyptus spp.				32					4
Moringa oleifera				16	8				3
Azadirachta indica		24							3
Total	1088	1940	2320	1444	1788	1720	936	1552	1599

these species to create space for crop agriculture or for use as timber or charcoal – all of which they consider more important than traditional medicine. Habitat conversion to agricultural landscapes is also a common cause of decline in medicinal plant species elsewhere (Lulekal et al., 2008; Maroyi, 2008; Singh & Singh, 2009). The conservation status of these species will likely improve only if farmers learn to value them enough to spare them in their crop fields. In the meantime, the very low abundance of these species in Nawaikoke means that residents who need them must spend considerable time in search for them. In an area where c. 60% of the inhabitants depend on traditional medicines (Tabuti et al., 2003), this can have important health implications.

Another indigenous species not found in any plots was *P. parviflora*, which is valued for its use as firewood. While the value of firewood is unmistakable, species that provide firewood are numerous and it is easy to substitute among species. This is probably why people are reluctant to invest resources in propagating firewood species.

It is important to point out that *P. parviflora* was not found in any plots despite the fact that over 40% of farmers report that they spare it (Tabuti et al., 2009). Similarly, *Markhamia lutea* valued for timber and house construction, had low densities and frequencies across the landscape even though about 30% of farmers report planting this species and nearly 40% report sparing it (Tabuti et al., 2009). This apparent contradiction indicates that what farmers wish for, and say, may not coincide exactly with what they actually do. On the other hand *M. excelsa* and *A. coriaria*, among the most abundant species, were reported by local inhabitants to be both "rare and

Table 4
Preferred species floristic structure indices in Nawaikoke sub-county (Rden = Relative Density; Rfreq = Relative Frequency; Rcov = Relative Coverage; IVI = Importance Value Index). Included also are observations of coppicing, disease and history of introduction.

Species	Rden	Rfreq	Rcov	IVI	Notes
Ficus sycomorus L.	12.9	11.8	45.1	69.8	Coppices
Ficus natalensis Hochst.	19.6	12.6	18.6	50.8	Coppices
Mangifera indica L.	19.1	16.6	14.4	50.1	Coppices
Milicia excelsa (Welw.) C.C. Berg	10.1	13.2	10.4	33.7	Coppices, regenerates from root suckers
Artocarpus heterophyllus Lam.	9.5	7.7	2.4	19.6	Affected by pests and diseases
Albizia coriaria Welw. ex Oliv.	6.1	8.0	4.6	18.7	Coppices
Combretum collinum Fresen.	3.6	6.6	0.6	10.8	Coppices
Acacia seyal Delile	4.2	5.4	0.8	10.4	Coppices
Senna spectabilis (DC.) H.S. Irwin & Barneby	4.6	4.0	1.2	9.8	Coppices
Citrus × *aurantium* L.	2.7	3.7	0.3	6.7	Affected by pests and diseases
Markhamia lutea (Benth.) K. Schum.	2.6	3.4	0.5	6.5	Coppices
Terminalia glaucescens Planch. ex Benth.	1.6	2.9	0.3	4.8	Coppices
Terminalia spp.	1.1	0.9	0.3	2.3	New introduction
Senna siamea (Lam.) H.S. Irwin & Barneby	1.0	0.9	0.2	2.1	
Persea americana Mill.	0.4	0.6	0.1	1.1	
Melia azedarach L.	0.3	0.6	0.1	1.0	New introduction; Coppices
Moringa oleifera Lam.	0.2	0.6	0	0.8	New introduction
Eucalyptus spp.	0.3	0.3	0	0.6	
Azadirachta indica A. Juss.	0.2	0.3	0	0.5	New introduction
Ziziphus pubescens Oliv.					Not encountered in plots
Casuarina spp.					"
Maesopsis eminii Engl.					"
Psorospermum febrifugum Spach					"
Psydrax parviflora subsp. *Parviflora*					"
Sarcocephalus latifolius (Sm.) Bruce					"
Securidaca longipedunculata Fresen.					"

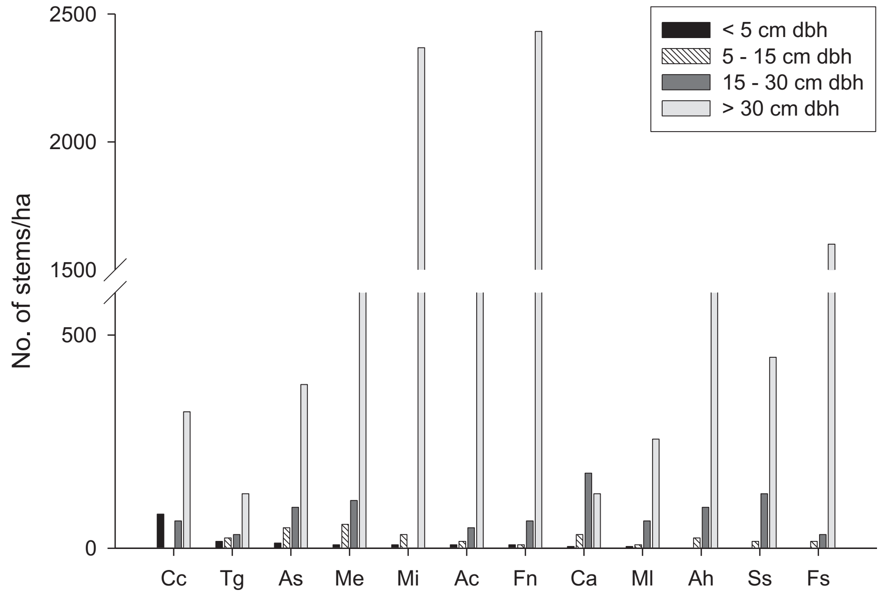

Fig. 3. Size class distribution of preferred species in NawaikokeSub-county. Abbreviations of species as in Fig. 2.

decreasing" (Tabuti et al., 2009). This perception may be because these species used to be much more abundant in the recent past, and have become relatively rare and are decreasing in the opinion of farmers. Therefore even those species that are found to be among the most abundant in ecological surveys may be considered scarce by local inhabitants, and should be targeted for augmentation. This suggests that when designing conservation strategies, participatory approaches to assess correlations between local perceptions and ecological data can be very important (Dovie, Witkowski, & Shackleton, 2008; Phuthego & Chanda, 2004).

Recommendations for conservation and conclusions

Regardless of their abundance, the size-class distributions of all of the preferred species illustrated little or no regeneration. This is expected for the recently introduced species, but for the naturalized and indigenous species, this finding is likely a result of farmers destroying juvenile stems as they clear land for cultivation. For example, the two naturalized *Senna* species, *S. spectabilis* and *S. siamea*, are prolific seeders but show little regeneration. Even though farmers report protecting juveniles of *M. excelsa* and *F. sycomorus* against livestock-browsing by using fences of thorny plants (Tabuti et al., 2009), there were almost no juveniles of these species recorded in the plots. These findings suggest that to persist in the future, both the naturalized and indigenous species will either need to be actively planted by farmers or else farmers will have to change their practices to spare at least some seedlings and saplings.

This great lack of juveniles combined with the fact that over one quarter of the preferred species were not found in a single plot across the landscape, and that one third of all the plots across the farmers' fields had none of the preferred woody species present, emphasize the need to work with farmers on conservation of these species over the long-term. However, our results also suggest that there is much potential for increasing the abundance of many of the preferred species. The CCA indicates that most of these species can grow in a variety of farm habitats: fields, young fallows and homegardens, even though they survive best on well drained soils (those soils best for crop cultivation) and avoid seasonally flooded soils (those that are not ideal for most crops in the area except rice). Therefore these species are well-suited to being propagated in Nawaikoke's farming landscape. The finding that the homestead or crop gardens are where most tree species were located suggests that initiatives to promote cultivation of a wider diversity of trees may be most effective if focused in these areas. However at the same time, the lower density of woody species elsewhere indicates that the cultivation and conservation of woody species is needed outside homesteads as well. This could be achieved by government initiatives on public lands. The fact that 90% of the farmers interviewed in our previous research report planting or retaining at least one tree species, and express strong interest in increasing the density of preferred trees (Tabuti et al., 2009), also indicates that the potential for promoting conservation of many of these species is high.

The high preference of farmers for trees used for shade, timber and food suggests that promoting the conservation of species with these uses may be most successful. While various of the introduced species meet these needs, from a conservation perspective it is clear that promoting indigenous trees with these uses should be a priority. This is especially important given that farmers already plant and retain a significantly higher proportion of non-indigenous (naturalized or alien) than indigenous species (Tabuti et al., 2009). However, our results also illustrate that species valued only by specific user groups (such as medicinal species) will need to be actively planted if they are to persist.

The leading cause of woody species decline in Nawaikoke is likely the conversion of native habitat into crop land. This is occurring as a result of a growing human population (Tabuti, 2007). For example, the expansion of crop agriculture into seasonally flooded wetlands is the most probable reason that the medicinal shrub, *S. latifolius*, was not found in a single plot. Similarly, only three of the preferred species, *Combretum collinum* and *Acacia seyal* (used for firewood and medicine) and *Terminalia glaucescens* (used for medicine) were found in fallows. Therefore, with the exception of one parish, these were absent or found in low densities across most of the landscape. Old fallows are restricted to seasonally flooded land now because this land is not suitable for food crops, and other lands are no longer left fallow for long periods. As fallow periods and areas decrease, these species and other fallow species will become more at risk (Augusseau et al., 2006). Dalle and de Blois (2006) also showed that in Quintana Roo Mexico, shorter fallow times was leading to an overall decrease in biomass of firewood species. If fallows, wetlands and other non-crop habitat continue to disappear, these species will require active planting in other areas in order to be maintained over the long-term.

In promoting cultivation and sparing of useful woody species, those that may simultaneously serve important ecological roles should be especially targeted. It is noteworthy that several of the most abundant preferred species, including the two species of *F. natalensis* and *F. sycomorus*, also provide key food resources for other organisms. Other research has demonstrated the important role that isolated trees in farms, in particular *Ficus* spp., can play in terms of attracting birds and other frugivorous animals into cultivated landscapes (Luck & Daily, 2003; Guevara, Laborde, & Sa'nchez-Rios, 2004; Martin et al., 2009).

Finally, in general the perceptions of Nawaikoke residents of the status of their woody trees (Table 1) coincided closely with the findings of our ecological survey. Other studies have also demonstrated that community perceptions of the status of natural resources often coincide well with ecological data (e.g. Gaoue & Ticktin, 2009; Tabuti, 2007). However, in the case of Nawaikoke Sub-county, there were also important exceptions. Appropriate conservation action for these species clearly requires consideration of both the ethnographic and ecological findings, and highlights the importance of combining social and ecological methods in designing conservation plans for culturally important species.

Acknowledgements

We acknowledge with gratitude the people of Nawikoke Sub-county for agreeing to set aside to participate in our interviews. We also thank our field assistants Mr. Charles Wambuzi and the late Ms. Rose Akello. This study was sponsored by Makerere School of Graduate Studies (Project No.: Mak/2006/0162). Additional support was received from COMPAS (Comparing and Supporting Endogenous Development) and a local NGO, Sustainable Use of Plant Diversity. Permission to conduct the study was granted by the Uganda national Council for Science and Technology (NS 97). We are also grateful to two anonymous referees from Applied Geography who made useful comments to the manuscript.

References

Atta-Krah, K., Kindt, R., Skilton, J. N., & Amaral, W. (2004). Managing biological and genetic diversity in tropical agroforestry. *Agroforestry Systems, 61*, 183–194.

Augusseau, X., Nikiéma, P., & Torquebiau, E. (2006). Tree biodiversity, land dynamics and farmers' strategies on the agricultural frontier of southwestern Burkina Faso. *Biodiversity and Conservation, 15*, 613–630.

Belcher, B., & Schreckenberg, K. (2007). Commercialisation of non-timber forest products: a reality check. *Development Policy Review, 25*, 355–377.

Dalle, S. P., & de Blois, S. (2006). Shorter fallow cycles affect the availability of noncrop plant resources in a shifting cultivation system. *Ecology and Society, 11*(2).

Dovie, D. B. K., Witkowski, E. T. F., & Shackleton, C. M. (2008). Knowledge of plant resource use based on location, gender and generation. *Applied Geography, 28*, 311–322.

FAO (Food and Agriculture Organization). (2009). *State of the World's forests 2009*. Rome: Food and Agriculture Organization of the United Nations.

Gaoue, O. G. G., & Ticktin, T. (2009). Fulani knowledge of the ecological impacts of Khaya senegalensis (Meliaceae) foliage harvest in Benin and its implications for sustainable harvest. *Economic Botany, 63*(3), 256–270.

Guevara, S., Laborde, J., & Sa'nchez-Rios, G. (2004). Rain forest regeneration beneath the canopy of fig trees isolated in pastures of Los Tuxtlas, Mexico. *Biotropica, 36*, 99–108.

Harvey, C. A., Villanueva, C., Villacis, J., Chacon, M., Munoz, D., Lopez, M., et al. (2005). Contribution of live fences to the ecological integrity of agricultural landscapes. *Agriculture Ecosystems & Environment, 111*, 200–230.

Langdale-Brown, I., Osmaston, H. A., & Wilson, J. G. (1964). *The vegetation of Uganda and its bearing on land-use*. Entebbe, Uganda: Government of Uganda.

Leakey, R. R. B., Schreckenberg, K., & Tchoundjeu, Z. (2003). The participatory domestication of West African indigenous fruits. *International Forestry Review, 5*(4), 338–347.

Luck, G., & Daily, G. (2003). Tropical countryside bird assemblages: richness, composition, and foraging differ by landscape context. *Ecological Applications, 13*, 235–247.

Lulekal, E., Kelbessa, E., Bekele, T., & Yineger, H. (2008). An ethnobotanical study of medicinal plants in Mana Angetu district, southeastern Ethiopia. *Journal of Ethnobiology and Ethnomedicine, 4*, 10.

Lykke, A. M. (1998). Assessment of species composition change in savanna vegetation by means of woody plants' size class distributions and local information. *Biodiversity and Conservation, 7*, 1261–1275.

Maroyi, A. (2008). Ethnobotanical study of two threatened medicinal plants in Zimbabwe. *International Journal of Biodiversity Science & Management, 4*(3), 148–153.

Martin, E. A., Ratsimisetra, L., Laloe, F., & Carrière, S. (2009). Conservation value for birds of traditionally managed isolated trees in an agricultural landscape of Madagascar. *Biodiversity and Conservation, 18*(10), 2719–2742.

McGarigal, K., Cushman, S., & Stafford, S. (2000). *Multivariate statistics for wildlife and ecology research*. New York: Springer-Verlag New York Inc.

Muthuramkumar, S., & Parthasarathy, N. (2000). Alpha diversity of lianas in a tropical evergreen forest in the Anamalais, Western Ghats, India. *Diversity and Distributions, 6*, 1–14.

NEMA (National Environment Management Authority). (2005). *State of the environment report for Uganda 2005*. Kampala: National Environment Management Authority.

Newton, A. C. (2007). *Forest ecology and conservation: A handbook of techniques*. New York: Oxford University Press.

Phuthego, T. C., & Chanda, R. (2004). Traditional ecological knowledge and community-based natural resource management: lessons from a Botswana wildlife management area. *Applied Geography, 24*, 57–76.

Rönnbäck, P., Kautsky, N., Pihl, L., Troell, M., Söderqvist, T., & Wennhage, H. (2007). Ecosystem goods and services from Swedish coastal habitats: identification, valuation, and implications of ecosystem shifts. *Ambio, 36*, 534–544.

Shackleton, S. E., Shackleton, C. M., Netshiluvhi, T. R., Geach, B. S., Ballance, A., & Fairbanks, D. H. K. (2002). Use patterns and value of Savanna resources in three rural villages in South Africa. *Economic Botany, 56*(2), 130–146.

Singh, A., & Singh, P. K. (2009). An ethnobotanical study of medicinal plants in Chandauli district of Uttar Pradesh, India. *Journal of Ethnopharmacology, 121*(2), 324–329.

Tabuti, J. R. S. (2007). The uses, local perceptions and ecological status of 16 woody species of Gadumire Sub-county, Uganda. *Biodiversity and Conservation, 16*, 1901–1915.

Tabuti, J. R. S., Dhillion, S. S., & Lye, K. A. (2003). Traditional medicine in Bulamogi county, Uganda: its practitioners, users and viability. *Journal of Ethnopharmacology, 85*, 119–129.

Tabuti, J. R. S., Ticktin, T., Arinaitwe, M. Z., & Muwanika, V. B. (2009). Community attitudes and preferences towards woody species: implications for conservation in Nawaikoke, Uganda natural resource management. *Oryx, 43*, 393–402.

UBoS (Uganda Bureau of Statistics). (2000). Statistical Abstracts, 2000. Uganda Bureau of Statistics, Kampala, Uganda.

Upadhyay, B. (2005). Women and natural resource management: illustrations from India and Nepal. *Natural Resources Forum, 29*, 224–232.

Varghese, A., & Ticktin, T. (2008). Regional variation in non-timber forest product harvest strategies, trade, and ecological impacts: the case of black dammar (Canarium strictum Roxb.) use and conservation in the Nilgiri Biosphere Reserve, India. *Ecology and Society, 13*(2), 11. http://www.ecologyandsociety.org/vol13/iss2/art11/ [online] URL.

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., & Berg, G. K. (2007). Forest environmental incomes and the rural poor. *Forest Policy and Economics, 9*, 869–879.

Wiersum, K. F. (1997). Indigenous exploitation and management of tropical forest resources: an evolutionary continuum in forest–people interactions. *Agriculture, Ecosystems & Environment, 63*, 1–16.