

Proof of *Acacia nilotica* stand expansion in Bekol Savanna, Baluran National Park, East Java, Indonesia through remote sensing and field observations

SUTOMO^{1,2}, EDDIE VAN ETTEN², LUTHFI WAHAB³

¹Eka Karya Bali Botanical Garden, Indonesian Institute of Sciences (LIPI), Candikuning, Baturiti, Tabanan 82191, Bali, Indonesia. Tel. +62-368-2033211, email: sutomo.uwa@gmail.com

²School of Natural Sciences, Edith Cowan University, Joondalup Drive, Perth Western Australia

³Postgraduate Studies, Faculty of Geography, Gadjah Mada University, Bulaksumur, Yogyakarta 55281, Indonesia

Manuscript received: 17 December 2015. Revision accepted: 12 February 2016.

Abstract. Sutomo, van Etten E, Wahab L. 2016. Proof of *Acacia nilotica* stand expansion in Bekol Savanna, Baluran National Park, East Java, Indonesia through remote sensing and field observations. *Biodiversitas* 17: 96-101. One of woody species that is known to inhabit certain savanna ecosystems is *Acacia nilotica*. The *Acacia nilotica* tree is widespread in the northern savannah regions, and its range extends from Mali to Sudan and Egypt. *Acacia nilotica* was first introduced to Java Island in 1850. It then spread to Bali, East Nusa Tenggara, Timor and Papua. Found in grasslands, savanna is reported as important colonizer at Baluran National Park in East Java and Wasur National Park Papua. We conducted Vegetation analysis in three areas of the Baluran Savanna namely: Grazed, burned and unburnt. Our observation result analysis showed that in terms of the three most important tree species in all of the sites that we sampled (grazed, burnt and unburnt savannas) *Acacia nilotica* appeared in each of these sites. The values however, vary between sites. *Acacia nilotica* Importance Value Index is highest in the unburnt savanna, with IVI reaching almost 250. The unburnt site is actually a burnt site but with moderate age or time since fire (approximately 6-7 years), whereas the burnt site is savanna with relatively young age/time since fire (few months to 1 year). We also conducted GIS analysis using Satellite Images (October 2013 and October 2014) to pick up changes in Bekol savanna. Result showed that expansion of *A. nilotica* stand occurred towards the savanna. Over dominance of the woody species *A. nilotica* could shift the savanna into another ecosystem state, i.e. secondary forest.

Keywords: *Acacia nilotica*, Baluran National Park, expansion, remote sensing, vegetation analysis

INTRODUCTION

Before the year 1928, A.H. Loe de Boer, from the Dutch Colonial, had areas of agriculture concession at Labuhan Merak and Mount Mesigit, Baluran. Since then, he had always interested in big mammals and thought that the areas will play important roles in conserving these animals. Following Indonesia independence, the Ministry of Agriculture also stated Baluran as game reserve area with decree No. SK/II/1962. Later on in 1980, the area then stated as a national park, the Baluran National Park with an areas of 25,000 ha. Baluran is known for its vast areas of savanna and is famous as the "Africa van Java" (Baluran National Park 2010).

Savanna is a term to define ecosystem in tropical and subtropical that typical of displaying a continuous herbaceous cover of C₄ grasses that has different patterns based on seasonality in which it is related to water, and where woody plants are also of important values but with sparse patterns and no closed canopy (Frost et al. 1986). Tropical savannas cover over 20% of the Earth surface, with the largest coverage is in Africa, Australia and South America, and just only approximately 10% occur in India and Southeast Asia (Bond and Wilgen 1996; Werner 1991).

Other savannas ecosystem have also been intensively studied such as eucalypt savanna woodlands in Northern

Australia (Burrows et al. 1991; Werner 1991), and the Miombo woodland of Southern Africa (Isango 2007). Indonesian savanna however remain somewhat unfamiliar to the scholarly with very few studies have been done. One of the foremost early studies on Indonesian flora was of Backer and van den Brink (1963) and van Steenis (1972). Mountain flora of Indonesia especially in Java Island was what van Steenis specialized. In his report, even in early 1900, grasslands on Java Mountains are already common. Fire, according to van Steenis (1972) was presumed as the major factor that drive the existence of grasslands on Java mountains especially in East Java which is subject to dryer dry season, lower precipitation compare to other parts of the island.

One of woody species that is known to inhabit certain savanna ecosystem is *Acacia nilotica* (Figure 1). *Acacia nilotica* is known to be abundant originally in Africa (Brenan 1983) and has been scantily studied. In a study by Skowno (1999) in Hluhluwe Game Reserve, South African savanna, *A. nilotica* was described in terms of their quantitative structure and distribution. In Australia, this species is dominant in Queensland where it has been declared as weeds, and only a few are found in Western Australia, New South Wales, Adelaide and Northern Territory (Reynolds and Carter 1990). In Australian savanna ecosystem's study by Radford (2001), *A. nilotica*



Figure 1. Sketch of *Acacia nilotica* subsp. *indica* from Baluran National Park (Illustrated by M. Sumerta, Bali Botanical Garden, Indonesia)

is acknowledged to have negative impacts on savannas. *A. nilotica* can be threatening to savannas as its adult trees are apparently fire tolerant and can form thorny thicket formation (Burrows et al. 1991).

Baluran savanna has also been introduced with the *A. nilotica* in the late 1960, where its original purpose was to create fire break to prevent fire to spread from Baluran Savanna to the adjacent teak forest. However today *A. nilotica* has spread rapidly and threatening the existence of Baluran Savanna and it has been observed to cause changes in ecosystem from open savannas to some extent a closed canopy of *A. nilotica* in some areas (Barata 2000; Djufri 2004). This condition could put large mammals of Baluran savanna such as barking deer (*Muntiacus muntjak*), sambar deer (*Cervus unicolor*) and banteng (*Bos javanicus*) in endangered due to the loss of browsing and grazing fields (Sabarno 2002).

This research objective are to provide up-dated information regarding the state of this exotic species *A. nilotica* in Bekol Savanna Baluran National Park and search for evidences of expansion of *A. nilotica* stand at the Bekol Savanna through field observation and Geographical Information System (GIS) application.

MATERIALS AND METHODS

Baluran National Park located in Banyuputih sub-District, belongs to Situbondo District in East Java Province, Indonesia (Coordinates: 7°50 S 114°22 E). Baluran National Park borders are adjacent to: On the north

it is bordered with Madura Strait, on the east is Bali Strait, on the south is Bajulmati River, Wonorejo Village and on the west is with Klokoran River, Sumberanyar Village. The park is a rough circle, with the extinct volcano, Baluran, at its center. Baluran has a relatively dry climate and mainly consists of savanna (40%), as well as lowland forests, mangrove forests and hills, with Mount Baluran (1,247m) as its highest peak. According to Schmidt and Fergusson classification, Baluran National Park (BNP) has type F dry climate with temperature ranging 27.2-30.9°C, relative humidity 77%, and wind speed average 7 knots. Rainy season in November to April, dry season is in April to October. Highest precipitation usually is in December to January. Baluran savanna has alluvial soil type. In dry season or drought the soil will crack and the deep of the crack could reach up to 80 cm.

We used vegetation analysis method by using quadrat plot to sample vegetation following Kent (2011) as seen in the Figure 2. Quantitative information including above-ground biomass and floristic composition obtained from each sites namely: burned, unburnt and grazed. Each site we created 10 plots for observation and so in total there were 30 plots all together, randomly located. All plant species in each plot identified (Indriyanto 2006). Field herbarium created so that the plants can be more easily recognized to species level in the subsequent field work, which demands rapid identification in the field. The identification assisted by Herbarium Baliensis of the Indonesian Institute of Sciences. Plant identification also make used of flora books such as Backer and Bakhuizen van den Brink (1963), van Steenis (1972), Soerjani et al. (1986), and Whitten et al. (1996). A diagram profile was also created by using a transect with 60 m long and 7 m wide and captured the woody habitus as well as sapling, seedling and grasses in the boundary area between the *A. nilotica* stand and the Bekol Savanna of Baluran National Park. Vegetation analysis was then conducted to calculate the value of Important Index (IVI) for tree habitus. Ordination analysis for tree species composition in the sampling plots was conducted using Non metric Multidimensional Scaling (NMDS) in the PRIMER V.5 Software (Clarke and Gorley 2005).

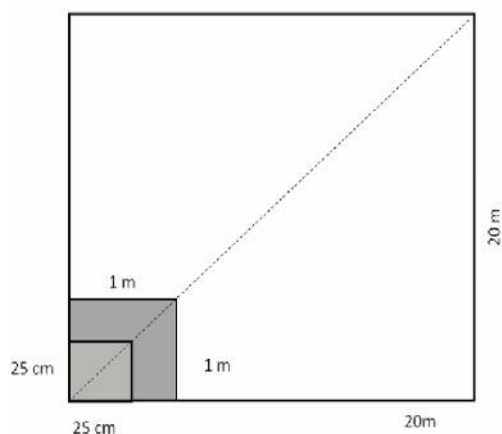


Figure 2. Shape and size of sampling plot (Kent and Coker 1992), 20 x 20 m² to observe and measure woody sapling and basal area. 1 x 1 m² to observe non woody species and 25 x 25 cm² for their biomass

Satellite images of the Bekol savanna in 2013 were obtained online using Universal Map Downloader (UMD) with highest level of pixel category to allow high standard images. The spatial data was download from Geo-Eye (Google Earth) using the UMD application. GeoEye-1/Digital Globe (Google Earth) has a resolution of 0.41-meter on panchromatic and 1.65-meter on multispectral imagery (Setiabudi et al. 2013). To cover Bekol savanna and the surrounding, many such small GeoEye-1 images were constructed by the UMD and stored in JPEG files to be merged and integrated into one mosaic of GeoEye-1 image. Finally the mosaic image was rectified or geo-referenced using coordinate data from Google Earth. The data were projected into WGS 1984-UTM, Zone_49S. In this way a detailed vegetative map was developed. The identification of *A. nilotica* stand is based on prior knowledge of the plant from the preliminary field observation in 2013. The interpretation result and up-date data was also checked through ground-truth observation in the field in 2014. Ground/field observation in 2014 was then compared with 2013 satellite image and was displayed using ARC-MAP software from ARC GIS.

RESULTS AND DISCUSSION

Our observation result analysis showed that in terms of the three most important tree species (described in Importance Value Index/IVI) in all of the sites that we sampled (grazed, burnt and unburnt savannas) *A. nilotica* appeared in each of these sites (Figure 3). The values however, vary between sites. *A. nilotica* IVI is highest in the unburnt savanna, with IVI reaching almost 250. The unburnt site is actually a burnt site but with moderate age or time since fire (approximately 6-7 years), whereas the

burnt site is savanna with relatively young age/time since fire (few months to 1 year). It is assumed that *A. nilotica* pods grazed by buffalo and spread the seeds to many areas of savanna including the burnt areas. Once it was experienced fire, the heat assisted in scarification process of the seeds and speed up the germination. When there was no subsequent fire for significant period of time, these seeds grow and become mature and dominating the unburnt site. In terms of species diversity, all of these sites have low species diversity (around 0.8) as measured by Shannon and Wiener and Simpson Index (Table 1). This is perhaps, due to over dominance of certain species, as can be seen from the next graph.

Ordination analysis (Figure 4) shows that the grazed and ungrazed sites were not as different in terms of the species composition as shown by the close position between the dots that represent the two sites and sometimes these dots were mixed. Whereas when we look at the burn site, we notice that the dot that represent the burn site is clearly separated from the other two sites although the points of the burn area were also has different pattern, some are clumped and some are scattered. These results imply that it is difficult to find a site that is purely ungrazed as animals move around in such a dynamic pace. We can only assume that site/plots that have no traces of scats/stools or remains of the herbivore to be the ungrazed site, however we know now that it is not adequate. Therefore the ungrazed and grazed sites have did not separate very well and imply that these sites has similarity

Table 1. Species diversity in three sampling sites

	Index Shannon	Index Simpson
Un-grazed	0.83080091	0.437944506
Grazed	0.845667704	0.447737829
Burnt	0.745068622	0.45753436

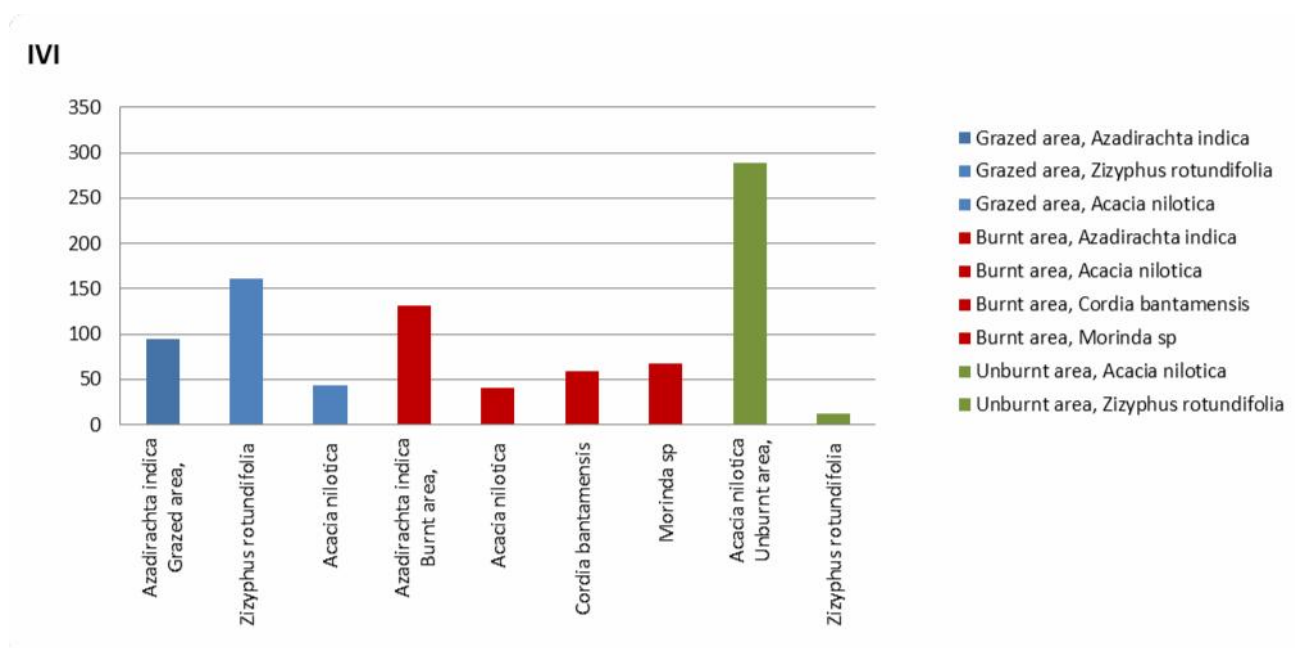


Figure 3. Importance Value Index analysis for tree habits at the sampling sites in Bekol Savanna, Baluran National Park, East Java, Indonesia

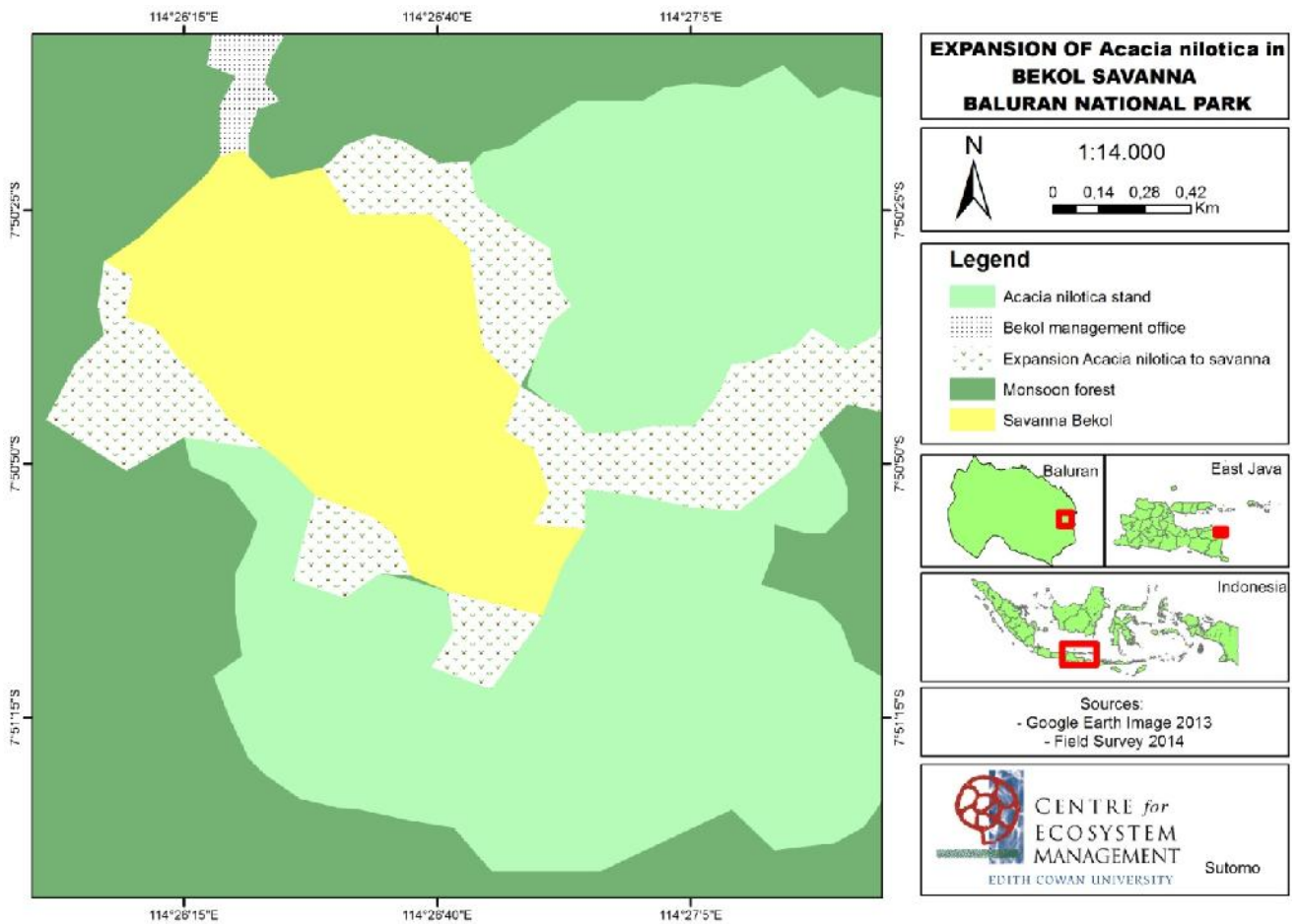


Figure 5. Result from GIS analysis and ground check showing expansion of *Acacia nilotica* stand at Bekol Savanna in 2014, Baluran National Park, East Java, Indonesia

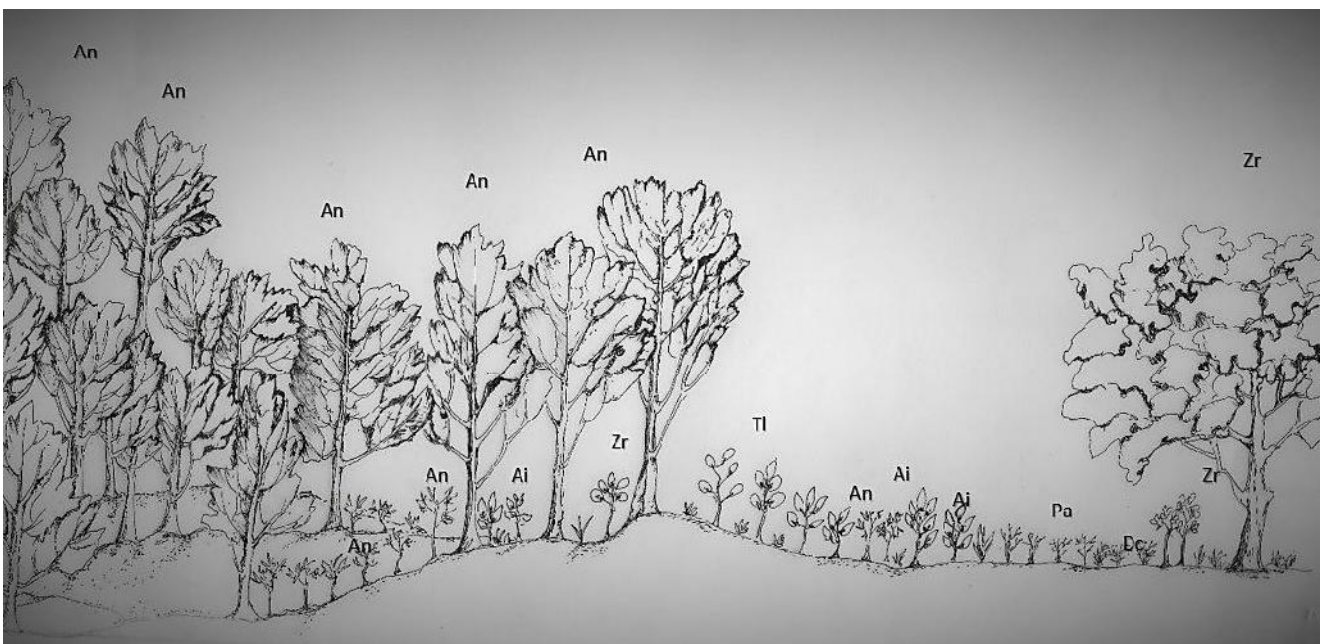


Figure 6. A profile diagram of the boundary area between the *A. nilotica* stand and Bekol Savanna, Baluran National Park, East Java, Indonesia. Notes: An = *Acacia nilotica*, Ai = *Azadirachta indica*, Zr = *Ziziphus rotundifolia*, Pa = *Polytrias amaaura*, Dc = *Dichantium coricosum*, Tl = *Thespesia lampas*

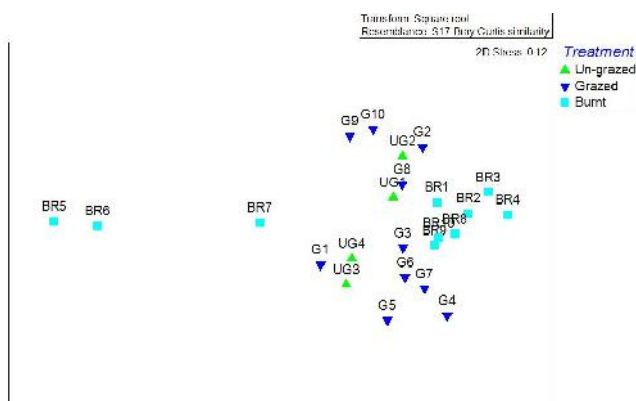


Figure 4. Result from NMDS ordination of sites in terms of their species composition at Baluran National Park, East Java, Indonesia

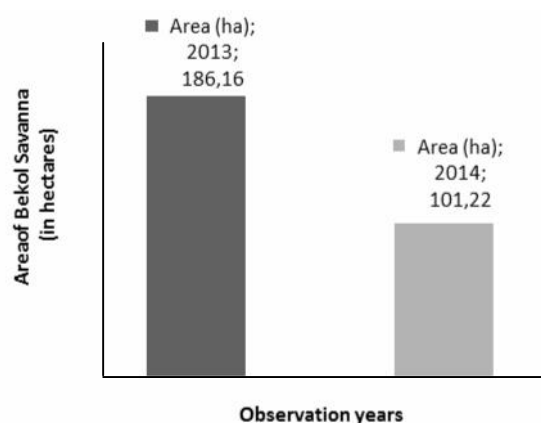


Figure 7. Decrease in area. Savanna Bekol, Baluran National Park, East Java, Indonesia from 2013-2014

in terms of their species composition. The burn site however was quite distinct in terms of species composition with the grazed and ungrazed sites. Burning create such a catastrophic condition in such a short time. Burning modified the environmental factors/microclimate in the area and thus changes the species composition.

Spatial analysis of the satellite images showed distinct patterns of expansion of *A. nilotica* stand. Older stand clumped together and form a dense dark green block like a carpet on the South and northeast of the Bekol Savanna. Meanwhile a younger stand identified by a lighter green color with a sparse density pattern that located at the front of each older stand (Figure 5). A profile diagram from field observation (Figure 6) revealed that these expansion areas were mainly comprises of species of younger *A. nilotica* in sapling sizes and also in seedling form. Beside *A. nilotica*, this area also mixed with other species but in less dominance namely *Azadirachta indica*, *Ziziphus rotundifolia*, *Thespesia lampas*, *Polytrias amaura* and *Dichanthium coricosum*. In just only 1 year there was a decrease in areas of the Bekol Savanna. As many as approximately 85 ha savanna areas have converted to *A. nilotica* stand (Figure 7).

Vegetation analysis and GIS application can be applied in combination as demonstrated in the present paper. *A. nilotica* survive and thrive in burned, unburnt, grazed and ungrazed areas of the Bekol Savanna in Baluran National Park. We know now that *A. nilotica* is aggressively invading Baluran savanna, but, what are the factors that encourage the spread and the domination of *A. nilotica* in the savanna? This question needs further research into seed ecology of *A. nilotica* and its dispersal agent, which will be addressed in our next paper.

ACKNOWLEDGEMENTS

This research was funded by the Rufford Small Grant for Conservation and supported by School of Natural Sciences Edith Cowan University and Bali Botanical

Garden. We would like to thanks to Josh Cole and Jane Raymond at Rufford Foundation, Director of the Baluran National Park for permission to conduct the field data collections, to Lutfan Nazar, Ketut Sandi for assisting in the field and lots of other kind helps that could not be mention here.

REFERENCES

- Backer CA, van den Brink Jr RCB. 1963. Flora of Java. The Rijksherbarium, Leiden.
- Baluran National Park. 2010. Baluran National Park, A Piece of Africa in Java. Center for Baluran National Park, Banyuwangi. [Indonesian]
- Barata UW. 2000. Biomass, composition and classification of below grown plant communities in the stands of *Acacia nilotica* in Baluran National Park, East Java. Faculty of Forestry. Universitas Gadjah Mada, Yogyakarta. [Indonesian]
- Bond WJ, Wilgen BWv. 1996. Fire and Plants. Chapman & Hall, London.
- Brenan JPM. 1983. Manual on Taxonomy of *Acacia* species: Present Taxonomy of Four Species of *Acacia* (*A. albidia*, *A. senegal*, *A. nilotica*, *A. tortilis*). United Nations FAO, Rome.
- Burrows WH, Carter JO, Scanlan JC, Anderson ER. 1991. Management of savannas for livestock production in North-East Australia: Contrast across the tree-grass continuum. In: Werner PA (ed). Savanna Ecology and Management. Blackwell, London.
- Clarke KR, Gorley RN. 2005. PRIMER: Plymouth Routines In Multivariate Ecological Research. PRIMER-E Ltd., Plymouth.
- Djufri. 2004. *Acacia nilotica* (L.) Willd. ex Del. and problematical in Baluran National Park, East Java. Biodiversitas 5: 96-104.
- Frost PGH., Menaut JC, Walker BH, Medina E, Solbrig OT. 1986. Responses of savannas to stress and disturbance. In: Scholes RJ, Walker BH (eds), An African Savanna: Synthesis of the Nylsvley Study. Cambridge University Press, Cambridge.
- Indriyanto. 2006. Forest Ecology. Penerbit Bumi Aksara, Jakarta. [Indonesian]
- Isango JA. 2007. Stand Structure and Tree Species Composition of Tanzania Miombo Woodlands: A Case Study from Miombo Woodlands of Community Based Forest Management in Iringa District. Management of Indigenous Tree Species for Ecosystem Restoration and Wood Production in Semi-Arid Miombo Woodlands in Eastern Africa. MITMIOMBO, Tanzania.
- Kent M. 2011. Vegetation Description and Data Analysis: A Practical Approach. John Wiley & Sons, New York.
- Kent M, Coker P. 1992. Vegetation Description and Analysis: A Practical Approach. John Wiley & Sons, New York.

- Radford IJ, Nicholas MD, Brown JR. 2001. Impact of prescribed burning on *Acacia nilotica* seed banks and seedlings in the *Astrelba* grasslands of Northern Australia. *J Arid Environ* 49: 795-807.
- Reynolds JA, Carter JO. 1990. Woody weeds in central western Queensland. Proceedings 6th Biennial Conference, Australian Rangelands Society, Carnarvon, Perth.
- Sabarno MY. 2002. Baluran Nasional Park Savanna. *Biodiversitas* 3: 207-212. [Indonesian]
- Setiabudi, Tjitrosoediro S, Mawardi I, Bachri S. 2013. Invasion of *Acacia nilotica* into savannas inside Baluran National Park, East Java, Indonesia. In: Bakar B, Kurniadi D, Tjitrosoediro S. (eds). Proceedings of the 24th Asian-Pacific Weed Science Society Conference, Bandung, Indonesia, October 22-25, 2013.
- Skowno ALM, Bond WJ, Balfour D. 1999. Secondary succession in *Acacia nilotica* (L.) savanna in the Hluhluwe Game Reserve, South Africa. *Plant Ecol* 145: 1-9.
- Soerjani M, Kostermans AJGH, Tjitrosoepomo G. 1986. Weeds of rice in Indonesia Balai Pustaka, Jakarta. [Indonesian]
- Van Steenis CGJ. 1972. The Mountain Flora of Java. E.J Brill, Leiden.
- Werner PA. 1991. Savanna Ecology and Management: Australian Perspective and Intercontinental Comparisons. Blackwell, London.
- Whitten T, Soeriaatmadja RE, Afiff SA. 1996. The Ecology of Indonesia series volume II: The Ecology of Java and Bali. Periplus, Hongkong.