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BALI STARLING (*Leucopsar rothschildi*) NATURAL HABITAT IN BALI BARAT NATIONAL PARK INDONESIA**

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ABSTRACT

Tropical savannas and dry forests in Indonesia are important types of ecosystems which provide habitat to support various endemic wildlife. Several of these endemic species are now seriously threatened and accordingly have high conservation status according to IUCN, including the Bali starling (*Leucopsar rotschildi*) which is mostly now restricted to the Bali Barat National Park. Given the high extinction risk facing such species, conservation programmes are likely to require multidisciplinary approaches that address both the biological attributes of the species itself, as well as their habitat requirements. Regrettably, for many species, their habitat ecology remains inadequately understood. The objectives of this paper are to: 1) characterise the habitat of the Bali starling in terms of structure and floristic composition; and 2) document evidence of vegetation cover changes in the Bali Barat National Park. Analysis of remote sensing imagery as well as field sampling for vegetation attributes was conducted to address these objectives. Normalized Difference Vegetation Index (NDVI) was calculated from Landsat imageries using red and near infrared bands. Tree cover percentage data were downloaded from Vegetation Continuous Fields (VCF) product from the University of Maryland's website. Results showed that forest and savanna are the dominant land cover types in the Bali Barat National Park but their distribution is somewhat dynamic with changes in vegetation cover and greenness found across the years in which increasing cover of woody plants is the general trend. In the Bali Barat National Park, the Bali starling is mostly found at or near distinct vegetation boundaries, such as the border between savanna-forest; savanna-cropland; savanna-shrubland; settlement-cropland; and forest-shrubland. Although Cekik area had planted species that has been known to be able to provide shelter and food for Bali Starling (so was Brumbun), the bird has not been observed to be presence in the area since the 1990s. These results further confirm the importance of examining habitat patterns of endemic bird within a landscape that are influenced by multiple factors that interact in space and time. Addressing data shortage in habitat patterns within endemic species distribution is important for conservation managers developing conservation management strategies. Evaluating the remaining habitat of the species is important for conservation of Bali starling and useful for the reintroduction and release program to their natural habitat.

Keywords: Habitat suitability, savanna, Bali starling

INTRODUCTION

Tropical savannas and dry forests are important types of ecosystems which comprise habitat that supports various endemic wildlife of Indonesia. A few of these species are now under serious threat of extinction and, consequently, have high conservation status according to the IUCN (IUCN 2014), such as Banteng (*Bos javanicus*) that is now mostly confined to savanna Baluran National Park in East Java, the Komodo dragon (*Varanus komodoensis*) endemic only in the Komodo Islands of East Nusa Tenggara and the endemic Bali starling bird (*Leucopsar rotschildi*) which is now mainly found in the savanna of Bali Barat National Park on the north-west tip of Bali. However, rapid and widespread habitat loss and variable capacity in natural reserve management pose considerable risk to the biodiversity (Purwandana *et al.* 2014).

The critically endangered Bali starling (*Leucopsar rothschildi*) is the only endemic bird found in Bali. Stresemann (1912) collected and described the first Bali starling known to science near Bubunan, Bali. The Bali starling is an attractive aviary bird being largely white, with black wing and tail tips and with bare skin of a turquoise-blue colour on the lores and behind the eye. On account of its restricted range, extremely small numbers in the wild and pressures on the last free ranging birds, the Bali starling is considered critically endangered according to the latest International Union for Conservation of Nature (IUCN) threat categories (IUCN 2014). Habitat destruction and capturing for the pet trade brought the species to the verge of extinction (van Balen *et al.* 2000). It was estimated that less than 20 birds remained in the wild in 1998 within a small area on the northwest tip of the island within the boundaries of Bali Barat National Park (BBNP) (Collins *et al.* 1998). Although the wild population is near extinction, Bali starlings have been successfully bred in captivity (Collins *et al.* 1998).

The original habitat of the Bali starling in Bali was described as 'dry savanna and shrub woodlands' and 'tall and dense forest' in the 1920s (van der Paardt 1926), and at this time was believed to be historically restricted to a narrow belt of dry monsoon climate in Northern Bali and East Java (van Balen *et al.* 2000). Its range shrunk between 1920-1960 to the fire-induced open shrub and savanna woodland, found below an elevation of 150–175 m in the northeast part of the Prapat Agung peninsular within the BBNP (van Balen *et al.* 2000). Patterns of bird distribution and abundance within a landscape are influenced by multiple factors that interact in space and time (Orians and Wittenberger 1991). Habitat structure and floristic composition, such as percent canopy cover, tree species diversity and the distribution of specific plant taxa, are known to have a significant role in defining the occurrence of bird species in space (James and Wamer 1982; Rice *et al.* 1984; Wiens and Rotenberry 1981).

Given the high extinction risk facing such species, conservation programmes are likely to require multidisciplinary approaches that address both the biological attributes and resource requirements of the species itself, as well as their habitat requirements and conditions (Estoque *et al.* 2012). Evaluating the remaining habitat is important in the conservation of Bali starling and useful for the reintroduction and release program to their natural habitat. Moreover, knowledge and understanding the likely potential distribution and habitat suitability of the Bali starling has important implications for selecting potential sites for future *ex-situ* conservation and breeding programs designed to save this endemic bird from its extinction. There have been many studies on the Bali starling; however, most of these have focussed on the bird itself ranging from its behaviour, reproduction, breeding, genetic, taxonomic, demography and reintroduction, among others (Collins and Smith 1994; Collins *et al.* 1998; De Iongh *et al.* 1982; Dirgayusa *et al.* 2000; Seibels *et al.* 1997; Williams and Feistner 2006). However, studies with regards to the Bali starling's habitat are scarce (but see Widodo 2014), especially considering that these habitats are vital to the ongoing maintenance of viable populations of Bali starling, but yet are also very prone to conversion, disturbances and degradation. Therefore the objectives of this paper are to: 1) describe the known current distribution of Bali starling and characterize its habitat structure in Bali Barat National Park in terms of its plant community structure and composition, 2) assess the cover and greenness index (NDVI) to quantify the dynamics of vegetation cover in these habitat areas; and 3), assess the degree of recent habitat change affecting the species more broadly in BBNP.

MATERIALS AND METHODS

The Bali Barat National Park is located on the northwestern side of Bali, Indonesia. The park covers around 19,000 ha which comprises of 15,588 ha of terrestrial areas and 3,415 ha of marine habitats. This area is approximately 5% of Bali's total land area. A seaport at Gilimanuk is located west of the park. The national park also bordered with several villages. The Bali Barat National Park can be reached by roads from Gilimanuk and Singaraja, or by using ferries from Ketapang, East Java. There are several major habitat types in the national park: savanna, mangroves, montane and mixed-monsoon forests, and coral islands. Bali Barat was designated as a National Park in 1984 based on the Ministry of Forestry decree (No. 096/Kpts-II/1984). Its area has mostly latosol type of soil being reddish in colour, weakly crumbed and sticky when wet although hardening and cracking when dry. The park is topographically varied, ranging from plains near the coast to steep hills and mountains. There are four mountains, namely Prapat Agung, Banyuwedang, Klatakan and Sangiang (the highest at 1,414 m). Off the coast, there are four islands that are also under Bali Barat National Park (BBNP) management jurisdiction, namely Menjangan, Burung, Gadung and Kalong Islands. Bali Barat National Park has a moderate seasonal climate with rain in each month, but more falling in the wet season (December to February). Annual average rainfall ranges from 900 – 1,500 mm and average temperature is 33°C (Masy'ud *et al.* 2008; Masy'ud *et al.* 2007; Whitten *et al.* 1996).

A number of reports on the Bali starling population, distribution and their habitat were obtained through a review of literature and also personal communications with BBNP rangers and managers. Location of Bali starling distribution was obtained from De Longh *et al.*, (1982), Whitten *et al.*, (1996), van Balen *et al.*, (2000) and BBNP manager, Wiryawan, (2014, pers.comm.). Based on this data, we divided Bali starling occurrence data into three eras of distribution, namely 1984, 1994 and 2010, because we considered these as the only 3 years in which reliable and accurate surveys were done and so these years were only used. We then conducted an overlay analysis of these Bali starling location data with Indonesia's topographical/earth surface map (Rupa Bumi Indonesia/RBI) for the year 2001 (scale 1 : 80,000) obtained from the Indonesian Geospatial Agency (BIG/BAKOSURTANAL). We used 2001 land use data because this was the most recent available. All data used the same datum and also the same map projection within the GIS (WGS 1984-UTM, Zone_50) to avoid misalignment.

The Vegetation Continuous Fields (VCF) collection contains proportional estimates for vegetative cover types: woody vegetation, herbaceous vegetation, and bare ground. The product is derived from all seven bands of the MODerate resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's Terra satellite. The continuous classification scheme of the VCF product may depict areas of heterogeneous land cover better than traditional discrete classification schemes. While traditional classification schemes indicate where land cover types are concentrated, this VCF product is great for showing how much of a land cover such as "forest" or "grassland" exists anywhere on a land surface (DiMiceli *et al.* 2011).

NDVI is an index derived from remotely sensed imagery which can differentiate between vegetation types by showing the difference between near infrared (which is strongly reflected by vegetation) and red light (which is absorbed by vegetation).NDVI is correlated to vegetation biomass, vigour and photosynthetic activity. This index exploits the reflectance patterns of ground elements in the red (R) and near-infrared (NIR) bands of the electromagnetic spectrum to distinguish green vegetation from its background soil brightness, and is calculated as (NIR - R)/ (NIR + R). NDVI values range from -1 to 1, with positive values representing vegetated areas and negative values representing non-vegetated regions (Sankaran 2001). The NDVI ratio approach usually adopted for land cover change estimation is used here in preference to the more commonly employed post-classification pixel-by-pixel comparison method (Lillesand *et al.* 2008) since it also permits identification of areas where changes in vegetative cover have been significant, but insufficient to cause change in class membership (Sankaran 2001).

In order to generate normalized difference vegetation index (NDVI), a number of Landsat images were used. Landsat images were downloaded from http://earthexplorer.usgs.gov/ path 117, row 066. When selecting images to be downloaded, we looked for images with minimal cloud cover percentage by selected scenes with at least image quality level 9 (no errors detected, perfect scene). Details of each image downloaded can be seen in Table 1.

Table 1. Details of images downloaded for NDVI analysis

Images	**Source**	**Date acquired**	**Spatial Resolution**	**Image quality**	**Cloud cover**
1	Landsat 4	21/03/1989	30 x 30 m	9	20
2	Landsat 7	12/11/1999	30 x 30 m	9	8.63
3	Landsat 7	31/05/2003	30 x 30 m	9	7.53
4	Landsat 8	11/06/2016	30 x 30 m	9	24.99

NDVI was generated using the NDVI feature in ArcMAP (ArcGIS 10.1) image analysis toolbar. Band 1, 2, 3, and 4 were chosen for Landsat 4 and 7, whereas band 2, 3, 4, and 5 were chosen for Landsat 8 as input images in ArcMAP which represent the blue, green, red and near infrared (NIR) bands. By choosing image analysis tab, all the bands layers were merged into one composite layer and then the RGB (Red-Green-Blue) channels were adjusted to just the NIR, red and green bands to extract the NDVI values. Once NDVI images were generated, different levels of a green colour scheme was applied for easier interpretation. We kept in mind that these NDVI values represent just one time in the year (due to the limited availability of good images for the chosen years) so it must be used carefully as NDVI will mainly reflect recent rainfall especially in terms of groundcover. Then, data points for the 1984, 1994 and 2010 Bali starling locations were overlaid on the NDVI images from different years (1989, 1999, 2003 and 2016). These years were chosen because these years were the closest years to the years of Bali Starling location (as clear image of the exact years of Bali Starling location cannot be found). The mean and SD from nine pixel values surrounding the exact coordinate locations of the Bali starling was then calculated from the NDVI images. Changes in mean NDVI of starling locations between different years were tested for significance using ANOVA in SPSS and, when significant difference detected, a post-hoc test was then performed.

Brumbun was a site where Bali starling was regularly observed in the period of 1979 to 1994. There was no surveys done in this area during 1995 – 2009 therefore no data on Bali starling in these locations could be obtained. Surveys were conducted by Bali Barat National Park in 2010 and found Bali starling in this location again. At another site, Cekik, the Bali starling was also observed in the period 1979-1994, but in 2010 survey by the BBNP management it was not found again in the area. Fieldwork was conducted in November 2014 in these two locations, namely Cekik and Brumbun. The study areas were cross-checked with a fire map based on MODIS burn area product from year 2000 to 2013 to obtain information on fire history (which showed no fires at these localities). Additionally, by looking at the Landsat imagery during this period there appears to be no major fires in BBNP.

In September to November 2014 (dry season), ten sampling plots (50 x 50 m) were established randomly in each savanna sites (Cekik, Brumbun). In each of the 50 x 50 m plots, I had smaller plots of 5 x 5 m nested randomly. Inside the 50 x 50 m plot we identified, measured and recorded all tree species ≥ 10 cm diameter at 1.3.m (dbh). In the smaller-nested plots we noted all groundcovers species (grasses, herbaceous and ferns) and estimated their cover. Species in each site were identified in the field where possible and a 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 was assisted by herbarium Bogoriense and herbarium Baliensis of the Indonesian Institute of Sciences (LIPI). Plant identification made use of flora books such as “Flora of Java” (Backer and van den Brink 1963), “Mountain Flora of Java” (van Steenis 1972), “Weeds of Rice in Indonesia” (Soerjani *et al.* 1986), “ Ecology of Java and Bali” (Whitten *et al.* 1996) and “Ecology of Nusa Tenggara and Maluku” (Monk *et al.* 2000) and names standardised based on the Plant List (www.theplantlist.org).

Importance Value Index or IVI (Kent 2011; Kent and Coker 1992) was calculated for each species in each plot to understand the structure and plant community composition in each of the savanna. Importance Value Index (IVI) (Curtis and McIntosh 1950; Kent and Coker 1992) was used to describe the quantitative structure of the community. This statistic represents the contribution that a species makes to the community in terms of the number of plants within the quadrats (density), its contribution to the community through its distribution (frequency), and its influence on the other species through its dominance.The Importance Value Index was calculated for each species of tree and ground cover in each of the study sites.

Using abundance data (cover), we tested for differences in plant community composition between Brumbun and Cekik savanna. The data were square-root transformed prior to constructing a resemblance matrix based on the Bray-Curtis similarity (Valessini 2009). A Non-metric Multidimensional Scaling (NMDS) ordination diagram was then generated based on the resemblance matrix. The difference in species composition between savannas was then tested for significance using one-way ANOSIM (analysis of similarity). The R_{ANOSIM} statistic values, generated by ANOSIM, are a relative measure of separation of the *a priori* defined groups. A zero (0) indicates that there is no difference among groups, while one (1) indicates that all samples within groups are more similar to one another than any samples from different groups (Clarke 1993). This multivariate analyses made use of the PRIMER v.6 package (Clarke and Gorley 2005).

RESULTS AND DISCUSSION

Based on our analysis of bird observations (Figure 1), it is mostly found in a relatively open vegetation (such as savanna and open shrubland) and their boundaries with other vegetation types in the Bali Barat National Park, and this confirms with reports in the literature (De Iongh *et al.* 1982; Dirgayusa *et al.* 2000). Based on the report from BBNP manager, the bird has been observed to be present at or near the ecotones between savanna-forest, savanna-cropland, savanna-shrub land, settlement-cropland, and forest-shrubland.

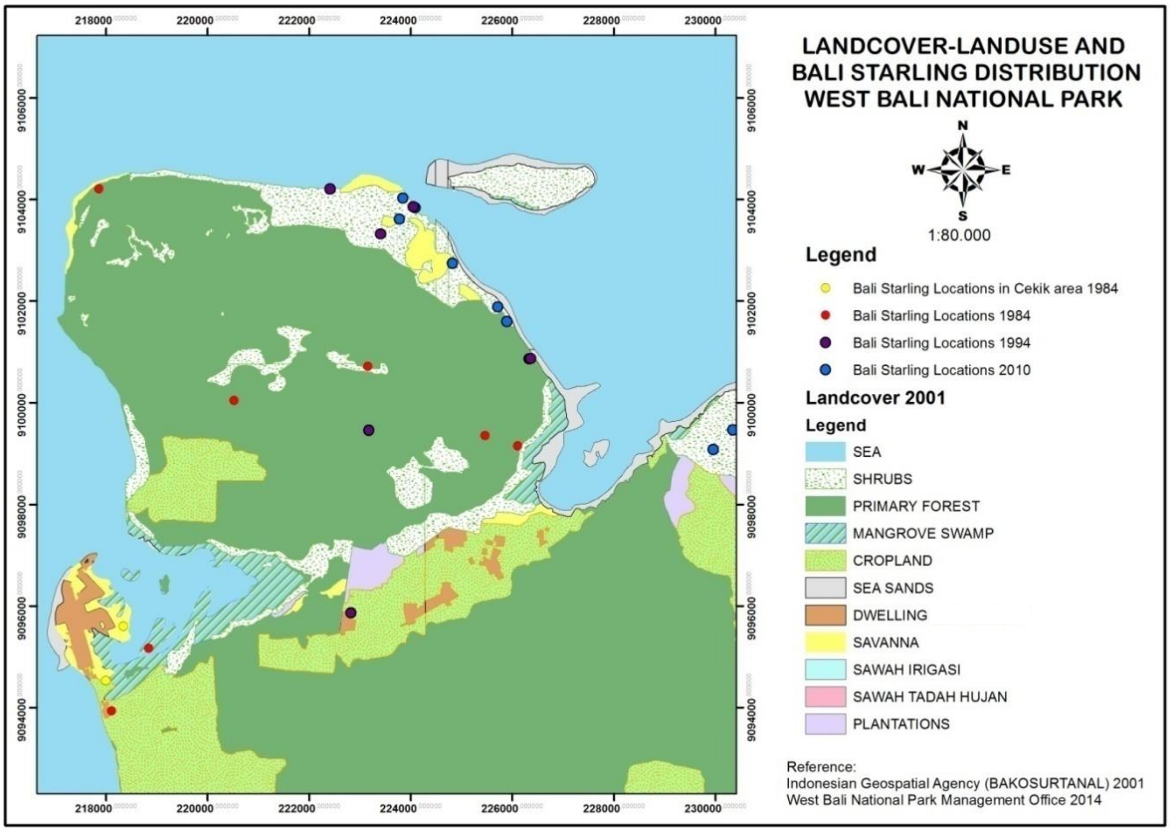

Figure 1 Overlay of Bali Starling occurences with the 2001 Land Use map of Bali Barat National Park. Notes: 'Sawah tadah hujan' refers to a rain fed paddy field. 'Sawah irigasi' refers to irigated paddy field.

This is supported by the NDVI analysis for the three years when the species localities were recorded (1984, 1994 and 2003) which showed there is a shift in preferred habitat of the Bali starling from primary forest type of habitat in the 1980s to more open vegetation areas including, but not limited to, dry forest/monsoon forest, secondary forest and savanna (Figure 2). These results further confirmed the results of van Balen *et al.* (2000) who found the Bali Starling range on Bali Island has shrunk to the fire-induced open shrub and savanna woodland below elevations of 150–175 m in the northeast part of the Prapat Agung peninsular of the Bali Barat National Park.

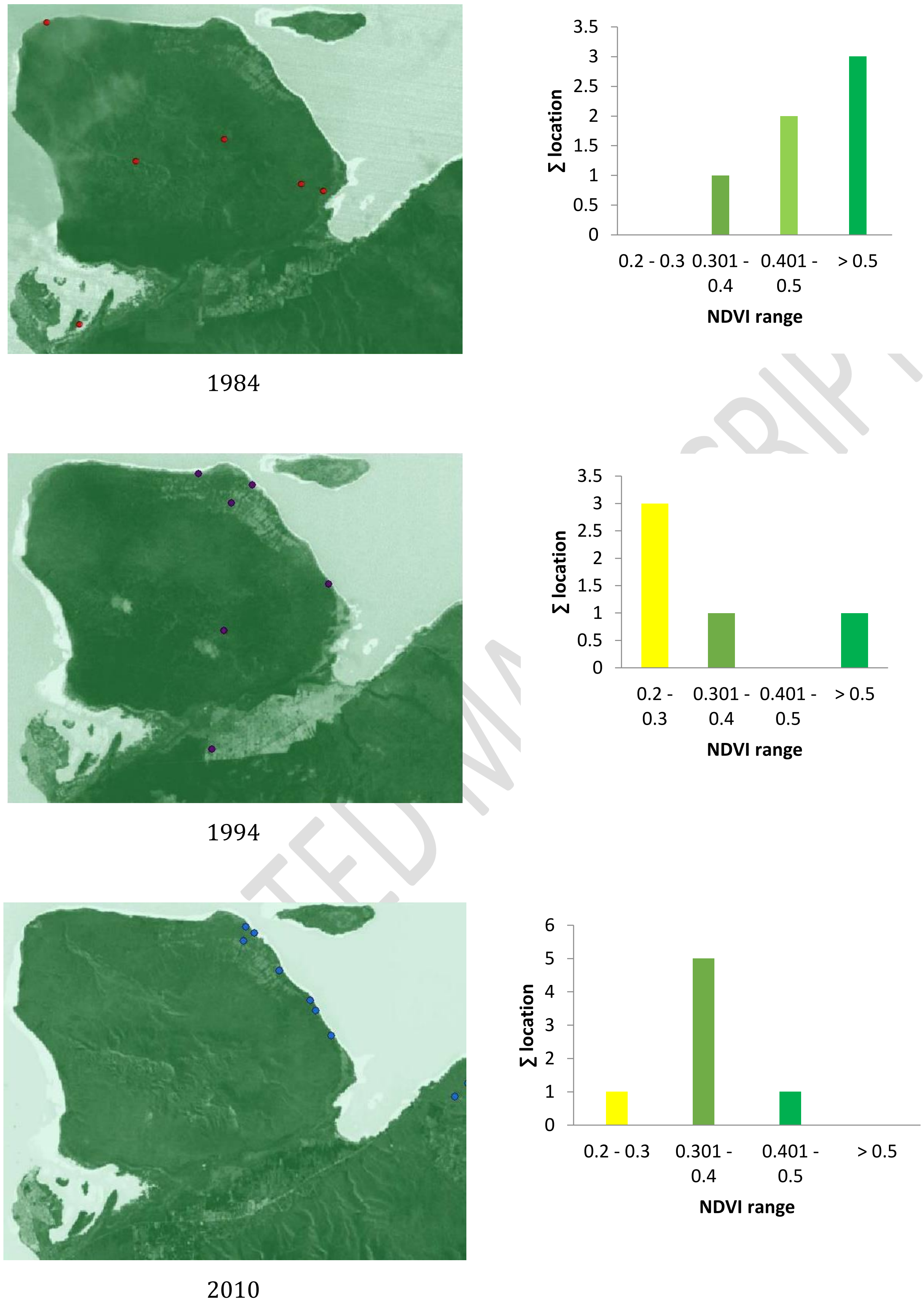

Figure 2 Bali Satrling habitat distribution based on their Normalized Difference Vegetation Index (NDVI) range class. Habitat and localities are presented for 1984 (upper, alligned with NDVI image data 21/03/1989), 1994 (middle, alignedwith NDVI image date 12/11/1999) and 2010 (lower, aligned with the NDVI image data 11/06/2016). Ranges of NDVI: 0.2 – 0.3 = Cropland-grassland-savanna; 0.301 – 0.4 = Savanna-shrubland-mangrove; 0.401 –

0.5 = Dry forest – monsoon forest; > 0.5 = Primary forest – broad leaves – evergreen forest. This NDVI classes follow Siswoyo (2014).

This apparent shift in Bali starling habitat preference is likely to have been influenced by several interacting factors. The first possible contributing cause is perhaps the lack of fire in the BBNP. Changes in fire regime has caused the habitat become more shaded as very little grasslands/savanna available. The second possible reason is increased human population and associated infrastructure and land use (dwellings, roads, croplands) in the areas adjacent to BBNP, thereby decreasing available Bali starling habitat. This is especially true of the Cekik - Gilimanuk area which has seen a major increase in human-dominated land uses, mainly through conversion of savanna. Accounts of local people indicate that the conversion of monsoon forest to agricultural land had a negative impact on Bali starlings (van Balen *et al.* 2000). Lastly, the shift in preferred habitat is perhaps due to changes in plant species composition and vegetation structure (which can also be traced to the lack of fire) which affect the Bali starling food sources and utilization of plants for foods and nesting.

We discovered as many as 22 plant species belonging to 14 families in the two savannas. At Cekik there were 10 species and eight families, whereas at Brumbun there were 20 species within 12 families. There were significant differences (R_{ANOSIM} = 0.228; P<0.003) in Bray-Curtis species similarity between the savanna sites (Figure3).

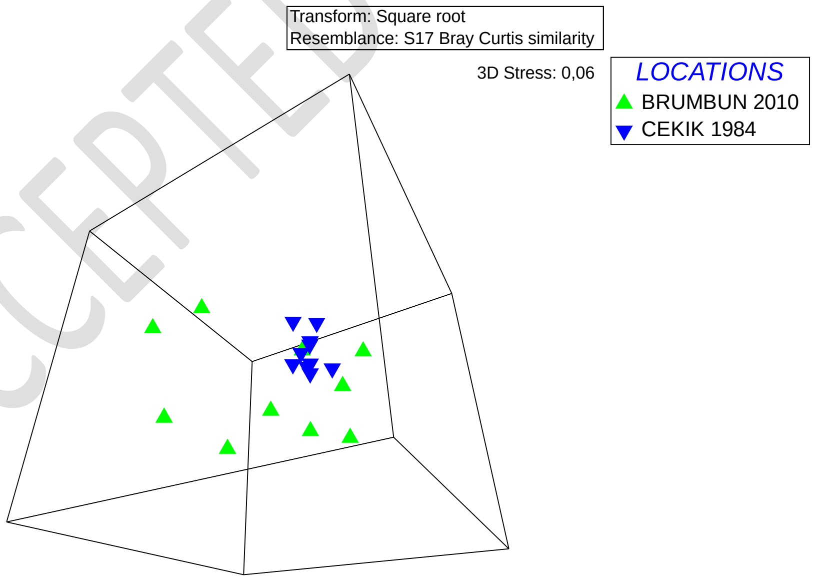

Figure 3. Non metric Multi Dimensional Scaling (NMDS) ordination based on the Bray Curtis Similarity index on plant species abundance and composition between Brumbun and Cekik savanna areas in Bali Barat National Park.

There was eight species that were present in both savannas (Cekik and Brumbun) namely *Chromolaena odorata, Lantana camara, Desmodium laxiflorum, Grewia eriocarpa, Bridelia stipularis, Cynodon dactylon, Calamagrostis australis*, and *Ziziphus mauritiana* (synonym *Z. jujuba*). There was no significant difference (P>0.05) in Shannon-Wiener species diversity between Brumbun and Cekik, however species richness among the two savannas was significantly different (P<0.05) (Figure 3). Brumbun had more species compared to Cekik.

Plant species composition was categorized into different uses by the Bali starling. The usage categories that were used namely: food, shelter (nesting) or a combination of both (Table 2). In terms of plants which provide food source, Cekik generally has higher cover. Six species were categorized as a food source for Bali starling namely *Z. mauritiana, G. eriocarpa, S. oleosa, Streblus asper, Azadirachta indica*, (tree species) and *L. camara* (herbaceous). Two species were used for shelter namely *B. flabellifer* (Arecaceae) and *Acacia leucophloea* (synonym *Vachellia leucophloea*) (Fabaceae). The latter (*A. leucophloea*) was also utilized by Bali starling as a food source (combined). There were used plant species that were only present in Cekik only and not in Brumbun (*S. oleosa* and *B. flabellifer*), as well as in Brumbun only and not Cekik (*S. asper, A. indica* and *A. leucophloea*). There were also plant species that were present in both of the locations such as *Z. mauritiana, G. eriocarpa* (tree species) and the invasive exotic climber *L. camara* (Table 2).

Table 2. Plant species used by Bali starling in sampling sites (Brumbun and Cekik) Bali Barat National Park

Species	**Family**	**Habitus**	**Usage**	**Found at and IVI**
Ziziphus mauritiana	Rhamnaceae	Tree	Food	Cekik (32.5) and Brumbun (32.5)
Grewia eriocarpa	Malvaceae	Tree	Food	Cekik (16.25) and Brumbun (16)
Schleicera oleosa	Fabaceae	Tree	Food	Cekik (16.25)
Borassus flabellifer	Arecaceae	Tree	Nest	Cekik (61.25)
Streblus asper	Moraceae	Tree	Food	Brumbun (16)
Azadirachta indica	Meliaceae	Tree	Food	Brumbun (16)
Acacia leucophloea	Fabaceae	Tree	Nest,food	Brumbun (16)
Lantana camara	Asteraceae	Herb	Food	Cekik (26.14) and Brumbun (9.8)

Bali starling absence in the Cekik area since the mid 1990s, although this area has plant species that are known to provide shelter and food for Bali starling (*Schleicera oleosa* and *Borassus flabellifer*) (Widodo 2014) similar to other areas known to be have been successfully recolonised by Bali starling in recent times, e.g. Brumbun with its *Acacia leucophloea*. The reason for this might be related to several factors such as plant species diversity and richness, increases in human habitation that may lead to decrease in plant species richness-diversity as well as increasing the risk of poaching. Plant species in Brumbun is richer compare to Cekik. Different species of tree dominate in Cekik and Brumbun however, although groundcover species composition between the two locations was relatively similar where exotic invasive species such as *Chromolaena odorata* and *Lantana camara* dominate the understorey. van Balen *et al.* (2000) wrote that Bali starling habitat in the late 1990s was open woodlands which were dominated by *A. leucophloea* trees with an undergrowth of *L. camara* and *C.odorata* shrubs, and *Imperata cylindrica* grass, and intersected by moister and more densely forested valleys with dominant trees *Grewia eriocarpa, Vitex pubescens, B. flabellifer* and *Schoutenia ovata.* This vegetation type might, however, be sub-optimal habitat for the Bali starling and it may have been driven there by poaching pressure (van Balen *et al.* 2000). In West Java, Fardila and Sjarmidi (2012) found that relatively low bird species diversity on the southern Bandung (urbanized areas) was attributable to humans. Land use and other aspects of the environment were interrelated to such an extent with bird communities, distribution in North Bandung, West Java (Fardila and Sjarmidi 2012). In other studies, Palomino and Carrascal (2006) found that bird species richness was significantly higher in natural than urban habitats in Spain.

Collins and Smith (1994) suggest that one of the factor in the decline of the Bali starling have been the conversion of savanna and forests to non-native tree plantations, crop land and villages. This is clear evidence of this in the Cekik area. The absence of the Bali starling in Cekik may also due to land use changes (fragmented landscape) and increase in human presence in the area. Cekik is located near Gilimanuk, a busy port of Bali that connects the island with Java Island. Whereas Brumbun, is located on the Prapat Agung Peninsula, a more remote area of the national park and also located near the ranger's outpost in the northern tip of the national park area. In fragmented landscapes, species persistence depends on their ability to use different habitats, so that less suitable habitats may still favour the connectivity of the most suitable habitats in the landscape (Calviño-Cancela *et al.* 2012). Remaining fragments of native habitats such as forests are often surrounded by a matrix of modified semi-natural habitats, such as tree plantations and crops, which can still provide habitat for species associated with natural forests (Lindenmayer and Hobbs 2004). In Spain, fragmented land, eucalypt plantations has lower species diversity compare to native forest, but eucalypt plantations provide habitat for species typical of shrublands when young, but do not contribute significantly to the maintenance of the understory biodiversity associated with native forests (Calviño-Cancela *et al.* 2012). In the case of Cekik and Brumbun, both locations provide suitable habitat for Bali starlings, although Cekik is decreasing in savanna-forest size, is more open and more human-populated. Most of the former habitat of the Bali starling has been converted into coconut and kapok plantations and human settlements. Cekik ability to provide habitat for species would be associated with the remaining natural vegetation. Relatively similar species richness with Brumbun and the distribution of specific plant taxa that influence the availability of shelter, feeding and breeding resources (*Ziziphus mauritiana*, *Grewia eriocarpa, Schleicera oleosa,* and *Borassus flabellifer*) contribute to the importance of this area for Bali starlings.

Poaching is the major threat to Bali starlings. In the 1960s, the Bali starling was trapped intensively to provide the demands of Indonesian, American and European private aviculturists. In 1966, the IUCN listed the species as endangered (Collins and Smith 1994). The Indonesian government responded with a 1971 law prohibiting hunting, capture and export of the bird (van Balen *et al.* 2000). However, there are reports that poaching has continued in spite of efforts to increase patrols by the park rangers (Collins and Smith 1994; Dirgayusa *et al.* 2000). In the Bali Barat National Park, specifically in Cekik, there is evidence of this as local rangers often encountered illegal poachers checking the handcrafted "pigeon holes" made by the Bali Barat Management to facilitate the survival of post-captivity bred Bali starling recently released in the area. Therefore, in Cekik, we suggest favouring more protection and, where feasible, restoration of native species to best improves conservation outcomes of the Bali starlings.

CONCLUSION

In summary, this study suggests that both forest and savanna are important land cover types and habitat for Bali Starling in Bali Barat National Park with changes in the relative proportions of these types, as well as availability of ecotones between them, are likely to be particularly important for this species. The increase in woody plant cover in the remaining savannas of northern BBNP where the Bali Starling is known to currently occur, and which may reflect a lack of burning in this area, is therefore of concern. The results of this study also further confirmed the importance of examining habitat characteristics and dynamics of endemic birds within landscapes that are influenced by multiple factors that interact in space and time (Fardila and Sjarmidi 2012; Orians and Wittenberger 1991). Habitat structure and floristic composition, such as percent canopy cover, tree species diversity and the distribution of specific plant taxa, are known to have a significant role in defining the occurrence of bird species in space (James and Wamer 1982; Rice *et al.* 1984; Wiens and Rotenberry 1981).

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REFERENCES

Backer C. A. & van den Brink R. C. B. 1963.*Flora of Java*. The Rijksherbarium, Leiden.

Calviño-Cancela M., Rubido- Bara M. & van Etten E. J. B. 2012. Do eucalypt plantations provide habitat for native forest biodiversity? *Forest Ecology and Management***270**, 153-62.

Clarke K. R. 1993. Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology***18**, 117-43.

Clarke K. R. &Gorley R. N. 2005. PRIMER: Plymouth Routines In Multivariate Ecological Research. PRIMER-E Ltd., Plymouth.

Collins M. S. & Smith T. B. 1994. Post Release Behaviour and Movements of the Bali Mynah (*Leucopsar rothschildi*). In: *AFA Watchbird* pp. 31-6. AFA Species Survival Plan, USA.

Collins M. S., Smith T. B., Seibels R. E. & Putra I. 1998.Approaches to the reintroduction of the Bali Mynah.*Zoo biology***17**, 267-84.

Curtis J. T. & McIntosh R. P. 1950.The interrelations of certain analytic and synthetic phytosociological characters.*Ecology***31**, 435-55.

De Iongh H. H., Komara A., Moeliono M., Soemarto P., Soebrata S., Spliethoff P. C. &Sunarja I. S. 1982.A survey of the Bali mynah *Leucopsar rothschildi* Stresemann 1912.*Biological Conservation***23**, 291-5.

DiMiceli C. M., Carroll M. L., Sohlberg R. A., Huang C., Hansen M. C. & Townshend J. R. G. 2011.Annual Global Automated MODIS Vegetation Continuous Fields (MOD44B) at 250 m Spatial Resolution for Data Years Beginning Day 65, 2000 2010, Collection 5 Percent Tree Cover. University of Maryland USA.

Dirgayusa I., Adi Putra I. &Prins H. H. T. 2000.Status and distribution of the endemic Bali starling *Leucopsar rothschildi*.*Oryx***34**, 188-97.

Estoque R. C., Estoque R. S. & Murayama Y. 2012.Prioritizing Areas for Rehabilitation by Monitoring Change in Barangay-Based Vegetation Cover.*ISPRS International Journal of Geo-Information***1**, 46-68.

Fardila D. &Sjarmidi A. 2012.Bird distribution along environmental gradients in North Bandung, West Java.*ProcSocIndonBiodiv Intl Conf***1**, 190-8.

IUCN.2014. The IUCN Red List of Threatened Species. International Union for Conservation of Nature, Cambridge.

James F. C. &Wamer N. O. 1982.Relationships between temperate forest bird communities and vegetation structure.*Ecology***3**, 159-71.

Kent M. 2011.*Vegetation description and data analysis: a practical approach*. John Wiley & Sons.

Kent M. & Coker P. 1992.*Vegetation Description and Analysis, A practical Approach.* John Wiley & Sons, New York.

Lillesand T. M., Kiefer R. W. &Chipman J. 2008.*Remote Sensing and Image Interpretation*. John Wiley and Sons, New York.

Lindenmayer D. B. & Hobbs R. J. 2004. Fauna conservation in Australian plantation forests: a review. *Biological Conservation***119**, 151-68.

Masy'ud B.,Kusuma I. H. &Rachmandani Y. 2008. Potency of food vegetation and habitat improvement effectivities of timor deer-Cervustimorensis, de Blainville 1822 in TanjungPasir West Bali National Park.

Masy'ud B., Wijaya R. &Santoso I. B. 2007.Distribution, Population and Daily Activities of Timor Deer-Cervustimorensis, de Blainville 1822 in Bali Barat National Park.*MEDIA KONSERVASI*.

Monk K. A., De Fretes Y., Reksodihardjo-Lilley &Gayatri. 2000.*Ekologi Nusa Tenggara dan Maluku*.Prenhallindo, Jakarta.

Orians G. H. &Wittenberger J. F. 1991. A habitat island approach to conserving birds in urban landscapes: Case studies from southern and northern Europe. *Biodiversity and Conservation***10**, 2023-43.

Palomino D. &Carrascal L. M. 2006. Urban influence on birds at a regional scale: A case study with the avifauna of northern Madrid province. *Landscape and Urban Planning* **77**, 276–90.

Purwandana D., Ariefiandy A., Imansyah M. J., Rudiharto H., Seno A., Ciofi C., Fordham D. A. & Jessop T. S. 2014. Demographic status of Komodo dragons populations in Komodo National Park. *Biological Conservation***171**, 29-35.

Rice J., Anderson B. &Ohman R. D. 1984. Comparison of the importance of different habitat attributes to avian community organization. *J. Wildl. Manage.* **48**, 895-911.

Sankaran M. (2001) Disturbance, diversity and community dynamics in a southern Indian savanna-grassland ecosystem. In: *Biology* p. 313. Syracuse University, Syracuse, New York.

Seibels R. E., Norton T. M. & Latimer K. S. 1997.*Husbandry guidelines for the Bali mynah (Leucopsarrothschildi): Species Survival Plan*. SC: Riverbanks Zoological Park and Botanical Gardens, Columbia.

Siswoyo A. 2014.PemodelanSpasialKesesuaian Habitat AkasiaBerduri (*Acacia nilotica*) di Taman NasionalBaluran.[Thesis]. Retrieved from *Department of Forestry* p. 72. InstitutPertanian Bogor, Bogor.

Soerjani M., Kostermans A. J. G. H. &Tjitrosoepomo G. 1986.*Weeds of rice in Indonesia* BalaiPustaka, Jakarta.

Stresemann E. 1912.Description of a new genus and new species of bird from the Dutch East India Islands.*Bulletin of the British Ornithologists' Club***31**, 4-6.

Valessini F. 2009.*NBIO528 Multivariate Techniques and Community Ecology: Course Handout*. Centre for Fish and Fisheries Research Murdoch University, Perth.

vanBalen S. B., Dirgayusa I. W. A., Adi Putra I. M. W. &Prins H. H. T. 2000.Status and distribution of the endemic Bali starling Leucopsarrothschildi*Oryx***34**, 188–97.

van der Paardt T. 1926.Manoekpoetih: *Leucopsar rothschildi*. *De TropischeNatuur***15**, 169–73.

vanSteenis C. G. G. J. 1972.*The Mountain Flora of Java*. E.J Brill, Leiden.

Whitten T., Soeriaatmadja R. E. &Afiff S. A. 1996.*The ecology of Indonesia series volume II: The ecology of Java and Bali*. Periplus, Hongkong.

Widodo W. 2014. Composition and important value index of birds in relation to study of bali starling (Leucopsarrothschildi) In the Bali Barat National Park *Zoo Indonesia***23**, 21-34.

Wiens J. A. &Rotenberry J. T. (1981) Habitat associations and community structure of birds in shrubsteppe environments.*Ecol. Monogr.* **51**, 21-41.

Williams T. M. &Feistner A. T. C. 2006.Reproduction of Bali starlings *Leucopsar rothschildi* at Durrell Wildlife Conservation Trust, Jersey.*International Zoo Yearbook***40**, 271-89.