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Land Use and Spatial Distribution of Two Gum And Incense Producing Tree Species In The Blue-nile Valley of Wogidi District, Ethiopia

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INTRODUCTION

In Ethiopia, drylands account for 60-64% of the country's area and are home to 12% and 26-30% of human and livestock populations respectively (Coppock, 1993; Getachew et al. 1998). These drylands have a rich diversity of natural vegetation that is capable of providing local communities with various natural products. Such possibilities include indigenous woody species such as, *Boswellia papyrifera* (Del.) Hochst and *Commiphora africana* (A. Rich.) Engl., which are known sources of gum and incense. To date eight species of *Boswellia*, forty-eight species of *Commiphora* and various multiple-use species of the *Acacia* genera have been identified as potential sources for gum and incense (Brientenbach, 1963; Ahmed, 1982; Velleson, 1989; Hedberg and Edwards, 1989; De Vletter, 1991; Azene et al., 1993).

The potential for gum and incense production in Ethiopia has a wide distribution, running across the dry zones of several regional states (Hedberg and Edwards, 1989; Azene et al., 1993). In the lower terraces of Blue-Nile and Tekeze valleys, frankincense producing *Boswellia papyrifera* frequently occurs either in pure stands or interspersed with trees and shrubs of other species, for example *Commiphora* and *Acacia* genera (FAO-UN, 1974).

In the Amhara National Regional State (ANRS) alone, such drylands traverse 34 districts consisting of about 600,000 hectares of conserved/rehabilitated woodland vegetation with the potential for gum and incense production. In the region, some seven species of *Boswellia*, fourteen species of *Commiphora*, two species of *Sterculia* and eighteen species of *Acacia* are known to have the potential for gum and incense production (ANRS-BoA, 1997). Of these potential areas, Wogidi district is one that partially shares the woodland vegetation of the Blue-Nile valley with pronounced stands of *Boswellia papyrifera*, *Commiphora africana*, and some other species of *Sterculia africana* and *Acacia* genera (ANRS-BoA, 1997; SWZ-AD, 1997).

Despite the above potential resources, there exists a striking land use pressure upon the available resources. This has been exacerbated by the increasing human and livestock populations. During the last half century, the uncontrolled utilisation of the country's forest and woodland resources; extensive shifting cultivation, woodcutting and cattle rearing has led to severe environmental degradation and other related problems (Wolde-Michael, 1978). Areas currently covered with scattered grasses, trees and shrubs have resulted from overgrazing and trampling by cattle. Equally important, these resources are threatened because they have evolved naturally fragile environments and therefore not suitable for cultivation and intensive grazing (Gebre-Markos, 1998). The ultimate effect of land use pressure has been manifested in deforestation, loss of productivity potential, and thereupon in shortages of both food and forest products.

In an attempt to tackle the problem of poverty while at the same time mitigating the effects of land use conflicts, the various regional states of Ethiopia have embarked on conservation and rehabilitation of their woodland resources. Further, the Government requires the regional states to develop integrated and sustainable resource use plans. In this respect, since 1997, a food security program has been initiated in the Amhara National Regional State (ANRS), with the aim of resolving part of the existing land use conflicts. The program also assumes that economic benefits arising from the use of non-wood products such as gum and incense are substantial when integrated with the existing land use systems (ANRS, 1997). In view of the potential resources the region has, many of its drought-prone districts (including Wogidi district) will have access to supplementary sources of income to alleviate food insecurity problems. Further, under this holistic approach to resource management, the need to conserve gum and incense potential areas for both marketable products as well as centres of biodiversity has been said essential. However, for these objectives to be realised, both conservation and development efforts must anchor on knowledge of the current status of existing resources and demands of each locality. This has become as a prerequisite because development factors such as lack of systematic inventory of resources, inappropriate land use and tenure have always presented constraints to effective resource management. In Ethiopia, whenever policy matters related to natural resource management and land use problems are considered, both ecological and socioeconomic concerns take a centre stage. The main aim is to conserve indigenous resources of socioeconomic value, especially those located in low potential areas. However, paucity in baseline data and information has for a long time been a constraint for policy makers to come up with locality-specific approach.

This study was designed to generate information on how both environmental and human factors affect the distribution of *B. papyrifera* and *C. africana*, which are important gum and incense producing tree species in the Blue-Nile valley of Wogidi district.

MATERIALS AND METHODS

Study Site

Location, Climate and Physiography: The study was undertaken in the Blue-Nile valley of Wogidi district. The area is located in the west extreme of South Wollo Administrative Zone and lies within the Eastern Blue-Nile basin of Amhara National Regional State. Blue-Nile valley, which is located in the west and Southwest fringes of the district, passes through four sub-districts namely 016, 017, 018, and 026. It lies approximately between 10° 22' 02'' & 10° 32' 31'' N Latitudes and 38° 27' 51'' & 38° 34' 49'' E Longitudes.

According to ANRS-BoA (1999), the study area falls under hot to warm moist sub-agroecological zone. The mean annual rainfall varies from 1200 to less than 1400 mm. with mean annual evapotranspiration of about 1300 mm. The mean annual temperature of the valley is 18.5 ^{0}C with minimum and maximum daily temperature of 11.4 ^{0}C and 25.5 ^{0}C respectively. Rainfall in the study area is also a function of altitude and the lower elevation receives low precipitation. Moreover, since the 1984 Sahelian drought, rainfall in the valley as well as the adjacent plateau has become so erratic and unreliable (FDRE-MWR, 1998).

The physiographic feature of the study area and the surrounding lowlands varies with altitude. The study site varies from 1050 to 1700 metres above sea level and has a distinct landscape of broken terrain dominated by steep to gentle slopes (FDRE-MWR, 1998).

Geology and Soils: According to FAO-UN (1986), the geology of Blue-Nile valley comprises of lithic phase with soil units of vitric andosols. Limestone, sandstone and basement complex materials that appear in the site, are another geological features of the area (Mesfin, 1970; Merla et al. 1973; Kasmin, 1975). Due to its variable topography and drainage system, the Blue-Nile valley has a shallow soil profile associated with stoniness (FAO-UN, 1984). Generally, the soil of the study area has been characterised as sandy, brown, and course textured (SWZ-AD, 1997).

Vegetation: The vegetation type of the study area falls under the category of open woodland vegetation of the region. Authorities have indicated that the study area also includes localised shrub lands, wooded grasslands (as derived savanna) and riverine forest patches following the drainage of rivers, mostly along the banks of Blue-Nile river. According to SWZ-AD (1997), for instance, the vegetation of the area is classified as woody vegetation, predominantly frankincense yielding *Boswellia* and other co-existing species of *Commiphora* and *Acacia*. ANRS-BoA (1999) classified the site as remnant vegetation patches of open woodland and shrub land. On the other hand, FDRE-MWR (1998) classified the area as important *Boswellia* woodland vegetation cover after cropping and grazing lands. More precise information regarding the vegetation classification of the area is found in the report generated by Breitenbach (1963). According this report, the Blue-Nile valley that intercepts Wogidi district is an extension of the extreme western lowland-woodlands of the ANRS surrounded by plateaus and sub-humid lowland savanna areas.

The vegetation cover and distribution of the study area seem to correlate with elevation, soil and topographic gradients. Along the banks of the Blue-Nile and its tributaries, plant species such as *Prunus africanus*, *Ximenea americana*, *Zizyphus spina-christi* and different *Ficus* species are prominent as riverine vegetation. Further away from the riverbanks towards the hillsides of the valley, *Boswellia papyrifera*, *Comiphora africana*, *Sterculia africana*, and *Combretum* spp. become dominant. Still further away from the river cuts of Blue-Nile and towards the higher elevation areas, shrub lands of *Dichrostachys cinerea*, *Acacia mearnsii* and other related stands appear to dominate. Patches of grassland vegetation characterised by tall grasses such as *Andropogon*, *Hyparrhenia and Cymbopogon, and* species of *Bidens* represent the aboveground cover of the area.

Experimental Design: For this study, land use and slope were considered as factors that determine the status of gum and incense trees in the study area. Depending on the population pressure exerted upon, five land use units (Luu 1 - Luu 5) were identified within the valley. Each land use unit had two slope aspects, i.e. >25% and <25%. Of the five land use units, Luu-1 was characterised by low population pressure and land use intensity, and therefore chosen as a control against the remaining land use units. This led to the application of a statistical design, Completely Randomised Design (CRD), under a 5x2 = 10 factorial arrangement (Steel and Torrie, 1980).

Upon allocating treatments, five similarly oriented 1 km long transects were laid down in each land use unit and passing through both slopes. Depending on the distances (in Km) from Luu-1 (control), transects were named as T_o, T_5, T_8, T_{11}, and T_{14} with corresponding to Luu-1, Luu-2, Luu-3, Luu-4, and Luu-5 respectively. Sampling plots were located at 80 m intervals along each transect. This design gave ten (10) plots each measuring 10m.by 20m., and five such plots lay in each of the two slope aspects. This gave 5x2x5 = 50 sampling points for vegetation measurements.

Collection of Woody Vegetation Data: At each plot, both topographic and vegetation variables were measured. Slope and ground distances were measured using clinometer and pedometer respectively. Measurements on vegetation were number of tree species and crown diameters. For *Boswellia papyrifera*, tree height was measured in order to estimate age structure. Vegetation attributes computed from these measurements were density, crown cover and tree age ratio.

To compute for density and percent crown cover, species count on hectare basis (Kershaw, 1973) and the crown diameter method (Muller-Dombois and Ellenberg, 1974) were used respectively. Tree age ratio for *B. papyrifera* was calculated depending on the proportion of young and mature stands which took the tree height categories, <2 and >2 metres respectively.

Data Analysis: Density, cover, and age ratio of trees were taken as suitable indicators of vegetation changes across land use units, and between the two slope aspects of each land use unit. These attributes were examined with respect to the main factors, land use and slope.

Data on vegetation attributes were analysed using the SPSS computer package. Dunnett's two-tailed test was used in comparing the control versus each of the remaining land use units (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

In the analysis of data on vegetation attributes, land use and slope did not show significant interaction ($P > 0.05$). Therefore, effects of land use and slope on all attributes of *B papyrifera* and *C. africana*, were synthesised and presented independently.

Effects of Land Use on Attributes of *B. papyrifera* Trees

There were significant differences ($P < 0.05$) in density, crown cover and age ratio of *B. papyrifera* due to land use (Table 1). Density of *B. papyrifera* was greater in the control site (Luu-1) than in Luu-3, Luu-4, and Luu-5, i.e. 260 (trees/ha) for Luu-1 as compared to 110, 130, and 155 trees/ha for Luu-3, Luu-4, and Luu-5 respectively. The density in Luu-2 (200 trees/ha.) was not statistically different from density in Luu-1. Crown cover of *B. papyrifera* was also affected by land use. There was no significant difference in the crown cover of *B. papyrifera* between Luu-1 and Luu-2 ($P > 0.05$). However, Luu-1 (with crown cover of 31.9%) had significantly higher crown cover ($P < 0.05$) than Luu-3, Luu-4, and Luu-5, which had 14.5%, 20% and 21% crown cover respectively.

The effect of land use on the age ratio of *B. papyrifera* showed a significant variation (P <

0.05) between the control site and the rest of the land use units. Luu-1 had a tree age ratio of 0.69, whereas Luu-2, Luu-3, Luu-4, and Luu-5 had age ratios of 0.30, 0.22, 0.25, and 0.16 respectively.

The difference in density and crown cover of *B. papyrifera* due to differences in land use pressure is an indicator to the general vegetation degradation of the area. SWZ-AD (1997) and Field (1986) reported a similar relationship. According to Thomas, (1986), cultivation of marginal lands, overgrazing or unsound livestock management, and overharvesting of bush and tree stands for wood, represented the major causes of woody vegetation degradation.

Table 1: Density, crown cover and age ratio of *B. papyrifera* on the five land use units

Land use units	*Attributes**		
	Density (Tree per ha.)	*Crown cover (%)*	*Age ratio*
Luu-1	260[a]	31.9[a]	0.69[a]
Luu-2	200[a]	25.5[a]	0.30[b]
Luu-3	110[b]	14.5[b]	0.22[b]
Luu-4	130[b]	20.0[b]	0.25[b]
Luu-5	155[b]	21.0[b]	0.16[b]
Overall means	171	22.6	0.32

Column means with different letter superscripts are significantly different ($P < 0.05$).
* Figures for each attribute are means values of 10 observations.

A number of pilot studies (ANRS-BoA, 1997; SWZ-AD, 1997) have reported that loss of biodiversity in the study area was on the increase.The use of trees for wood and wood products, and clearing of land for wide spread agriculture have been responsible for bringing major changes. It was reported by SWZ-AD (1997) that in spite of the relatively hostile ecological conditions in all incense forest areas of the zone, human influence particularly in terms of agricultural encroachment has been a major negative factor.

The analysis of age ratio indicated that there was low proportion of young stands of *B. papyrifera* in all land use units except the control (Luu-1). This has been attributed to low seedling establishment on these sites, mainly due to trampling and destruction of the succulent stands by large animals (SWZ-AD, 1997). The woody vegetation structure, therefore, may indicate patterns of utilisation. In ecologically comparable areas of the country, Gebre-Markos (1998) reported that with increasing grazing intensity, the number of *Boswellia* trees had shown a sharp decline. Further, height of woody vegetation, and therefore accessibility of leaves and buds to browses determine how browsers affect the plants (Field, 1986).

In the less disturbed sites, the ratio of young trees to mature stands was not comparable to what had been documented before. Previous field assessment reports (WD-AO, 1996; SWZ-AD, 1997) have indicated the possibility of counting 110 to 144 young *B. papyrifera* trees per hectare. The local people partially attributed the regressive survival of *B. papyrifera* seedlings/saplings to the browsing effects by warthogs. Further the change in other environmental factors such as soil and moisture status and human interventions are a hindrance to woody vegetation establishment.

In general, the causes said to be responsible for poor regeneration of gum and incense trees are closely associated with the proximity of people and concentration of livestock in the incense forests. Therefore, expansion of cropping and grazing activities, cutting of trees for different purposes, and use of inappropriate taping methods, as also reported by SWZ-AD (1997) and Gebre-Markos, (1998) can be said to be the major factors responsible for real deterioration of the country's incense forests.

Effects of Land Use on Attributes of *C. africana* Trees

There was no significant difference in the density of *C. africana* across the five land use units ($P > 0.05$). However, percent crown cover of *C. africana* had significant variation ($P < 0.05$) across land use units (Table 2). Comparison of mean values of Luu-1 against the rest of land use units revealed that crown cover of *C. africana* was lower in Luu-2, Luu-3, Luu-4, and Luu-5 than in Luu-1.

The analysis of density of *C. africana* shows that none of the intervened sites had different stocking densities compared to the control site. Although with insignificant variation, better stock counts were observed in Luu-1, Luu-2 and Luu-4, for which other vegetation attributes of the species responded differently.

To this particular species, three possible reasons can be suggested in relation to the random nature of its distribution. First, the conspicuous pattern of *C. africana* may be related to the localised soil differences. As reported by Lewis and Berry (1988), the close relationship between ecosystem structure and soils may lead to differentiation of certain vegetation types associated with certain soil characteristics. Second, as also suggested by local residents, such a distribution could be linked to the morphological characteristics. For instance, its roughness might allow it to tolerate physical damages as compared to those of the most sensitive and succulent saplings of *B. papyrifera*. Lastly, it is possible that agropastoralists in the area could take more care of *Commiphora* stands, due to their importance as sources of livestock feeds in the area. In the Sahelian countries for example, *C. africana* plays a significant role in the pastoral lifestyle and therefore is generously managed (Clanet and Gillet, 1980). Crown cover of *C. africana* did manifest a distinct variation across the land use units. The difference in cover of *C. africana* between the control site and the rest of the land use units can be linked with several reasons. Notable among others, given different browsing pressure or any other defoliation activities are practised in the area, such a significant difference can be suggested as an inevitable outcome.

Table 2 Density and crown cover of *C. africana* on the five land use units

Land use units	Attributes* Density (Tree per ha.)	Crown cover (%)
Luu-1	105[a]	11.0[a]
Luu-2	100[a]	6.8[b]
Luu-3	60[a]	2.4[b]
Luu-4	95[a]	4.2[b]
Luu-5	65[a]	2.4[b]
Overall means	85	5.34

Column means with different letter superscripts are significantly different ($P < 0.05$).
* Figures for each attribute are mean values of 10 observations.

Effect of slope on attributes of *B. papyrifera* and *C. africana*

Table 3 shows the effects of slope on attributes of *B. papyrifera* and *C. africana*. The density of *B. papyrifera* was significantly different between the two slope classes ($P < 0.05$) i.e. as high as 196 trees per ha. on the >25% slope and as low as 146 trees per ha. on the ⩽25% slope. There was significant difference in percent crown cover of *B. papyrifera* ($P < 0.05$) between the slope categories. Measures of percent crown cover for *B. papyrifera* were 26.4% and 18.7% on the >25% and ⩽25% slopes respectively. Variation in slope, however, did not influence the proportion of different age groups of this species ($P > 0.05$).

There was significant difference ($P < 0.05$) in density of *C. africana* between the two slope ranges of the area. Across all land use units, *C. africana* had higher density (102 trees per ha.) on ⩽25% slope than on >25% slope, which had a density of 68 trees per ha. Similarly, the percent crown cover of *C. africana* was different between the two slope aspects ($P < 0.05$). It was as high as 6.1% on the gentle slope (⩽25%) and as low as 4.1% on the steeper slope (>25%).

As stated by Herlocker (1999), environmental factors are important variables in determining the Africa's dry-woodland ecosystem. In the study area, both land use and slope are important factors that determine the vegetation attributes of both species. While *B. Papyrifera* had extensive stock in steep slopes, *C. africana* stands had much better density on the gentle slopes. This is in agreement with the statement that *B. papyrifera* prefers steep and rocky sites (Breitenbach, 1963; Azene et al., 1993; ANRS-BoA, 1997; Gebre-Markos, 1998). Hedberg and Edwards (1989) also reported that *B. papyrifera* trees are in favour of steep and rocky sites, and *C. africana* stands usually prefer sites where rocks are associated with overlying sandy soils. Clanet and Gillet (1980) also reported favourite habitats of *C. africana* as sandy soils where they appear as pure stands,

Table 3: Attributes of *B. papyrifera* and *C. africana* on the two slope aspects

Tree Species	Slope (%)	Attributes* Density (Tree per ha.)	Crown cover (%)	Age ratio
B. papyrifera	>25	196[a]	26.4[a]	0.26[a]
	<25	146[b]	18.7[b]	0.39[a]
C. africana	>25	68[a]	4.1[a]	-
	<25	102[b]	6.1[b]	-

Column values for the same species with different letters superscripts are significantly different ($P < 0.05$).
* Figures for each attribute are mean values of 25 observations.

and as occasional stands on rocky and stony escarpments.

The soil parent material of the study area influences the distribution pattern of both species, which is dominantly gypsum origin (Merla et al., 1973; Kasmin, 1975). According to the argument of Herlocker (1999) for instance, if an area is invaded by gypsum soils, it could exhibit a great influence on composition and structure of vegetation than do soils developed from other parent materials. Depending on the characteristics of trees and shrubs, although not exclusively so, high densities of certain trees and shrubs of open woodlands can be associated with sandy soils and areas favoured by run-on (Friedel, 1986). In West Africa, for example, slope and soil drainage have been reported to influence woody vegetation distribution (Lewis and Berry, 1988).

Owing to the correlation between the chemical as well as the physical characteristics of soils and the vegetation types they grow upon, the site specificity for each species could be manifested. Similarly, correlation between topography and soil types, and the horizontal distribution of tree species have been reported from the tropical riverine forest of southeastern Brazil by Oliveira-Filho et al. (1994).

The relationship between slope and the physical attributes of *B. papyrifera* and *C. africana* can also be viewed from the multitude range of altitude they occupy. According to Hedberg and Edwards (1989) and Gebre-Markos (1998), the altitude range for *B. papyrifera* and *C. africana* was reported as 500-950-1800 and 250-1300 meters above sea level respectively. But, based on Breitenbach (1963) and ANRS-BoA (1997), the elevation range was 500-1300 for both species. Whereas in the study area, it was observed that *B. papyrifera* and *C. africana* trees dominate in the elevation range of 1100-1500 meters above sea level. This, therefore, implies that the spatial distribution of these species is influenced to a large degree by the slope and/or soil characteristics of the area than the elevation alone.

Age ratio of *B. papyrifera* trees showed no significant variation between slopes >25% and <25%. Since young trees are the most vulnerable to human and livestock physical damages, seedlings/saplings of *B. papyrifera* might be highly affected in the sloppy and rocky areas. Regardless of the differences with respect to certain microhabitat determinants, both species are in favour of sites, where the parent materials are mainly enriched by sandstone and/or limestone. Therefore, it is quite conceivable that the co-existence as well as the niche partitioning of *B. papyrifera* and *C. africana* stands, within the study area, may be explained largely due to the horizontally varying environmental factors. It may also be together with the strategies that the species used to respond to the dynamics of man-made and ecological processes.

CONCLUSION AND SUGGESTIONS

Density, cover and age ratio, as major vegetation attributes of gum and incense producing tree population, were examined and documented with respect to land use as one of the limiting factors of the study area. Analysis of vegetation attributes for *B. papyrifera* and *C. africana* revealed that land use pressure had influence on the structure and standing stock of trees. The degree to which two of these species were influenced, however, varied with respect to the type of species and the vegetation attributes considered. Both density and crown cover of *B. papyrifera*, for instance, were affected by land use. Whereas, for *C. africana*, only crown cover appeared to be governed by the effects of land use. With similar effect, land use had an influential effect on the composition of different age groups of *B. papyrifera* stands. In sum, they were better in the less-interfered sites such as the control site (Luu-1) compared to the rest, which were characterised by high population pressure.

Likewise, the diversity of the physical factor (slope) largely explained the observed differences, in the density and cover of *B. papyrifera* and *C. africana*. This made sense in its core implication that, in analysing vegetation data, the due considerable effects usually come from a combination of man-made stresses and environmental factors. The results demonstrated therefore the importance of topography and land use in characterising the stock population and stand structure of gum and incense producing tree species in the study area.

In the Blue-Nile valley of Wogidi district, such physical socio-economic parameters (slope and land use) were identified as determinant factors of resource management. Most likely, attributed to the disparity of land use intensification between the topographic highs and lows of the study area, the effects of the two factors were rather independent. The principal impact of land use on the standing stock of woody vegetation in the area is brought about by the fact that there was no legislation covering the utilisation of land and its limited resources on a long-term sustainable basis. Such a limitation was particularly evidenced from the point of land allocation among different uses as regards potential and local needs. It was found associated with overuse of the available resources through green biomass off-takes (grazing, woodcutting and clearing). The depletion of the biological support system and the resultant effects, manifested in the loss of productivity, expansion of poverty and unprecedented growth of population, were evidenced as major and overriding grass-root problems.

In summary, such a vicious circle can be broken by the adoption of locally applicable land use as regards potential and topography with sound government policies on natural resources not only to ensure sustainable use of renewable resources but also provide livelihood for the local people. To fill this gap, therefore, the following are suggested to be substantial for future sustainable management of woody vegetation of the area.

Research Need:

- To come up with a clear picture of the resource base in general, the progressive or regressive trend analysis of major biophysical factors including soils, climate, and vegetation should be a subject of further research. The study, of course, should be combined with estimates of future demand for various goods and services that can be obtained from the forest/woodland and alternative forms of land use.

Policy Implications:

- In order to narrow the gaps existing between the immediate needs of the local people and the conservationists, and at the same time to ensure socially, economically and ecologically equitable environment, identification of problems and possible solutions should be addressed on a participatory basis.
- Appropriate local incentives including multi-disciplinary training in the field of diversification of local peoples' activities such as bee keeping and acceptable methods of gum and incense production, and locally sound technical intervention to the crop-livestock system with facilitation of infrastructures should be given emphasis.
- To minimise the general shortfall of wood-based products in the district, farm wood lots and homestead plantations should be encouraged. To achieve these, open grazing systems particularly in and around farmlands should be checked. The land tenure system of the area should also account all local parameters such as sustainable use of renewable resources by the indigenous people, which involves private and common property including conservation areas.
- To be able to consider major land-use alternatives, site delineation in the area should be based on certain biophysical determinants of the area. For practical purposes, at least two social and ecological areas of relevance to the implementation of site delineation may be suggested as:
    - What has been mapped out as an effective area of *Boswellia* and *Commiphora* stands – as site of gum and incense production promotion
    - The upper woodland category of the area including the extreme upper lowland portion of the valley – as buffer zone and as the same time for specific grazing, wood harvesting, and as an area of other related wood lot promoting activities.
- Finally, creation of mass awareness focused on the resolution of population pressures, land scarcity and associated resource management constraints should be emphasised as part of rural development policies.

KEY WORDS Land Use. Vegetation. Spatial Distribution. Topography

ABSTRACT The study was conducted in the Blue-Nile valley of Wogidi district in Ethiopia, where woody vegetation degradation associated with intensive land use activities has become a national concern. It was undertaken with an overall objective of documenting the impacts of land use and topography on the spatial distribution of two gum and incense producing tree species, Boswellia papyrifera (Del.) Hochst and Commiphora africana (A. Rich.) Engl.. Five land use units, each with

two slope categories (⩽25% and > 25%) were subjected to a 5x2 factorial arrangement and a total of 50 sample points were employed to measure density, crown cover, and age ratio of trees. Analysis of vegetation attributes revealed that, except for density of C. africana, all the vegetation attributes did show lower status in the heavily populated land use units than the control site reflecting the differential impact of intensive land use pressure against protection. In the heavily populated land use unit (Luu-3) for example, density, cover and age ratio of B. papyrifera trees were as low as 8.3 trees/ha, 7.7% and 0.21 respectively. In contrast to this, i.e. in the site of low population pressure (the control) the same attributes appeared to be measured as 77 trees/ha, 7.7% and 0.51 respectively. However, attached to the proximity ecological position, density and crown cover of B. papyrifera showed no significant difference (P. > 0.05) between Luu-1 and Luu-2. Density of C. africana, most likely due to its affinity to a specific microhabitat, it did not differ among all land use units (P > 0.05). Between the slope aspects of the area, B. papyrifera and C. africana were found to dominate the steep (>25%) and gentle (⩽25%) slopes respectively. Regarding density of B. papyrifera, while it was 196 trees/ha in the steep slope, 146 trees/ha were documented from the lower slope aspect. Inversely related to this, C. africana had 68 and 102 trees/ha on >25% and ⩽25% slopes respectively. Age ratio analysis of B. papyrifera trees, however, did not show significant difference (P > 0.05) between these two slope categories. In the study area therefore, land use and slope were identified as determinant factors to the spatial distribution of woody vegetation and policy frameworks to account these factors are suggested to be substantial in the management of such resources.

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