# Interpreting Resource Gradients and Patches for the Conservation of Woody Plant Diversity at Mt. Kasigau, Kenya

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Research

## Abstract

Biodiversity conservation at Mt. Kasigau, Kenya in the Eastern Arc Mountains relies on understanding how plants are distributed on the mountain and integrated into local livelihoods. We focus on woody plants, and ask: (1) how does resource richness change with altitude; and, (2) can resource patches be identified that prioritize plant conservation within vegetation zones? The study measured the composition, structure, and use of woody plants in 55 nested plots stratified across bushland, montane woodland, and evergreen forest. Plant uses average highest in bushland below human settlements, show greatest variation in montane woodland, and are significantly lower in evergreen forest. Resource diversity correlates with species richness along the altitudinal gradient (r= 0.89), especially for food (0.64) and construction (0.59), but also shows distinct resource patches at locations in montane woodland. Species richness patterns at Mt. Kasigau confirm a high diversity of plant communities that can be used to collaboratively guide conservation planning.

## Introduction

Biodiversity conservation relies on understanding how plant resources are distributed across complex landscapes and modified for human livelihoods (Cunningham 2001). For example, conservation agencies recognize geographically uneven occurrences of high species richness and rare and endemic plants in their designation of biodiversity hotspots (Myers 2003, Myers *et al*. 2000) or ecoregions (Olson & Dinerstein 1998, WWF 2007). These localities are then prioritized by the degree to which human activities threaten existing patterns (e.g., Brooks *et al*. 2002). Diversity patterns at different geographic scales, however, may be created or degraded by physical-environmental conditions and human-historical processes that influence resource availability and habitat heterogeneity (Huston 1994, Posey 1993). Biodiversity studies need to more inclusively explore how these factors define continua and patches across landscapes and guide local conservation strategies (Zimmerer & Young 1998).

Conservation, according to Holt (2005:213), is a "social process" derived from experiences and learning in place as it can guide institutions and arrangements for management policy. Much of the debate between conservation strategies relate to whose viewpoints count as the ruling narrative (Adams & Hulme 2001). Wilshusen *et al*. (2002:25) emphasize that: "there are different ways of understanding and appreciating nature that directly affect dialogue on and proposals for biodiversity protection." These contrasting views help to explain the ongoing debates between community-based natural resource management and protected areas and also the conservation science that supports these arguments (Mascia *et al*. 2003, Medley & Kalibo 2007). Field research that links ecological measures on the composition and structure of vegetation with ethnobotanical knowledge on resource uses provides opportunities for collaborative learning about a place that can be applied to identify the opportunities, or map the social assets (see del Campo & Wali

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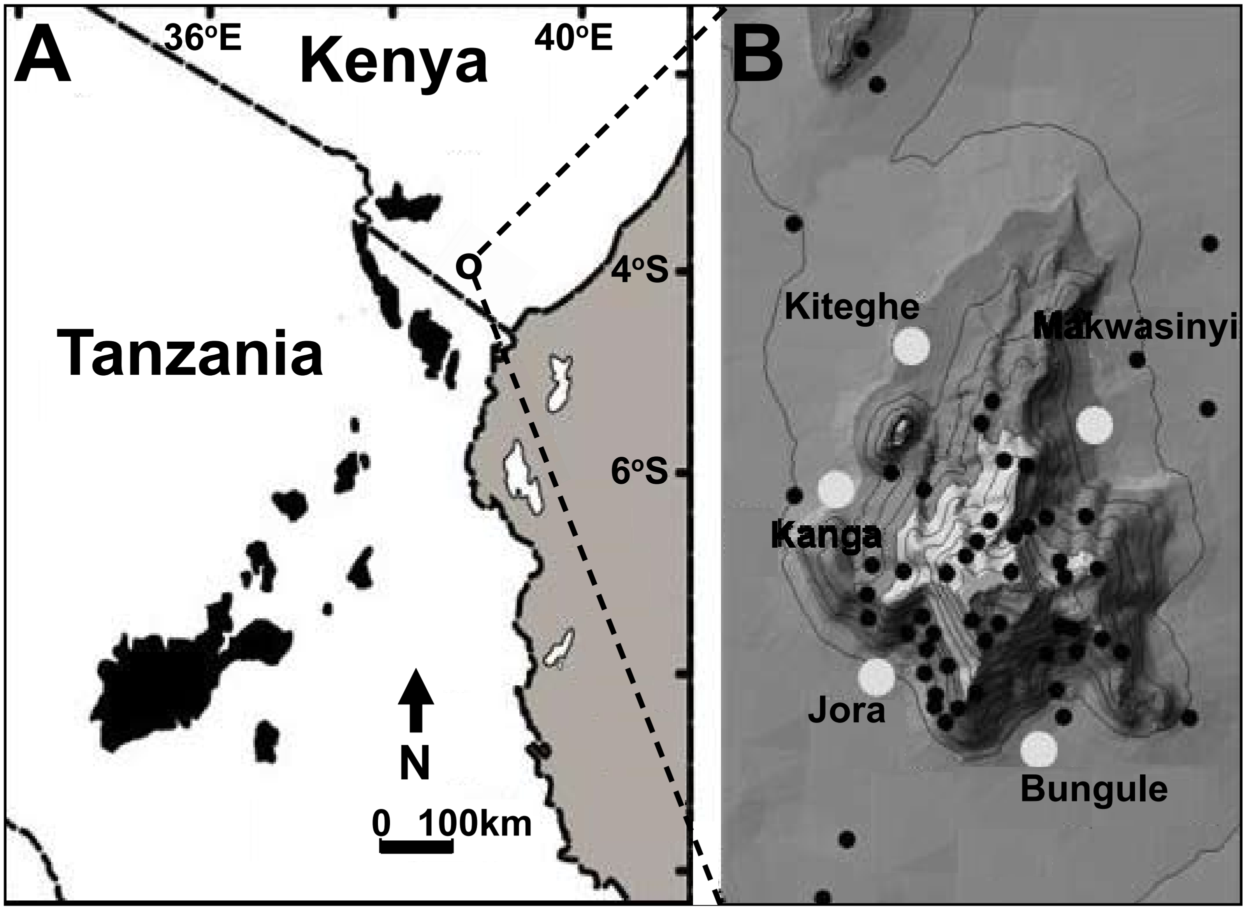


**Figure 1**. The study area: A. Location of Mt. Kasigau in the Eastern Arc Mountains of Kenya and Tanzania. B. Location of the 55 ecological plots, working from the villages of Rukanga, Jora, Bungule, Makwasinyi, and Kiteghe, in *Acacia-Commiphora* bushland below 650 meters (medium gray), montane woodland (~650-1000 m, dark gray), and evergreen forest (mostly >1000 m, light gray). The white circles show the approximate locations of the village centers with human settlements and farms occurring at the base of the mountain between the bushland and montane woodland. The figure is adapted with permission from Medley *et al*. 2007.

2007:27) for conservation at that place. Biodiversity conservation strategies can then be positioned to consider simultaneously the factors that influence ecological diversity patterns and human livelihoods in relation with these natural resources.

For this study, we focus on the ecology and ethnobotany of woody plants at Mt. Kasigau, the most northeastern peak in the Eastern Arc Mountains of Kenya and Tanzania (Figure 1). Tropical forests on these ancient crystalline mountains are globally recognized by Conservation International (CI) as part of the Afromontane biodiversity hot spot (Mittermeier *et al*. 2004) and rank among World Wildlife Fund's Global 200 Ecoregions (Olson & Dinerstein 1998) because of their high species richness, high concentration of endemic species, and their highly-fragmented and potentially threatened status (Newmark 2002). Altitudinal changes in vegetation composition and structure at Mt. Kasigau occur across short linear distances (2-4 km) from mostly deciduous *Acacia-Commiphora* bushland (<650 m), through semi-evergreen to evergreen montane woodland (650-1000 m), and to evergreen forest (>1000 m) just below the exposed rock on the mountain's summit at 1641 m (Figure 1B; Figure 2). When compared with other mountains in the Eastern Arc, changes in vegetation physiognomy (e.g., deciduous bushland to evergreen forest) are compressed within a narrow altitudinal range but floristic changes in species are predicted to be individualistic forming continua within the respective zones (c.f. Lovett 1998). The Kasigau Taita live at the base of the mountain in an agro-ecological mosaic of homes, gardens, surrounding farm fields, and pastoral lands in the bushland.

Two research questions guided our study of geographic patterns of diversity on the mountain: (1) how does the distribution of woody plant resources change with altitude; and (2) can resource patches be identified that prioritize

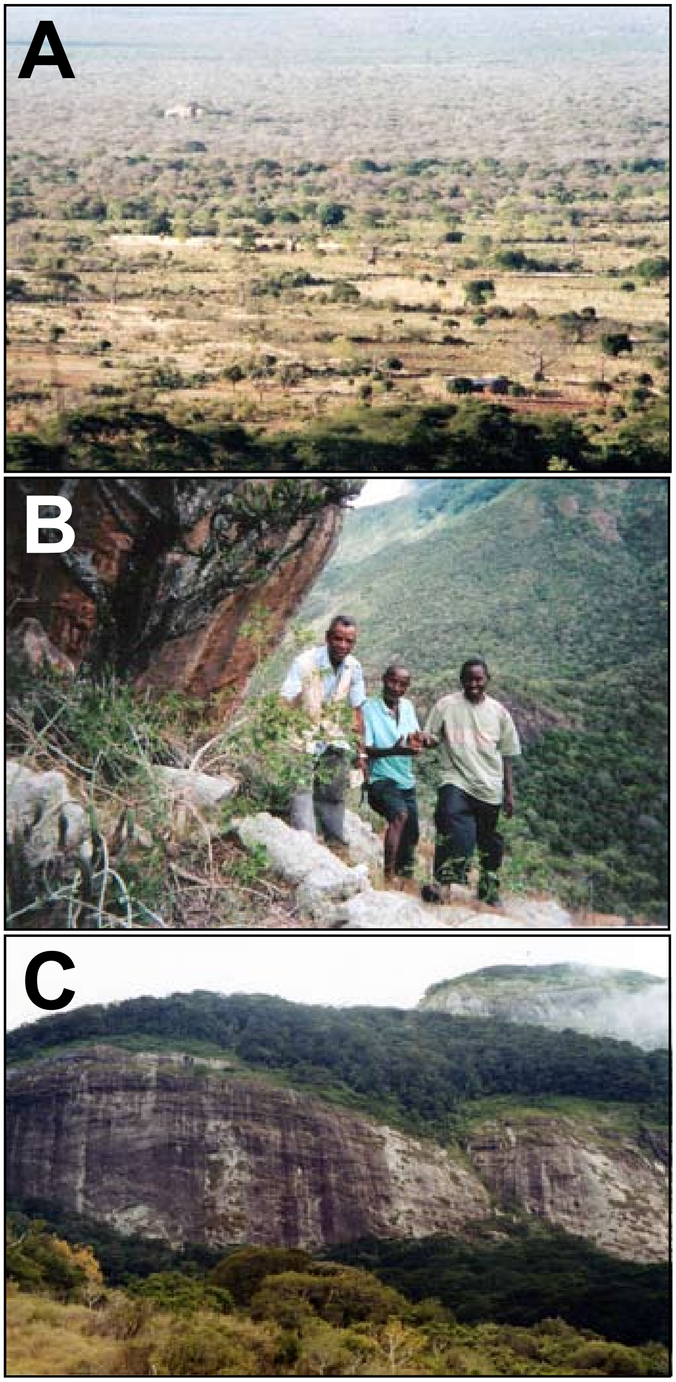


**Figure 2**. Representative photos from the three vegetation zones: A. *Acacia-Commiphora* bushland (<650 m)- deciduous trees <10 m ht with a closed to open canopy and a mostly open understory; B. montane woodland (650 m-1000 m)- mixed deciduous to semi-evergreen closed forest with trees usually below 15 m, including a closed evergreen coppiced woodland of 10-12 m; and C. evergreen forest (>1000 m)- high-stature closed forest of evergreen trees that are >20 m in height and including near the summit an evergreen elfin cloud forest with trees about 10 m in height and a dense understory.

plant conservation within vegetation zones? At the onset of the study, woody plant resources were hypothesized to be higher in the more accessible bushland below their settlements, and, in contrast to other Eastern Arc mountains, much lower on the steep montane slopes (c.f. CEPF 2005). We explored relationships between altitudinal vegetation changes and ethnobotany at Mt. Kasigau in order to better understand how the Kasigau Taita might adapt resource extraction practices to the distribution patterns of woody plant resources across an environmentally and historically complex landscape above and below their settlements.

## Data and Methods

The sudden rise of Mt. Kasigau (3˚49' S, 38˚40'E) from the semiarid plains between Tsavo East and West national parks defined the study area, where we worked with residents from five villages at the mountain's base (Figure 1B). These villages each receive a piped water supply from the mountain, average below 200 households except for the market center at Rukanga with less than 500 households, and provide primary schools and some market services. The Kasigau Taita are mixed farmers, who cultivate mostly maize and beans in small farm plots and maintain some livestock (goats, chicken, and cattle). Currently their settlements occur across a transitional zone between the *Acacia-Commiphora* bushland and lower montane woodland, but historical narratives and participatory maps document a dynamic settlement pattern over time at different elevations on the mountain in evergreen forest and montane woodland (c.f. Kalibo & Medley 2007, Medley *et al*. 2007).

Between 2002 and 2006, Medley *et al*. (2007) recorded ethnobotanical data on woody plants and confirmed the identification of voucher specimens now held at the East African Herbarium (EA) and/or the Miami University Willard-Sherman Turrell Herbarium (MU) through collaborative field research in the region. We recorded 338 wild (native or naturalized) woody plants, including 205 plants with uses and a sum of 757 different plant uses (Medley *et al*. 2007). Concurrent with the ethnobotanical survey, we also measured the composition and structure of woody vegetation in 55 ecological plots located at different elevations between their resource collection areas in the bushland and to the mountain's summit from the five villages (Figure 1B). The plots were placed near trails that followed alongside the current water pipes from their source in evergreen forest to the respective villages, and also included trails of significance to other water sources or historical paths between villages that were still accessible. While constrained by accessibility, our goal was to stratify the plots across elevations within *Acacia-Commiphora* bushland, montane woodland, and evergreen forest (Figure 2) and to include differences in the physical-environmental conditions within these broadly-defined vegetation types as influenced by their topographic aspect, slope setting (concavities and convexities), and/or soil conditions. For example, the bushland plots varied by their placement in lateritic or black-cotton soils, four evergreen woodland (montane) plots were placed where this vegetation type occurs along passes or in slope concavities between 957 m and 1100 m, and three evergreen forest plots were placed along streams between 610-800 m above southeast-facing Bungule village.

Local participants helped to characterize the samples by their landscape history and topographic setting, and we recorded their location and elevation using a GPS unit and altimeter. In 50 x 20 m (0.1 ha) plots, we counted and measured the diameters at breast height (dbh) for canopy trees that were >10 cm dbh. In nested 20 x 10 m (200 m2) plots, we counted the number of small trees, shrubs, and woody vines by species that were >1 m in height and <10 cm dbh. The study was collaborative, working with at least one key plant informant, a field assistant who helped record the plant uses and assisted with translations from Kasigau Taita to Swahili and English, botanical consultants from the East African Herbarium in Nairobi, and local field guides from the respective villages who gained training in the ecological techniques and the ethnobotany of their local flora (Medley & Kalibo 2005, 2007, Medley *et al*. 2007).

We used data compiled from ecological sampling and the ethnobotanical inventory to compare floristic and resource differences among the ecological plots. We first looked at how diversity, based on species richness (number of woody plant species) and the relative dominance of plant species (e.g., Simpson's diversity index, $D_s$ = 1-λ, McCune & Grace 200, c.f. Begossi 1996), varied among the plots sampled along the altitudinal gradient. The density (number/ha) and basal area ($m^2$/ha) of trees >10 cm dbh characterized differences in the ecological structure of the bushland/woodland/forest canopy at each location. We then quantified resource diversity for the plots by calculating the number of woody plant species with uses, the proportion of plants with uses, the number of uses, and the number of plants for particular uses as they varied among the plots. Following Prance *et al*. (1987), plant uses were grouped into seven use categories: food, fodder, construction, technology, remedy, fuel, and ecosystem services (Medley *et al*. 2007).

The first research question examined how the distribution of woody plant resources varied with elevation and among the vegetation zones. Scattergrams were constructed to show relationships between elevation and the number of woody plants with uses, the number of uses, and the number of species for particular uses. These trends were examined using linear and polynomial regression analyses. We focused on where resources were most abundant along the altitudinal gradient and the correlation among plant uses that may be used to designate important altitudinal zones for resource conservation. The second question examined how certain plots varied from the predicted altitudinal relationships and what factors might best explain areas of high documented uses. Resource patches characterized by a high diversity of species with uses, a high diversity of uses, and a high number of species for particular uses were mapped and compared for the Mt. Kasigau region.

## Results

### *Ecological Diversity and Gradients at Mt. Kasigau*

Species occurrences for woody plants, canopy trees (>10 cm dbh) and understory woody vegetation (>1 m in height and <10 cm dbh), provide an important measure of floristic diversity for Mt. Kasigau (Table 1). All the sample plots were structurally dominated by a tree canopy and woody plants in the understory. In the 55 sample plots, we recorded 234 woody plant species in 153 genera and 51 families. Among these plants, 144 occurred as canopy trees (31 unique to this size class) and 206 occurred in the understory (91 unique to this size class). *Commiphora baluensis* Engl. was the most common large tree (>10 cm dbh), occurring in 14 plots, and over 33% of the trees only occurred in one plot. Species diversity, employing the Simpson's index ($D_s$), averaged 0.72 for large trees. Lowest values of < 0.40 occurred in nearly monodominant stands of *Euphorbia quinquecostata* Volkens ($D_s$ = 0.33) in woodland or *Newtonia buchananii* (Baker f.) G.C.C. Gilbert & Boutique ($D_s$ = 0.35 and 0.39) in evergreen forest, and high values of >0.90 occurred in semi-evergreen or evergreen woodland stands. *Combretum exalatum* Engl. (a shrub) and *Uvaria acuminata* Oliv. (woody vine) were most common in the understory, occurring in 19 plots, and 38% of the woody plants in the understory occurred in only one plot.

Ecological changes in the composition and structure of the woody vegetation was significant over short linear distances and corresponding altitudinal changes on the mountain. Highest species richness for all woody plants, when averaged for the plots, occurred in montane woodland and lowest in bushland and evergreen forest (Table 2). A polynomial regression significantly fits the relationship between species richness and elevation but the line only explains 24% ($R^2$ = 0.24, prob. < 0.001) of the variability among the plots (Figure 3A). Species richness is much higher than that predicted by the regression line in some woodland plots above 900 m (>30 species) or below the predicted value in plots between 1050-1150 m that were dominated by particular species like *Trichocladus ellipticus* Eckl. & Zeyh. subsp. *malosanus* (Bak.) Verdc. in evergreen woodland and *N. buchananii* in evergreen for-

**Table 1**. Floristic and ethnobotanical data compiled for canopy trees (>10 cm dbh) and understory (>1 m in height and <10 cm dbh) woody plants measured in the 55 sample plots at Mt. Kasigau. See Medley *et al*. (2007) for a description of the plant uses.

| Floristic Measures of Woody Plant Diversity | | |
|---|---|---|
| **Measure** | | **Number of taxa** |
| Species | | 234 |
| Genera | | 153 |
| Families | | 51 |
| Canopy tree species (>10 cm dbh) | | 144 |
| Understory woody plant species (>1 m in height and <10 cm dbh) | | 206 |
| **Ethnobotanical Measures of Woody Plant Resource Diversity** | | |
| Total woody plant species with uses (>1 m in height) | | 149 |
| Total uses for woody plants (>1 m in height) | | 627 |
| **Use Categories** | **Number of uses** | **Number of species** |
| **Food**- fruits, leaves for tea, roots eaten or pounded for water; seeds eaten or crushed for oil. | 57 | 66 |
| **Fodder**- leaves, seeds, or fruits for livestock. | 49 | 48 |
| **Construction**- Poles/posts, boards, rafters, cross poles, fences. | 80 | 67 |
| **Technology**- basins, arrows, glue, utensils, beehives, glue, rope, tools, pounding/walking sticks, furniture. | 154 | 87 |
| **Remedy**- leaves, roots, and/or bark are boiled, squeezed, crushed or soaked for ailments. | 116 | 59 |
| **Fuel**- firewood, charcoal. | 74 | 59 |
| **Ecosystem Services**- shade, nectar, sign of rain, aromatic; soil fertility, place to hang hives; rain making. | 88 | 57 |

**Table 2**. Ecological changes in woody plant species and resource diversity measured for the sample plots in bushland, montane woodland, and evergreen forest at Mt. Kasigau.

| | Plot Categories | | |
|---|---|---|---|
| | **Bushland** | **Montane Woodland** | **Evergreen Forest** |
| Number of plots | 9 | 27 | 19 |
| Woody plant richness mean (range) | 15 (11-16) | 23 (9-36) | 18 (12-26) |
| Canopy basal area ($m^2$/ha) mean (range) | 4.28 (0.31-7.32) | 17.63 (4.40-51.59) | 17 (1-40) |
| Canopy density (number/ha) mean (range) | 117 (20-220) | 415 (80-1040) | 403 (160-950) |
| Woody plant species with uses mean (range) | 14 (10-16) | 19(4-32) | 90 (10-151) |
| Percentage of woody plant species with uses mean (range) | 93% (81-100%) | 81% (44-100%) | 36% (6-71%) |
| Total number of uses mean (range) | 92 (63-113) | 90 (10-151) | 17 (1-40) |

est. Changes in the basal area ($m^2$/ha) of large trees show a mostly linear increase in forest canopy stature from an open deciduous bushland toward evergreen forest ($R^2$=0.42, prob. < 0.001), but rises and falls in basal areas up the mountain do correlate with visible structural changes from high stature semi-evergreen forest (around 700 m with *C. baluensis*), to low stature but diverse evergreen woodland at 850-1000 m, to high-stature evergreen forest between 1200-1400 m, and to a stunted cloud forest just below the summit at about 1600 m (Figure 3B). Tree densities for the most part also show a linear trend with elevation ($R^2$= 0.21, prob. < 0.001), but highest densities occur in some evergreen woodland plots between 800-950 m (Figure 3C). We also recorded the lowest value (80/ha) at an open rocky site above Makwasinyi village, and a low value (110/ha) in a plot that occurred at the site of the historic Ndomokonyi settlement above Jora village (c.f. Kalibo & Medley 2007). The highest density value (950/ha)

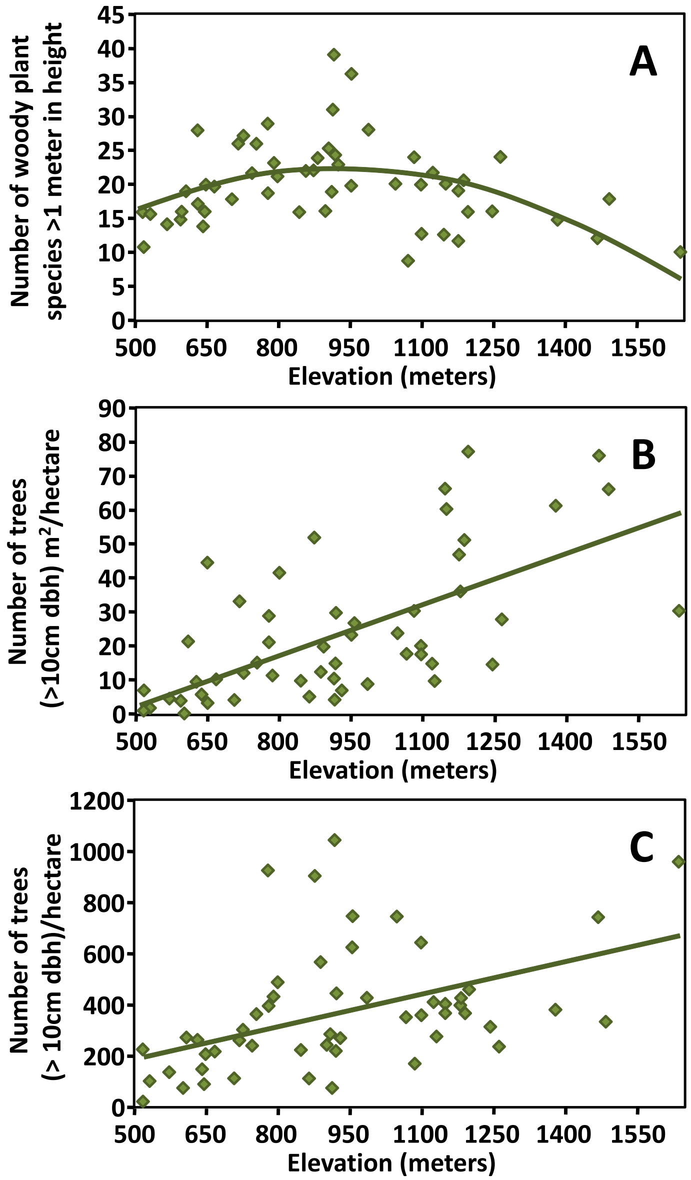


**Figure 3**. Altitudinal trends in the composition and structure of woody vegetation based on measures in 55 sample plots at Mt. Kasigau, Kenya: A) species richness for woody plants >1 m in height; B) basal area cover ($m^2$/ha) for canopy trees >10 cm dbh; and C) density (number/ha) for canopy trees >10 cm dbh.

was in the cloud forest below the summit. These findings suggest that physical-site differences and the history of human influences also contribute to differences in the ecological structure of plant communities along the altitudinal gradient.

***Resource Diversity and Gradients at Mt. Kasigau***

The number of plants with recorded uses and their use characteristics provide important measures of ethnobotanical diversity for the Kasigau Taita. In the sample plots, we confirmed 149 woody plant species with uses, and recorded 627 uses for these plants in a sum of 434 use categories (Table 1). The Kasigau Taita reported uses for 64% of the plants recorded in the plots. Approximately 30% of the plants in the plots had only one use (49 species), and 10 species were recorded with ten or more uses. For example, *Vangueria madagascariensis* J.F. Gmel. (**mnyanga**) and *Manilkara sulcata* (Engl.) Dubard (**mshaughi**) are montane woodland trees well known among the Kasigau Taita because of their very sweet fruits. *Zanthoxylum chalybeum* Engl. var. *chalybeum* (**genjeka**), which occurs between the bushland and lower montane woodland, provides 16 uses in six of the seven use categories. Among the 145 canopy trees >10 cm dbh, 98 had recorded uses.

Recognized woody plant resources are highest at the mountain's base in bushland (<650 m) and the montane woodland (650-1000 m; Table 2). Polynomial regressions with elevation for the ecological plots provide the best fit, showing a slight increase in the number of plants with uses to a peak at around 700 m (in woodland) and a highest predicted number of uses below 650 m (in bushland; Figure 4). Both regressions predict a significant drop in woody plant resources above 1000 m in the evergreen forest. The proportion of woody plants with uses dropped from a mean of 93% for the bushland plots, to 81% for woodland, and 36% for evergreen forest (Table 2). We only recorded an average of seven trees with uses in evergreen forest and from 1 to 16 uses in the evergreen forest plots (Table 2). Less than three uses were recorded for the woody plants identified in the plots above 1400 m (Figure 4B).

The calculated regressions with elevation are significant (prob. $< 0.001$), explaining approximately 49% of the change in woody plants with uses ($R2= 0.49$) and the number of recorded uses ($R2= 0.49$), respectively. The woodland plots show greatest variability, from 4-32 in their number of woody plants with recorded uses and from 10-151 in the number of uses recorded for these plants in the respective plots (Table 2). Participant observations and local narratives substantiate our measures for the sampled plots: local residents rely mostly on the bushland for their resources but the elders lived on the mountain in the past and residents go "around the mountain" ("**milimanyi**") to meet their needs when access to these locations is more convenient or necessary because of elephants in the bushland (Kalibo & Medley 2007).

Altitudinal changes in resource availability show similar declines at high elevations when compared among different material use categories (see Table 1, Figure 5). The number of recorded uses cor-

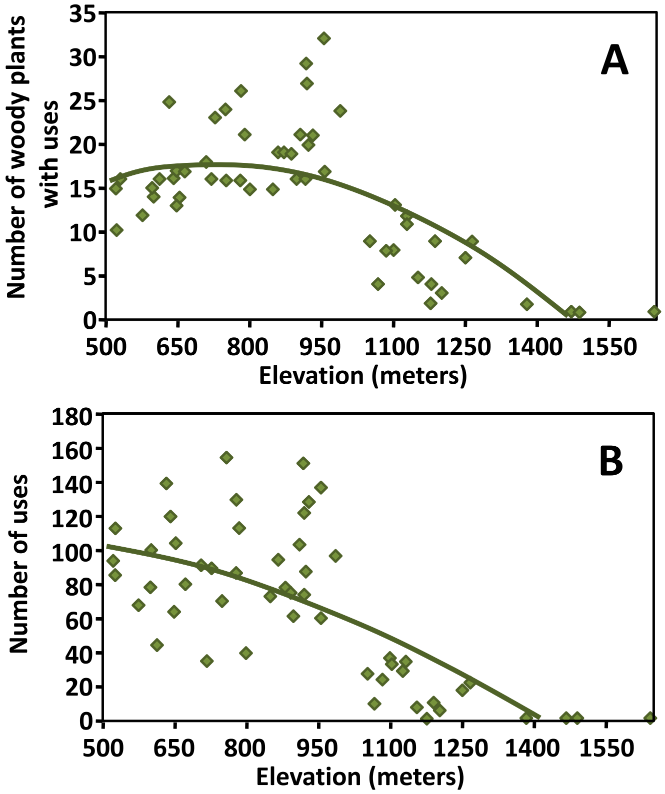


**Figure 4**. Altitudinal trends in the number of woody plants with uses and the number of uses recorded for plants in 55 ecological plots at Mt. Kasigau, Kenya.

relates significantly (prob. <.001) with woody plant species richness (r= 0.89), especially for food (r = 0.64) and remedy (r = 0.51). Accordingly, species richness of woody plants for these uses show a polynomial trend with elevation and highest values in montane forest (Figure 5). For example, many plants around and on the mountain produced edible fruits that the Kasigau Taita collected casually and most of the recorded medicinal uses were known commonly by the local population to treat illnesses and did not require an herbalist (Medley *et al*. 2007). Predicted relationships with species richness were lower for fodder (r = 0.36) and fuel (r = 0.48). These resources show a more linear trend with elevation ($R^2$ = 0.49 for fodder and 0.47 for fuel); a finding that may be more related to accessibility, or where they go for these resources in relation to their current settlements (Figure 5). Local residents at Mt. Kasigau identified a large number of plants with similarly good uses, especially for construction, technology, and fuelwood, and seemed to shift their use practices between the bushland and lower montane forests. Plant uses for all use categories are mostly below predicted trends in evergreen forest (> 1000 m). Local plant experts at Kiteghe confirmed a name (**mngima**) and described a construction use for one large tree in evergreen forest, *Cassipourea gummiflua* Tul. var. *gummiflua*, but local experts from the other villages were not familiar with the tree.

### *Resource Patches*

Local informants agreed that resource extraction levels were highest in the bushland, but the diversity of trees with uses and the occurrence of woody plants for particular uses were highest at certain montane woodland localities (Figure 6). Above Kiteghe village, we recorded 31 woody plant species in a west facing spur ridge plot: 27 of these plants had a sum of 151 uses with 27 uses for remedies and 23 for fuel. Along the Siriri River above Kiteghe, one site had 36 species; 32 of these species had 137 recorded uses with 34 uses for remedies and 16 for fuel. On a route between Jora and Rukanga, we recorded 26 woody plant species in a montane woodland plot: 24 of these species had 155 recorded uses with 35 for remedies and 22 for fuel. The site showed signs of extraction and was utilized when access to the bushland was dangerous because of elephant populations. In a lower montane location between Bungule and Makwasinyi (near "Mwarashua"), we recorded 28 species: 25 of these species had 140 uses with 28 for remedies and 19 for fuel. The site had species common to the bushland and montane woodland and was frequently used by Bungule women as a source of fuelwood. These sites are characterized by physical-site conditions that support high species richness and also human-historical conditions like the location of old settlements on the mountain that hypothesize a past reliance by the Kasigau Taita on plants at these locations. Their occurrence in montane woodland elevates the importance of this zone for the Kasigau Taita and predicts a potential threat to certain woodland localities for their diversity of extractive resources

## Discussion and Conclusions

Mt. Kasigau harbors a diverse flora, which contrasts distinctly in its composition and structure from the surrounding *Acacia-Commiphora* bushland of the Tsavo ecosystem. According to Newmark (2002:161): "[the] Eastern Arc Mountains are for their size, biologically the richest site in Tanzania and Kenya." Research on biodiversity hotspots clearly documents their high species richness and particularly the high occurrences of endemic species (e.g., Burgess *et al*. 2002, CEPF 2005, Mittermeier *et al*. 2004), but less is known about how diversity varies among plant community types and the factors that might explain local diversity patterns (Newmark 2002). Current protection efforts in the Eastern Arc mountains focus on evergreen forests, above 1000 m, which on Mt. Kasigau were gazetted as a 202 ha national forest reserve in 1941 (Mbuthia 2003). Our study findings, however, identify distinct altitudinal changes in the composition and structure of woody vegetation up the steep mountain slopes. Montane woodland, reported to be highly fragmented in other

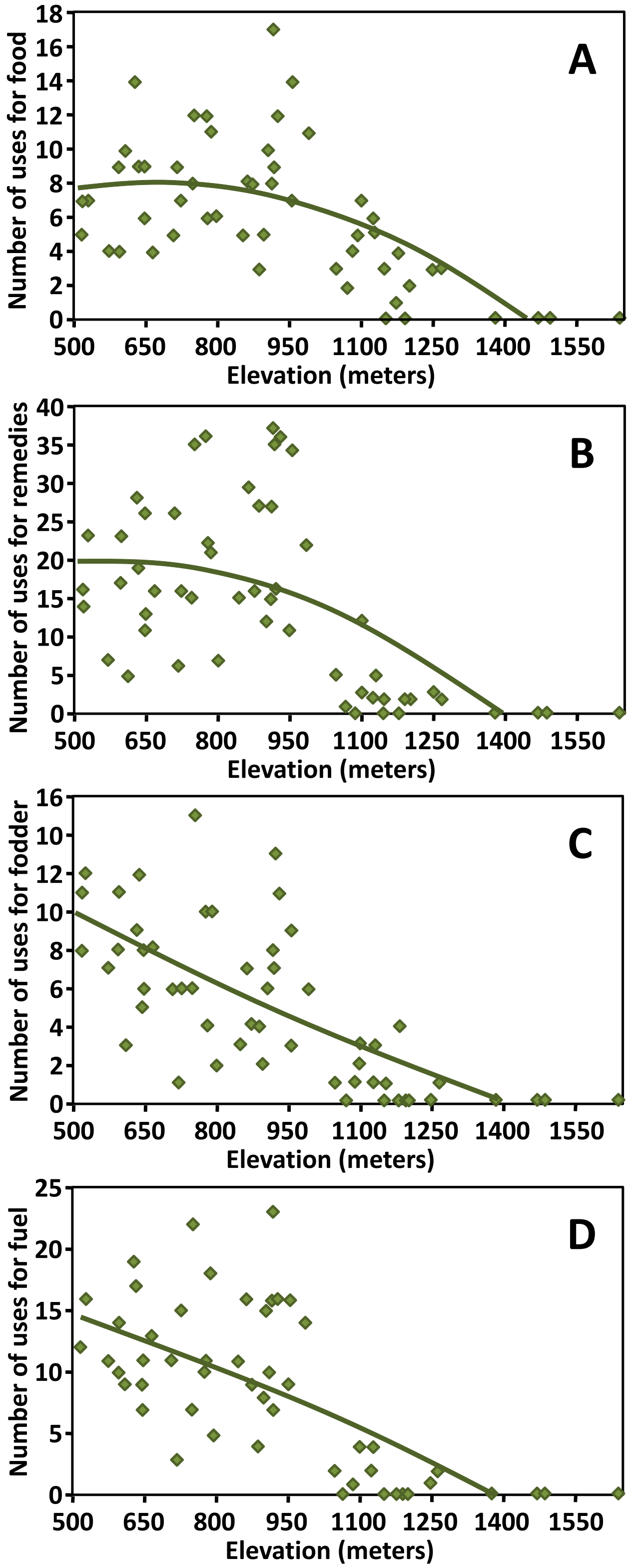


**Figure 5**. Altitudinal trends in the number of woody plants >1 m tall measured in sample plots at Mt. Kasigau, Kenya with material uses for A) food, B) remedies, C) fodder, and D) fuel.

Eastern Arc locations (e.g., Burgess *et al*. 2002 for the Uluguru mountains in Tanzania), contributes significantly to the diverse woody flora at Mt. Kasigau.

We also recorded highest diversity in the composition and structural attributes of montane woodland among the sample plots on Mt. Kasigau. High diversity at mid elevations may be explained by an increase in productivity (Newmark 2002 for the Usambaras), a decrease in the altitudinal ranges of the respective species (Behera & Kushwaha 2007 in the Eastern Himalayas), and a peak in heterogeneous site conditions for forest species (Sergio & Pedrini 2007 for the Alps; Whittaker & Niering 1975 for the Santa Catalina mountains in Arizona). Diversity patterns on Mt. Kasigau, while related to changes in elevation, become even more complex in response to physical-environmental heterogeneity (c.f. Whittaker 1956, Whittaker & Niering 1975) and human activities that transform the composition and structure of the natural landscape and influence human-resource relations (Posey 1993, Rocheleau *et al*. 2001). Our study highlights high species richness on northwest facing slopes above Kiteghe and Rukanga, and in some protected stream corridors like the Siriri river or slope concavities. Lower species richness and forest stature were recorded for plots on exposed rock, in a past settlement above Jora village, and in plots where site conditions and/or past disturbances promote dominance by a single tree species. Altitudinal changes in the composition and structure of woody vegetation and the ecological variability we recorded at similar elevations contribute to a high 'beta' diversity of different community types at Mt. Kasigau (sensu Whittaker 1975).

About 64% of the woody plants identified in the sample plots between the bushland and the mountain's summit have a recorded use by the Kasigau Taita. Our record of plant use is slightly lower than the 69% recorded by Luoga *et al*. (2000) in Eastern Tanzania or the 76% reported by Gemedo-Dalle *et al*. (2005) for the Borana pastoralists in Ethiopia, and may be explained by the high diversity of plant community types and their relative accessibility from the human settlements. The number of plants with uses varies from 100% of the recorded woody plants for some sites between 500 and 950 m, to <10% at high elevations above 1000 m. The number of plant species with uses corresponds with high species richness in montane woodland, but the highest number of plant uses occurs at a lower elevation toward the surrounding bushland. In contrast to findings for the Dusun of Mt. Kinabalu (Salick *et al*. 1999), the proportion of useful plants does vary in relation to species diversity along the altitudinal gradient (Begossi 1996). Residents utilize a high proportion of woody plants that for the most part serve many purposes in the bushland and around the base of the mountain, but the number of plants with recorded uses in

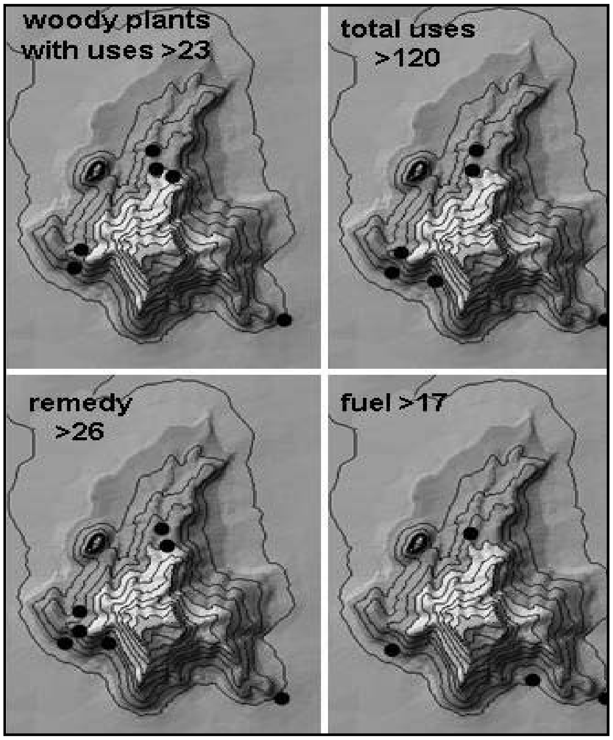


**Figure 6**. Location of plots at Mt. Kasigau, Kenya showing the highest occurrences of woody plant species with uses, highest number of uses, and the highest number of uses for remedy and fuel.

all the use categories is significantly lower in the evergreen forest zone.

The study also documents a large number of plants between the bushland and montane forest with similar uses. Following Thomas *et al*. (2008), the Kasigau Taita are "diversity followers" for food and remedy, where the increase in plants for these uses correlates more directly with species richness, and "diversity laggards" for fuel and fodder, where accessibility on the mountain may also influence the recognition of plant uses and utilization practices. Their recognition of many plants for similar uses show how the Kasigau Taita practice a "diverse portfolio of activities" (Ellis 1998:4) that provide choices and greater adaptability to local conditions. For example, Kasigau women go up or down from their homes to acquire preferred fuelwood species, depending on their work schedule or threats from bushland. A high diversity of recognized resources, their distribution across a broad altitudinal range between bushland and woodland, and the occurrence of resource patches at certain montane localities expand their "latitudes of choice" (Narzarea 1999:105) and adaptability to local contexts (Alcorn 1995). Our study of local knowledge systems about plants provides an important first step toward mapping "assets" across the landscape that have local meaning and local relevance to collaborative and adaptive conservation planning (see del Campo & Wali 2007).

We focused on how the Kasigau Taita utilize extractive plant resources from their surrounding landscape below their settlements in the *Acacia-Commiphora* bushland and above their settlements in montane woodland to evergreen forest. They live at the base of the mountain, ecologically at the transition between these lowland and montane vegetation types. Earlier research at Makwasinyi and Jora, documented a high diversity of native plant resources across their homes and farms and accordingly a high number of plants with many uses (see Medley & Kalibo 2005, 2007). The ecological setting of their current settlements shows potential for the production of valued resources that might enrich landscape conditions to serve their needs (Unruh 1994). The management of these currently 'disturbed' land areas also needs to be integrated into the assessment of "social assets" on the landscape and the evaluation of innovative practices that can best ensure sustainable access to extractive resources (del Campo & Wali 2007).

Our study highlights spatial patterns in the diversity of woody plants at Mt. Kasigau and explores how the Kasigau Taita might adapt resource extraction to altitudinal changes in vegetation and the occurrence of resource patches. By linking an ethnobotanical survey of plant uses with ecological samples that document the composition and structure of woody plants, we explore how species richness of plant community types varies along the altitudinal gradient and within elevation zones. Ecological and ethnobotanical interpretations of diversity patterns, when they couple the recognition of valued resources with species richness and structural variability in the plant community types, broadens the scope of "asset mapping" across this complex landscape (see del Campo & Wali 2007). Ethnobotanical data contribute to an integrative measure of species richness that incorporates local stakeholders in the scientific process (Sithole *et al*. 2002) and accordingly changes power relations to strengthen the importance of local views on biodiversity for conservation plans in the hotspot (Medley & Kalibo 2007, Nemarundwe & Richards 2002).

We document significant contributions of woody-plant resources to local livelihoods, especially at the transition between the bushland and the mountain, and predict the essential 'protection' of evergreen forests from resource extraction. Resource patches emerge on the landscape in relation to physical-environmental conditions or as a result of land use histories that can be used to guide site specific strategies for the conservation, restoration, or enrichment of 'direct' material goods and 'indirect' ecosystem services for rural livelihoods (Campbell & Luckert 2002). Our ecological and ethnobotanical study of altitudinal patterns in woody plants provides an important first step in the collaborative assessment of biodiversity conditions (Mc-

Neely 2002), biodiversity trends (Hellier *et al*. 1999), and biodiversity assets (del Campo & Wali 2007) that can ultimately contribute to the integrative management of bushland, montane woodland, and evergreen forest vegetation at Mt. Kasigau in the Eastern Arc Mountains.

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