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Growth and Habitat Preference of *Acacia decurrens* Willd. (Fabaceae) after the 2010 Eruption of Mount Merapi, Indonesia

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ABSTRACT— ***Succession of Mount Merapi supported the spread of invasive species. Mount Merapi after the eruption in 2010 was dominated by Acacia decurrens. This research was conducted from December 2014 to March 2015 at locations that heavily damaged by the eruption such as Cangkringan and Kemalang Resort. All of sample units were taken using random sampling. Analysis of vegetation in plot observations were made using line transect with length of line 20 x 200 m and direction perpendicular to the contour. Morphometric variables of two habitats were carried out such as diameter at breast height (dbh), basal area, height, and volume. Habitat preference was calculated using Principle Component Analysis (PCA) in PAST 3.06. A. decurrens population after 5 years eruption has reached the level of growth poles. High density condition of A. decurrens was predicted to be able to disturb the growth of other species. Habitat preference of A. decurrens strongly correlated with temperature and slope conditions. The study about the growth condition and habitat preference of A. decurrens are important for management area and restoration program.***

Keywords— *Acacia decurrens*, growth, habitat preference, restoration

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1. INTRODUCTION

Succession of Mount Merapi will support the spread of invasive species that often live in nutrient-poor habitat, it because almost all invasive species cannot adapt in vegetation which already climax and also difficult to integrate (Steenis, 2006). *A. decurrens* was one of dominated colonies species after the eruption in 2006 (Suryanto *et al*., 2010a) and in 2010 (Gunawan *et al*., 2015; Suryawan *et al*., 2015; Sutomo, 2010).

History of *A. decurrens* on Mount Merapi was initially introduced by Perhutani as a native species from Australia. It has several benefits such as a basic substance for making charcoal and bark extract for batik material (Gunawan *et al*., 2015). *A. decurrens* has a specific characteristic to grow in area that affected by eruption because the seed can grow rapidly when exposed to heat (Desitarani *et al*., 2014; Richardson & Kluge, 2008). *A. decurrens* is fast growing species. After the eruption in 2006, the highest mean of diameter stock= 14.22 ± 1.85 cm, mean of height= 5.97 ± 0.66 m, mean of basal area= 72.07 ± 18.51 m^2/ha, and mean of volume= 184.44 ± 24.59 m^3/ha (Suryanto *et al*., 2010b). Distribution pattern of *A. decurrens* is clumped in habitat (Suryanto *et al*., 2010c).

Other species of Acasia that already reported to be invasive in Indonesia is *A. nilotica* at Baluran National Park, it caused herbivore feeding become recessive (Caesariantika *et al*., 2011; Djufri, 2004; Setyawati & Susminto, 2015; Tjitrosoedirdjo, 2005). Furthermore *A. Mangium* also was indicated invasive in Tanjung Puting National Park (Sunaryo & Girmansyah, 2015). *A. Mangium* also found on Mount Merapi National Park (MMNP) after the eruption in 2010 even though there was not many (MMNP, 2011a). In Europe, especially in France, Italy, Portugal, and Spain, *A. dealbata*, *A. melanoxylon*, and *A. longifolia* reported as serious threat (Lorenzo *et al*., 2010). The aims of this research were (1) to determine the growth conditions of *A. decurrens* based on morphometric and (2) to identify the habitat preference of *A. decurrens* after the 2010 eruption of Mount Merapi.

2. METHOD

2.1. Study site

MMNP is administratively located in 2 provinces, Yogyakarta Province (Sleman District) and Central Java Province (Magelang, Boyolali, and Klaten District). The research locations were at heavily damage, Cangkringan Resort (CR) and Kemalang Resort (KR). Heavily damaged areas are habitat affected by the eruption thereby there is no vegetation left. The research was conducted from December 2014 to March 2015, approximately after 5 year the eruption in 2010.

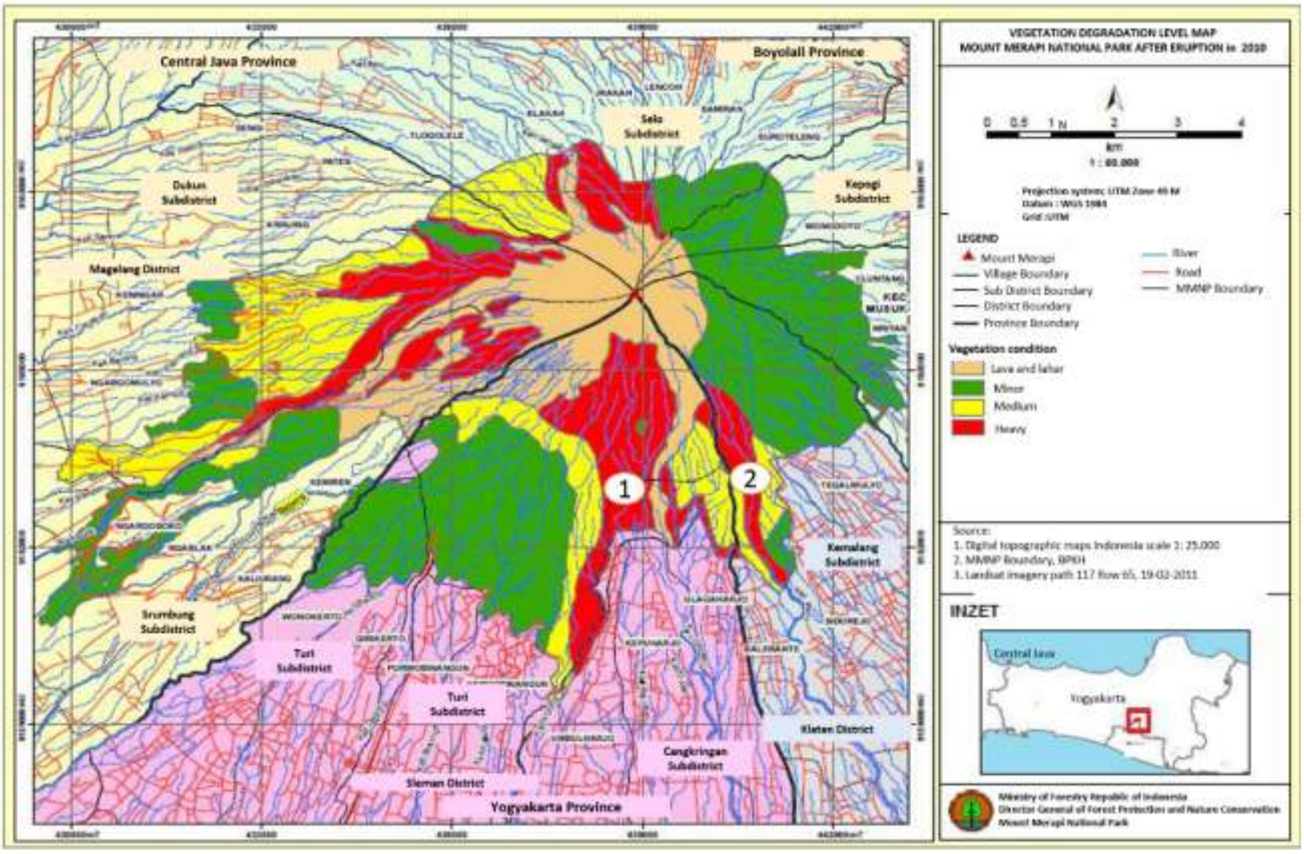

Figure 1: Map of sampling sites on Merapi Mount. Heavily damage area indicated by red color. (1) Cangkringan Resort and (2) Kemalang Resort (MMNP 2011b).

2.2. Sampling

All of sample units were taken using random sampling method. Analysis of vegetation in plot observations were made using line transect method with length of line 20 m x 200 m direction perpendicular to the contour. Vegetation sampling was made in a plot that is divided into each plots 20 m x 20 m (tree), 10 m x 10 m (pole), 5 m x 5 m (sapling), and 2 m x 2 m (seedling). Total sampling plots were determined using species area curve (Cain 1938; Scheiner 2003). A hagameter was used to determine height of *A. decurrens*. A phi-band was used to determine diameter at breast height (dbh) of *A. decurrens*. Global positioning system (GPS) was used to determine elevation. A clinometer sunto was used to determine slope. A thermo hygrometer was used to determine temperature and humidity. Line intercept method was used to determine cover (combine canopy and undergrowth covers).

2.3 Analysis data

The important quantitative analysis such as density, basal area, and volume is an expression of the numerical strength of species where the total number of individuals of each species in all plot is divided by the total number of plot studied.

Density calculated by the equation:

$$\text{Density} = \frac{\text{Total individual of species}}{\text{Total of plot (ha)}}$$

Basal area per plot was calculated by:

Basal area $= \sum_{i=1}^{n} \frac{1}{4}\, \pi\, dbhi^2$

Volume per plot was calculated by:

Volume $= \sum_{i=1}^{n} \frac{1}{4}\, \pi\, dbhi^2\, h\ 0.8$

Description: dbhi is diameter at breast height (dbh) on the plot to i; and h is the height.

Differences median value of morphometric variables of two habitat were calculated using non-parametric analysis Mann-Whitney (Fowler, 1998). Calculating difference mean value of abiotic environmental variables such as elevation, slope, temperature, humidity, cover of two habitats were used T-test analysis (Fowler, 1989). All of those analyses were calculated using SPSS 16. Habitat preference was calculated using multivariate analysis of Principle Component Analysis (PCA) in PAST 3.06. PCA is a statistical analysis techniques to transform original variables that still correlate into a set of new variables to eventually become uncorrelated (Widarjano, 2010).

3. RESULTS AND DISCUSSION

3.1 Dynamic growth

The result of dinamic growth showed that the mean of dbh (13.53 ± 3.28 cm) and mean of height (10.65 ± 2.29 m) in CR was similar mean of dbh (13.58 ± 2.61 cm) and mean of height (11.84 ± 2.35 m) in KR. Meanwhile, mean of basal area (0.10 ± 0.05 m^2 /ha) and mean of volume (0.92 ± 0.61 m^3/ha) in CK is higher than mean of basal area (0.01 ± 0.01 m^2/ha) and mean of volume (0.14 ± 0.02 m^3/ha) in KR. Analysis of difference median in both showed that *A. decurrens* has significant differences on height (U= 2268.50; $P < 0.001$), basal area (U= 0.00; $P < 0.001$), and volume (U= 8.00; $P < 0.001$) (Table 1).

Table 1 Mean of morphometric of *A. decurrens* in CR and KR.

Morphometric	Location		Mann-Whitney	
	CR	KR	U	P
dbh (cm)	13.53 ± 3.28	13.58 ± 2.61	3141.00	ns
Height (m)	10.65 ± 2.29	11.84 ± 2.35	2268.50	***
Basal area (m^2/ha)	0.10 ± 0.05	0.01 ± 0.01	0.00	***
Volume (m^3/ha)	0.92 ± 0.61	0.14 ± 0.02	8.00	***

The morphometric of *A. decurrens* was tested using Mann-Whitney U test. U values their significance are: *$P < 0.05$; **$P < 0.01$; *** $P < 0.001$

The density of seedlings, saplings and poles in CR were higher than KR. Condition of *A. decurrens* in both habitats have high dominance, it can give negative impact to growth of others species. Density conditions in CR and KR showed in Figure 2. Tree stage is still found in both habitats because it is not affected by the eruption in 2010. Abundance of *A. decurrens* in CR was dominated by sapling (173 individuals) and pole (100 individuals), and it is higher than in KR. Abundance of seedling and tree in both habitats is low. Suryawan *et al*., (2015) revealed that number of seedlings of *A. decurrens* in both locations was lower than sapling and poles. Those conditions showed that the "*J*" curve was not inverted because absence of regeneration species was not adequate (Dendang & Handy, 2015; Hilman, 2012). Steenis (2006) stated that under herb will be grown the fast growing woody trees (tree weeds) after finding a chance to germinate, settle down and have a rapid growth. However, after age of 10-25 years, the tree weeds will die and others perfect trees will appear.

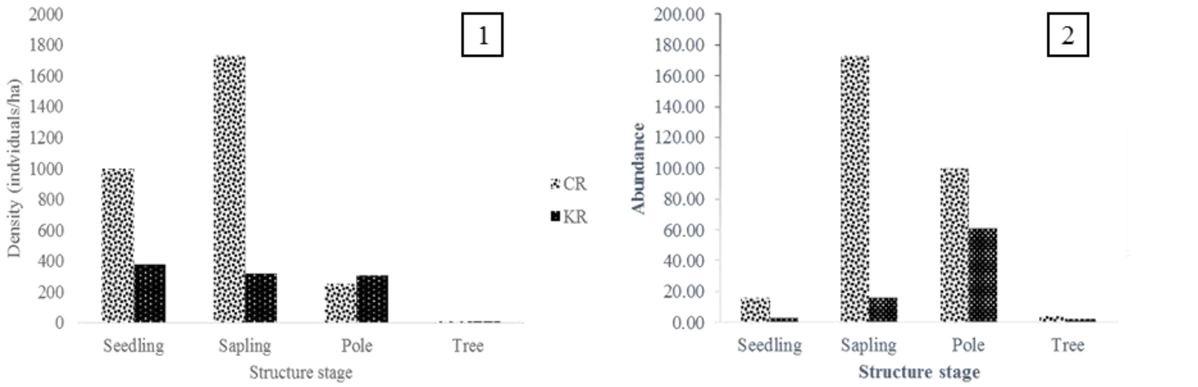

Figure 2: (1) Density and (2) abundance condition of *A. decurrens*

3.2 Habitat preference

T-test difference mean between two habitat showed significant differences on elevation (t = -7.48; P < 0.001), temperature (t = 0.00; P< 0.001), and humidity (t = 0.28; P < 0.05). PCA performed can be grouped into 2 components that have eigenvalue > 1. The first Principal Component (PC 1) has eigenvalues 2.20 and able to explain variance 36.67 % of total data. The second Principal Component (PC 2) has eigenvalues 1.50 and able to explain variance 24.97 % of total data. The cumulative of principal component 1 and 2 can able explain variance 61.64% of total data.

Table 3 Principal component analysis on five abiotic environment variables and abundance of *A. decurrens*.

PC	Eigenvalue	% variance	Cumulative eigenvalue	Cumulative %
1	2.20	36.67	2.20	36.67
2	1.50	24.97	3.70	61.64
3	0.94	15.72	4.64	77.36
4	0.81	13.57	5.46	90.93
5	0.44	7.28	5.89	98.21
6	0.11	1.79	6.00	100.00

PC1 indicated that value of temperature (0.60) and humidity (-0.47) have the highest effect. PC 2 indicated that value of cover (0.65) and slope (0.56) have the highest effect. Colonies of *A. decurrens* can be dominant because its character of this species include the ability to grow in various types of habitat (Maslin & McDonald, 2004).

Table 3: Factor loadings of principal component analysis on five abiotic environment variables and abundance of *A. decurrens*. High factor loadings are indicated by gray cells.

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
Elevation	-0.41	0.56	-0.06	0.03	-0.58	0.43
Slope	0.33	0.18	0.29	0.88	0.00	0.05
Temperature	0.60	0.14	-0.27	-0.21	0.22	0.67
Humidity	-0.47	-0.46	0.34	0.13	0.29	0.59
Cover	-0.21	0.65	0.26	-0.13	0.66	-0.10
Abundance	0.31	0.01	0.81	-0.39	-0.30	0.02

Figure 3 showed that the presence of *A. decurrens* scattered in various environmental conditions in both habitat. Abundance was positively correlated with slope and temperature. Temperature arrow has angle adjacent with abundance of *A. decurrens* arrow that indicates strong correlation. Cover, elevation, and humidity negatively correlated with abundance of *A. decurrens*. Acacia species tend to like heat conditions because positively correlated with germination ability (Brown *et al*., 2003; Danthu *et al*., 2003).

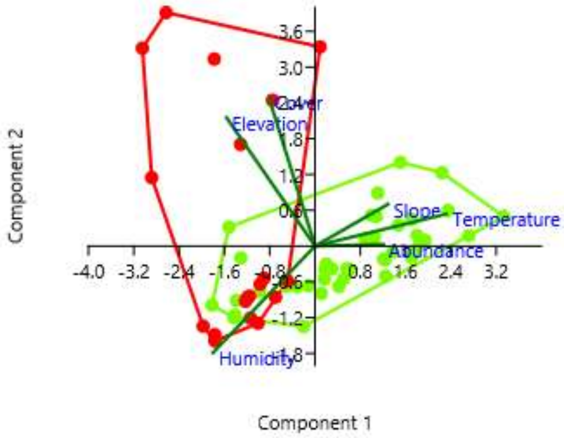

Figure 3: Biplot of PCA relation between abiotic with abundance of *A. decurrens.* CR indicated by green color and KR by red color.

3.3 Conservation implication

Information characteristics habitat of *A. decurrens* can be used as database for management area. Some treatments that can be applied to control invasive species were (1) Biological control (Meyer & Fourdrigniez, 2011; Pouteau *et al*., 2015). Fungi of *Colletotrichum gloeosporioides* f. sp. miconiae reported successfully controlled of invasive species *Miconia calvescens* (Meyer and Fourdrigniez, 2012), whereas, in South Africa reported *A. longifolia* successfully pressed reproduction by insect *Trichilogaster acaciaelongifoliae* Froggatt (Dennill & Donnelly, 1991) and also *A. pycnantha* with *Trichilogaster* sp. A (Hoffman *et al*., 2002). (2) Planting native species is also an important factor in restoration program. MMNP has doing restoration by planting *Schima wallichii*. *S. wallichii* recommended is main crop of 95 native species on Mount Merapi (GMU, 2011). Preliminary data from MMNP suggest that only *S. wallichii* can grow than others native species such as *Syzygium polyanthum*, *Inocarpus fagiferus*, *Syzygium cumini*. Native species restoration must have high growth rate because population growth rate of invasive species (λ) is higher than native species (Ramula *et al*., 2008).

More importantly, restoration must consider specific of local conditions (Wakler *et al*., 2009). Existence of invasive species should be studied, especially about environmental impacts, because in handling the problems require high cost (Rejmanék *et al*., 2013). Negative effect of *A. decurrens* should be considered for other species. For example, other species of Acacia reported has anegative effects due to allelopathic among others, thermed *A. nilotica* (Bashir, 1991; El Khawas & Shehata, 2005; Al Wakeel *et al*., 2007), *A. auriculiformis* (Jadhav & Gaynar, 1992; Rafiqul *et al*., 2003; Vijayan, 2015), *A. confusa* (Chou *et al*., 1998), *A. dealbata* (Lorenzo *et al*., 2008), *A. melanoxylon* (Gonzales *et al*., 1995; Souto *et al*., 2001), *A. cyanophylla* (El Ayeb *et al*., 2014), *A. mangium* (Ismail & Metali, 2014), *A. tortilis* (Noumi & Chaieb, 2011), *A. saligna* (Kamel & Hammad, 2015), *A. holosericea* (Quddus *et al*., 2014). Another important side to be considered is condition of Mount Merapi, where still has potential eruption. Existence of *A. decurrens* which has a high density could be an obstacle and deterrent to pyroclastic flows.

4. CONCLUSION

A. decurrens growth after the eruption in 2010 showed has reaching the pole, which height, basal area, and volume of *A. decurrens* have significant differences in both locations. Habitat preference of *A.decurrens* positively correlated with temperature and slope conditions. Information about the growth dynamics and habitat preference can be used as a consideration to restoration programs.

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