A Survey of Small-Scale Farmers Using Trees in Pastures in Herrera Province, Panama

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ABSTRACT. Herrera province in Panama has suffered extensive deforestation due to cattle ranching. Scientific knowledge of tree species use in Herreran pastures is limited and baseline information is necessary for the development of viable silvopastoral systems. The present study employed surveys to describe the current use of trees in Herreran pastures. The Ministry of Agricultural and Livestock Development (MIDA) and Panama Peace Corps identified eight informants who were interviewed in order to develop a semi-structured interview. The developed interview was then administered to 45 randomly selected small-scale (< 20 hec) Herreran pasture owners, with stratification by informant gender and farm ecozone. Nine different tree uses were identified. There were

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differences in the popularity and perceived species richness of these uses. Sørenson's similarity index indicated that percent similarity between uses ranged from 0-51%. Abundance-diversity curves for uses were steep with only a few dominant species. Native species (e.g., *Byrsonima crassifolia, Guazuma ulmifolia, Cordia alliodora*) tended to receive the highest multipurpose tree priority ratings. Protein banks were not used and are likely inappropriate for most small-scale farmers. However, fodder trees (e.g., *Guazuma ulmifolia, Enterolobium cyclocarpum*) were often retained in pastures and agricultural by-products (stover, immature fruits) were commonly used as feed supplements. Trees provide a number of products and services in Herreran pastures and require further research, with special attention to native species.

KEYWORDS. Agroforestry, silvopastoralism, small-scale farmers, multipurpose trees, protein banks, *Guazuma ulmifolia, Byrsonima crassifolia,* Panama

INTRODUCTION

Multipurpose trees are woody perennials, grown by farmers to provide more than one main product or service (Huxley 1985). This contrasts with the often single product crop approaches of forestry and agricultural sciences (Huxley 2001). Research into multipurpose trees was first reported in the 1970s (Bene et al., 1977). Multipurpose trees are viewed as particularly appropriate for small-scale farmers (Hedge and Daniel 1992) and are present in silvopastoral systems (Cajas-Giron and Sinclair 2001). Agroforestry researchers in Panama have noted the importance of multipurpose trees (Aguilar and Condit 2001) and, specifically, multipurpose timber species (Simmons et al., 2002). Little is known about many multipurpose trees, and more research into their management and physiology is needed (Huxley 2001).

Herrera province Panama is dominated by pasture, which covers ~ 50% of its landmass (Contraloria 2000b), but there has been little research into pasture trees in this region. Previous work has described Herrera's flora (Holdridge 1970) and identified promising living fence species (Cannon and Galloway 1995) however, there have been few botanical collecting expeditions (Galdames pers. comm., 2003). In contrast to recent work on traditional silvopastoral systems in other regions of Central America (Dagang and Nair 2001; Harvey and Haber 1999), little information is available regarding the management of trees in Herreran pastures, although Fischer (1998) indicated Herreran agroforestry and silvopastoral systems were documented by the National Environment Authority (ANAM) in 1991.

Fodder is an important product of multipurpose trees (Gutteridge and Shelton 1994). Fodder trees have a long history (Robinson 1985), but protein banks are a new technology (Kapp 1999). Protein banks are high-density plantings of shrubs or trees that are usually leguminous, and produce high protein foliage (Schlonvoigt and Ibrahim 2001). Trees' resistance to drought may permit the supplementation of cattle diets with high protein fodder during the dry season (Paterson et al., 1998). In Herrera, protein banks were introduced in the 1980s (Urriola pers. comm., 2002). Protein banks are a production-oriented technology (Murgueitio 2001) and their economic value has been assessed (Holmann and Ibrahim 2001). Adoption of leguminous forage technologies in the tropics has been poor (Sumberg 2002) and protein banks are no exception (Paterson et al., 1998). Nevertheless, some researchers are optimistic about protein banks and feel more research is necessary (Schlonvoigt and Ibrahim 2001).

Large research institutes can only pursue the genetic improvement of a limited number of multipurpose trees (ICRAF 1993). Prioritization of multipurpose tree species for research and genetic improvement is necessary for efficient resource use. Some prioritization methodologies rely on expert-defined needs, ecozone adaptability, and the use of pre-existing databases (von Carlowitz 1989), with farmer participation occasionally encouraged at the evaluation stage (Wood and Burley 1991). Other schemes directly incorporate farmers, by allowing them to rank tree products and services (von Carlowitz 1984), and occasionally tree species (Franzel et al., 1996). Farmer gender (Wiersum 1989; Franzel et al., 1995) and ecozone (Huxley 2001) are important considerations because they may affect the appropriateness of a given species for a particular region and clientele.

Multidisciplinary diagnosis of problems is very important when designing technologies for farmers (Simmonds 1986). Surveys are a practical and efficient way of obtaining baseline information (Bernard 2002) on farmers' views.

This study aimed to conduct a survey of small-scale pasture owners in order to:

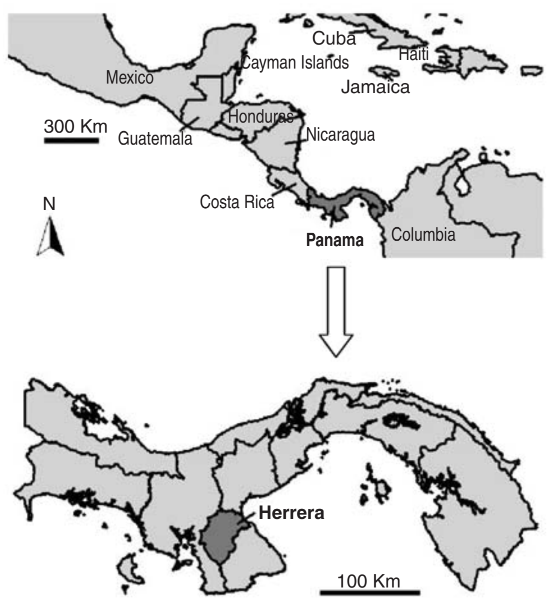
- Describe the use of trees in Herreran pastures and their multipurpose nature, considering the effects of different uses, ecozone, and informant gender on perceived tree species richness.
- Prioritize multipurpose species in Herrera for further research.
- Investigate the current status of protein banks in Herreran silvopastoral systems.

MATERIALS AND METHODS

Study Area

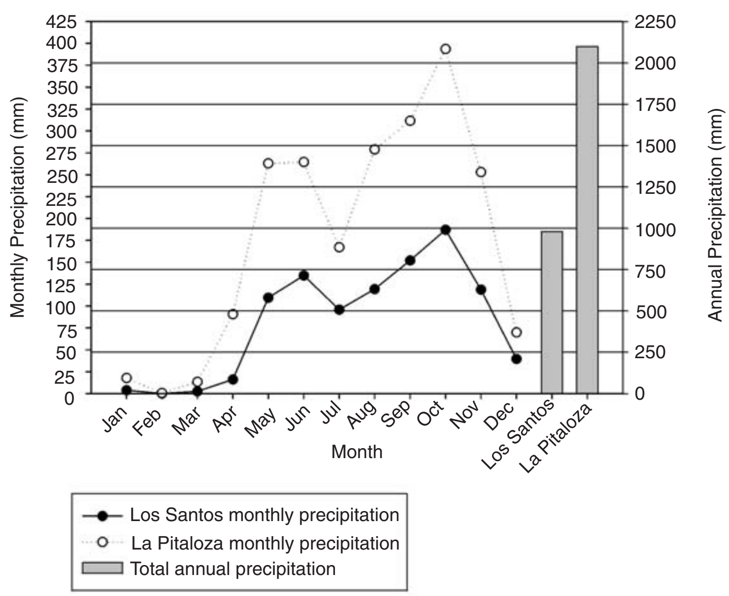
Panama is a small Central American country of 75,500 km^2 located between 7°12′07′′ and 9°38′46′′ N and 77°09′24′′ and 83°03′07′′ W (Comisión Nacional de Recursos Fitogenéticos de Panamá 1995) (Figure 1). Panama's Herrera province is situated between 7°13′00′′and 7° 37′30′′ N and 80°4′30′′ and 80°22′30′′ W (Jaen 1962) and covers 2 300 km^2 (Figure 1).

FIGURE 1. Map of research area in relation to Central America and the republic of Panama.



Herrera is thought to have one of the longest histories of human habitation in Panama (Holdridge 1967) and has a large number of small-scale farms and cattle ranches (Jaen Suarez 1978). Of Herrera's 190,000 ha of agricultural land, 129,000 ha (68%) is in pasture, with traditional pasture species covering 85,000 ha (Contraloria, 2000b). In contrast, forest covered only 4% of Herrera in 1998 (ANAM 1999). Ministry of Agricultural and Livestock Development (MIDA) officials perceive Herrera as being divided into three ecozones: lowland, transition, and mountainous (Moreno, pers. comm. 2003). Weather stations in La Villa de Los Santos and La Pitaloza define the precipitation range of Herrera province. La Villa de Los Santos and La Pitaloza received annual mean precipitation of 980 mm and 2,100 mm, respectively, between 1983 and 1997 (IRHE 1998). There is a pronounced dry season during the months of December to April and a bimodal rainy season between May and November (Figure 2). Annual mean temperature at La Villa de Los Santos is 27.5°C and varies little throughout the year (Alvarado and Farbridge 1986). No temperature data are available for La Pitaloza.

FIGURE 2. Average monthly and annual rainfall in La Villa Los Santos and La Pitaloza (1983-1997 Instituto de Recursos Hidraulicos y Electrificacion Data).



Methods

The study employed in-home interviews and pasture visits with male and female heads of pasture-owning[1] households. Female household heads were the wives of male household heads except in two instances, where they were the sole head of the household. Initially, MIDA and Panama Peace Corps identified eight informants for unstructured interviewing. A semi-structured format was developed based on these unstructured interviews, and pre-tested with an informant. Semi-structured interviews were then conducted with 45 small-scale pasture owners in the province of Herrera. Pasture owners were selected using random sampling (Bernard 2002), stratified by MIDA ecozone and informant gender. Small-scale was defined as owning ≤ 20 ha of pasture, excluding other agricultural holdings.

Gender stratification was used because gender affects species preference (Franzel et al., 1996) and use (Just and Murray 1996). Agricultural spaces may also be gendered (Garrett and Espinosa 1988). In Latin America, women make significant labor and management contributions to home gardens (Fisher and Vasseur 2000), while cattle ranching is culturally a male activity in Panama (Heckadon-Moreno 1985).

The number of small-scale cattle ranches in each district was determined using year 2000 unpublished agricultural census data (Contraloria 2001). The number of interviews conducted in each district was weighted by the proportion of provincial cattle ranches in each district. This number was then adjusted to stratify by ecozone (lowland, transition, and mountainous). Towns with > 20 households involved in agriculture, and accessible by public transport, were thereafter identified. A subset of towns was randomly selected and visited.

A maximum of two informants were interviewed per town. Informants were selected by convenience: available and willing to participate. In each town stratification by gender was attempted but was not possible because pastures are a gendered male agricultural space and willing female informants were difficult to find. If informants could not be found, the next nearest town(s) was (were) visited until two interviews had been conducted.

Interviews took ~40 minutes and consisted of four categories of questions: (1) pasture owner information (age, off-farm work, etc.); (2) cattle information (quantity, type, etc.); (3) pasture information (quantity, age, management, etc.); and (4) tree information (species, uses, preference, etc.). Responses and post-interview notes were recorded in a notebook. It was assumed that home interviews would force farmers to recall tree species and their uses solely on the basis of memory. Cajas-Giron and Sinclair (2001) used similar interview techniques to characterize silvopastoral systems. Remembered species and uses are thought to be those of greatest agronomic interest to farmers. Thus, home interviews were expected to identify fewer species and uses than pasture visits, which provide visual cueing. Harvey and Haber's (1999) survey employed pasture visits and found 19 reasons for having remnant trees in pastures, including aesthetics, oxygen production, and fruit for birds. When possible, pastures were visited and notes taken about the presence and absence of species. When a species could not be identified in the field or during an interview, a leaf sample was taken and identified at the University of Panama's and/or the Smithsonian Tropical Research Institute's herbaria Panama City, Panama. If a tree could not be identified and no botanical sample could be obtained, it was not included in analyses.

Prior to conducting research the Human Research Ethics Board of the Faculty of Agriculture, Forestry, and Home Economics at the University of Alberta, reviewed and approved this study. An information sheet and a signed consent form were used in the study to ensure that informants' rights were respected.

Statistical Analysis

Semi-structured interviews allowed informants to guide the interview, resulting in response rates of less than 100% for some questions. For descriptive statistics, response rates of less than 100% are indicated. For inferential statistics, unanswered questions were treated as missing data. Spearman rank correlation (Spearman 1904) was used to analyze associations between variables with non-normal distributions. The species richness of different tree uses was evaluated using a parametric two-way analysis of variance with informant as block, and the result was substantiated using rank transformation (Conover and Iman 1976) for the same analysis. Tukey's test (Zar 1999) was used to perform multiple comparisons between treatment means.

For each tree use informant gender and farm ecozone effects on species richness were assessed using the Mann-Whitney non-parametric t-test (Zar 1999) and the Kruskal-Wallis non-parametric one-way analysis of variance (Kruskal and Wallis 1952), respectively. An α-level of 0.05 was used for all tests. Abundance-diversity curves (Zarin et al., 1999) and Sørenson's similarity index (Zarin et al., 1999) were used to compare species diversity and similarity between different tree uses, respectively.

Rating Multipurpose Species

Pasture owners often perceived all products and services as being of similar importance, making prioritization of tree species on the basis of conventional ranking difficult. Pairwise ranking (Fielding et al., 1998) is an alternative, but in the present study would have been too time consuming given the large number of tree uses and species involved. Drawing on the prioritization schemes of Franzel et al. (1996), an alternative prioritization scheme was developed on the basis of species use plurality, frequency of use, and indications of preference.

Use plurality can be present at the level of the community or the level of the individual. At one extreme a tree species may be used by nine different pasture owners for nine different uses, while at the other extreme one pasture owner may use one tree species for nine different uses. "Total number of uses" reported for a species by all informants captures use plurality at the community level, while "mean number of uses" for a species adjusts for use plurality at the user level. Unfortunately, a species mentioned by only a few farmers as having a large number of uses will score high for both parameters. This is tempered by the "frequency of use" parameter. Frequency of use is reflected by the percentage of informants reporting use of a species. Informants may be able to identify species that are preferred for a particular use. "Species preference" within each use was ranked and points assigned for placement (10 points 1st place, 8 points 2nd place, 6 points 3rd place, 2 points all other places). Species for which preference was not indicated did not receive points, increasing the chance they would receive the high ranks. It is assumed because species are being used that none of them are considered poor and such data was not recorded. Points were then summed for each species across all uses, and species ranked on the basis of total points.

An overall rating was assigned to each species by summing its ranks for each parameter and dividing by the number of parameters. Frequency of use is important because it indicates the potential for widespread adoption and therefore this parameter was given double weight. Species mentioned by only one pasture owner and having only one reported use were not considered. However, species reported by more than one informant and having only one reported use were considered. Ratings were carried out for Herrera province as a whole.

RESULTS AND DISCUSSION

Participants

Forty-five interviews were obtained from 51 approached pasture owners (88% response rate). A high percentage of informants (16%) were small kiosk owners. Storeowners were more likely to be captured in the study because they were available during the day and accustomed to conversing. Kiosks also generate cash flow that can be invested in cattle, so kiosk owners often had cattle and pastureland.

Tree Uses

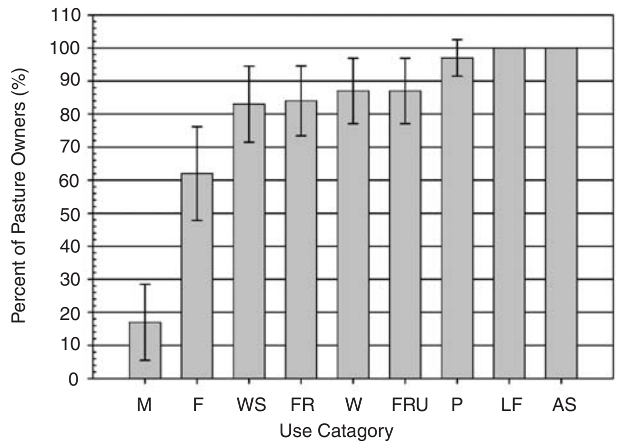
Unstructured interviews identified eight distinct uses for which trees were maintained in pastures: (1) shade for animals, (2) shade for water, (3) fodder for animals, (4) living fence stakes, (5) fruit, (6) construction wood, (7) firewood, and (8) medicinal products. A ninth category–posts–was added after five semi-structured interviews. It became apparent that users distinguished between living and dead fence posts, and different tree species populate each of these uses. For three uses (medicinal products, shade for water, and posts), responses were obtained from less than 45 informants (41, 41, and 34 respondents, respectively).

The number of pasture owners reporting maintenance (not weeding out and, in some cases, planting) of tree species in their pastures for particular uses differed substantially between use categories. Whereas, only 17% of pasture owners reported retention of trees for medicinal products, 100% of pasture owners reported retaining trees for shade for animals and living fence stakes (Figure 3). The proportion of pasture owners reporting use was not the same for all uses ($p < 0.001$) according to Cochran's Q test (Cochran 1950). With the exception of shade for water, shade for animals, and living fences, all of the uses are extractive. Although fruit and fodder uses are low intensity extraction, they are not likely to adversely affect tree health (Hetch and Cockburn 1989), and may facilitate seed dispersal.

Tree Species Richness

Hubbell (2001) defined species richness as "the total number of species in a defined space at a given time." Small-scale pasture owners in Herrera reported using a total of 82 different tree species in pastures (Table 1). However, pasture visits on 36% of the farms revealed that far

FIGURE 3. Percentage (± 95% confidence interval) of pasture owners reporting retention of trees for nine different use categories in a survey of 45 small-scale pasture owners in Herrera, Panama.



M = Medicinal, F = Fodder, WS = Water Shade, FR = Firewood, W = Wood, FR = Fruit, P = Posts, LF = Living Fence Stakes, AS = Animal Shade.

more species were present than actually mentioned. In some cases this was the result of the cultural construction and perception of uses. Palma real (*Attalea butyracea*) is a common pasture species and used for roof thatch, but was infrequently reported because roof thatch did not belong to any of the uses. This situation might be rectified by adding/modifying uses, or by having species-specific questions for such exceptions.

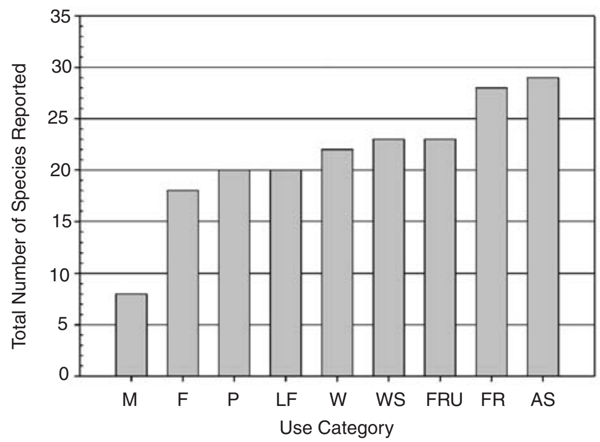
Some uses are more species rich than others. Medicinal use contained only 8 species, whereas, the shade for animals use contained 29 species (Figure 4). Species richness of uses was not associated with the number of pasture owners reporting tree retention ($r = 0.5$, $p = 0.18$). This suggests that uses may be species rich, irrespective of whether tree retention for that particular purpose is popular or not. Species richness within a given use can be considered in terms of all pasture owners, or only in terms of pasture owners reporting use. This study only examined species richness in terms of all pasture owners.

Medicinal use had lower species richness than all other use categories except fodder (Table 2). Fodder had lower species richness than all others except water shade and posts. Wood, posts, and water shade had lower species richness than living fences (Table 2). Mean species rich-

TABLE 1. List of 82 species reported by 45 small-scale pasture owners in Herrera province, Panama.

Common Name	Species Name	Common Name	Species Name
Agallo	*Caesalpinia coriaria*	Jobo	*Spondias mombin*
Aguacate	*Persea americana*	Jobo lagarto	*Sciadodendron excelsum*
Alcabu	*Zanothoxylum* sp.	Juagua	*Genipa americana*
Amarrilla	*Terminalia* sp.	Laurel	*Cordia alliodora*
Arraijan	*Miconia* sp.	Lazo	*Matayba* sp.
Balo	*Gliricidia sepium*	Lazo macho	*Cupania guatemalensis*
Bamboo	*Bambusa* sp.	Leucaena	*Leucaena leucocephala*
Biyuyu	*Cordia* sp.	Macano	*Diphysa robinioides*
Cabimo	*Copaifora aromatica*	Malagueta	*Xylopia frutescens*
Caimito	*Chrysophyllum cainito*	Malagueto	*Xylopia aromatica*
Camaroncillo	*Hirtella racemosa*	Mamey	*Pouteria sapota*
Cañaza	*Bambusa* sp.	Mangle boton	*Conocarpus erectus*
Canillo	*Miconia argentea*	Mango	*Mangifera indica*
Caoba	*Swietenia macrophylla*	Marañon	*Anacardium occidentale*
Carate	*Bursera simaruba*	Maria	*Calophyllum longifolium*
Caratillo	*Bursera tomentosa*	Nance	*Byrsonima crassifolia*
Carbonero	*Colubrina glandulosa*	Naranja	*Citrus sinensis*
Cedro Amargo	*Cedrela odorata*	Negro	*Pollalesta discolor*
Cedro Espino	*Bombacopsis quinatum*	Olivo	*Sapium glandulosum*
Ciruela	*Spondias purpurea*	Palma Pacora	*Aculeata acromonia*
Coquillo	*Jatropha curcas*	Palma Real	*Attalea butyracea*
Corotú	*Enterolobium cyclocarpum*	Palo Santo	*Erythrina poeppigiana*
Cortezo	*Apeiba aspera*	Papo	*Hibiscus rosa-sinensis*
Espave	*Anacardium excelsum*	Pazmo	*Siparuna* sp.
Espino Amarillo	*Chloroleucon mangense*	Pino Nacional	*Podocarpus oleifolius*
Espino Vaca	*Chomelia spinosa*	Pitajaya	*Acanthocereus pentagonus*
Eucalipto	*Eucalyptus globulus*	Pito	*Erythrina costaricensis*
Guabilo	*Albizia* sp.	Puma Rosa	*Psisigium lambo*
Guabito	*Inga* sp.	Rascador	*Licania arborea*
Guachapalí	*Samanea saman*	Roble	*Tabebuia rosea*
Guácimo	*Guazuma ulmifolia*	Rosetillo	*Randia* sp.
Guacimo macho	*Luhea spinosa*	Sajinillo	*Sinamomum* sp.
Guanábana	*Annona muricata*	Sapote	*Licania platypus*
Guava	*Inga vera*	Sastra	*Garcinia* sp.
Guayacan	*Tabebuia guayacan*	Sigua	*Phoebe cinnamomifolia*
Guayacan	*Tabebuia ochracea*	Tamarindo	*Tamarindus indica*
Guayaba	*Psidium guinensis*	Teca	*Tectona grandis*
Guinda	*Zyzyphus mauritiana*	Tuli Viejo	*Jacquinia macrocarpum*
Herrero	*Mimosa tenuiflora*	Tumpito, Zumbo	*Alibertia edulis*
Higo	*Ficus* sp.	Uvero	*Coccoloba lasseri*
Jarino	*Andira inermis*	Uvito	*Ardisia revoluta*

FIGURE 4. Total number of tree species reported by 45 small-scale pasture owners for nine different use categories in Herrera, Panama.



M = Medicinal, F = Fodder, WS = Water Shade, FR = Firewood, W = Wood, FR = Fruit, P = Posts, LF = Living Fence Stakes, AS = Animal Shade.

ness tended to be low for all uses: ranging from 0.3 to 4 (Table 2). The total number of species retained per farm ranged from 6 to 25, with an average of 13, and was positively correlated with pasture size ($r = 0.4$, $p < 0.01$). Herreran silvopastoral systems do not appear to be species rich on the basis of species reported for use. This suggests, for any given need, Herreran pasture owners do not purposefully retain many tree species in pastures. This does not mean that pasture owners' needs are satisfied by these few species. Aguilar and Condit (2001) suggested that a Hispanic community in Panama's Canal Zone obtained most woody species products from forests, and not pastures. Herreran silvopastoral systems are also far richer when unreported species are considered. A 100% and a 50% sample of trees in two living fences on two farms in Herrera's lowland zone identified 28 and 40 different species, respectively. Pasture owners had reported only 6 living fence species in both cases. The reported species were generally the most abundant species in the surveys.

Differences in species richness were tested for each use on the basis of informant gender and pasture ecozone membership. No differences were found on the basis of ecozone. Lack of an ecozone effect may indicate that, although the species for a given use may change between ecozones, the average number of species retained for a particular use

TABLE 2. Mean species richness (± 95% confidence interval) for pasture owner identified uses in a survey of 45 pasture owners in Herrera province, Panama.

	All Pasture Owners		
Use Category	**DF[1]**	**Mean ± 95% CI[2]**	**Test CI[3]**
Living Fence	45	3.5 ± 0.4 a	0.4
Firewood	45	2.7 ± 0.6 ab	0.4
Fruit	45	2.7 ± 0.6 ab	0.4
Animal Shade	45	2.5 ± 0.3 ab	0.4
Wood	45	2.1 ± 0.4 b	0.4
Water Shade	43	1.8 ± 0.5 bd	0.4
Posts	36	2.0 ± 0.5 bd	0.5
Fodder	45	1.2 ± 0.4 cd	0.4
Medicinal	41	0.3 ± 0.2 d	0.4

[1]Degrees of freedom.

[2]95% confidence interval of the mean.

[3]95% confidence interval of the test.

Numbers followed by different letters are significantly different from each other for an $\alpha = 0.05$ according to a pairwise test (SAS Institute Inc. 1999) for multiple comparisons after conducting a parametric two-way analysis of variance substantiated by rank transformation (Conover and Iman 1976).

does not. Alternatively, the three ecozones defined in this study may not have been appropriate for detecting differences.

Female informants mentioned more fruit tree species (Table 3). Fischer (1998) and Wiersum (1989) reported that women prefer fruit trees. Lack of gender effects for most uses in the present study may indicate that men and women have similar interests in pasture trees. Franzel et al. (1995) found men and women in Burundi had similar interest in tree species. Our present results also indicate that women are sufficiently knowledgeable of pasture tree species to name numbers of species comparable to those mentioned by males, despite pastures being male-gendered spaces.

Abundance-Diversity Curves

Abundance-diversity curves graphically represent diversity by ranking species by abundance and plotting relative species abundance (percent

TABLE 3. Mean species richness (± 95% confidence interval) for pasture owner identified uses by gender in a survey of 45 pasture owners in Herrera province, Panama.

	All Pasture Owners			
Use Category	**DF[1]**	**Male**	**Female**	**Difference**
Living Fence	31, 14	3.6 ± 0.5	3.3 ± 0.7	ns
Firewood	31, 14	2.7 ± 0.7	2.6 ±1.0	ns
Fruit	31, 14	2.0 ± 0.7	4.1 ± 1.0	2.1 ± 1.3*
Animal Shade	31, 14	2.5 ± 0.4	2.6 ± 0.5	ns
Wood	31, 14	2.0 ± 0.5	2.4 ± 0.7	ns
Water Shade	29, 14	1.8 ± 0.5	1.6 ± 0.8	ns
Posts	27, 9	2.2 ± 0.5	1.6 ± 0.9	ns
Fodder	31, 14	1.4 ± 0.5	0.8 ± 0.7	ns
Medicinal	27, 14	0.1 ± 0.3	0.6 ± 0.4	ns

[1]Degrees of freedom (male, female).

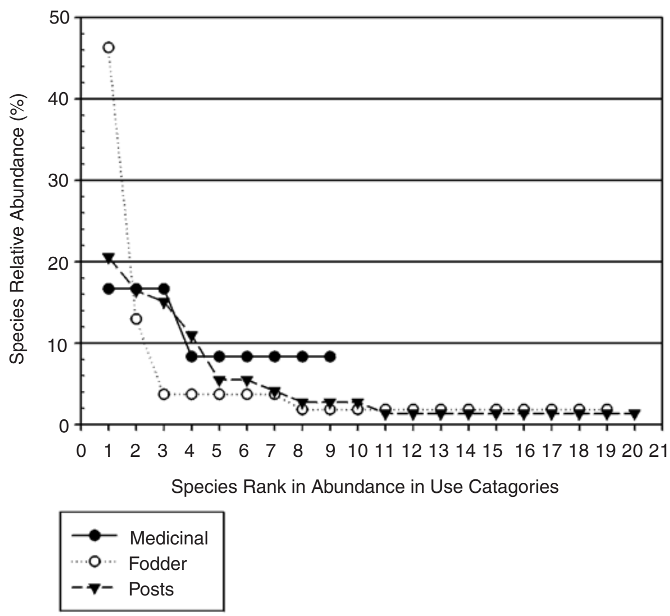
* Indicates significance at $\alpha = 0.05$ as determined by the Mann-Whitney non-parametric t-test (Zar 1999). Means and confidence intervals were calculated using least square means in a general linear model (SAS Institute Inc. 1999).

Note: Variability of test is based on the spread of the sum of the ranks and is not shown.

of total abundance represented by a given species) against these ranks for each species (Zarin et al., 1999). With the exception of medicinal use, for which a small number of species were mentioned, uses had only a few dominant species (large relative abundance) and a large number of rare species (small relative abundance) (Figure 5). That is, only a few species were commonly mentioned, while most species were mentioned rarely. This general lack of evenness suggests a reliance on only a few species for each use, due to preference or ecological reasons. Nevertheless, many other tree species are reported at low frequencies.

Fodder, wood, firewood, water shade uses had very steep abundance-diversity curves, suggesting greater reliance on a few species. Animal shade, posts, living fence, and fruit trees also had steep abundance-diversity curves, compared to medicinally used trees, but their curves were less steep than those previously mentioned uses. Considering species with a relative abundance ≥ 10% for a given use (Table 4) focuses attention on tree species making recognizable con-

FIGURE 5. Abundance-diversity curves for fodder, post, and medicinal use categories as representative of highly, moderately, and not uneven species diversity in pasture owner identified use categories in Herrera, Panama.



tributions to a given use. Such species may be of particular interest when designing silvopastoral systems with single uses in mind. Only 16 species of the 82 mentioned in the survey meet this criterion. Three such species were medicinal, which is not a popular reason for retaining trees in pastures. Five species were mentioned for more than one use. These five species (Nance–*Byrsonima crassifolia*, Guácimo–*Guazuma ulmifolia*, Laurel–*Cordia alliodora*, Cedro Amargo–*Cedrela odorata*, Mango–*Mangifera indica*) are popular multipurpose trees.

Similarity

Sørenson's similarity index measures the percent similarity between different groups of species (Zarin et al., 1999). Uses, on average, shared 25 ± 5% similarity with other use categories, and percent similarity ranged between 0 and 51% (Table 5). The maximum percent similarity

TABLE 4. Tree species mentioned most often (≥ 10% relative abundance) for pasture owner identified uses in a survey of 45 pasture owners in Herrera province, Panama.

Species	Relative Abundance (%)	Use Category(ies)
Nance–*Byrsonima crassifolia*	28, 16, 15	FR, AS, P
Guácimo–*Guazuma ulmifolia*	12, 46, 14	FR, F, AS
Laurel–*Cordia alliodora*	10, 11, 21	FR, W, P
Cedro Amargo–*Cedrela odorata*	27, 11	W, P
Corotú–*Enterolobium cyclocarpum*	13	F
Eucalipto–*Eucalyptus globulus*	17	M
Guanábana–*Annona muricata*	17	M
Pazmo–*Siparuna* sp.	17	M
Mango–*Mangifera indica*	15, 24	AS, FRU
Marañon–*Anacardium occidentale*	10	FRU
Guava–*Inga vera*	12	WS
Espave–*Anacardium excelsum*	32	WS
Macano–*Diphysa robinioides*	16	P
Carate–*Bursera simaruba*	23	LF
Caratillo–*Bursera tomentosa*	13	LF
Balo–*Gliricidia sepium*	15	LF

M = Medicinal, F = Fodder, WS = Water Shade, FR = Firewood, W = Wood, FR = Fruit, P = Posts, LF = Living Fence Stakes, AS = Animal Shade.

(51%) is similar to the maximum of 50% similarity found between forest gardens in Indonesia (Kaya et al., 2002). Trees used for fruit and medicinal purposes tended not to share many species with other uses, with percent similarities ranging from 5-24% and 0-13%, respectively (Table 5). Firewood, shade for animals and shade for water trees had higher percent similarities with other uses (6-51%, 5-50%, and 5-50%, respectively) (Table 5).

In the case of firewood this may reflect the notion that any tree species is useable once dry. Trees used for water shade, animal shade and fodder all had high percent similarities with each other (32-43%). This implies that riparian areas in pastures could be managed for fodder and shade, which may prevent deforestation or encourage afforestation.[2]

TABLE 5. Sørenson's similarity index for comparison of pasture owner identified uses in a survey of 45 pasture owners in Herrera province, Panama.

	Firewood	**Fruit**	**Living Fence**	**Medicinal**	**Animal Shade**	**Water Shade**	**Posts**	**Wood**
Fodder	35	24	37	0	43	32	29	30
Firewood		16	33	6	49	50	51	44
Fruit			14	13	12	5	17	13
Living Fence				0	41	30	19	29
Medicinal					5	7	0	7
Animal Shade						37	50	43
Water Shade							33	22
Posts								38

Note: All values are percent similarity as calculated by Sørenson's similarity index, which is the number of species two categories have in common divided by the sum of the total number of species in each category.

Multipurpose Nature

There was a positive association between the number of pasture owners reporting use of a tree species and its mean number of uses (the average number of uses per species per pasture owner) ($r = 0.58$, $p < 0.0001$). This association suggests that multipurpose trees are slightly favored for retention within pastures.

In contrast to this finding, 36 of the 82 species (44%) reported in the present study had only one use. However, 18 (50%) of these single-use trees were reported by only one pasture owner. This may be because species are dispersal limited. Given that 100% of pasture owners reported retention of trees by managing natural regeneration, whereas, only 49% reported planting trees in their pastures, dispersal limitations are likely. Simmons et al. (2002) also found that close to 50% of 95 surveyed households in the Darién region of Panama reported tree-planting activities, albeit in plantations instead of pastures.

Low rates of tree planting and reliance on natural regeneration, for which dispersal limitations are probable (Muller-Landau et al., 2002), make spatial constraint of pasture species in Herrera probable. Condit et al. (2002) reported that dispersal limitations in Panama result in forest plots 50 km apart only sharing 1% to 15% of their species. Thus, the species reported for a given use by a farmer may be specific to geographic location. Alternatively, species may be specific to informant interest in using and/or reporting certain trees.

Of the tree species reported by 25% or more of users, 87% are multipurpose (Table 6). Nance (*Byrsonima crassifolia*) is the most used and the most multipurpose in Herrera province (Table 6). Overall it was mentioned for 8 uses and had an average number of uses of 2.2. Such a species, while quite valuable, may be difficult to 'improve' genetically because selection for characteristics pertinent for one use may select against useful characteristics for another (Huxley 2001). However, given the low average number of uses per species per farm, it may be possible to develop 'improved' varieties (larger fruit, quality timber) that are well suited for one or a few uses, and still meet pasture owners' needs. Any attempt at genetic improvement will face the obstacle of pasture owners' preference for managing natural regeneration to recruit trees for pastures.

TABLE 6. Average number of uses, total number of uses and use category membership of the 20 most reported tree species in pastures in Herrera.

Species		Average	Total									
	Users	Uses	Uses	F	FR	FRU	LF	M	AS	P	WS	W
Nance–*Byrsonima crassifolia*	40	2.2	8	1	1	1	1		1	1	1	1
Carate–*Bursera simaruba*	37	1.2	5	1	1		1		1	1		
Guácimo–*Guazuma ulmifolia*	33	1.9	6	1	1				1	1	1	1
Mango–*Mangifera indica*	30	1.9	6	1	1	1			1		1	1
Cedro Amargo–*Cedrela odorata*	27	1.4	5				1		1	1	1	1
Espave–*Anacardium excelsum*	25	1.5	5	1	1				1	1	1	1
Laurel–*Cordia alliodora*	24	2.0	6	1			1		1	1	1	1
Balo–*Gliricidia sepium*	23	1.1	3	1			1			1		
Caratillo–*Bursera tomentosa*	21	1.0	1				1					
Coquillo–*Jatropha curcas*	20	1.2	3				1	1	1			
Marañon–*Anacardium occidentale*	18	1.4	5	1	1	1	1		1			
Ciruela–*Spondias purpurea*	16	1.2	5		1	1	1		1			1
Macano–*Diphysa robinioides*	16	1.4	4		1		1			1		1
Caoba–*Swietenia macrophylla*	12	1.0	1									1
Corotú–*Enterolobium cyclocarpum*	12	1.8	5	1	1				1		1	1

M = Medicinal, F = Fodder, WS = Water Shade, FR = Firewood, W = Wood, FR = Fruit, P = Posts, LF = Living Fence Stakes, AS = Animal Shade.

Multipurpose Index

The overall rating for the top 25 species ranged from 2-31 with decreases occurring gradually rather than at noticeable breakpoints (Table 7). Ranks for the different parameters ranged from 1-56 (Table 7) indicating that poor ranking in any one category did not exclude species from receiving an overall high rating. Of the top 25 rated species only 2 were exotic species [e.g., *Mangifera indica* (Mango)], *Tectona grandis* (Teca), indicating the importance of native species in Herreran silvopastoral systems.

Single Purpose Trees

Trees with only one use but mentioned by a large number of users are of particular interest. Genetic improvement of these species for pastures is likely to benefit users and will not compete with other uses (Huxley 2001). Only two species in pastures were mentioned by more than 25% of users for a single use category: *Bursera tomentosa* for living fences (21 informants) and *Swietenia macrophylla* for wood (12 informants). These two species also appear in the top 25 species of the multipurpose species index because of low 'frequency of use' and 'preference' rankings (Table 6).

Protein Banks

No single purpose tree identified in the present study was used for fodder. None of the 43 informants questioned managed protein banks. Informants cited a number of reasons for not having protein banks. Six pasture owners cited not enough space, another six cited poor palatability, four felt education was lacking, and two suggested the cost of establishment would be too great. Fischer and Vasseur (2000) reported that small-scale farmers in Panama lacked space to establish agroforestry plots. Tropical fodders' poor palatability is recognized as a limitation to its intensive use (Lowry 1990). Grist et al. (1999) found it took four years to recoup the cost of establishing a fodder legume as an alley-crop. These technical limitations aside, the reason most informants cited for not having a protein bank was already having sufficient forage. Interestingly, the eleven pasture owners reporting sufficient forage also reported cattle weight loss during the dry season. Prevention of weight loss is one reason protein banks are promoted for small-scale farmers.

TABLE 7. Ranking of multipurpose tree species' attributes and overall rating for 25 tree species in Herrera province, Panama.[1]

Species	Preference Rank	Total Uses Rank	Average Uses Rank	Users Rank	Overall Rating
Nance–*Byrsonima crassifolia*	4	1	1	1	2
Guácimo–*Guazuma ulmifolia*	1	3	5	3	3
Mango–*Mangifera indica*	4	3	6	4	4
Laurel–*Cordia alliodora*	5	3	4	7	5
Cedro Amargo–*Cedrela odorata*	2	8	17	5	7
Espave–*Anacardium excelsum*	7	8	13	6	8
Carate–*Bursera simaruba*	13	8	27	2	10
Corotú–*Enterolobium cyclocarpum*	10	8	7	15	11
Macano–*Diphysa robinioides*	10	14	18	13	13
Lazo–*Matayba* sp.	13	14	11	19	15
Balo–*Gliricidia sepium*	7	22	33	8	15
Higo–*Ficus* sp.	10	14	20	19	16
Jarino–*Andira inermis*	10	22	15	21	17
Marañón–*Anacardium occidentale*	43	8	15	11	18
Ciruela–*Spondias purpurea*	43	8	29	13	21
Canillo–*Miconia argentea*	43	8	15	21	21
Coquillo–*Jatropha curcas*	43	22	28	10	22
Teca–*Tectona grandis*	43	14	21	24	25
Guabito–*Inga* sp.	20	37	19	26	25
Caratillo–*Bursera tomentosa*	16	56	50	9	28
Guava–*Inga vera*	43	22	32	22	28
Aguacate–*Persea americana*	43	37	30	17	28
Jobo–*Spondias mombin*	43	22	31	24	28
Caoba–*Swietenia macrophylla*	13	56	50	15	30
Palo Santo–*Erythrina poeppigiana*	43	22	24	34	31

All values have been rounded to zero decimal places.

[1]Ranks are assigned total number of uses, average number of uses, and number of users across all use categories. Rank for preference is assigned by ranking species based on the number of users reporting preference within each use category, averaging preference ranks across all categories and ranking the resulting average ranks. Overall rating is an average of the above-mentioned ranks in which rank for users is weighted twice.

In some cases pastures are rented out, so demand for forage is seasonal. Thus, forage is considered sufficient even if annual pasture productivity is low. However, pastures with scrub brush (first years of regrowth after forest clearing) are rented during the summer months and may be a traditional protein bank. Of the 43 pasture owners asked about renting, 14 indicated that they rented their pasture to other pasture owners and 19 indicated that they rented pasture from other pasture owners. Thus, 78% of questioned pasture owners are engaged in some sort of rental arrangement. While renting out pasture it is not possible to improve the land because tenants demands take precedent. Conversely, if inexpensive pasture can be rented, there is no need to improve existing pastures.

In cases where pasture owners have cattle, 41% reported owning cattle for unexpected expenses, as savings, or out of tradition: rather than for production. Productivity improving technologies will not always suit these pasture owners. Similar scenarios have been reported for African pastoralists (Tapson 1991). During the dry season, Herrera's small-scale pasture owners may be more concerned with cattle survivorship than weight gain. Ironically, protein banks have been shown to increase calf mortality (Campbell et al.,1996). However, some cattle owners reported owning cattle for production and also claimed to have sufficient forage, despite dry season weight loss. This may be related to how cattle are sold and how their feed is supplemented in Herrera.

Cattle tend to be purchased by visual inspection rather than by weight and meat quality. Thus, some weight loss is tolerable and economic analysis of protein banks based on input and output prices (Holmann and Ibrahim 2001) is questionable. Dry season supplementation with non-fodder resources may also explain the lack of protein banks. Seventy-one percent of 41 pasture owners reported supplementing their cattle's diet during the dry season. A total of 14 different supplements were mentioned, but only the use of sugar cane waste, maize stover, salt, concentrate, and cane molasses was mentioned often. The number of supplements reported by pasture owners ranged from 1 to 7 with an average of 3 supplements being administered. Other studies have also found that agricultural by-products are important feed supplements in developing countries (Devendra 1988). Generally, protein banks do not seem to be appropriate for small-scale farmers given their current management practices and economic goals. Specifically, cattle survivorship is likely more important than cattle weight gain.

Fodder Species

Despite the lack of protein banks, fodder trees are an important pasture resource. Sixty-two percent of pasture owners reported retaining a total of 18 tree species for fodder, and 98% of pasture owners were aware that their cattle consumed fodder. Apart from purposefully retained fodder species, 14 additional species were identified as being consumed by cattle (Table 8). Only 8 of these 32 fodder species were leguminous but all 8 were purposefully retained, suggesting farmers recognize the value of leguminous fodder. Many of these fodder species were valued for their fruit, which drops during the dry season, rather than for their foliage. Some pasture owners also reported that hungry cattle eat all manner of fodder, even physiologically inefficient species (high fiber, low protein) such as mango, cashew, and bamboo leaves. Of the 18 species retained for fodder in pastures, only two (*Enterolobium cyclocarpum* and *Guazuma ulmifolia*) were reported by an appreciable number of pasture owners (7 users and 24 users, respectively). The average number of fodder species used by pasture owners was 1.9 with 12 pasture owners reporting only one species. This indicates that pasture owners rely heavily on a few fodder species.

Living Fence Protein Banks

A modification of the protein bank concept is to provide fodder by periodically pruning a living fence of leguminous tree species (Romero et al., 1993). This technique may be in direct conflict with pasture owners' current management practices. In the present survey, 83% of 35 informants pruned their fences in order to obtain stakes. These stakes are used to repair and expand existing living fences. Stakes are roughly two meters in length, and larger diameter stakes are considered more valuable (personal observation). Management of a living fence for fodder conflicts with stake production, because periodic pruning prevents the development of appropriately sized stakes. Still, pasture owners recognized the value of living fence foliage as fodder, with 63% of 30 informants reporting feeding fence prunings to their cattle.

CONCLUSIONS

Trees are retained in Herreran pastures for many reasons. Medicinal use was the least popular. Species richness was low for all uses but there were differences between uses. Living fence, firewood, and fruit uses had the highest species richness, while medicinal uses had the lowest. There were more tree species in pastures than were reported during in-

TABLE 8. Fodder species mentioned by small-scale pasture owners as being purposefully retained in pastures or observed being consumed by cattle in Herrera province, Panama.

Common Name	Scientific Name	Leguminous	Principle Fodder
Purposefully Retained			
Balo	*Gliricidia sepium*	Y	L
Bobo	*Erythrina fusca*	Y	L
Carate	*Bursera simaruba*	N	L
Corotú	*Enterolobium cyclocarpum*	Y	F
Espave	*Anacardium excelsum*	N	F
Guácimo	*Guazuma ulmifolia*	N	F
Guachapalí	*Samanea saman*	Y	F
Guava	*Inga vera*	Y	F
Higo	*Ficus* sp.	N	F
Jobo	*Spondias mombin*	N	F
Leucaena	*Leucaena leucocephala*	Y	L
Mango	*Mangifera indica*	N	F
Marañon	*Anacardium occidentale*	N	F
Nance	*Byrsonima crassifolia*	N	F
Palma Real	*Attalea butyracea*	N	F
Palo Santo	*Erythrina poeppigiana*	Y	L
Pito	*Erythrina costaricensis*	Y	L
Palma Pacora	*Acrocomia aculeata*	N	F
Observed Consuming			
Papo	*Hibiscus rosa-sinensis*	N	L
Caratillo	*Bursera tomentosa*	N	L
Caimito	*Chrysophyllum cainito*	N	F
Sapote	*Licania platypus*	N	F
Guayaba	*Psidium guinensis*	N	F
Ciruela	*Spondias purpurea*	N	F
Cañaza	*Bambusa* sp.	N	L
Lazo	*Matayba* sp.	N	L
Caoba	*Swietenia macrophylla*	N	L
Bamboo	*Bambusa* sp.	N	L
Tamarindo	*Tamarindus indica*	N	F
Aguacate	*Persea americana*	N	F
Laurel	*Cordia alliodora*	N	L
Naranja	*Citrus sinensis*	N	F

Leguminous Y = Yes, N = No. Fodder Type L = Leaf, F = Fruit.

terviews. These unreported species have known uses, but they tended not to be directly used by the pasture owner questioned. Species richness did not differ for ecozone, either because this is so, or because ecozones were not adequately defined.

Women mentioned more fruit species. This may reflect greater interest in, or knowledge of, fruit species on the basis of gender. Sørenson's similarity index indicated that use categories had percent similarities ranging from 0% to 51%. Most use category diversity was uneven, with only a few species being dominant in each category. Multipurpose tree species were slightly favoured for retention in pastures.

Prioritization of tree species on the basis of preference, frequency of use, and plurality of use identified mainly native species as having top priority ratings: Nance (*Byrsonima crassifolia*), Guácimo (*Guazuma ulmifolia*), Laurel (*Cordia alliodora*), Cedro Amargo (*Cedrela odorata*), Espave (*Anacardium excelsum*), Carate (*Bursera simaruba*), Corotú (*Enterolobium cyclocarpum*), Macano (*Diphysa robinioides*). Mango (*Mangifera indica*) was one of the few exotic species that received a high priority rating. Caoba (*Swietenia macrophylla*) and Caratillo (*Bursera tomentosa*) distinguished themselves as popular single purpose species for construction wood and living fences, respectively.

Protein banks, despite having been introduced to the region in the 1980s, (IDIAP 1986) were not prevalent and appear not to complement small-scale pasture owners' reasons for owning cattle. Cattle survivorship is probably more important than cattle productivity (weight gain), given small-scale farmers' objectives. However, farmers retained trees in pastures for fodder, and often supplemented cattle feed with agricultural residues. Living fences are unlikely to be used for fodder because this conflicts with their current management for replacement stakes.

RECOMMENDATIONS

There is need to study existing pasture tree species richness and compare it to reported species richness. Nance (*Byrsonima crassifolia*) deserves research attention (germplasm collection, varietal improvement) because it is a popular and often preferred multipurpose pasture tree in the province of Herrera. More consideration needs to be given to native species in Herreran silvopastoral systems. Fodder tree research should focus on the management of isolated trees to increase the production and quality of fallen fruit during the dry season. Genetic selection and chemical fertilization of isolated pasture trees for increased fodder production and quality could lead to increase pasture carrying-capacity during the dry season. Guácimo (*Guazuma ulmifolia*) and Corotú (*Enterolobium cyclocarpum*) are popular fodder species that merit such research. Riparian areas in pastures should be considered for fodder and shade species, in order to encourage the maintenance of tree cover in these areas.

NOTES

1. Ownership was considered in terms of social rather than legal recognition of possession. That is, a pasture may be on untitled land but locally the pasture is considered to be owned and managed by a particular farmer.
2. Deforestation of riparian areas in pastures may occur for reasons other than extractive use of woody species. For instance, pasture creation can drive the deforestation of riparian areas.

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