Evaluation of Vegetation Characteristics and Habitat Utilization by Birds in Some Airports in Nigeria

By

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Introduction

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Nigerian Airlines Lament Loss Of N5.4b To Bird Strike Incidents

Bird strike incidents usually affect the engines of aircraft, which cost about $1.5 million (N547.5 million) to replace, depending on the type and capacity of the aircraft involved in the incident.

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Birdstrikes in Nigeria (2002-2015)

- Murtala Muhammad Int'l Airport (MMIA)(106)
- Port Harcourt Int'l airport (41)
- Nnmandi Azikwe Int'l Airport (40)
- Yakubu Gowon Airport (3)
- Sir Abubakar Tafawa Balewa Int'l Airport (SATBIA) (1) amongst others (NCAA, 2015).

- Black Kite *Milvus migrans* and Cattle Egret *Bubulcus ibis* identified as some of the hazardous species (Oduntan *et al.*, 2012; NCAA, 2015)

Justification

- Given that birds utilize habitats differently, the knowledge of vegetation characteristics and what birds are using airports landscape is critical to reducing bird strikes.

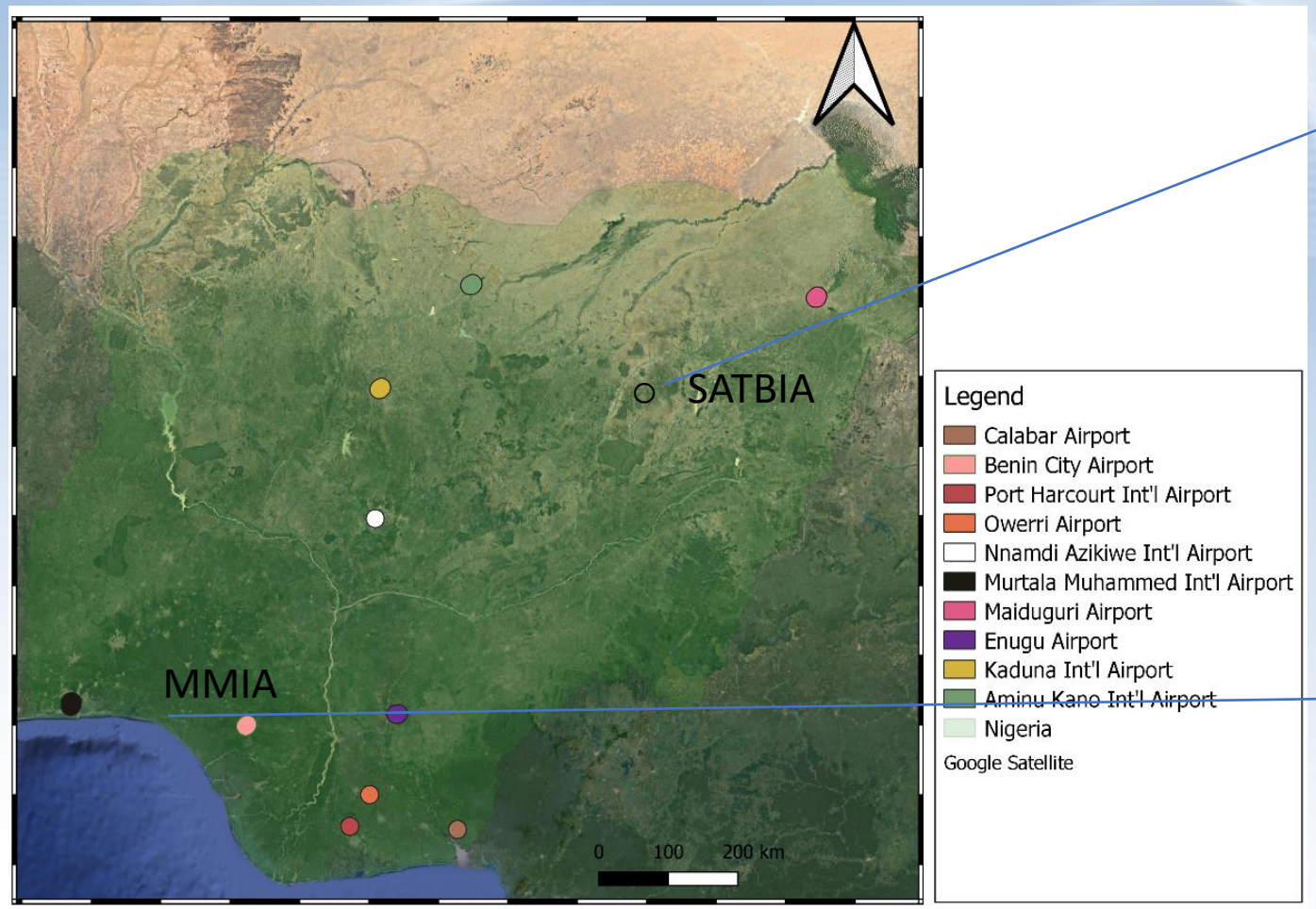
Aim and Objectives

- The aim of this study was to evaluate vegetation characteristics and how it influence avian habitat utilization and birdstrike occurrences in some airports in Nigeria.

Objectives

- To determine the influence of vegetation characteristics on abundance and richness of birds within and between airports.
- To determine how birds utilize the habitat within the airport landscape.
- To determine the effect of vegetation characteristics and aircraft movement on birdstrike occurrence.

Methodology



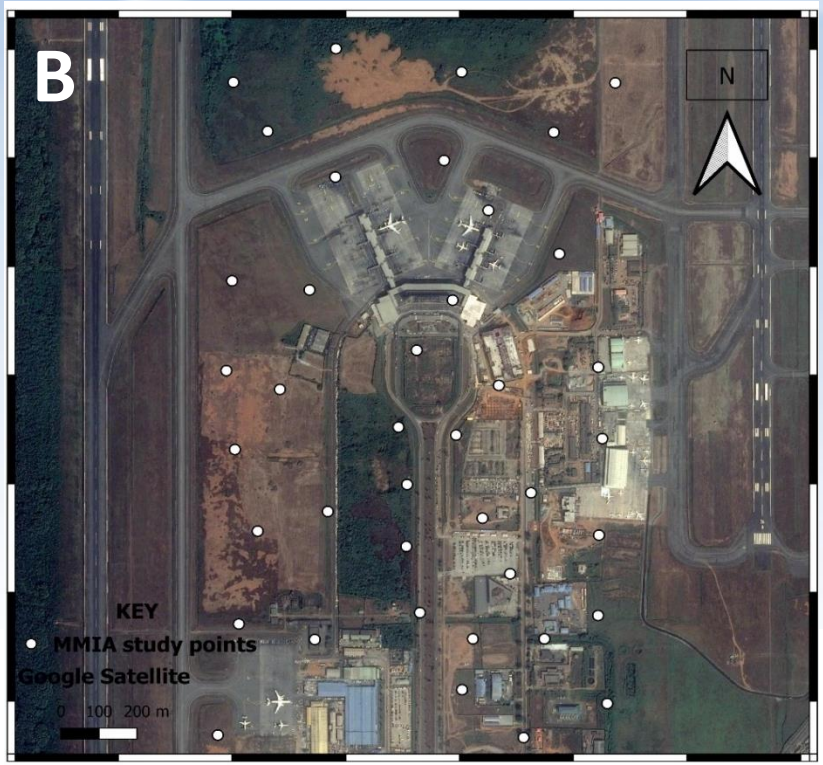
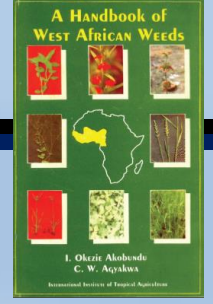


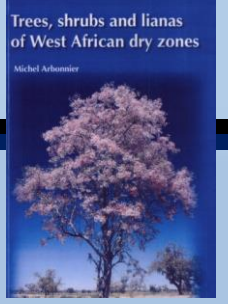
Figure 1: Map showing study sites with reported birdstrikes and aircraft movement records (centered) and ground observation sites (A & B); Murtala Muhammed International Airport (MMIA) and Sir Abubakar Tafawa Balewa International Airport (SATBIA)

Collection of bird data

- Point count method (Bibby et al., 2000).
  - 40 point count stations in each airport (>100m apart)
  - 5 minutes for bird count (from 7:00 to 11:00 AM and 3:00 to 6:00 PM).
  - 10 visits to each point except for 5 points and 8 others in MMIA that were visited twice and once, respectively due to accessibility challenges to the airside.
- Focal-bird approach was employed to hazardous species.

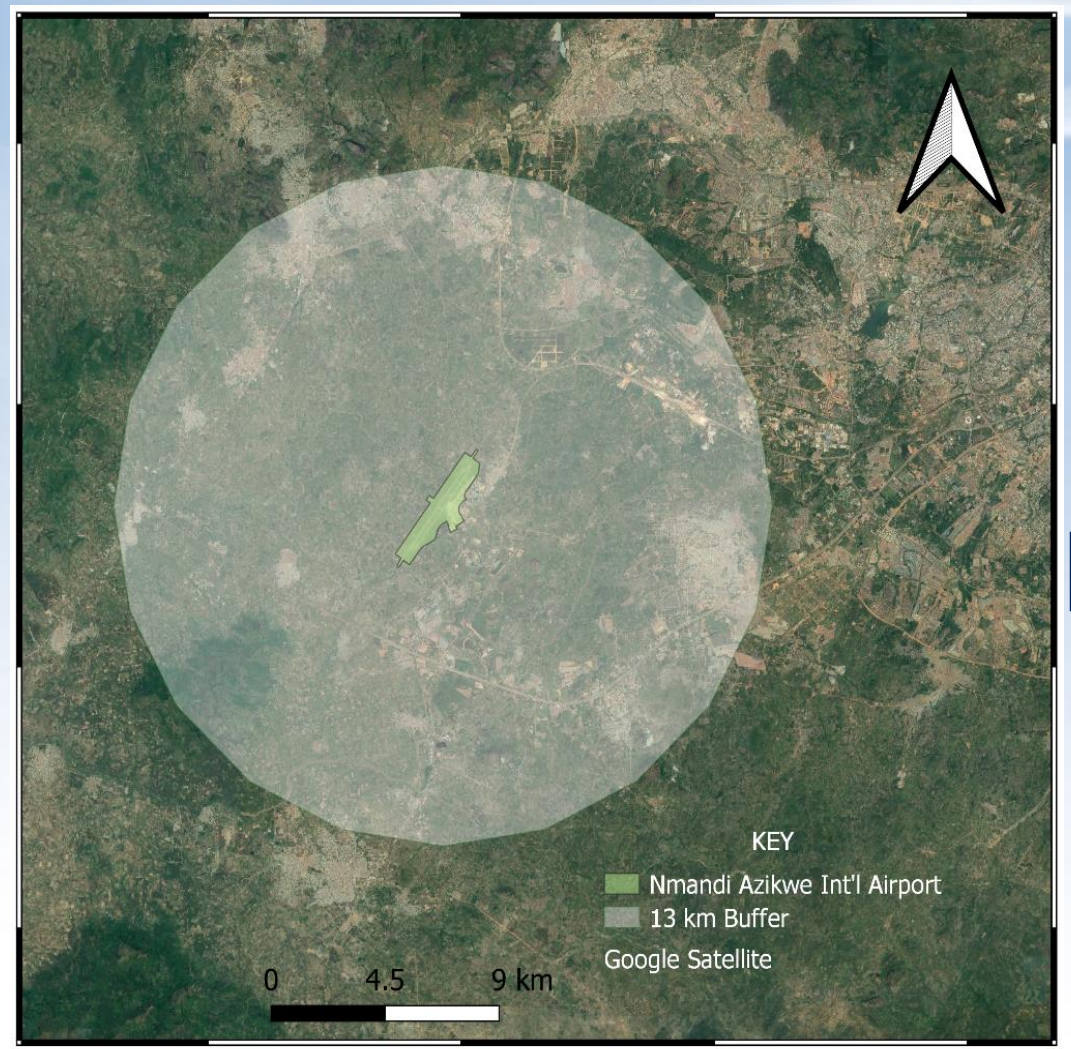
Vegetation measurement





- 30m^2 quadrat was laid for woody vegetation (short and tall shrubs, small and big trees) measurement at each point count station.
- Five 1m^2 quadrat was used for grass vegetation (grass height and percentage grass cover) measurement at each point count station.
- Habitats: Grassland, woody vegetation, developed areas, and farmland.

Geospatial vegetation data



- MODIS (Moderate Imaging Spectrodiometer) Vegetation Continuous Fields product of 10 airports was downloaded at two extents:
  - within-airport (proximate scale) and 13 km radius (landscape scale).

Geospatial veg. variables

1. percentage tree cover,
2. percentage non-tree vegetation,
3. and percentage non-vegetated

Figure 2: Illustration of 13 km radius buffer of Nmandi Azikwe International Airport

Data analysis

Normalized difference vegetation index (NDVI)

- $NDVI = \frac{NIR - RED}{NIR + RED}$

- $\text{Heterogeneity index} = \frac{\sum (max - min)}{\sum x}$

- Frequency distribution histogram and kolmogorov smirnov test

- Collinearity test of explanatory variables

Data analysis

- Independent sample t-test was used to compare vegetation characteristics between airports.
- Generalized Linear Mixed Models were used to model the effects of vegetation characteristics on bird abundance, richness, and to relate birdstrikes with vegetation cover data.
- Manual backward deletion model refinement and AIC function to select best models.
- Performed Generalized Linear Models (family binomial) for focal species data.

Results and Discussion

- A total of 5373 individuals belonging to 88 species in 39 families were recorded in the two airports.

- Of the focal species in the study, Cattle Egret was more abundant in MMIA (217 individuals; proportion: of 10.8%) than in SATBIA (117 individuals with a proportion of 3.6%).

- Black Kite was more abundant in SATBIA (66 individuals with a proportion of 2%) than MMIA (22 individuals with a proportion of 1.1%).

Table 1: Difference in vegetation characteristics between airports

Vegetation variable	mean (MMIA)	mean (SATBIA)	t	df	*p*
Heterogeneity index	0.31	0.70	-5.20	73.74	<0.001
Grass height	35.31	86.89	-5.75	63.68	<0.001
Tall shrubs	0.95	3.90	-2.09	77.28	0.04
Percentage grass cover	25.96	60.21	-5.74	67.19	<0.001
Short shrubs	1.68	19.73	-5.71	45.90	<0.001
Small trees	1.18	2.20	-0.70	2.20	0.49
NDVI	0.21	0.44	-8.69	77.95	<0.001
Woody sp. richness	0.38	4.68	-7.05	45.26	<0.001

Distinguishing between MMIA and SATBIA based on their bird species richness

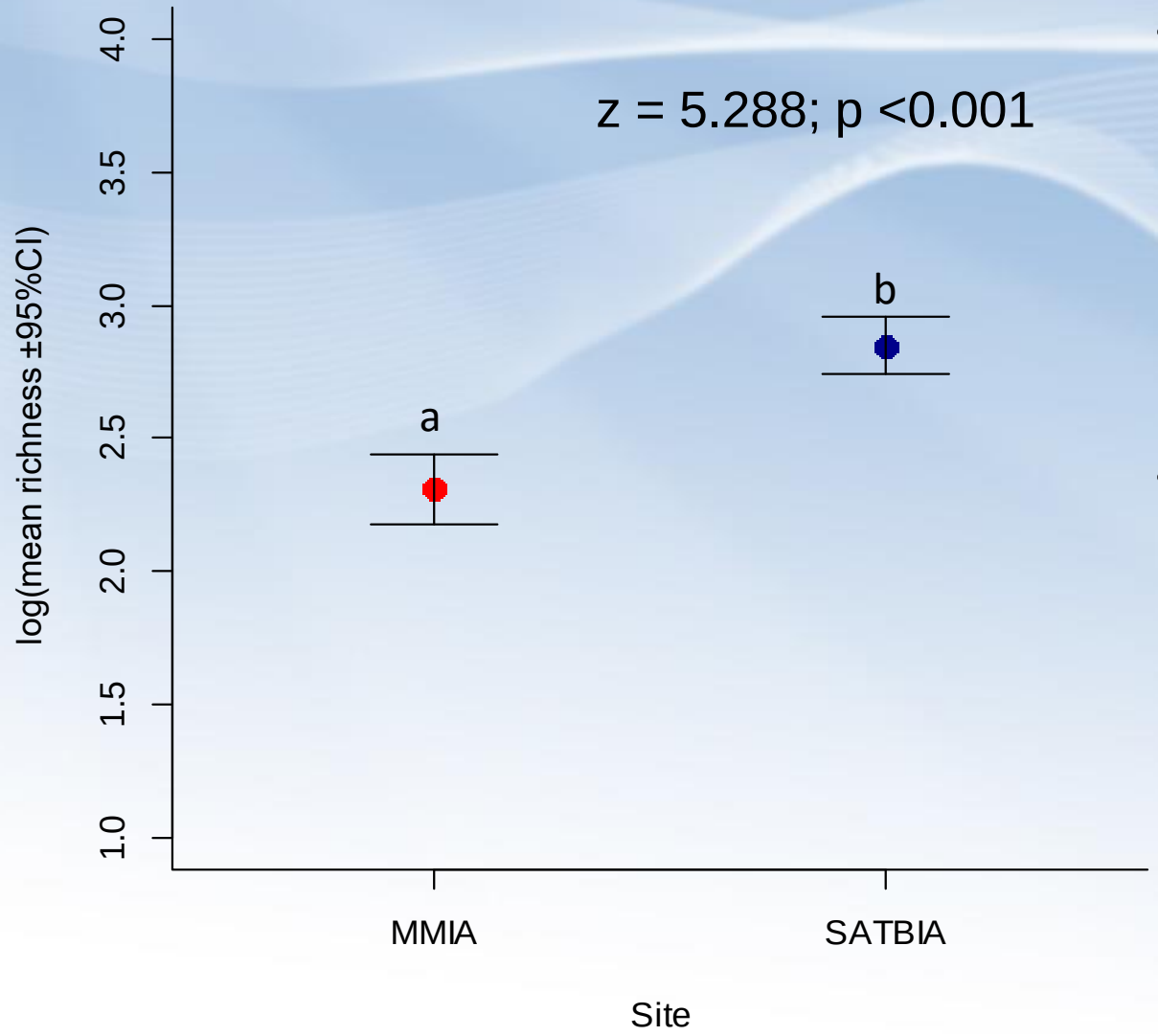
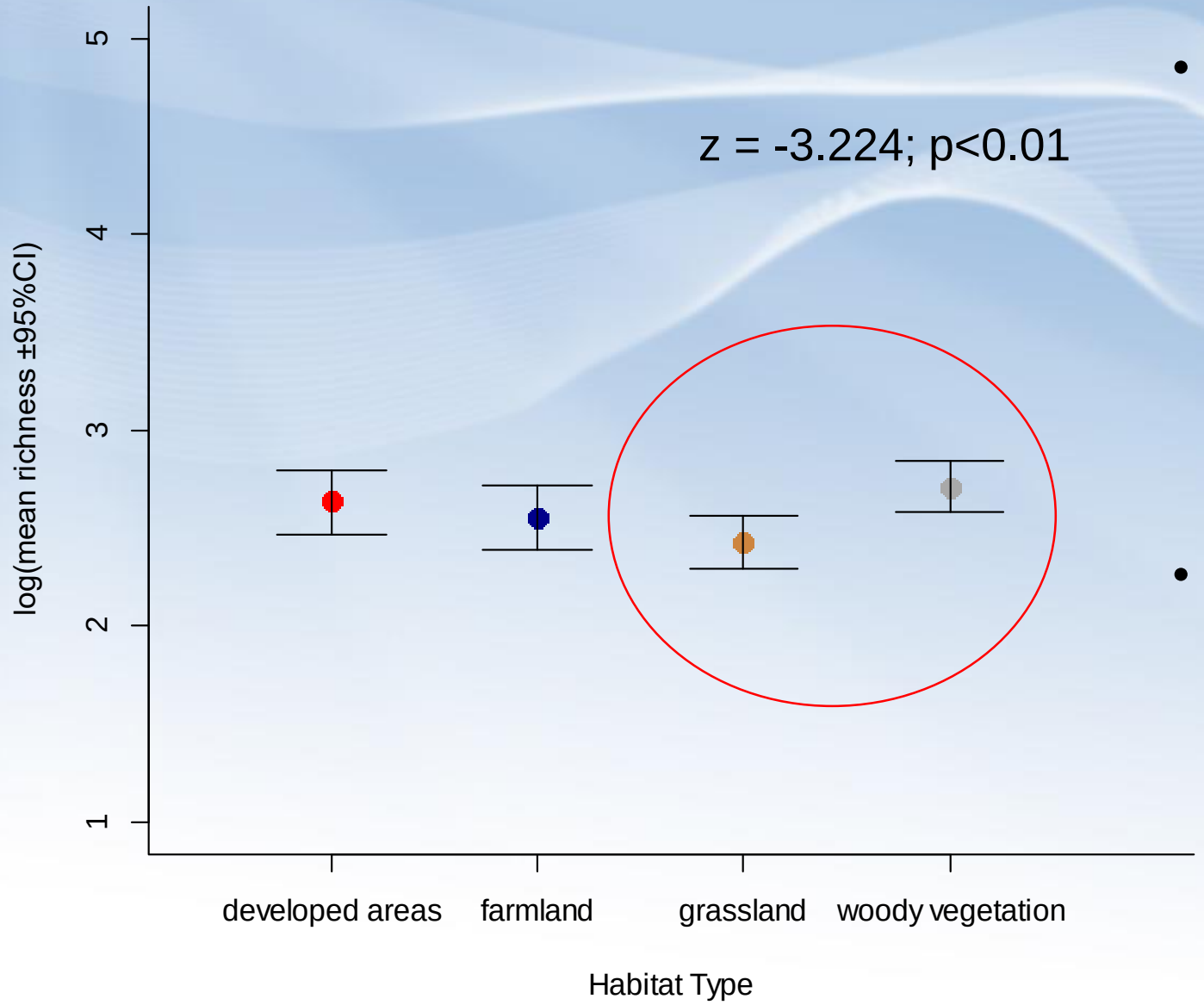


Figure 5: Differences in bird species richness between airports

- SATBIA had higher scores in all vegetation characteristics metric, hence more complex and heterogenous.
- Habitat heterogeneity and complexity in vegetation composition supports higher bird species richness by providing more ecological niches (MacArthur & MacArthur, 1961; Rotenberry & Wiens, 1980; Lee & Rotenberry, 2005; Ghadiri *et al.*, 2012; Carrasco *et al.*, 2018).

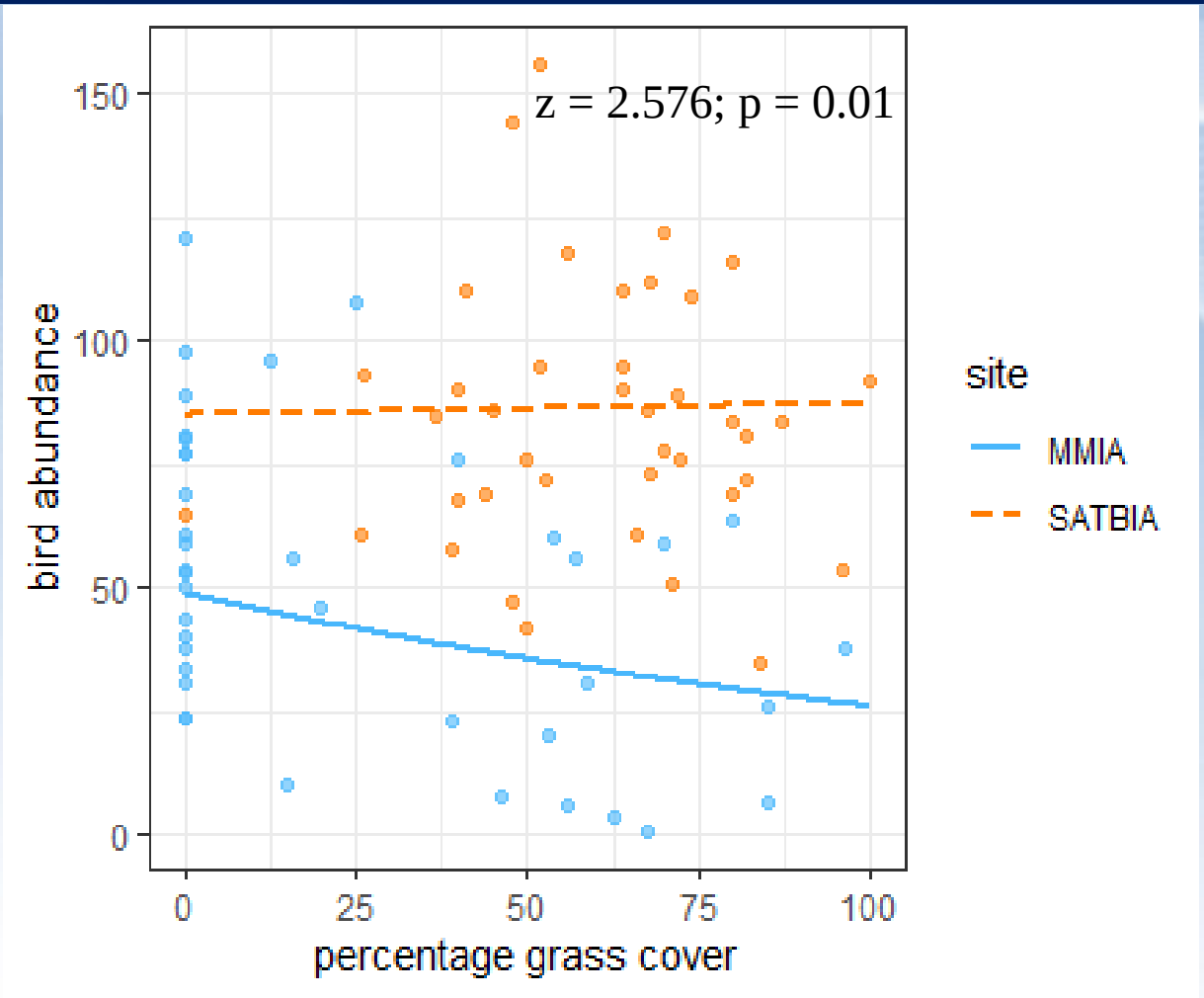
Bird species richness by habitat types in MMIA and SATBIA



- Woody vegetation, such as trees and shrubs serve as habitats for different bird species in airports (Lefebvre & Mott, 1987; Dolbeer, 1994; Cleary and Dolbeer 2005; Marcus *et al.*, 2000; Barras *et al.*, 2003).
- Also, well managed grassland could effectively reduce bird species richness within airports (DeVault et al., 2013; Deacon & Rochard, 2000; Walmsley & Turf, 2010).

Figure 6: Differences in bird species richness across habitat types

Relationship between grass cover and bird species abundance in MMIA and SATBIA



- MMIA was highly characterized by turf grasses (such as *Axonopus compressus* and *Cynodon dactylon*) which have been shown that when maintained well, can reduce the abundance of bird species in airports (Deacon & Rochard, 2000; DeVault *et al.*, 2013).

Figure 3: Effect of percentage grass cover on bird abundance by airports

Distinguishing between airside and landside based on their bird species richness

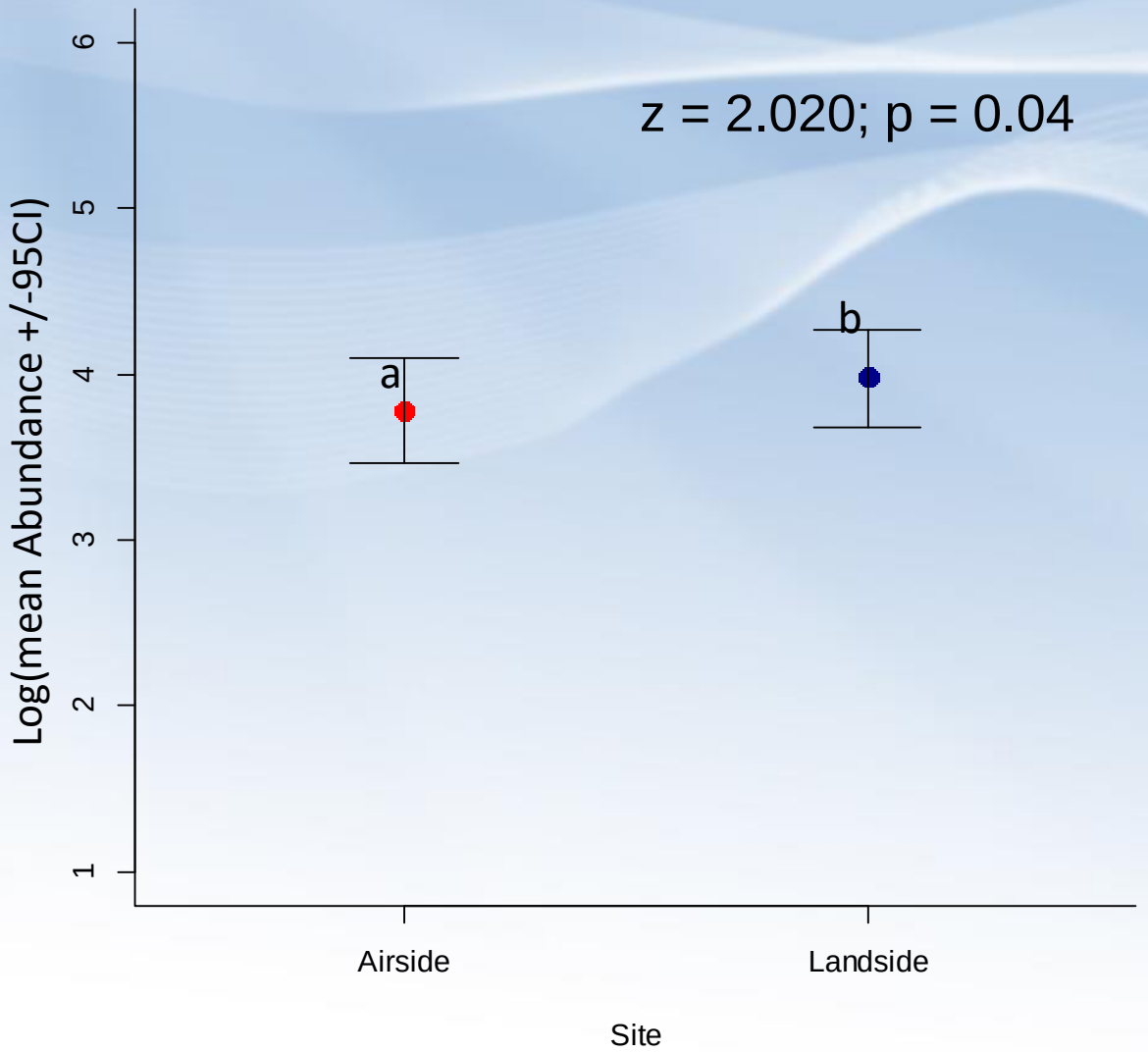


Figure 4: Difference in bird abundance between airside and landside

Effect of vegetation characteristics on occurrence of hazardous bird species

Table 2: Generalized Linear Model showing the influence of vegetation characteristics on the occurrence of Black Kite

Variables	Estimate	±SE	z value	*p*
(Intercept)	7.89	4.69	1.68	0.09
Heterogeneity Index	-0.31	1.63	-0.19	0.85
Grass Cover	-0.06	0.04	-1.40	0.16
NDVI	-14.23	10.61	-1.34	0.18
Tall shrub	0.34	0.30	1.11	0.27

Effect of vegetation characteristics on occurrence of hazardous bird species

Table 3: Generalized Linear Model showing the influence of vegetation characteristics on the occurrence of Cattle Egret

Variables	Estimate	±SE	z value	*p*
(Intercept)	-1.41	1.31	-1.08	0.28
Heterogeneity index	0.90	1.61	0.56	0.58
Grass cover	0.03	0.03	1.00	0.32
NDVI	1.08	4.68	0.23	0.82
small tree	-0.12	0.11	-1.06	0.29

- Habitat preference in Black Kite and Cattle Egret may be contrasting...

Table 4. Effect of vegetation characteristics and aircraft movement on birdstrike

Variables	Estimate	±SE	z-value	*p*
(Intercept)	1.171	0.172	6.820	<0.001
Aircraft movement	1.631	0.589	2.769	<0.01
Proximate non-tree vegetation	-2.238	0.728	-3.074	<0.01
Proximate tree cover	-0.378	0.811	-0.466	0.641
Landscape non-tree vegetation	1.318	0.709	1.860	0.063
Landscape tree cover	-0.854	0.742	-1.151	0.250
Landscape non-tree vegetation:				
Landscape tree cover	6.960	1.737	4.007	<0.001

Results and Discussion

- The relationship of birdstrike with proximate non-tree vegetation is similar to the effect of grass cover on bird species abundance observed during ground observations at MMIA.

- However, the relationship obtained with proximate tree cover is not consistent with the ground observation that have shown woody vegetation support higher bird species richness than other vegetation types.

- Land cover and landscape diversity in areas surrounding airports influence birdstrike occurrence (DeVault et al, 2016; Iglay et al., 2017; Coccon et al., 2015; Pfei et al., 2018).

Conclusion

- Birdstrikes occurrence is not only dependent on within-airport vegetation or bird species abundance and richness but is also dependent on the vegetation surrounding airports as well as aircraft movement.

- Woody vegetation supports bird species richness and the presence of managed grass-dominated landcover in the airports could reduce bird species richness.

- Human activities on the landside of the airports support a high number of bird species and which can be hazardous to aircraft if care is not taken.

Recommendation

- Vegetation management should be airport-specific and targeted at hazardous species present considering their habitat requirements.
- Also, grass management practices should consider using grass species that are unattractive to birds instead of having it bare ground.
- Awareness programmes should be carried out on the landside and developed areas to curb human activities that may attract bird species abundance.

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Appendices

Appendix 1: Effect of vegetation characteristics on bird species richness

Parameters	Marginal mean (±95CI)	Slope(±SE)	Df	F	*p*
Site			**1**	**118**	**<0.001**
MMIA	2.31 (2.18; 2.44)				
SATBIA	2.85 (2.74;2.96)				
Habitat			**3**	**5.29**	**0.01**
developed areas	2.64 (2.47;2.80)				
farmland	2.55 (2.39;2.72)				
grassland	2.43 (2.29;2.56)				
woody vegetation	2.71 (2.58;2.84)				
Airport Section			1	3.43	0.067
airside	2.49 (2.39;2.60)				
landside	2.64 (2.54;2.74)				
NDVI		0.66 (0.34)	1	3.48	0.051
heterogeneity index		0.11 (0.10)	1	0.86	0.257

Appendix 2: Pairwise Tukey post hoc test of the difference in bird species richness across different habitat types in SATBIA and MMIA

Contrast	Estimate	SE	z ratio	*p*
developed areas – farmland	0.084	0.134	0.627	0.924
developed areas – grassland	0.213	0.126	1.687	0.331
developed areas – woody vegetation	-0.071	0.124	-0.570	0.941
farmland – grassland	0.129	0.101	1.280	0.575
farmland – woody vegetation	-0.155	0.096	-1.616	0.370
grassland – woody vegetation	**-0.283**	**0.088**	**-3.224**	**0.007**

Appendix 3. Effect of vegetation characteristics on bird abundance

Parameters	Marginal means (±95CI)	Slope(±SE)	Df	F	*p*
Site			**1**	**9.52**	**0.001**
MMIA	3.40 (3.06, 3.74)				
SATBIA	4.36 (3.87.4.85)				
Water source			1	3.25	0.079
present	3.79 (3.49;4.09)				
absent	3.97 (3.65;4.28)				
Habitat			3	5.4	0.055
developed areas	4.10 (3.72;4.48)				
farmland	3.82 (3.46;4.17)				
grassland	3.68 (3.37;4.00)				
woody vegetation	3.92 (3.59;4.24)				
Airport Section			**1**	**2.64**	**0.043**
airside	3.78 (3.47;4.10)				
landside	3.98 (3.68;4.27)				
NDVI		0.32(0.445)	1	5.43	0.471
heterogeneity index		0.059(0.124)	1	0.05	0.634
tall shrubs		-0.036(0.025)	1	12	0.16
I(tall shrubs^2)		0.002(0.001)	1	0.01	0.055
grass cover		-0.007(0.002)	1	7.73	0.054
small trees		0.009(0.006)	1	0.26	0.16
site:Gcover		**0.008(0.003)**	**1**	**6.65**	**0.01**