ORIGINAL ARTICLE

STATUS OF INDIGENOUS TREE SPECIES REGENERATION UNDER EXOTIC PLANTATIONS IN BELETE FOREST, SOUTH WEST ETHIOPIA

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Abstract

The potential for regeneration of native woody species in exotic plantation stands and in the adjacent natural forest in Belete forest was studied. The objective of the study was to assess the diversity and density of the naturally regenerated woody species in plantations at Belete forest. Vegetation assessment within the stands was conducted using a line transect survey using square plot of size 10 m X 10 m which were established at 100m intervals along line transects which were 100 m apart. A total of 60 woody plant species belonging to 50 genera and 31 families were recorded regenerating under the canopy of exotic plantations and a natural forest at Belete forest. Only 40 of the species were found in the plantations while 20 of them found only in the natural forest. The highest density of regeneration was recorded for Pinus patula followed by Cuppressus lucitanica. Cuppressus lucitanica plantation stand exhibited the highest value of Shannon diversity and evenness (2.5 and 0.84) followed by Eucalyptus saligna (2.13 and 0.83). Highest similarity index was observed between the plantation stands of Cuppressus lucitanica and Eucalyptus saligna (0.67). On the other hand the Cuppressus lucitanica and Eucalyptus camaldulensis plantation stands showed relatively weak similarity (0.36). Pinus patula and Cuppressus lucitanica plantations had the highest similarity to the natural forest. The regeneration of native woody species under the canopies of exotic plantations in moist montane forest areas suggests the possibility of restoring degraded areas in southwestern Ethiopia using these exotic plantation stands.

Key words: Exotic, Regeneration, Belete forest, Restoration

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INTRODUCTION

Natural forests in Ethiopia are declining rapidly due to their conversion to arable lands coupled with unwise and excessive utilization triggered by increasing population growth. This had and continues to have serious consequences on various ecosystems in Ethiopia.

With the objective of satisfying the increasing demand for wood, relieving the pressure from natural forests and rehabilitating lands in Ethiopia, forest tree plantations have been initiated since the turn of this century, mainly with introduced species of E*ucalyptus, Cupressus, Acacia, Pinus, Cassuarina,* etc (Amare Getahun, *et al*. 1990).

Plantation establishments using exotic species have both advantages and disadvantages (Lugo, 1992). The potential advantages includes: a) readily available information on propagation techniques, silvicultural behavior and management practices of the species; b) relatively fast growing rates, and provision of wood that can be used for various purposes in a relatively short period of time. In addition, exotic plantations facilitate the regeneration of native species under their canopy and catalyze the subsequent succession processes (Lugo, 19992; Parrotta *et al*, 1997). It improves degraded lands by stabilizing soils, improving soil nutrient status and increasing soil organic matter through enhancing of aboveground litter production (Lugo, 1992).

The potential disadvantages include: a) unforeseen risks, such as problems of adaptability and susceptibility of the species to diseases, b) negative impacts on the environment, e.g. undesirable changes in the physical, chemical and biological conditions of the soil; and c) undesirable invasion /colonization of arable lands, pastures and native vegetation as well as displacement of the local flora (Feyera Senbeta *et al*. 2002).

Despite the various benefits that accrue as a result of establishing plantations of exotic species, there is a growing concern among people regarding the disadvantage of such ventures resulting in reluctance or resistance of people to the introduction and establishment of exotic species. However, little research work has been undertaken to elucidate the harmful and beneficial impacts of exotic plantations. In the absence of empirical evidences, any claim against the establishment of exotic species can not be warranted, in countries such as Ethiopia where there is a desperate and urgent need of expanding the forest resource base to meet the ever-increasing demand for wood (Bone *et al.*1997; Feyera Senbeta and Demel Teketay, 2001).

Recently many studies have indicated that forest plantations can foster the regeneration of native woody species under their canopy and catalyze the subsequent succession processes (Bone *et al.* 1997; Yitebitu Moges, 1998; Feyera Senbeta and Demel Teketay, 2001; Feyera Senbeta *et al.* 2002; Getachew Tesfaye and Abiyot Berhanu, 2006).

While the catalytic role of plantations in enhancing native woody regenerations as well as improving degraded lands have been widely observed in many countries, understanding of the mechanisms and processes involved is quite limited. For instance, knowledge on the relationships among the catalyzing effect of tree plantations on succession of forests, the role of dispersal mode, origin of seeds (seed bank or seed rain), and the effect of management and types of species, is scanty (Yitebitu Moges, 1998; Feyera Senbeta and Demel Teketay, 2001).

Monitoring composition, densities and the role of seed rain, soil seed banks and advance regeneration in the colonization of indigenous woody species following plantation establishment is of paramount importance. In addition, changes in the biotic and physical components of the plantation site, both temporally and spatially are gaps that need investigation in the future. Understanding of the processes that may allow us to develop plantation management for provision of urgently required goods and services, coupled with enhancement and maintenance of biodiversity, are very essential. Therefore, the objective of this study was to assess the diversity, density, and height class distribution of the naturally regenerated woody species in plantations at Belete forest.

MATERIALS AND METHODS

Description of the study area

Belete forest is situated in Shabe Sombo *wereda*, Jimma zone, Oromiya National regional state; 375 km south west of Addis Ababa and it is part of the Belete Gera National Forest Priority Area and located at longitudes between 36^{0}15'E and 36^{0}45' E and latitudes 7^{0}30' N and 7^{0}45'N (Belete Gera PFMP, 2006).

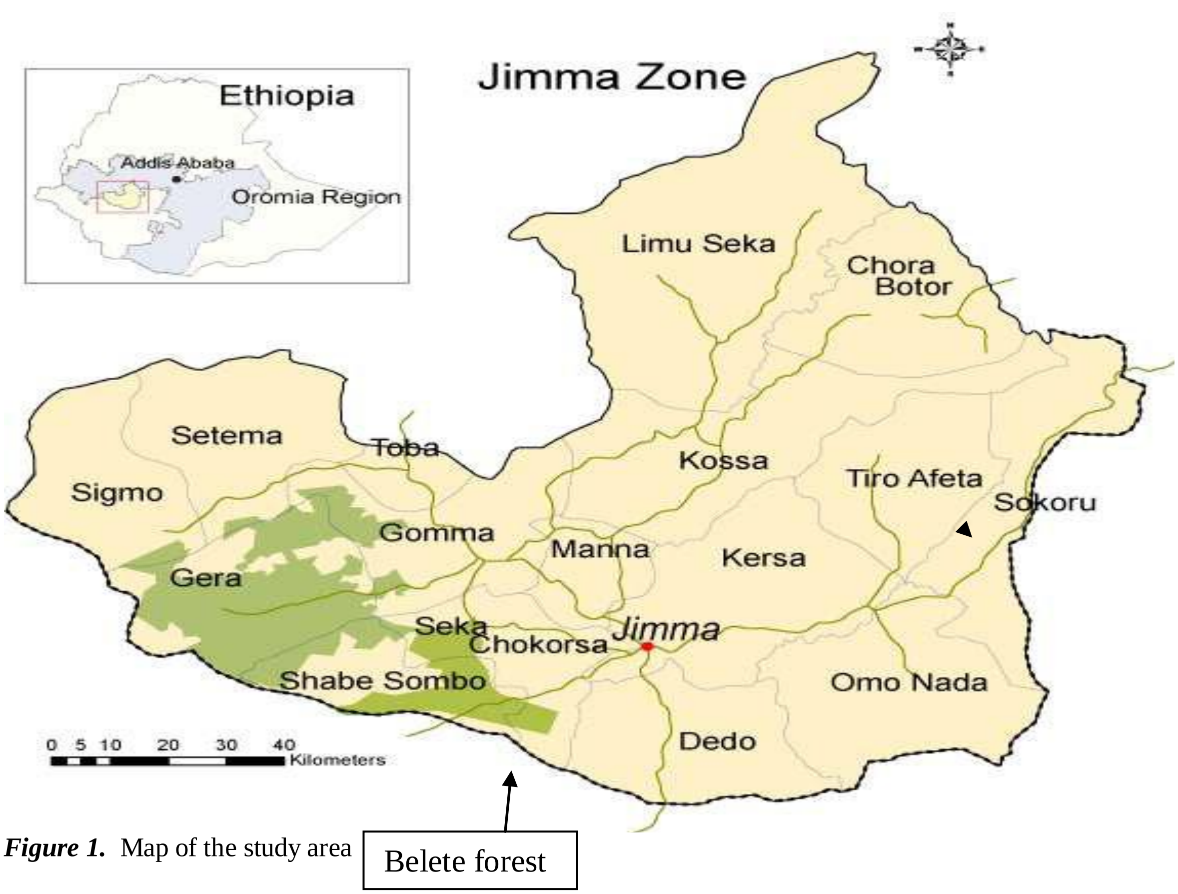

Figure 1. Map of the study area

Soils of the study area are largely volcanic in origin and relatively fertile and the dominant soil types are nitosols ((Bridges et al. 1998). Tertiary volcanic and related volcano-clastic sediments underlie the area (Murphy, 1968). The mean annual rainfall of the area is between 1800 mm and 2300 mm with maximum rainfall between the months of June and September. The mean annual temperature of the area is between 15^{o}C and 22^{o}C (EMA, 1988).

In Belete forest there is huge plantation of exotic tree species such as *Eucalyptus*, *Cupressus*, *Pinus* and *Cassuarina* spp. with different age and size.

Methods Of Data Collection

Vegetation assessment within the stands was conducted using a line transect survey. 32 plots of size 10 m X 10 m were established at 100m intervals along line transects which were 100 m apart. The starting point of all line transects were located randomly in each stand. The plots were laid down in each stand and the first plot was located randomly. All sample plots were located at least 50 m from plantation edges/road to avoid edge effect.

In each plot, all of the naturally regenerated woody species were identified and counted. When identification proved difficult in the field, specimens were collected for identification. Species identification was conducted at Jimma University Herbarium. The nomenclature of plant species follows Hedberg and Edwards (1989, 1995) and Edwards, *et al*. (1995, 1997, 2000).

Method Of Data Analysis

The Shanon-Wiener diversity index (H') and Shanon evenness (E) were computed following Magurran (1988). Similarity in species composition among the plantation stands was computed using Sorensen Similarity index (Kent and Coker, 1993).

RESULTS

There is a variation in diameter at breast height (DBH) and height among the plantation stands (Table 1). Mean basal area, mean DBH and crown cover is lower for *E. camaldulensis*. The density of planted trees showed considerable variation among the plantation stands. The density (stem/ha) of *Cuppresus lucitanica* is greater than the four species while that of *Pinus patula* is the lowest (Table 1).

Table 1. Characteristics of plantation stands sampled in Belete forest, 2008

species	Mean basal area cm^2	Mean DBH cm	Mean height m	Stem/ha	Crown cover (%)
Cuppresus lucitanica	16	34	25	1000	80
Eucalyptus saligna	21	26	28	675	65
E. camaldulensis	13	21	24	456	40
Pinus patula	35	30	28	190	85

A total of 60 woody plant species belonging to 50 genera and 31 families were recorded regenerating under the canopy of exotic plantations and a natural forest at Belete forest (Table 2). Only 40 of the species were found in the plantations while 20 of them found only in the natural forest. Six of the regenerated species in the exotic plantations belongs to the upper and medium canopy tree species in the adjacent natural forest (Table 2). Fifteen of the regenerating species were found in four of the exotic plantations while the remaining were found in one or more of the four exotic plantations (Table 2). *Rhytrigea neglecta*, *Pterolobium stellatum*, *Oxyanthus spaceous*, *Galineria saxifraga*, and *Calpurina aurera* are the most common regenerating woody species (Table 2).

Table 2. Density of regenerating species/ ha under the exotic plantations in Belete forest, 2008

Species	**Family**	**NF**	**EC**	**CL**	**PP**	**ES**
Acacia abyssinica	Fabaceae	15	-	-	-	-
Acacia sp.	Fabaceae	24	-	-	-	-
Acanthus pubescence	Acanthaceae	95	50	100	100	-
Albiza gumifera	Fabaceae	40	10	15	40	25
Albiza schimperiana	Fabaceae	50	12	23	35	43
Allophylus abyssinica	Sapindaceae	550		650	100	100
Macaranga capensis	euphorbiaceae	35	12	23	-	12
Aningeria- adolfi-friedrichi	Sapotaceae	25	-	-	-	-
Apodytes dimidiata	Icacianaceae	28	-	-	-	-
Bersama abyssinica	Melianthaceae	350	230	150	100	120
Brucea antidysentrica	Simarobiaceae	30	-	50	400	35
Calpurina aurera	Fabaceae	580	350	250	480	300
Carrisa spinarium	Apocynaceae	25	15	50	200	150
Celtis Africana	Ulmaceae	25	30	35	60	-
Clausenia anisata	Rutaceae	350	45	120	60	-
Coffea arabica	Rubiaceae	45	-	-	-	-
Combretum paniculatum	Combertaceae	36	35	35		25
Cordia africana	Boraginaceae	35	40	35	60	-
Croton macrostachyus	Euphorbiaceae	450	300	200	400	45
Diosporyus abyssinica	Ebenaceae	25	-	-	-	-
Discopodium peninervum	Solanaceae	340	-	200	200	-
Dombeya torrida	Striculariaceae	15	10	-	40	35
Ehertia cymosa	Boraginaceae	45	-	-	125	245
Ekebergia capensis	Meliaceae	25	-	-	-	-
Embelia schimperi	Myrsinaceae	250	-	200	400	-
Euclea racimosa	Ebenaceae	90	35	-	40	-
Ficus sychomorus	Moraceae	15	-	-	-	-
Ficus thoningii.	Moraceae	25	-	-	-	-
Ficus vasta	Moraceae	15	-	-	-	-
Galineria saxifraga	Rubiaceae	250	600	1150	120	120

Table 2. continued

Species	Family	NF	EC	CL	PP	ES
Ilex mitis	Aquifoliaceae	25	-	-	-	-
Jasmium abyssinica	Oleaceae	200	-	50	100	-
Maesa lanceolata	Myrsinaceae	240	100	750	40	75
Maytenus gracilipes	Celasteraceae	24	120	235	234	75
Maytenus arbutifolia	Celasteraceae	35	200	-	43	-
Maytenus undata	Celasteraceae	250	234	-	-	235
Miletia ferugnea	Fabaceae	35	40	50	40	-
Paveta abyssinica	Rubiacea	25	50	50	100	-
Ocimum lamifolium	Lamiaceae	70	35	69	47	25
Olea capensis	Oleaceae	25	-	-	-	-
Olea welwetschi	Oleaceae	350	-	-	-	-
Oxyanthus speciosus	Rubiaceae	300	200	450	100	50
Pittosporum viridiflorum	Pittosporaceae	25	-	-	-	-
Podocarpus falcatus	Podocarpaceae	15	-	-	-	-
Polyscias fulva	Araliaceae	35	-	-	-	-
Prunus africana	Rosaceae	25	-	10	30	-
Pterolobium Stellatum	Fabaceae	200	200	230	145	250
Rhamnus prinoides	Rhamnaceae	150	15	45	100	-
Rhytrigea neglecta	Rubiaceae	2700	2000	1200	2600	1200
Rothmannia urcelliformis	Rubiaceae	29	-	-	-	-
Rubus apetalus	Rubiaceae	35	-	200	400	-
Rubus steudneri	Rubiaceae	34	-	100	600	-
Sapium ellipticum	Euphorbiaceae	35	-	-	-	-
Schefleria abyssinica	Araliaceae	45	-	-	-	-
Senna didymobottra	Fabaceae	38	-	150	680	-
Syziguim guinensee	Myrtaceae	500	30	100	60	50
Teclea noblis	Rutaceae	20	45	35	100	
Vernonia amygdalina	Asteraceae	30	-	-	-	-
Vernonia auriculifera	Asteraceae	250	1000	-	85	-
Vepris dainellii	Rutaceae	230	34	150	60	35
Total sp.		60	36	40	40	24
Total density		10058	6113	7200	8564	3274

NF, Natural forest; EC, *Eucalyptus camaldulensis*; ES, *E. Saligna*; PP, *Pinus patula*; CL, *Cuppressus lucitanica*

The different plantation stands showed marked variation in the number of regenerating woody plant species under their canopies. The highest number of species was recorded under *Cupressus lucitanica* and *Pinus patula* each with 40 species and the least under *Eucalyptus saligna* with only 24 species (Table 2).

Variation in density of regenerated species

There is a considerable variation in the density of regenerated plants in the plantation stands. The highest density of regeneration (number of regenerated individuals per hectare) was recorded for *Pinus patula* followed with *Cuppressus lucitanica* (Table 2).

Diversity and similarity of regeneration under plantation stands

Table 3. Shanon Diversity and Evenness of the Plantation stands in Belete forest, 2008

Plantation stand	H'	Evenness (E)
Cuppresus lucitanica	2.5	0.84
Eucalyptus camaldulensis	2.02	0.69
E. saligna	2.13	0.83
Pinus patula	1.99	0.78

Shannon diversity index and evenness showed considerable variation among the plantation stands. *Cuppressus lucitanica* plantation stand exhibited the highest value of Shannon diversity and evenness (2.5 and 0.84) followed by *Eucalyptus saligna* (2.13 and 0.83) (Table 3).

Highest similarity index was observed between the plantation stands of *Cuppressus lucitanica* and *Eucalyptus saligna* (0.67) (Table 4). On the other hand, the *Cuppressus lucitanica* and *Eucalyptus camaldulensis* plantation stands showed relatively weak similarity (0.36). *Pinus patula* and *Cuppressus lucitanica* plantations had the highest similarity to the natural forest (Table 4).

Table 4. Sorrenson similarity index among plantation stands in Belete forest, 2008

	PP	EC	CL	ES
EC	0.63	-		
CL	0.64	0.36	-	
ES	0.56	0.45	0.67	-
NF	0.8	0.67	0.8	0.57

NF, Natural forest; EC, *Eucalyptus camaldulensis*; ES, *E. Saligna*; PP, *Pinus patula*; CL, *Cuppressus lucitanica*

DISCUSSION

The total number of regenerated species at the present study site (60 species) is very close to previous reports from Munessa Shashemene (55) (Feyera Senbeta, *et al*. 2002) but higher than in the Menagesha forest (37) (Feyera Senbeta and Demel Teketay, 2001). Of the plant species regenerated under the plantation stand, *Syzigium guinensee, Albizia gumifera* and *A. schimperiana* are found to be canopy species that also occur in natural forest. The most common timber species such as *Aningeria adolfi-friedrchii, Afrocarpus falcatus* and *Prunus africana* were absent under the canopies of exotic plantation stands.

In the present study, species richness was higher in the *Pinus patula* and *Cuppressus lucitanica* plantations each with 40 species but *E. globulus* had higher number of species in Menagesha forest (Feyera Senbeta, *et al*. 2002) with 27 species and Eucalyptus camaldulensis with 24 species (Getachew Tesfaye and Abiot Berhanu, 2006). The density of regenerated plants ranged from 3274 to 8564 individuals /ha.

These results are within the range that have been reported from Munessa Shashemene forest (Feyera Senbeta, *et al*. 2002) and relatively lower than the Jiren forest reported by Getachew Tesfaye and Abiot Berhanu (2006). The variation in density of the regenerated species could be attributed to site specific differences, difference due to species composition or management history of the forest.

The shanon-diversity index was higher for *Cuppressus lucitanica* in the present study while it was highest for *E. camaldulensis* in Jiren Forest (Getachew Tesfaye and Abiot Berhanu, 2006) and for *E. globulus* for Menagesha forest (Feyera Senbeta and Demel Teketay, 2001). Getachew Tesfaye and Abiot Berhanu (2006) recommended that Eucalyptus plantation stand could be more preferred to other exotic species for the purpose of ecosystem restoration through exotic plantations and maintenance of biodiversity on degraded fields but this is not supported by the present study.

Implications for restoration

The regeneration of native woody species under the canopies of exotic plantations in moist montane forest areas suggests that it is possible to restore degraded areas in southwestern Ethiopia using these exotic plantation stands. The absence of regenerating important timber species such as *Aningeria adolfi-friedrichi, Podocarpus falcatus and Prunus Africana* can be attributed to scarcity of seed sources or the ecological requirements for seed germination and seedling growth of the species. In the restoration of degraded areas, knowledge of ecological factors such as availability of seed sources, environmental factors for seed germination and seedling growth of the species under the canopies of exotic plantations is very important.

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