Jurnal Penelitian Kehutanan Wallacea (2019) **8**(2), 147-157

Jurnal Penelitian Kehutanan Wallacea

Akreditasi LIPI: 764/AU1/P2MI-LIPI/10/2016
Akreditasi KEMENRISTEKDIKTI: 36b/E/KPT/2016

eISSN 2407-7860
pISSN 2302-299X

J P K WALLACEA

www.jurnal.balithutmakassar.org

STAND AND SITE CHARACTERISTICS OF KABESAK (*Acacia leucophloea*) IN TIMOR ISLAND, EAST NUSA TENGGARA, INDONESIA

(Karakteristik Tegakan dan Tempat Hidup Kabesak (Acacia leucophloea) di Pulau Timor, Nusa Tenggara Timur, Indonesia)

Arnold C. Hendrik[1*], **Cecep Kusmana**[2], dan **Muhdin**[3]

[1]Program of Tropical Silviculture, Graduate School, Bogor Agricultural University
Jl. Lingkar Akademik Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia
[2]Department of Silviculture, Faculty of Forestry, Bogor Agricultural University
Jl. Lingkar Akademik Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia
[3]Department of Forest Management, Faculty of Forestry, Bogor Agricultural University
Jl. Lingkar Akademik Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia

Article Info

Article History:
Received 10 June 2019; received in revised form 02 August 2019; accepted 08 August 2019.
Available online since 30 August 2019

Keywords:
Acacia leucophloea,
stand structure,
West Timor,
site characteristics

ABSTRACT

Kabesak (*Acacia leucophloea*) is a particular plant species and recognized to have important benefits to the local people of Timor Island. The people of Timor Island use kabesak leaves as animal feed in the dry season and kabesak wood is used as building materials and furniture. The purpose of this study was to determine the stand and site characteristics of kabesak in the western region of Timor, Indonesia. The means of density, frequency, dominance, and importance value index were analyzed. The results showed kabesak stand structure in secondary forest land, grassland, and shrubs, as well as garden showed the J-inverted shaped, which implies that natural regeneration was a proper continuation. Kabesak had significant associations with a few plants' species, both negative and positive types. The result of regression analysis of the principal components showed that the contribution of edaphic factor influences the population density of kabesak. Silt fraction and phosphorus content were found to have the highest positive effect on the density, while sand fraction and sodium content were found to have the highest negative effects of kabesak. A test for altitude with Tukey test (α = 0.05) reveals that kabesak from 0-300 m a.s.l., 300-600 m. asl., 600-900 m a.s.l. were not different from each other, while altitude >900 m a.s.l. was significantly different from the other groups.

Kata Kunci:
Acacia leucophloea,
struktur tegakan,
Timor Barat,
karakteristik tapak

ABSTRAK

Kabesak (Acacia leucophloea) adalah spesies tanaman yang dikenal memiliki manfaat penting bagi penduduk lokal Pulau Timor. Masyarakat Pulau Timor memanfaatkan daun kabesak sebagai pakan ternak di musim kemarau dan kayunya dimanfaatkan sebagai bahan bangunan dan meubel. Tujuan dari penelitian ini adalah untuk menentukan karakteristik tegakan dan tempat hidup kabesak di wilayah Timor Barat, Indonesia. Penelitian ini dianalisis dengan menggunakan indeks kepadatan, frekuensi, dominansi, dan indeks nilai penting. Struktur tegakan kabesak di lahan hutan sekunder, padang rumput, dan semak belukar, serta taman menunjukkan bentuk J terbalik, yang menyiratkan bahwa regenerasi pada tiga jenis lahan berjalan baik. Kabesak memiliki hubungan yang signifikan dengan beberapa spesies tanaman, baik tipe negatif maupun positif. Hasil analisis regresi komponen utama menunjukkan bahwa kontribusi faktor tanah mempengaruhi kepadatan populasi kabesak (individu ha^{-1}*). Variabel tanah yang memiliki efek positif tertinggi terhadap kepadatan kabesak adalah fraksi debu tanah dan fosfor (P), sedangkan yang memiliki efek negatif tertinggi adalah tanah berpasir dan fraksi natrium. Tes ketinggian dengan uji Tukey (α = 0,05) mengungkapkan bahwa 0-300 m dpl., 300-600 m dpl., 600-900 m dpl tidak berbeda satu sama lain, sementara ketinggian> 900 m dpl secara signifikan berbeda dari kelompok lain.*

[*] Corresponding author. Tel/Fax: +62 2518626806
E-mail address: arnold_hendrik@yahoo.co.id (A.C. Hendrik)

http://dx.doi.org/10.18330/jwallacea.2019.vol8iss2pp147-157

I. INTRODUCTION

Kabesak (*Acacia leucophloea* (Roxb.) Willd.) is a tree species of the Fabaceae family, Mimosoideae sub-family. This species is known to be native to Southeast Asia and South Asia that grows in India, Pakistan, Nepal, Sri Lanka, Myanmar, Thailand, Vietnam and Indonesia. Kabesak is a species of acacia that is able to survive in drought conditions and tolerate sites with low fertility and poor nutrients soils. The plant generally grows in semi-arid regions that have a dry period of 9-10 months, with annual rainfall of 500-1400 mm (NFTA, 1996).

People of South Asia generally utilize the kabesak plant as a traditional medicine, and moreover for astringent, demulcent, thermogenic, anthelmintic and expectorant necessities. Imran et al. (2011) revealed the use of stem bark as a cure for indigestion and respiratory disorders. Sowndhararajan et al. (2013) asserted that acetone and methanol from kabesak stem bark extract show good antioxidant activity based on various antioxidant tests. Arthanarieswaran et al. (2015) also described that the fibers of *A. leucophloea* bark could be the alternative to synthetic fibers in a composite structure. In Timor Island, kabesak is a peculiar type of native plant that grows in the wild. Kabesak leaves are used to feed cattle and goats. During the dry season, Kabesak leaves are remain green so that they are regularly used to replace dried grass as a source of livestock food. By this means, kabesak possesses the potential to be developed in a silvopasture. In addition, kabesak wood is also used by the people of Timor Island for constructions and furniture. The quality of kabesak wood according to Rianawati (2014), is categorized into II-III strength wood class, and according to Heyne (1987), it is included into III durability wood class and II wood strength class.

The high utilization of kabesak by the people of Timor Island can lead to a decline in its population. Until now, kabesak still grows wildly and has not been specifically cultivated by the people of Timor Island. For the cultivation and utilization of kabesak in the future, it is necessary to study the characteristics of kabesak's population on Timor Island. Njurumana (2015) has expressed descriptively kabesak's ecology and its utilization in the District of South Central Timor (TTS). Research on the characteristics of kabesak population needs to be done not only in South Central Timor District but also in Kupang District which has abundant resources of kabesak. Understanding of the structure of the stands, the diversity of species within the community in which the tree was found, and the ecological processes affecting it are important aspect for the purposes of conservation and management (Tang et al., 2011; Antos et al., 2016). The stand structure and spatial pattern of a plant is an important attribute to be studied, as it may reflect patterns of population dynamics and relationships with the environment, to better understand the mechanisms of population expansion and development (Kai et al., 2013; Li & Zhang, 2015). The structure of the stand is the individual expression of a population to its environmental conditions and its microhabitat. One of the environmental conditions that greatly affect the population of a plant is human activity. Therefore, in this study, the structure of kabesak stands is assessed based on the type of land use, in an aim to examine the effects of human activities either directly or indirectly on kabesak stands, as well as to examine the environmental factors that most influence kabesak stands.

II. RESEARCH METHODS

A. Study Area

This research was conducted upon the natural forest area in West Timor Island, East Nusa Tenggara (Figure 1). Based on data from the Meteorology, Climatology and Geophysics Agency (BMKG), the Lasiana Climatology Station from 2011-2015 found that the average monthly temperature on Timor Island ranged from 26.0°C - 29.2°C with a monthly average temperature of 27.31°C every year. The climate type of Timor Island includes a rather dry and dry category (E and F) based on climate classification according to Schmidt-Ferguson. Rainfall data for 2011-2015 shows that the highest rainfall months are December to March, December and January recorded the highest rainfall with the highest average of 418 mm and 378 mm, respectively. Soil types in Kupang and TTS Regency consist of soil type: (1) alluvial, (2) cambisol district, (3) cambisol eutric, (4) cambisol oustic, (5) latosol, (6) latosol district, (7) latosol eutrik, (8) humic latosol, (9) mediterranean haplic, (10) regosol, and (11) renzina. Analysis of soil samples was conducted at the Laboratory of the Department of Soil Science and Land Resources of the Faculty of Agriculture, Bogor Agricultural University. The field research was conducted from April to August 2016. The observation of kabesak stands in Timor Island was only conducted in Kupang and TTS districts which have an abundant supply of kabesak stands. The sample observation area was determined using judgment/purposive sampling method, based on the altitude and type of land use (primary forest, secondary forest, shrub and grassland, and garden). The sample plots in this study were in Kupang District which spreaded over 7 villages and TTS District spreaded over 9 villages. So that, the total plot was rendered as 70 units (Figure 1).

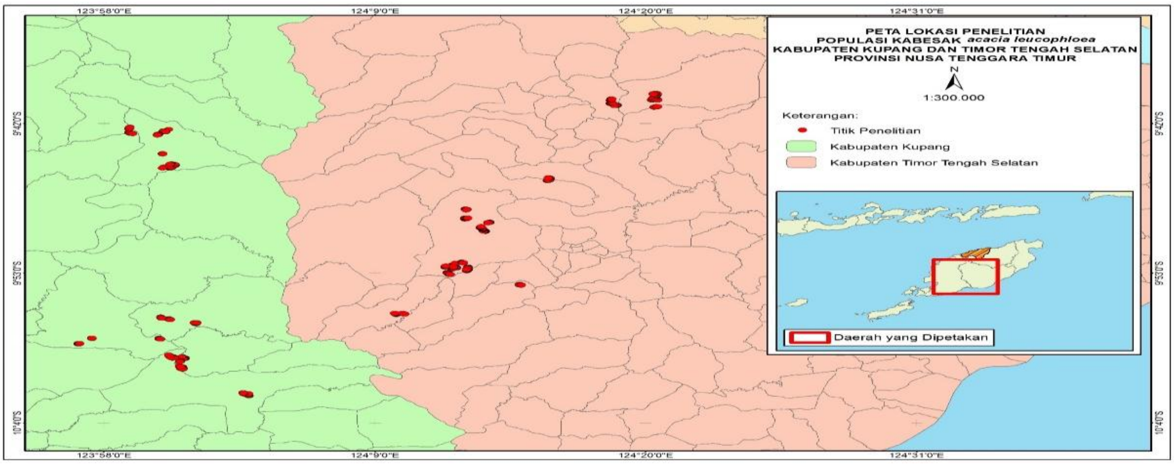

Figure 1. Study site in the western part of Kupang and South Central Timor Districts of Timor Island, East Nusa Tenggara
Gambar 1. *Lokasi penelitian di wilayah Kabupaten Kupang dan Timor Tengah Selatan, Nusa Tenggara Timur*

B. Vegetation and Soil Sampling

In the designated locations, sample plots wereselected using a plotline technique in which large plots contain smaller plots called nested sampling (Kusmana, 1997). On each plotline was constructed 4 plots measuring 20 m x 20 m for tree stage (diameter at breast height (DBH) > 20 cm) observation , 10 m x 10 m for pole stage (DBH 10-20 cm), 5 m x 5 m for sapling stage (DBH 3-<10 cm and height >1.5 m), and 2 m x 2 m for seedling stage (DBH < 3 cm and height ≤ 1.5 m). Each initial position of the sample plot wasnoted where the geographical position is located by using GPS.

Soil sampling was conducted in each type of land, which comprises of 4 samples in the primary forest, 5 samples in the secondary forest, 4 samples in the gardens, and 3 samples in the bushes and grasslands. Each soil sample in each plot is taken from 5 randomly selected points. Upon all sample points were taken constructs from top layer soil and sub-layer soil. The difference in soil layer determined by the transition of soil color. Each layer was then combined into a composite sample. Thereby, the total sample size was obtained as 32 soil constructs. The chemical properties which were analyzed include soil pH, organic carbon content, organic matter content of N Total, P, Ca, Mg, K, Na, base saturation and cation exchange capacity (CEC). Moreover, the soil physical properties which were analyzed included soil texture.

C. Data Analysis

Data population which includes the abundance of species such as density, relative density, frequency, relative frequency, dominance, relative dominance and important value index (IVI) of species, was determined following the Mueller-Dombois and Ellenberg (1974). The association between kabesak and other species was analyzed for each type of land for combined pole and tree growth stages. Kabesak was tested with 10 other species using a 2x2 contingency table. The value of χ^2 counts from the contingency table is compared to the χ^2 table value at a 90% confidence level.

Characteristics of physical and chemical properties of the soil in which kabesak grows on are described based on the average values of edaphic parameters in each type of land. Evaluation of soil parameters is based on the assessment criteria of soil analysis results according to Soil Research Institute (Balittanah, 2009). The effect of the soil's physical and chemical properties on the density of kabesak was analyzed using regression analysis of the principal components using Minitab program, which is a development of principal components analysis (PCA) combined with the classical regression. Considering eigenvalues (root characteristics) as PC scores (component scores) and eigenvector (feature vectors) can be determined the contribution of a factor. As a regression analysis in general, the independent variable (X) is used, namely the soil factor and the dependent variable (Y), namely the parameters of the kabesak population, namely the density of the kabesak population. the main component regression model to explain the effect of independent variables on non-independent variables, analysis with the following models:

$$Y = b0 + b1X1 + b2X2 + b3X3 + b4X4 + \ldots + b13X13 + \varepsilon \quad (1)$$

Remarks:

Y	= Density of kabesak population;		
b0	= Intersep;		
b1-b18	= Coefficient of the regression variable;		
ε	= Error;	X7	= K ;
X1	= pH ;	X8	= Na;
X2	= C ;	X9	= CEC;
X3	= N;	X10	= Base saturation;
X4	= P;	X11	= Sand;
X5	= Ca;	X12	= Silt;
X6	= Mg;	X13	= Clay

The soil's physical and chemical properties used in the regression analysis include soil texture (sand, silt, and clay), soil pH, organic carbon, total nitrogen elements, phosphorus, calcium, magnesium, potassium, sodium, base saturation and cation exchange capacity (CEC). The relationship of topographic variables (altitude, slope, and aspect) to the presence of kabesak was analyzed by generalized linear model (GLM) and continued by a Tukey test to see the significance between categories of each topographic variable. For the sake of GLM analysis the variable height is categorized into 1 = altitude 0-300 m a.s.l., 2 = 300-600 m a.s.l., 3 = 600-900 m a.s.l., 4 = 900-1200 m a.s.l. The slope variable is categorized into 1 = flat, 2 = gentle, 3 = rather steep, 4 = steep, 5 = very steep. Slope direction variables are categorized as 1 = flat (-1), 2 = north east (0-90), 3 = south east (90-180), 4 = south west (180-270), and 5 = north west (270 -360)

III. RESULTS AND DISCUSSION

A. Kabesak Abundance in Each Type of Land

Kabesak abundance in all 4 land types is shown in Table 1. High IVI of kabesak shows that kabesak population spreads and grows well on different types of land in Timor Island. The success growth of kabesak which spreads and grows well on various types of land is affected by the carrying capacity of physical environmental factors (temperature, light, soil physical and chemical characteristics, humidity, etc.), biotic factors (interaction between species, competition, parasitism and others) and chemistry factors that includes the availability of water, oxygen, pH, nutrients in the soil and others (Krebs, 2002). To remember that in each type of land it grows naturally, if there are kabesak that grow on every land, especially in the garden, it is generally left to grow by the people of Timor Island. The density values between growth stages in secondary forests, grasslands, and shrubs exhibit a similar trend, where the rate of regeneration is greater than the above level, which means that kabesak regeneration runs properly. General appearance of kabesak stands in each type of land is shown in Figure 2.

Table 1. Abundance of kabesak in Kupang and South Central Timor Districts
Tabel 1. *Kelimpahan kabesak di Kabupaten Kupang dan Timor Tengah Selatan*

Growth stages *(Tingkat pertumbuhan)*	**Land use types *(Penggunaan lahan)***			
	PF	**SF**	**SB/GRL**	**GRD**
Seedling (Semai)				
1. Density (kerapatan) (individu ha^{-1})	5855.26	2861.32	4208.33	7179.48
2. Frequency (frekuensi)	0.65	0.71	0.61	0.66
Sapling (Pancang)				
1. Density (kerapatan) (individu ha^{-1})	5.26	118.75	146.66	65
2. Relative density (kerapatan relatif) (%)	0.14	3.95	4.34	1.92
3. Frequency (frekuensi)	0.01	0.18	0.2	0.10
4. Relative frequency (frekuensi relatif) (%)	0.34	5.74	5.28	3.07
5. IVI (INP) (%)	0.48	9.70	9.63	5.00
Pole (Tiang)				
1. Density (kerapatan) (individu ha^{-1})	6.57	62.5	71.66	73.07
2. Relative density (kerapatan relatif) (%)	0.92	9.85	9.95	13.90
3. Frequency (frekuensi)	0.06	0.34	0.41	0.38
4. Relative frequency (frekuensi relatif) (%)	2.14	11.89	14.28	14.21
5. Dominance (dominansi) (m^2/ha)	1.29	11.16	13.35	13.52
6. Relative dominance (dominansi relatif) (%)	1.05	9.47	11.78	14.08
7. IVI (INP) (%)	4.12	31.21	36.02	42.20
Tree (Pohon)				
1. Density (kerapatan) (individu ha^{-1})	99.34	86.32	50.41	67.62
2. Relative density (kerapatan relatif) (%)	34.43	32.59	24.64	21.95
3. Frequency (frekuensi)	0.947	0.93	0.86	0.87
4. Relative frequency (frekuensi relatif) (%)	20.57	22.81	22.80	18.13
5. Dominance (dominansi) (m^2/ha)	210.33	154.76	58.56	75.16
6. Relative dominance (dominansi relatif) (%)	59.65	57.76	40.92	29.65
7. IVI (INP) (%)	114.66	113.17	88.37	69.73

Remarks: PF: primary forest, SF: secondary forest, SB/GRL: grassland and shrub, GRD: garden
Keterangan: PF: hutan primer, SF: hutan sekunder, SB/GRL: semak belukar dan padang rumput, GRD: kebun

Figure 2. Kabesak (*Acacia leucophloea*) on land types: primary forest (a), secondary forest (b), garden (c), and grassland and shrubs (d).
Gambar 2. *Kabesak (Acacia leucophloea) pada tipe lahan: hutan primer (a), hutan sekunder (b), kebun (c), dan padang rumput dan semak belukar (d).*

Based on Shankar's criteria (2001), the regeneration status of kabesak in primary forests and the gardens is quite fair, while in the secondary forests and the shrubs and grasslands, is categorized as good. The regeneration of primary forests is considered to be sufficient due to the high density of kabesak at the seedling stage, yet it does decrease very sharply during sapling. Moreover, the tree-stage density value is greater than the stage of sapling and pole. Therefore, it is concluded that the regeneration of kabesak in the primary forest was not optimal. The difference in density between the seedling and saplings stage is very large, which shows that the kabesak seedlings were not able to grow well to reach the sapling stage. The inability of seedlings to grow to reach the sapling stage is allegedly due to competition for resources such as sunlight, water, and soil nutrient needs. The overstory canopies of the primary forest are relatively tight, that can reduce the existing understory vegetation (Botequim et al., 2015; Fonseca & Duarte, 2017). Hence kabesak seedlings are exposed to lesser light. Kabesak is included in the category of shade-intolerant plants which require light to grow. This premise is in accordance with that of NFTA (1996) which declares that nursery seedlings need sunlight to grow. Due to the densely packed characteristics of the primary forest, kabesak's seedlings are not able to grow well, causing many seeds to die. It is difficult to find kabesak in the growth stage of saplings or poles in the primary forest. This shade-intolerant attribute is similar to other Acacia genera such as *A. koa, A. dealbata, A. mangium* (Baker et al., 2009; Fuentes-Ramirez et al., 2011).

Regeneration status of kabesak in secondary forests, grasslands and shrubs is categorized as good, yet it is apparent that the density of saplings and seedlings differs to a high degree, which can mean that many seedlings will eventually die. The secondary forest is generally subject to logging activities, hence is exposed to an open canopy that should provide favorable conditions for the growing of the plants that requires light (Clark & Clair, 2011), for example according to Karyati et al. (2017) *A. mangium* has the highest increase in diameter growth on the secondary forest of Sarawak. Such circumstance may have an effect on growth, however, did not affect the survival of kabesak seedlings in secondary forests, gardens, grasslands, and shrubs on Timor Island. Other disturbance factors such as loose grazing and fires are thought to be the main causes of death of the kabesak seedling. Kabesak seedlings are known to be sensitive to fires, freezing due to cold temperatures and competition with weeds (NFTA, 1996). The traditions of the Timor Island people who are cultivating livestock loosely and shifting cultivation by clearing slash-and-burn techniques are known to influence the seedlings and saplings of *Eucalyptus urophylla* (Riwu-Kaho, 2010). Independent cattle grazing allegedly affects only the newly grown Kabesak seedlings that are yet to develop thorns. If the kabesak seedlings have formed long, sharp thorns, the livestock effects will be smaller. There is no known exact time for kabesak to form sharp and long thorns, but it is suspected that the thorns will form when kabesak has been able to develop branch out. The effects of grazing and fires on the deaths of juvenile plants have been widely reported, and fire trends are a factor in the creation of bottleneck recruitment at the sapling class in the tropical savanna (Midgley et al., 2010; Prior et al., 2011). Another factor that can cause the death of the kabesak seedling is drought, drought has been reported to have cause the death of plant seedlings in various ecosystem types such as tropical Montana forests, temperate rainforest, and savanna (Suarez & Kitzberger, 2008; Zida et al., 2008; Gallegos et al., 2016). The long dry season in Timor Island can cause the surface of the soil to dry so that the dormant cavity whose roots are still short can not absorb water. But it is necessary to conduct a more thoroughly research to know the effect of drought towards the death of the kabesak seedlings.

B. Stand Structure of Kabesak

According to Herrero-Jauregui et al. (2012), diameter size can determine the structure of stands with the assumption that the largest tree is to be oldest. Analysis of the structure of the diameter can add temporal depth to a spatial survey of tree recruitment and can illustrate the availability of stands at each growth period or diameter class (Muhdin et al., 2008). Horizontal stand structure of trees based on the diameter class above 10 cm in the four types of land is shown in Figure 3. A horizontal tree standing structures in secondary forests, grasslands, and gardens decrease with an increasing diameter or negative exponential distribution (inverted J shape). In general, the negative linear relationship between stand density and the diameter class indicates a balance between growth, recruitment, and death in the population or generally used by biologists as an indication of a healthy regenerating population (Venter & Witkowski, 2010; Hidayat, 2014).

The diameter class of kabesak poles and trees in the secondary forest spreads mostly in the diameter class of 10 cm to 59 cm. In the garden and grassland and shrub, the largest diameter class spread is found in the 10 to 49 cm diameter class, while in the primary forest, the largest diameter of the tree spreads in diameter class of 30 to 69 cm. If it is assumed that the diameter class represents the age of the plant, it will imply that secondary forests, gardens, grasslands, and shrubs are made up of younger stands, whereas in primary forests are that of older stands. The difference in diameter class between each type of land tends to be influenced by disturbances caused by human activities that mostly affect the structure of the kabesak stands. In secondary forests, grasslands and gardens there is no prohibition for cutting down trees, which results in logging activities by local communities. Therefore in those three type land uses maximum tree stand diameter tend to be lower compare to that of primary forest, where larger trees remain uncut. The variations of the horizontal standing structure are strongly influenced by factors such as competition over resources, regeneration processes, human disturbances such as logging, and microhabitat conditions (Fortini & Zarin, 2011; Li & Zhang, 2015)

Upon the land which has been disrupted by human activities, kabesak with DBH > 50 cm is found to be fewer in numbers because the plants have been cut down by local people for sale or to be used as building material. According to the local community at the research site, kabesak is alleged to be found in abundance, yet due to the high local activities utilizing the plant, those with the size of DBH > 50 cm are decreasing. Kabesak wood is used by the people of Timor Island as for raw material for construction means, and its leaves are used for livestock feeding (Njurumana, 2015). Utilization of kabesak leaves as animal feed, especially in the dry season leaves the trees as only stems and branches.

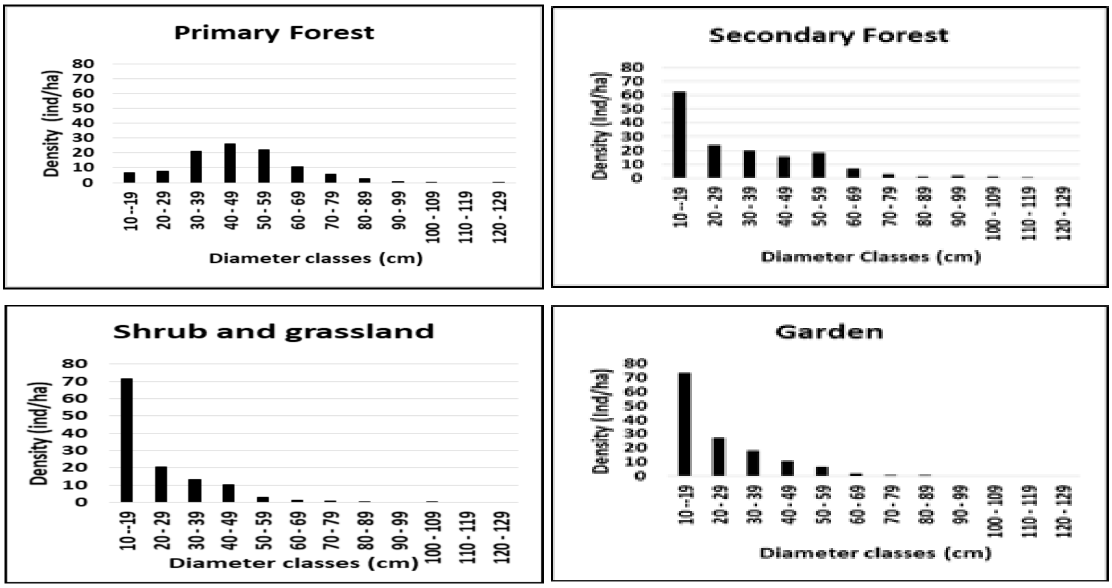

Figure 3. Horizontal tree stand structure of kabesak
Gambar 3. *Struktur tegakan horizontal pohon kabesak*

C. Association of Kabesak with Other Plant Species

The association test was conducted upon kabesak with other plants at the growth stages of the poles and trees in the 4 types of land. The association test demonstrated that kabesak was significantly associated with only a few plant species. Table 2 shows the types of plants that after tested, were associated with kabesak. The form of association of kabesak with other plants is both negative and positive.

Positive associations of kabesak with other plant species indicate that the kabesak species have similar resemblance to the habitat and provide the same response to both biotic and abiotic factors. The negative association indicates that the species pair does not show tolerance to living together in the same area, or there is no mutually beneficial relationship, especially in the spatial distribution of living space (Kurniawan et al., 2008). Positive associations between kabesak and *Ziziphus timoriensis* in primary and secondary forests is related to the tolerance in living space distribution, where *Z. timoriensis* as a relatively small tree, able to grow and develop under the canopy of kabesak. *Ziziphus celtidifolia* is a plant that occupies the primary forest's top canopy, analogous to kabesak. The similarities in habitat and response to biotic and abiotic factors render both types of plants to be able to live together. Positive associations are also found between kabesak and *Acacia nilotica* in scrubland and grasslands. *A. nilotica* is reported to be a highly invasive plant species in savanna Baluran National Park (Djufri, 2004). In Timor Island, this plant also looks very invasive on scrubland and grassland. Positive associations between kabesak and *A. nilotica* show that both plants able to occupy and grow together at the one particular site.

D. Edaphic characteristics of the habitat of Kabesak

Characteristics of soil physical and chemical properties in which kabesak grows can be seen in Table 3. Based on the assessment criteria of Balittanah (2009), in the primary forests, the average values of soil chemical parameters that are included in the medium category are N, P, and Na. Those which belong to the high category are C, C / N, Mg, and CEC, while the average values that are categorized as very high are that of Ca, K, and base saturation. In the secondary forest, the average values of Ca, K, and base saturation soil parameters are categorized as very high. C / N, Mg, and CEC are in the high category, C, P, and Na are in the medium category, while the average values of N parameter are in a low category. Furthermore, the average values of soil parameters categorized as very high in shrubs and grasslands belong to Ca, Na, and base saturation.

The high category comprises of Mg, K, while the parameters belonging to the medium category are C, C / N, P, CEC. The low category is made up solely by N. In the garden area, the average values of soil parameters in Ca and base saturation are included in the very high category. K and CEC are included in the high category, while N, P, and Mg are in the medium category. The low category is made up by C and C / N. This implies that kabesak can live on infertile soils, and several species of the Acacia genus such as *A. koa* and *A. mangium* are also known to be able to live on less fertile soils (Baker et al., 2009; Krisnawati et al., 2011).

Ca and base saturations are identified to have average values which point to a very high category in all land types. This can be explained by the high quantities of rocks and minerals that produce Ca in the soils of Timor Island. Ca plays an important role in the plant as part of the cell

Table 2. Kabesak associations with other plant species in different types of land
***Tabel 2.** Asosiasi kabesak dengan tanaman lain di beberapa tipe lahan*

Species (*Spesies*)	$\chi^2_{0.1}$	χ^2 values (X^2 hitung)	Association (*Asosiasi*)	Type of association (*Tipe asosiasi*)
Primary forest (Hutan primer)				
1 *Ziziphus timoriensis*	2.70	2.89	Significant	Positive
2 *Ziziphus celtidifolia*	2.70	2.99	Significant	Positive
Secondary forest (Hutan sekunder)				
1 *Ziziphus timoriensis*	2.70	4.22	Significant	Positive
Grassland and shrub (padang rumput dan semak belukar)				
1 *Cassia javanica*	2.70	5.45	Significant	Negative
2 *Acacia nilotica*	2.70	2.96	Significant	Positive
3 *Alstonia villosa*	2.70	3.03	Significant	Negative
Garden (Kebun)				
1 *Sterculia pentandra*	2.70	5.10	Significant	Negative
2 *Casuarina junghuhniana*	2.70	3.61	Significant	Negative
3 *Psidium eugenii*	2.70	7.22	Significant	Negative

Table 3. Soil physical and chemical characteristics under kabesakk stands
Tabel 3. *Karakteristik fisika dan kimia tanah di bawah tegakan kabesak*

No.	Variable (*Variabel*)	Primary forest (*Hutan primer*)	Secondary forest (*Hutan sekunder*)	Grassland and shrub (*Padang rumput dan semak belukar*)	Garden (*Kebun*)
1.	pH	7.31±0.13	7.41±0.22	7.37±0.48	7.29±0.25
2.	C (%)	3.44±2.08	3.00±1.95	2.09±1.39	2.00±1.03
3.	N (%)	0.24±0.12	0.20±0.11	0.17±0.10	0.31±0.23
4.	C/N (%)	21.73±26.27	16.05±9.58	11.32±1.96	9.39±5.09
5.	P (ppm)	10.73±5.24	10.83±6.57	8.32±3.78	8.88±3.89
6.	Ca (cmol $^{(+)}$/kg)	65.19±4.56	60.97±11.59	41.43±9.45	55.28±11.45
7.	Mg (cmol $^{(+)}$/kg)	3.27±0.92	3.17±1.47	2.70±1.10	1.42±0.60
8.	K (cmol $^{(+)}$/kg)	1.80±1.79	1.44±0.83	0.78±0.66	0.82±0.80
9.	Na (cmol $^{(+)}$/kg)	0.61±0.29	0.54±0.14	1.23±1.87	0.39±0.17
10.	CEC (KTK) (cmol $^{(+)}$/kg)	40.77±16.13	35.75±17.57	19.07±12.45	28.86±13.03
11.	Base saturation (kejenuhan basa) (%)	154.51±42.45	130.62±30.83	102.32±5.47	184.31±100.06
12.	Sand (pasir) (%)	9.30±4.92	17.39±12.14	28.43±9.47	26.21±20.66
13.	Silt (debu) (%)	33.83±6.73	28.99±14.60	32.71±19.15	40.21±18.27
14.	Clay (liat) (%)	56.85±4.00	53.6±12.06	38.85±24.66	33.20±17.69

structure of the wall and cell membrane, which contributes to the formation or division of new cells. The high saturation value of the base is suspected to be related to the high value of Ca element in the soils of Timor Island, and therefore soil fertility failed to be properly described.

E. Density of Kabesak with Edaphic Factors

Analysis results of the principal component on 13 variables of the edaphic factors point to 5 principal components (PC) factors which are adequate to explain the whole data. The five components are able to account for 83.2% of the total diversity of soil properties data. The five principal components (PC1, PC2, PC3, PC4, and PC5) contributed to the various soil properties as of 34.1%, 16.1%, 15.4%, 11.1%, and 6.4%, respectively. This shows that the first principal component is more prominent in explaining the information regarding the edaphic factor that affects kabesak abundance compared to the others. The other principal components also contribute to the diversity that describes and explains the condition of the edaphic factors in which kabesak grows on, with relatively no significant values apart between them. The eigenvalue and eigenvector values of each edaphic factor variable are presented in Table 4.

The clay fraction component is the most influential edaphic factors in the first principal component factor (PC1), followed by the cation exchange rate (CEC) variable, pH, C organic, and Ca. The second principal component variables which show the most influential are the base saturation and nitrogen. Moreover, the elemental variables of Phosphorus and Potassium are the most influential edaphic factor in the third principal component. Nitrogen, calcium, and base saturation element variables are identified to be the most influential factors in the fourth principal component. Lastly, of the fifth principal component, base saturation and silt fraction are

Table 4. Eigenvalue and factor values of each additional variable in kabesak habitats
Tabel 4. *Nilai eigenvalue dan nilai faktor masing-masing variabel edafis tempat tumbuh kabesak*

No.	Variable	PC1	PC2	PC3	PC4	PC5
1.	Eigenvalue	4.439	2.094	2	1.444	0.831
2.	Proportion	0.341	0.161	0.154	0.111	0.064
3.	Cumulative	0.341	0.503	0.656	0.768	0.832
4.	pH	-0.338	0.243	0.04	-0.193	-0.115
5.	C-org	0.327	-0.004	0.431	-0.087	0.118
6.	N	0.16	-0.357	-0.125	0.391	0.212
7.	P	0.292	-0.052	0.401	-0.242	0.284
8.	Ca	0.334	0.047	-0.151	-0.487	-0.108
9.	Mg	0.195	0.476	0.133	0.129	-0.33
10.	K	0.292	0.176	0.414	0.052	0.182
11.	Na	-0.191	0.323	0.287	0.158	-0.428
12.	CEC	0.345	0.027	-0.364	-0.075	-0.225
13.	Base saturation	0.015	-0.396	0.047	-0.519	-0.425
14.	Sand	-0.204	-0.44	0.38	0.116	-0.265
15.	Silt	-0.277	0.286	-0.095	-0.355	0.446
16.	Clay	0.396	0.118	-0.226	0.211	-0.165

Table 5. Results of a generalized linear model of topographic factors on the density of kabesak
Tabel 5. *Hasil generalized linear model faktor topografi terhadap kelimpahan kabesak*

No.	Source (*Sumber*)	Type III Sum of Squares	df (db)	Mean Square (*Rata-rata*)	F (*F*)	Sig. (*Sig*)
1.	Corrected Model (model terkoreksi)	395,654[a]	42	9,420	1,779	0,004
2.	Intercept (intersepsi)	830,747	1	830,747	156,885	0,000
3.	Altitude (ketinggian)	33,889	3	11,296	2,133	0,097
4.	Slope (kelerengan)	0,173	4	0,043	0,008	1,000
5.	Aspect (arah lereng)	9,452	4	2,363	0,446	0,775
6.	Altitude * Slope (ketinggian*kelerengan)	19,829	6	3,305	0,624	0,711
7.	Altitude * Aspect (ketinggian*arah lereng)	25,952	9	2,884	0,545	0,841
8.	Slope * Aspect (kelerengan*arah lereng)	33,857	11	3,078	0,581	0,843
9.	Altitude * Slope * Aspect (ketinggian * kelerengan*arah lereng	19,333	4	4,833	0,913	0,457

the most influential factors.

The result of regression analysis of the principal components shows that the contribution of edaphic factor influences the population density of kabesak (individual / ha) as much as 37.7%. This indicates that 37.7% of kabesak abundance is influenced by edaphic variables, while the remaining 62.7% is influenced by other variables not included in the model. The regression equations of the principal components that are formed in sequence are as follows:

Y (Density of Kabesak) = 85.90 + 2.12 * pH + 1.22 * C-org (%) - 3.40 * N + 4.48 * P + 4.42 * Ca - 2.88 * Mg + 2.14 * K - 6.43 * Na - 1.07 * CEC - 4.24 * base saturation - 10.34 * sand + 13.00 * silt - 2.92 * Clay.

The regression model formulated points to several variables showing a considerable influence on kabesak density, which comprise of positive influences such as soil silt fraction and Phosphorus, as well as negative influences such as sand and sodium fractions. The silt fraction has a positive effect on the density of the silt because the soil with high fraction content of silt and clay has medium infiltration rate, which is more able to support the water for plants and is also more supportive of root plant development. Phosphorus elements also have a positive effect on the density of kabesak, because Phosphorus is one of the essential nutrients in the soil. Phosphorus plays an important role in the process of photosynthesis and carbohydrate metabolism. Sand fraction negatively affects the density of kabesak because soil with high sand content has low binding capacity towards water and nutrients required by plants (Hardjowigeno, 1992). Sodium (Na) is one of the nutrients for plants that can be a substitute for element K, especially as an enzyme activator.

F. Relationship of Kabesak Density and Topography Factor

Kabesak in Timor Island is found in all types of slope and aspect and is also found to grow in the altitudes of 1173 meters above sea level (ASL). The results of GLM analysis shown in Table 5, with p <0.10 indicate that the land altitude influences the density of the kabesak. Further results showed that the slope and the aspect had no significant effect on the density of the kabesak. Similarly, the analysis of interactions between altitude and slope, altitude with an aspect, slopes with an aspect, as well as the interactions of altitude, slope, and aspect, does not significantly affect kabesak feces at p <0.10. With R2 of 24.10%, the model is sufficient to explain only 24.10% of the presence of kabesak in a particular place. Kabesak is a plant that needs sunlight to grow so it can be expected that the influence of slopes and aspect on the Island of Timor does not reduce the intensity of sun exposure required by kabesak. Kabesak is also suspected to be one of the pioneer plants on the Island of Timor that initially fill in open fields forming the forest so that kabesak can inhabit the top layer of natural forest in Timor Island. A further test for altitude with Tukey test (α = 0.05) reveals that 0-300 m a.s.l., 300-600 m a.s.l., 600-900 m a.s.l. are not different from each other, while altitude > 900 m a.s.l. is significantly different from the other groups. This suggests that kabesak will more likely to grow at altitudes <900 m a.s.l and decreases its density at altitudes> 900 m a.s.l. Kabesaks can be categorized into lowland plants or zoning zones, both in the monsoon dry forest and monsoon savanna.

IV. CONCLUSIONS AND RECOMMENDATION

A. Conclusion

This research concludes that the structure of kabesak stands in secondary forest land, grassland or shrubs, and gardens show an inverse J-shaped, which points to good regeneration in those land types. In the primary forest, the saplings or poles of kabesak were found as very little compared to that of tree stages, which implies that the regeneration of the kabesak requires sunlight to grow, whereas the dense canopy in primary forests do block sunlight. There are many plants living alongside kabesak, yet only a few plants are associated with kabesak. Kabesak is a lowland plant that spreads more dominantly below 900 m a.s.l. The soil variables that have the highest positive effect on the density of kabesak are fraction silt of soil and phosphorus (P), while those having the highest negative effects are sandy soil and sodium fraction.

B. Recommendation

It is necessary to think about steps to maintain the regeneration in primary forests so that the regeneration of plants in primary forests continues. Kabesak has important benefits for the people of Timor Island because the cultivation efforts need to get attention from the local Government. Information about kabesak cultivation techniques needs to be studied further.

ACKNOWLEDGEMENTS

We thank Iman D. Kause and Junaidi Sabuna for providing help in data collection; Chaikal Adiyansyah for performed the statistical analysis; Rio Bire for wrote the article.

REFERENCES

Antos, J.A., Filipescu, C.N., & Negrave, R.W. (2016). Ecology of western redcedar (*Thuja plicata*): Implications for management of a high-value multiple-use resource. *Forest Ecology and Management* 375: 211-222.

Arthanarieswaran, V.P., Kumaravel, A., & Saravanakumar, S.S. (2015). Characterization of new natural cellulosic Fiber from *Acacia leucophloea* bark. *International Journal of Polymer Analysis and Characterization* 20 (4): 367-376.

[Balittanah] Badan Penelitian Tanah. (2009). *Petunjuk teknis: analisis kimia tanah, tanaman, air dan pupuk.* Jakarta: Departemen Pertanian. [Indonesian]

Baker, P.J., Scowcroft, P.G., & Ewel J.J. (2009). *Koa (Acacia koa) ecology and silviculture*. Gen. Tech. Rep. PSW-GTR-211. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Botequim, B., Zubizarreta-Gerendiain, A., Garcia-Gonzalo, J., Silva, A., Marques, S., Fernandes, P.M., Pereira, J.M.C., & Tome, M. (2015). A model of shrub biomass accumulation as a tool to support management of Portuguese forests. *iForest - Biogeosciences and Forestry, 8*, 114-125. doi:10.3832/ifor0931-008

Clark, A.L., & Clair S.B.S. (2011). Mycorrhizas and secondary succession in aspen–conifer forests: Light limitation differentially affects a dominant early and late successional species. *Forest Ecology and Management 262*, 203-207.

Djufri. (2004). *Acacia nilotica* (L.) Willd. ex Del. dan permasalahannya di Taman Nasional Baluran Jawa Timur.. *Biodiversitas, 5*(2), 96-104.

Fonseca, T.F., & Duarte, J.C. (2017). A silvicultural stand density model to control understory in maritime pine stands. *iForest -Biogeosciences and Forestry,* 10, 829-836. doi: 10.3832/ifor2173-010 [online 2017-09-25]

Fortini, L.B,. & Zarin, D.J. (2011). Population dynamics and management of Amazon tidal floodplain forests: Links to the past, present and future. *Forest Ecology and Management, 261*, 551-561.

Fuentes-Ramirez, A., Pauchard, A., Cavieres, L.A., & Garcia, R.A. (2011). Survival and growth of *Acacia dealbata* vs. native trees across an invasion front in South-Central Chile. *Forest Ecology and Management, 261*, 1003-1009.

Gallegos, S.C., Beck, S.G., Hensen, I., Saavedra, F., Lippok, D., & Schleuning, M. (2016). Factors limiting montane forest regeneration in bracken-dominated habitats in the tropics. *Forest Ecology and Management, 381*, 168-176.

Heyne, K. (1987). *Useful plants of Indonesia Jilid ke-3.*: Jakarta: Badan Penelitian dan Pengembangan Kehutanan, Departemen Kehutanan. [Indonesian]

Hardjowigeno, S. (1992). *Soil Science.* Jakarta: PT Melton Putra. [Indonesian]

Herrero-Jauregui, C., Sist, P., & Casado, M.A. (2012). Population structure of two low density neotropical tree species under different management systems. *Forest Ecology and Management,* 280: 31-39.

Hidayat, S. (2014). Kondisi vegetasi di Hutan Lindung Sesaot, Kabupaten Lombok Barat,Nusa Tenggara Barat, sebagai informasi dasar pengelolaan Kawasan. *Jurnal Penelitian Kehutanan Wallacea, 3*(2), 97-105.

Imran, I., Hussain, L., Zia-Ul-Haq, M., Janbaz, K.H., Gilani, A.H., & De Feo, V. (2011). Gastrointestial and respiratory activities of *Acacia leucophloea. Journal ethnopharmacol*, *138*(3), 676-682.

Kai, M., Genyou, L., Leijie, Z., Caixia, Y., & Houhua X. (2013). Population structure and distribution patterns of the rare and endangered *Ardisia violacea* (Myrsinaceae). *Acta Ecologica sinica, 33,* 72-79.

Karyati., Ipor, I.B., Jusoh, I., & Wasli, M.E. (2017). The diameter increment of selected tree species in a secondary tropical forest in Sarawak, Malaysia. *Biodiversitas, 18*(1), 304-311.

Krebs, CK. (2002). *Ecological methodology*. Ed ke-2. New York: Harper & Row Publisher.

Krisnawati, H., Kallio, M., & Kanninen, M. (2011). *Acacia mangium Willd. Ecology, silviculture and productivity*. Bogor: Center for International Forestry Research (CIFOR).

Kurniawan, A., Unduharta, N.K.E., & Pendit, I.M.R. (2008). Association of dominant tree species in lowland forest Tangkoko Nature Reserve, Bitung, North Sulawesi. *Biodiversitas*, *9*(3),199-203.

Kusmana, C. (1997). *Metode survei vegetasi*. Bogor: Institut Pertanian Bogor (IPB).

Li, W., & Zhang G.F. (2015). Population structure and spatial pattern of the endemic and endangered subtropical tree *Parrotia subaequalis* (Hamamelidaceae). *Flora,* 212, 10-18.

Midgley, J.J., Lawes, M.J., & Chamaille-Jammes, S. (2010). Savanna woody plant dynamics: the role of fire and herbivory, separately and synergistically. *Australian Journal of Botany, 58*, 1-11.

Muhdin, Suhendang, E., Wahjono, D., Purnomo, H., Istomo., & Simangunsong B.C.H. (2008). Keragaman struktur tegakan hutan alam sekunder. *Jurnal Manajemen Hutan Tropika* 2, 81-87. [Indonesian].

Mueller-Dombois, D., & Ellenberg, D.H. (1974). *Aims and methods of vegetation ecology.* New York: John Wiley & Sons, Inc.

Njurumana, G.N. (2015). Ekologi sosial pilang (*Acacia leucophloea*) di Kabupaten Timor Tengah Selatan, Nusa Tenggara Timur. In: Setyawan A.D, Sugiyarto, Pitoyo A, Hernawan U.E, Sutomo, Widiastuti A, Raqib S.M, Suwandhi I, Rosleine D (eds). *Proceeding of National Seminary Indonesian Biodiversity Comunnity*. Bandung, 13 June 2015. [Indonesia]

[NFTA]. (1996). *Acacia leucophloea - shade and fodder for livestock in arid environments*. NFTA 96-04. www.nzdl.org/gsdlmod

Prior, L.D., McCaw, W.L., Grierson, P.F., Murphy, B.P., & Bowman, D.M.J.S. (2011). Population structures of the widespread Australian conifer *Callitris columellaris* are a bio-indicator of continental environmental change. *Forest Ecology and Management,* 262, 252 - 262.

Rianawati, H. (2014). Studi kelas kuat kayu kabesak (*Acacia leucophloea* (Roxb.) Willd.). *Majalah Warta Cendana, 7*(2), 1-5.

Riwu-Kaho, N. (2010). *The relationship between free grazing & forest fire frequency to the Eucalyptus urophylla (Ampupu) stands in Mount Mutis Nature Reserve, West Timor, East Nusa Tenggara*. [Thesis]. Gadjah Mada University, Yogyakarta.

Shankar, U. (2001). A case of high tree diversity in sal (*Shorea robusta*) dominated lowland forest of Eastern Himalaya: floristic composition, regeneration, and conservation. *Current Science*, *81*(7), 776-786.

Sowndhararajan, K., Joseph, J.M., & Manian, S. (2013). Antioxidant and free radical scavenging activities of Indian Acacias: *Acacia leucophloea* (Roxb.) Willd., *Acacia Ferruginea* Dc., *Acacia Dealbata* Link. and *Acacia Pennata* (L.) Willd,. *International Journal of Food Properties, 16*(8), 1717-1729.

Suarez, M.L., & Kitzberger, T. (2008). Recruitment patterns following a severe drought: long-term compositional shifts in Patagonian forest. *Canadian Journal of Forest Research, 38,* 3002-3010.

Tang, C.Q., Yang, Y., Ohsawa, M., Momohara, A., Hara, M., Cheng, S., & Fan, S. (2011). Population structure of relict *Metasequoia glyptostroboides* and its habitat fragmentation and degradation in south-central China. *Biological Conservation, 144*, 279-289.

Venter, S.M., & Witkowski, E.T.F. (2010). Baobab (*Adansonia digitata* L.) density, size-class distribution and population trends between four land-use types in Northern Venda, South Africa. *Forest Ecology and Management, 259*, 294-300.

Zida D, Tigabu M, Sawadogo L, & Oden P.C. (2008). Initial seedling morphological characteristics and field performance of two Sudanian savanna species in relation to nursery production period and watering regimes. *Forest Ecology and Management 255*, 2151-2162.