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COMPOSITION AND SOME ECOPHYSIOLOGICAL CHARACTERS OF WATER CATCHMENT AREA'S VEGETATION OF GEGER SPRING, BANTUL, YOGYAKARTA, INDONESIA

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ABSTRACT

Water debit of GegerSpring, Pundong, Bantul, Yogyakartahascalled attention due to decreasing of water resource within 8 years lately. Water Catchment Area (WCA) of Geger Spring as an ecosystem had been struck by rapidly changed of landuse. This research aims to analysethe vegetation composition and its physiological characters of dominant plant cover species in Geger spring's WCA. WCA was constructed using Quickbird image, topographic and geohydrological map; and plant cover classification was delineated based on its image.Geger spring's WCA is 9,875.3 ha size,20.0% of WCA is still coverred by dense plantation dominated by Swietenia mahagoni (IV=110.8 %), and more than 68%of area is dominated by teak and Gnetum gnemonplantations (IV=92.1%) represented medium plant cover class. The shrubs, herbaceous and grasses of floor vegetation are dominated with Chromolaenaodorata and Ageratum conyzoides, Piperomia pellucida and Oplismenus burmanii.Transpiration rate of dominant tree seedlings (3 months) from high to low are F. benjamina(> 2 yrs) , T. grandis, S.aqueum, I. fagiverus, and G. gnemon. Water suction by roots from high to low are T. grandis, I. fagiverus, F. benjamina, Syzygium sp. and G. gnemon respectively. Percentage of water infiltration of land covered by shrubs is 75.2% and covered by herbaceous and grasses is 77.6%.

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Plant species selection for revegetation of spring WCA is very important in order to ensure water spring sustainability.

Keywords: Geger spring, WCA, plant composition, physiological character

INTRODUCTION

Geger spring is located in Karst ecosystem at Pundong, Bantul, Yogyakarta. It was a continuous spring and has been abundance ofwater resource until 2006, and now it becomes an intermitten spring. Potential water supply infiltrated to the ground from rainfall (range annual rainfall 1500-1900 mm) is not highly supported in Karst eco-system, that probably vegetation can not grow well on this WCA.

The decrease of water resource of a spring mainly because of afforestation in the catchment area (Dye & Versfeld, 2007) and in Geger case predicted due to landuse changes (Sancayaningsih *et al*., 2016) and geohydrological position.

Water Catchment Area (WCA) of a spring is a sub-system of hydrological cycle system on earth that is boundaried by hills creates a basin to collect rainwater. This WCA is a complex and open ecosystem (Wagener *et. al*., 2007 inSaputra, 2014), and spring conservation relates closely to the WCA conservation (Che-Ngahand Othman, 2011).Logically, the wider and denser plant cover of the WCA, the more sustainable water resourse is. As an ecosystem, the WCA conservation is managed (Marsono, 2008) simultaneously in a conserved forest area thatmostly located in upstream and may be cross border of administrative authority.

The local people and local authority of surrounding a water spring may not understand ofthe WCA boundaries, limitations, and its plant coverconsiderations. Since2005,teak plantation has been promoted as the most promising

wood commodity that make people in Gunungkidul and Bantul districts plant teak on their land, including WCA of Geger spring at Pundong, Bantul, Yogyakarta.

VEGETATION CONTRIBUTION TO WATER CONSERVATION

Vegetation contribution to ground water conservation in WCA is especially through improvement on rainwater infiltration, and retain run-off and at the same time retain soil erossion(Asdac, 2010; Rangkisani, 2012). Connection between plant cover in a WCA and the decrease of spring water debit may not be understood completely, therefore this research aims to analyze eco-physiological characters of vegetation composition and its specific contribution to conserve water debit in Geger spring's WCA

METHODOLOGY

WCA was constructed using topographic map, and water accumulation flow can be analyzed using interpretation of contour, geohydrological position by Arc-GIS computer software prgram; and plant cover classification was using visual interpretation using quickbird satellite imagery.

Vegetation analysis was carried out using quadratic plot (10 x 10 m^2 for trees, 2 x 2 m^2 for sapling and shrubs, and 1 x 1 m2 for floor vegetation) methods, and plots were taken random proportionally to plant cover class areas. There were 45 tree plots, and 89 plots for seedling and floor vegetation. Geger spring is located between 07^0 44' 04" – 08^0 00' 27" latitude and 110^0 12' 34" – 110^0 31' 08" longitude. The research was conducted from June 2015 to May 2016.

Rainfall surface flow model was conducted by setting up 3 replicates of 0.5 x 0.5 m^2 plot models each for control, grass and herbaceous, and shrubs growth forms in surrounding spring. In this model, less than 5^o land-slope was selected, in order to get better initial data. Thirty liter of water was poured into plots homogenously with average water flow rate of 2.2 $m^3sec^{-1}$of the simulated water rainfall. Total duration time of simulation and the first time when surface flow was observed were recorded.The amount of water infiltrated was calculated from the total amount of water poured deducted with the amount of water collected as asurface flow.

Ecophysiological characters of selected trees were conducted in a green house. Three month-old seedling pots of 5 selected tree species were treated with 3 different soil humidities in order to obtain transpiration response to soil humidity. Tree transpiration was measured using Licor 6400 XP on the third leaves; while for trees and floor vegetation's (shrubs, herbaceous, and grasses) transpiration in the field were measured using Cobalt chloride test paper. Time duration of color change were recorded.

Water suction experiment by plant roots was conducted in a greenhouse using 3 month old seedlings of 5 selected species (*Ficus benjamina*, *Tectona grandis*, *Inocarpus fagiverus*, *Swietenia mahagoni*, and *Gnetum gnemon*), except for *Ficus*of 2 year seedlings.

RESULTS AND DISCUSSIONS

Plant cover classification

Based on visual interpretation on quickbird imagery, plant cover classification was grouped in Geger spring WCA as follows (Fig 2.). Class 5 represents rice paddy field, therefore analysis only based on 4 classes.

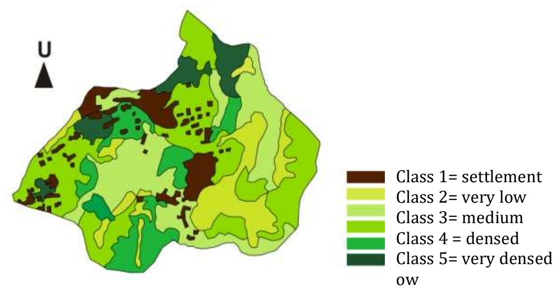

Fig.1. Plant cover classification in Geger WCA

Table 1. Plant cover classification and its area width

Number	Category	Area (m^2)	%
Class 1	Very densed	67.454,9	7
Class 2	Densed	127.792,7	13
Class 3	Moderate	315.697,2	32
Class 4	Low	223.821,9	23
Class 5	Very low	142.342,2	14
	Settlement	110.417,6	11
	Total	**987.526,4**	**100**

(Adopted from Putri, 2016)

VEGETATION COMPOSITION

There were 22 tree species belongs to 13 familia, 23 species of sapling, and 12 species of seedlingfound in the WCA of Geger spring. Important value of each growth form of dominant species in each classes were presented in Table 2, 3, and 4 for trees, sapling and seedling.

Table 2. Important values (%) of 3 dominant species of trees in 4 classes of WCA

Species	Important values of 3 dominant species in			
	Class 1	Class 2	Class 3	Class 4
A. auriculiformis	-	8.6	19.1	-
Artocarpuselasticus	12.6	-	-	-
Cocos nucifera	-	-	-	5.9
Gnetumgnemon	**26.5**	-	**23.6**	**27.5**
Swietenia mahagoni	-	29.8	-	-
Tectona grandis	**11.6**	**33.0**	**42.0**	**76.4**

(Adopted from Binsasi, 2016)

Tectona grandis and *Gnetum gnemon* have the highest important values (IV) in almost all classes (Table 2.), the biggest contribution of the IV for both tree species is the relative basal area. This means that both tree species are big trees and had been exist for long period of time. Teak has the highest economic and most popular wood species that had been planted by local people in the karst area. *Gnetum gnemon* also has an economic value and used by local people for food. Beside economic reason, both tree species are adapted in karst ecosystems.
Since among 4 classes of plant cover in Geger spring has different width area, and class 2 and 3 represented the highest area (68%), therefore discussion on vegetation analysis was only focussed on both classes.

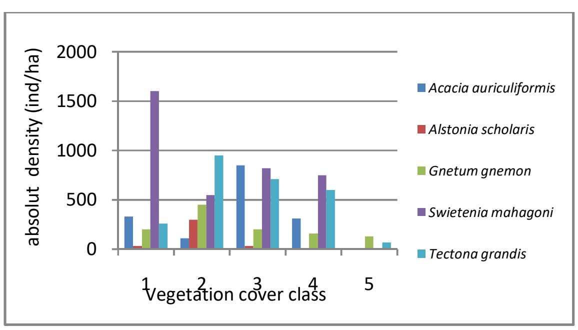

Fig.2. Absolut density of dominant tree species in each vegetation cover class in geger spring WCA

Fig. 2. shows the absolut density (individu/ha) of 5 dominant species in Geger spring's WCA. It shows that species with economical values of*T. grandis,* and*S. mahagoni* have the highest density(represent 600 – 950 ind/ha), while *G. gnemon*130 – 450 ind/ha

Of the sapling species analysis showed that among 23 sapling species found in Geger spring WCA, only 5 species had higher IV value in all classes (Table 3.). Important values of sapling showed higher values comparred to trees IV values. This indicates that existence of seedlings is promissing to continue the future community

Table 3. Important values (%) of 3 dominant species of sapling in 4 classes of WCA

Species	Important values of 3 dominant species in			
	Class 1	Class 2	Class 3	Class 4
A. auriculiformis	-	-	45.5	27.1
Ceiba pentandra	6.2	-	-	-
Gnetumgnemon	-	**14.8**	**29.3**	-
Swietenia mahagoni	**110.8**	**14.6**	**-**	**32.6**
Tectona grandis	**15.5**	**50.3**	**29.6**	**54.1**

(Adopted from Binsasi, 2016)

Of the Table 3 shows that both *Tectona grandis and Swietenia mahagoni* are dominant in almost all classes. This high IV value in sapling are contributed by both relative frequency and relative basal area values. This means that both species are distributed widely and had a better chance to survive. These two species have high economic value of wood. In terms of plant sustainability, *Tectona grandis* and *Gnetum gnemon* are the most spread and sustain species due to their high IV values in both Class 2 and 3 of Geger spring vegetation cover area.

Results of seedling plant species analysis of 12 species found in Geger spring were presented in Table 4. below. It shows on Table 4. that among 12 seedling species, only 6 species dominated in 4 classes, and the trend of species composition is different from tree or sapling. In seedling community, 2 species of *Alstonia scholaris* and *Swietenia mahagoni* are the most dominant and have the highest IV in at least 3 vegetation classes.

Table 4. Important values (%) of 3 dominant species of seedling in 4 classes of WCA

Species	Important values of 3 dominant species in			
	Class 1	Class 2	Class 3	Class 4
A. auriculiformis	4.8	-	6.4	-
Alstonia scholaris	-	**2.9**	**2.3**	**5.0**
Gnetumgnemon	-	**6.4**	**-**	-
Mangifera indica	-	**-**	**-**	4.9
Psidium guajava	6.0	**-**	**-**	-
Swietenia mahagoni	**-**	**5.9**	**12.7**	**5.4**

(Adopted from Binsasi, 2016)

Alstonia scholaris is exist in 3 vegetation cover classes, eventhough it was not dominant in sapling and tree growth forms. This probably due to natural distribution from trees which had been established in this area for long time, refering that germination of seedlings is not difficult but it should be away from the seed source.

Floor vegetation composition

There were 81 species of floor vegetation in the form of shrubs, lianas, seedlings, grasses and herbaceous plants. These belong to 37 familia. On the summary of floor vegetation composition in 4 classes of vegetation cover in Geger spring WCA was presented in Fig. 3 that shows the highest IV of each species of each growth forms.

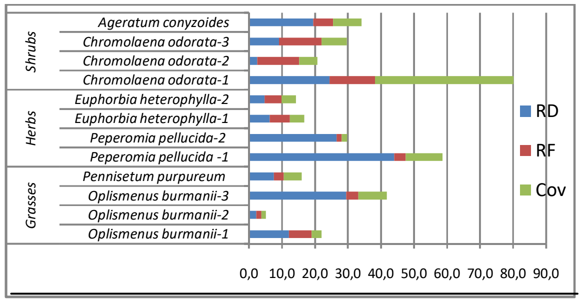

Fig.3. Species of each growth forms with the highest IV values in 4 vegetation cover classes in Geger spring WCA

The high IV values of grasses, herbaceous, and shrubs growth forms shown in Fig. 3. *Chromolaena odorata*, *Peperomia pellucida*, and *Oplismenus burmanii* had the highest IV values in almost all classes for shrubs, herbs, and grasses respectively. These three species were also observed become dominant species in other surrounding Springs (Sancayaningsih *et al*., 2015)

Herbaceous species and shrubs species had similar pattern of density to the tree vegetation classes (the most dense trees class corresponds to the highdensity of herbs and shrubs), not for grasses. This indicates that both dominant species of herbs and shrubs are shading tolerant adapted, while grasses of Cyperaceae and the most dominant species of *Oplismenus burmanii*is adapted in both sun or shading areas. The high IV for grasses and herbs except shrub were mostly contributed by their high relative density values. Both relative density and relative frequency of *Chromolaena odorata* highly contributed to its IV (Fig. 3.). This indicates that *C. odorata* is distributed easily and widely.

Ecophysiological Character of Some Selected

Tree Species

Transpiration rate experiment was conducted using 5 selected species, two of them are representing economic and fast growing tree species (*T. grandis* and *G. gnemon*). All test plant is 3 month-old seedling, except for *F. benjamina* are treated with 3 different soil humidities. Of the Table 5. shows that 2 years F. benjamina seedling perform high transpiration rate compared to other tree species in low up to high soil humidity condition. T. grandis, however shows the highest rate of transpiration in a high soil humidity condition, eventhough the seedling is 3 month old. This means that in high soil humidity teak is transpiring water more and equal to seedling of 2 years old of *F. benjamina*transpiration rate.

As a fast growing tree, all physiological proscess such as transpiration, respiration, and photosynthesis run faslty, and this needs more resources (water in this case) to carried out.

Table 5. Transpiration rates of 5 selected tree species at 3 different soil humidities condition

	Transpiration rate (mmol m^{-2} sec^{-1}) at 3 different soil humidities		
	Low	Medium	High
F.benjamina (>2 yrs)	**0.613**	**0.522**	**0.450**
Tectonagrandis	0.130	0.143	**0.460**
Syzygiumaqueum	0.269	0.196	0.317
Inocarpusfagiferus	-0.062	0.045	0.065
Gnetumgnemon	0.043	0.083	0.008

Among those 5 tree species, the first 3 species considered have high transpiration rates comparred to the last two species (*Inocarpus fagiverus* and *Gnetum gnemon*)

Experiment of water suction by root was carried out in a green house using the same of those 5 selected tree species before, in order to compare the water need for plant growth. The results of the experiment are presented in Table 6.

Table 6. Water suction by roots of 5 selected tree species

Species	Water suction by roots (ml/kg/day) in 3 different soil humidity levels		
	Low	Medium	High
Tectonagrandis	**195.7**	**198.8**	**112, 8**
Inocarpusfagiferus	96.6	88.6	67.8
Ficusbenjamina(2 yrs)	62.5	56.0	56.8
Syzygiumaqueum	50.4	34.1	40.1
Gnetumgnemon	44.0	32.2	30.5

Theoretically, water suction by roots decreases with the increase of soil humidity. Those 5 tree species follow the trend. Among those tree species, the highest water suction ability is *T. grandis*, followed by *I. fagiverus, F. benjamina, S. aquosum* and the last *G. gnemon*. The value of water suction of *T. grandis*amazingly twice higher than 2 year old *F. benjamina* seedling (112.8 and 56.8) in the high soil humidity. While in the low soil humidity, *T. grandis* needs more water (3 times bigger than *F. benjamina*) (Table 5.). This means that *T. grandis* consumed water more than the last 3 species. This experiment provides data that teak is wastes water, therefore landuse plantation in WCA by teak is not reccommended and worried about that results the spring dried out (Sancayaningsih *et. al*., 2015).

Water infiltration experiment

Water infiltration is the ability of soil to absorb rainfallwater, and this depends on soil porosity, soil texture, soil humidity, slope and plant cover (Arsyad and Rustiati, 2008; Asdak, 2010).

Table 7. Water Infiltration experiment on 5 month of *T. grandis* seedling and 2 years *F. benjamina* seedling with two different soil humidity

Species	water infiltration (%) &absorbtion rate (% sec^{-1})			
	Low soil humidity(50 %)		High soil humidity (80%)	
	Infl (%)	Infl.rate (% sec^{-1})	Infl (%)	Infl. rate (% sec^{-1})
*T. grandis*5 months	63.5	0.5	34.2	0.1
F. benjamina>2 yrs	65.8	0.4	35.2	0.2

Table 7. shows that water infiltration of *T. grandis* and *F. benjamina* seedling is comparable, and infiltration is high (63.5%–63.8%) in low soil humidity which is still lower than shrubs water infiltration (75.2%). Root contribution to the soil media was not reflected in the infiltration ability strongly, because of soil compaction condition in the seedling soil growth medium, or its root nature is large straight growth with small portion of adventitious roots. Comparred to the control (bareland) in Table 8. Water infiltration of both *T. grandis* and *F. benjamina* in high soil humidity is still higher (34.2% > 25.6%).

Table 8. Water Infiltration experiment on land covered by floor vegetation (shrubs, herbs & grasses)

Growth form Covered	volume run off	volume infiltrated	Total	%
Shrubs	7,430.3	2,2569.7	30,000.0	75.2
Grasses and Herbs	6,728.3	2,3271.7	30,000.0	77.6
Control/bareland	22,320.0	7,680.0	30,000.0	25.6

The water infiltration experiment for shrubs, grasses and herbaceous plants using artificial rainfall are presented in Table 8. The higher value of water infiltration in grasses and herbaceous plants comparred to shrubs (77.6% compared to 75.2%) is because they have more fibrous roots than the shrubs, therefore water become easier to infiltrate into soils.

Of the discussions above reveals that Geger WCA management needs to beevaluated, especially the exceeding WCA area planted by teaks. Physiological character of replantation should be selected concerning its character related to ground water conservation.

CONCLUSIONS

Main conclusions of the research are:

1. Sixty eight percent of the WCA area of Geger spring is dominated by *T. grandis, S. mahagoni* and *G. gnemon*of trees; T. grandis and *S mahagoni*for saplings; and *S. mahagoni* and *A. scholaris* for seedlings.
2. The shrubs, herbaceous and grasses of floor vegetation are dominated with *Chromolaenaodorata* and *Ageratum conyzoides*, *Piperomia pellucida* and *Oplismenus burmanii* respectively.
3. T. grandis has higher root water suction compared to *F. benjamina*, *I. fagiverus, S. aqueum*, and *G. gnemon*
4. Percentage of water infiltration of land covered by shrubs is 75.2% and covered by herbaceous and grasses is 77.6%.

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