

1 **HABITAT CHARACTERISTICS OF WINTERING WOOD WARBLER (*Phylloscopus***  
2 ***sibilatrix*) IN CENTRE REGION OF CAMEROON: CONSERVATION**  
3 **IMPLICATIONS**  
4

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20 **ABSTRACT**  
21

22 Populations of many Afro-Palaearctic birds have declined, with those wintering in sub-Saharan  
23 Africa, such as Wood Warbler *Phylloscopus sibilatrix*, particularly affected. In this study we  
24 investigated the relationship between habitat characteristics on Wood Warbler  
25 presence/absence in Centre Region of Cameroon. A total of six transects were established in  
26 three habitat types (forest, forest-savannah transitional zone and savannah). Call playback  
27 surveys were conducted monthly from November 2015 to April 2016 to determine Wood  
28 Warbler presence / absence. Detailed habitat measurements were also recorded in each  
29 transect. A total of 86 responses were recorded: 33 (mean  $6.6 \pm 2.3$ ) in forest habitat, 47  
30 (mean  $9.4 \pm 3.36$ ) in forest-savannah transitional zone, and 6 (mean  $2 \pm 1.1$ ) in savannah  
31 habitat. Wood Warbler presence increased significantly with the number of trees between 3 -  
32 7 m in height, and decreased significantly with the number of shrubs between 0.5 - 3 m in  
33 height. Anthropogenic disturbance such as agriculture cycle and burning were not found to  
34 have an effect on Wood Warblers presence / absence. We conclude that Wood Warblers

35 overwinter in forested habitats with a relatively low canopy and an open understorey,  
36 supporting a similar study in West Africa. Forest clearance in sub-Saharan Africa potentially  
37 threatens wintering habitat for Wood Warblers.

38 **Keywords:** Wood Warbler, Wintering habitat, Habitat characteristics

## 39 INTRODUCTION

40

41 Biodiversity conservation and environmental sustainability have become global priorities that  
42 shape international policy (United Nation et al. 2000). Biodiversity faces multiple threats  
43 ranging from agricultural expansion, overexploitation, forest fires and habitat fragmentation  
44 (Laurance et al. 2009). In many cases, species are particularly vulnerable if their geographic  
45 range spans multiple habitats or even continents (Grendelmeier 2011), as is the case with  
46 migrant birds.

47

48 There is increasing evidence from Europe suggesting that many migrant birds from the  
49 African - Palearctic region (Afro-Palearctic migrants) are undergoing population declines  
50 (Evans et al. 2012). This decline is more marked in long distance migrants that overwinter in  
51 sub-Saharan Africa and breed in Eurasia than short distance and sedentary species (Heldbjerg  
52 and Fox 2008). However, the mechanisms leading to the decline of these species are poorly  
53 understood (Evans et al. 2012). Moreover, almost nothing is known of the wintering ecology  
54 of many species (Hobson et al. 2014).

55

56 The Wood Warbler (*Phylloscopus sibilatrix*) is one of such migrants that have undergone a  
57 striking population decline (PECBMS 2011). Wood warblers breed in Europe and Central  
58 Asia, and winter in Equatorial Africa (Urban et al. 2007). Natural and semi-natural  
59 broadleaved as well as coniferous woodland is the preferred breeding habitat, with densities  
60 highest where Oak *Quercus* is dominant (Wesołowski and Bazaars 2009; Mallord et al.  
61 2012a). Wood Warbler populations declined significantly in Europe and between 1990 and  
62 2006 (Voříšek et al. 2008), but it remains obscure whether this pattern of change is due to  
63 events in the breeding areas or on wintering grounds, or both. Preliminary data from Great  
64 Britain (Mallord et al. 2012a, 2012b) and Switzerland (Gerber 2011; Grendelmeier 2011), do  
65 not indicate that changes on the breeding grounds are implicated in declines. Thus, events  
66 occurring outside the breeding grounds are likely more important (Hobson 2014). Despite  
67 this, the information about their ecology on their wintering ground is poorly known,  
68 particularly in Central Africa (Evans et al. 2012; Mallord et al. 2016). In a review of the

69 potential factors that are driving migrant bird declines, Vickery et al. (2014) highlighted the  
70 urgent need for detailed studies on the wintering grounds to inform conservation management,  
71 where there is a paucity of ecological information for most species. Such is the case with  
72 Wood Warbler wintering habitat use which is poorly understood, making it difficult to  
73 identify potential threats and hindering conservation efforts. In particular, no studies to date  
74 have quantified habitat use throughout the entire wintering period, which could change in  
75 response to resource availability and environmental cues.

76

77 This paper presents the first systematic study carried out to investigate the relationship  
78 between habitat characteristics on Wood Warbler presence/absence in Central Africa. Based  
79 on work from West Africa (Mallord et al. 2016), we expected that (1) Wood Warblers would  
80 prefer the forest savannah transitional zone, and (2) that anthropogenic activities such as  
81 agricultural practices and burning would negatively influence Wood Warblers presence.

82

## 83 **MATERIALS AND METHODS**

84

### 85 **Study area**

86 The study was conducted in the Centre Region of Cameroon, at three sites that differed in  
87 broad vegetation characteristics identified from satellite imagery and assessments on the  
88 ground: Batschenga (4°16'60" N 11°39'0" E) characterized by its forest cover, Nachtigal  
89 (4°20'48.01" N 11°38'5.99" E) characterized by its forest savannah transitional zone cover  
90 and Ntui (4°27'0"N 11°37'60" E) characterized by its savannah cover (Figure 1). The study  
91 area holds a high diversity of floral species such as Ebony (*Diopyros spp*), Sapelli  
92 (*Entandrophragma cylindricum*), Moabi (*Baillonella toxisperma*), White Doussie (*Afzelia*  
93 *pachyloba*), Ayous (*Triplochytton sceroxylon*) and Fraké (*Terminalia superba*). The area has  
94 no legal protection status. Two transects of 2 km of length were established in each of the  
95 study sites (forest, forest savannah transitional zone and savannah) by non - random sampling  
96 based on homogeneity of habitat.

97

### 98 **Wood Warblers presence / absence**

99 The data was collected in repeated manner from November 2015 to April 2016 and a day per  
100 month was devoted to the visit of each transect. Surveys began at 06:20 am and were  
101 completed at 11:00 am; since birds are more active during this period and their detectability is  
102 high (Bibby 2000). Along each transect we established 20 listening points at intervals of 100

103 m measured using a handheld GPS. Given that Wood Warbler have a small size (Hobson et  
104 al. 2014) and are easily overlooked when not singing or calling, we used call playback  
105 (Sutherland et al. 2004) to increase Wood Warbler detectability. At each station along the  
106 transect, the advertising call of Wood Warbler (recording taken from Chappuis 2001) was  
107 played using an mp3 player connected to a “Radio Shack” mini Amplifier-Speaker,  
108 alternating in all directions during 30 seconds (short period to minimize disturbance) and 10  
109 seconds (to avoid attracting a bird from outside afar). Presence/absence was recorded on a  
110 data sheet alongside the GPS position. This method is described by RSPB / BTO in  
111 collaboration with Naturama and Ghana wildlife society, in their migrant project  
112 (*unpublished*).

113

### 114 **Habitat characteristics**

115 Habitat characteristics within 50 m of each point were described with variables referring to  
116 habitat structure and anthropogenic activities. Data were collected at all bird survey points,  
117 and additionally at 200 m intervals between points. Table 1 below shows the different  
118 variables recorded.

119

### 120 **Statistical analysis**

121 The effects of habitat structure and land management practices on Wood Warbler presence /  
122 absence at a listening point were modelled using a Generalised Linear Mixed effects Model  
123 (GLMM) with a binomial error structure. There was no multicollinearity between predictors  
124 ( $r = < 0.6$ ). Continuous fixed effects in the model were *n* trees 3-7 m, *n* trees 7-14 m, *n* trees >  
125 14 m, *n* shrubs 0.5-3 m, *n* shrubs 3 – 5 m, vegetation density (mean of four measurements  
126 taken at the cardinal points). Burning period, wood removal and agricultural cycle were  
127 included in the model as categorical factors. Continuous fixed effects were mean centred and  
128 scaled by 1 standard deviation to compare coefficient effect sizes ( $\beta$ ). Point ID nested in  
129 transect was included as a random intercept to account for pseudo replication. The minimum  
130 adequate model was selected using likelihood ratio tests, and 95% confidence intervals were  
131 bootstrapped.

132 After selecting the minimum adequate model for habitat structure and land management  
133 practices, we then tested if there was a seasonal effect on wood warbler presence/absence.  
134 This was done by re-running the minimum adequate model with the addition of month as a  
135 fixed effect, and also including a two-way interaction between month and each of the

136 remaining habitat structure / land management variables. All analyses were conducted using R  
137 (R Core Team 2014) and the lme4 package (Bates et al. 2014).

138

## 139 **RESULTS**

140

141 During the six month survey, a total of 86 responses were recorded. Respectively, 33 (mean  
142  $6.6 \pm 2.3$ ) responses were recorded in forest habitat, 47 (mean  $9.4 \pm 3.36$ ) responses were  
143 recorded in the forest-savannah transitional zone, and 6 (mean  $2 \pm 1.1$ ) responses were  
144 recorded in savannah habitat (Figure 2).

145

146 The maximum number of responses were recorded in January, and by April no birds were  
147 detected (Figure 3). In other words, few responses were recorded in November and this  
148 gradually peaked over time until the maximum number of records in January, with no  
149 responses recorded in April.

150

### 151 **Habitat Preferences**

152 The best minimum adequate GLMM (Table 2) for Wood Warbler presence included only the  
153 fixed effects of  $n$  trees 3-7 m and  $n$  shrubs 0.5-3 m. The probability of Wood Warbler  
154 presence was positively correlated with  $n$  trees 3-7 m ( $\beta = 0.45$ ,  $p = 0.014$ ; Figure 4), and  
155 negatively correlated with  $n$  shrubs at 0.5-3 m ( $\beta = -0.66$ ,  $p = 0.019$ ; Figure 5). Based on  $\beta$   
156 effect sizes,  $n$  shrubs at 0.5-3 m had a greater influence on Wood Warbler presence. Marginal  
157  $R^2$  for the minimum adequate model was 13%. The number of responses did not vary  
158 significantly during the season, and there was no evidence of seasonal changes in habitat  
159 preferences based on the interactions tested ( $P > 0.05$ )

160

161 Conditional modes of the intercept for the random effect of study site (Batschenga, forest;  
162 Nachtigal, forest-savannah transition; Ntui, savannah) showed that the probability of detecting  
163 Wood Warblers was, on average, greatest in the forest-savannah transition zone (Figure 6).

164

165 The various anthropogenic activities recorded as potential threat on Wood Warbler habitat in  
166 the study area are agricultural activities dominated by perennial cultures (100% in forest,  
167 33,33% in forest-savannah transitional zone and 83,33% in savannah), pasture (5% present  
168 only in forest-savannah transitional), bush fires (55% in forest-savannah transitional zone,

169 45% in savannah and absent in forest), wood removal (40% in forest, 29% in forest-savannah  
170 transitional zone, 47% in savannah).

171

## 172 **DISCUSSION**

173

174 This study is the first to investigate Wood Warbler habitat preferences in Central Africa. The  
175 majority of responses were recorded in forest-savannah transitional zone with a greater  
176 probability of Wood Warbler detection in its two transects (NAT1 and NAT2) than those of  
177 others habitats. Our results are consistent with those of Mallord et al. (2016) in similar study  
178 in Burkina Faso and Ghana, and Evans et al. (2012) using stable isotope for declining avian  
179 migrants wintering habitat investigation. These could be due to the proximity of our forest-  
180 savannah transitional zone (in Nachtigal) to Sanaga River, which provide a micro climate,  
181 suitable for abundance of a broad insect's diversity, principal food resources of Wood  
182 Warbler. Miguel and Aide (2008) found in Puerto Rico that, Migratory species were mostly  
183 abundant in habitats situated near a river. This abundance could be due to the availability of  
184 nutritive resources (Lefebvre et al. 1994; Lefebvre and Poulin 1996), characterized by a broad  
185 specific insects richness and abundance (Meades et al. 2002), considered as the main food  
186 resources of a large number of these migratory species (Russell, 1980; Lefebvre et al. 1994).  
187 Also, bioavailability of insects in this habitat could reduce competition between Wood  
188 Warbler and others insectivores of the same or different taxa (Moreau, 1952; Miguel and Aide  
189 2008). Furthermore, more than one response was recorded at some listening points, mostly in  
190 forest and forest-savannah transitional zone habitats. This observation is similar with those  
191 found by Mallord et al. (2016) and suggests that, Wood Warblers are not territorial on the  
192 wintering grounds, and forms ephemeral intra- and inter-specific feeding flocks (Mallord et  
193 al. 2016).

194

### 195 **Effect of wintering period on Wood Warbler presence/absence**

196 A great number of responses were recorded in January, while no response in April. This  
197 means that Wood Warbler wintering population is completely installed in January, and return  
198 to Europe by end of March and early April. Also we found no seasonal change in habitat  
199 preferences of Wood Warbler during its wintering period. Then we could hypothesize that,  
200 this Afro Palearctic birds arrive very quickly in Cameroon, setup a non-breeding territory,  
201 stay for five months then quickly depart. This fast departure could be justified by the fact that

202 they should synchronize their reproductive period with the time of prey availability on the  
203 breeding grounds (Wesolowski and Maziarz 2009).

204

### 205 **Effect of Habitat characteristics on Wood Warbler presence/absence**

206 Probability of Wood Warbler detection or presence increased significantly (estimate = 0.45; p  
207 = 0.014) with number of trees between 3 - 7 m in height (which were dominant in forest-  
208 savannah transitional zone). This result is consistent with those of Mallord et al. (2016) in  
209 Burkina Faso and Ghana. This could be due to the fact that Wood Warbler preferred wooded  
210 habitat with relative widely-spaced branches to allow movement and foraging (Gerber 2011).  
211 Also, spacing between branches requires a certain vegetation height (Glutz von Blotzheim and  
212 Bauer 1991). In addition, these trees could provide adequate cover and camouflage,  
213 particularly when roosting. Preference for these trees could suggest that Wood Warblers like  
214 landscape with open canopy structure which probably increased the physical availability of  
215 prey (Mallord et al. 2016). Probability of Wood Warbler detection or presence decreased  
216 significantly (estimate = -0.66; p = 0.019) with number of shrubs between 0.5 – 3m in height  
217 (which were dominant in savannah habitat). Based on absolute effect sizes, the *n* shrubs 0.5 –  
218 3 m has a greater effect than *n* trees 3- 7 m. This result could be justified by the fact that, a  
219 high shrub density obstructs Wood Warbler moving or foraging. In addition, Quelle and  
220 Lemke (1988); Delahaye and Vandevyvre (2008); Marti (2007); Hillig (2009); Reinhardt and  
221 Bauer (2009) found in Wood Warbler breeding ground that high shrubs density limit the  
222 establishment of a dense herb layer, which is necessary to conceal Wood Warbler nests from  
223 predators. Furthermore, herb cover and herb height were found to have significant influences  
224 on Wood Warbler territory choice (Gerber 2011), yet we found that they weren't have  
225 significant influence on Wood Warbler presence/absence in this study. This could be due to  
226 contrasting habitat requirements on the breeding grounds and during the overwintering period.

227

228 Marginal  $R^2$  for the minimum adequate model was 13%. This means that only 13% of  
229 variation in Wood Warbler presence/absence was explained by the most parsimonious model.  
230 Suggesting Wood Warbler presence could dependent on other factors that we did not look at.  
231 These might include, for example, the availability of food resources or specific tree species.  
232 Since Mallord et al. (2016) found a significant correlation between Wood Warbler presence  
233 and tree species like *Albizia sp* and *Anogeissus leiocarpus*, this could play an important part in  
234 determining Wood Warbler presence that was overlooked during this study.

235

236 Anthropogenic activities such as agriculture are amongst the main causes of deforestation in  
237 Africa and greater threats on avifauna (Bobo 2007). Agriculture was found in all sites and was  
238 dominated by cocoa land, mostly in Forest habitat in Batchenga following by savannah in  
239 Ntui. But we found that activities like agriculture and bush fire were not having significant  
240 effect on Wood Warbler presence/absence. These results are similar with those found by  
241 Mallord et al. (2016). This suggests that species tolerate farm land holding high density of  
242 trees. Nonetheless, Wood Warblers, like other Afro-Paleartic migrants could be vulnerable to  
243 woodland loss due to the land-use change in tropical Africa (Mallord et al. 2016).

244

245 Wood Warblers were mostly found in forest-savannah transitional zone habitat, and prefer  
246 forested habitats with a relatively low canopy and an open understory which probably favors  
247 the species' foraging strategy. Wood Warbler shows fine-scale selection in terms of tree  
248 height, and land-use change and forest clearance in sub-Saharan Africa could therefore be  
249 contributing to declines by deforestation of wooded land. We suggest future conservation  
250 research to focus on investigating changes in Wood Warbler habitat. This study encourages  
251 farmers to retain trees on farmland to increase suitable tree cover on farmland required by  
252 Wood Warbler. Also regenerate degraded woodland with a diversity of trees which could help  
253 the species and others birds. Furthermore, managing these regenerated forests by  
254 incorporating crop rotation, edge type forest, crop activity, given that Wood Warbler avoid  
255 close forest and may be consider as species that require adoption of wildlife-friendly farming  
256 practices that integrate the needs of birds and people.

257

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259

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264

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**TABLES**

**Table 1:** Variable names and descriptions recorded in each of the three habitats (forest, forest-savannah transitional zone and savannah).

<b>Variable</b>	<b>Description</b>
<b>Dominant land cover</b>	Dominant vegetation: dense forest, open forest, agricultural/natural mosaic, others (arable, bare ground, grassland, plantation, shrub land)
<b>Tree cover</b>	Tree cover: 1 = 0%, 2 = 1 – 4%, 3 = 4 – 15%, 4 = 15 – 40%, 5 = 40 – 65%, 6 = >65%
<b>Tree 3 – 7 m</b>	Number of trees
<b>Tree 7 – 14 m</b>	Number of trees
<b>Tree &gt; 14 m</b>	Number of trees
<b>Shrub cover</b>	Shrub cover: 1 = 0%, 2 = 1 – 4%, 3 = 4 – 15%, 4 = 15 – 40%, 5 = 40 – 65%, 6 = >65%
<b>Shrub 0.5 – 3 m</b>	Number of shrubs
<b>Shrub 3 – 5 m</b>	Number of shrubs
<b>Grass cover</b>	1 = 0%, 2 = 1 – 4%, 3 = 4 – 15%, 4 = 15 – 40%, 5 = 40 – 65%, 6 = >65%
<b>Grass 0.03 – 0.3 m</b>	Grass with height of 0.03 – 0.3 m
<b>Grass 0.3 – 1 m</b>	Grass with height of 0.3 – 1 m
<b>Grass 1 – 3 m</b>	Grass with height of 1 – 3 m
<b>Wood</b>	Evidence of wood removal (whole trees, branches or for charcoal): yes/no

<b>Burn</b>	Evidence of burning, either in this year, the previous year or not at all: yes/no
<b>Agriculture</b>	Evidence of agriculture cycle: 1 = annual, 2 = perennial, 3 = 2 crops / year.
<b>Vegetation density</b>	Mean of four measurements taken at the cardinal points.

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380 **Table 2:** Habitat characteristics explaining Wood Warbler presence/absence from the best  
381 GLMM.  $\beta$  coefficients are given on the link scale (odds-ratios)

Variable	$\beta$	-95% CI	+95% CI	P
<b>Intercept</b>	-2.57	-3.45	-1.97	< 0.001
<b>n trees 3-7m</b>	0.45	0.04	0.84	0.014
<b>n shrubs 0.5-3 m</b>	-0.66	-1.31	-0.13	0.019

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420 **FIGURE LEGENDS**

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422 **Figure 1:** Map of study area and study site in Centre Region of Cameroon.

423 **Figure 2:** Average number of responses per habitat

424 **Figure 3:** Number of responses recorded per month surveyed

425 **Figure 4:** Fitted values (red line +/- 95% CI) from the top GLMM explaining Wood Warbler  
426 presence showing the effect of  $n$  trees 3-7 m on Wood Warbler presence at a survey point.

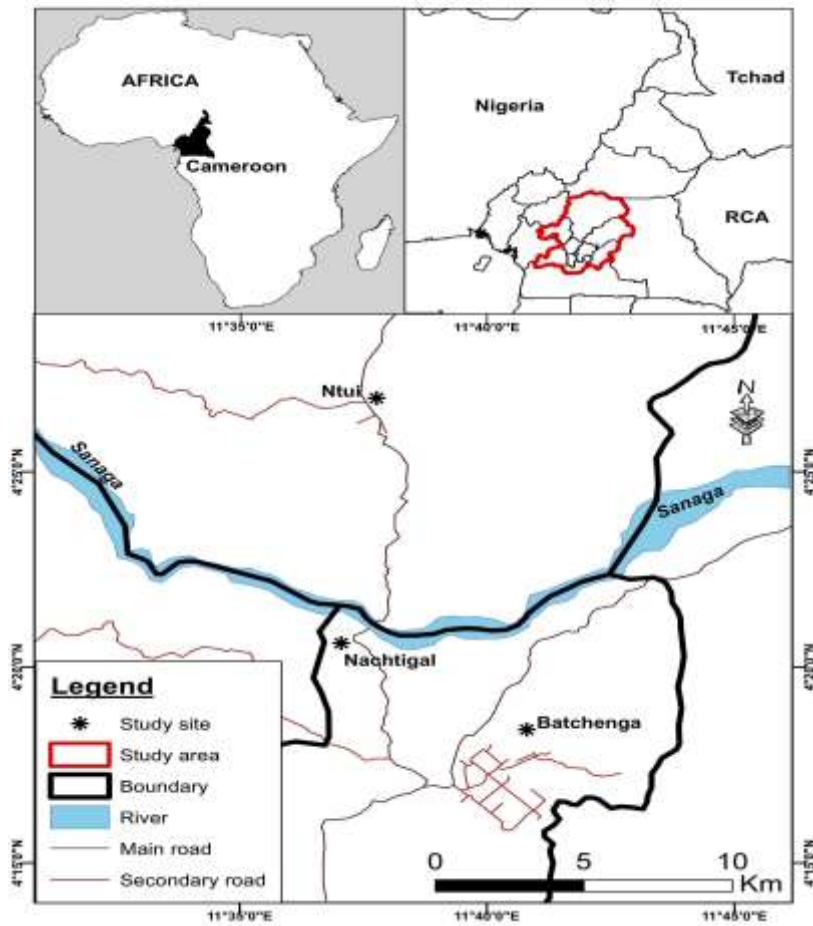
427 The histograms show the frequency of presence/absence for a given value on the x-axis.

428 **Figure 5:** Fitted values (red line +/- 95% CI) from the top GLMM explaining Wood Warbler  
429 presence showing the effect of  $n$  shrubs 0.5 - 3 m on Wood Warbler presence at a survey  
430 point. The histograms show the frequency of presence/absence for a given value on the x-axis.

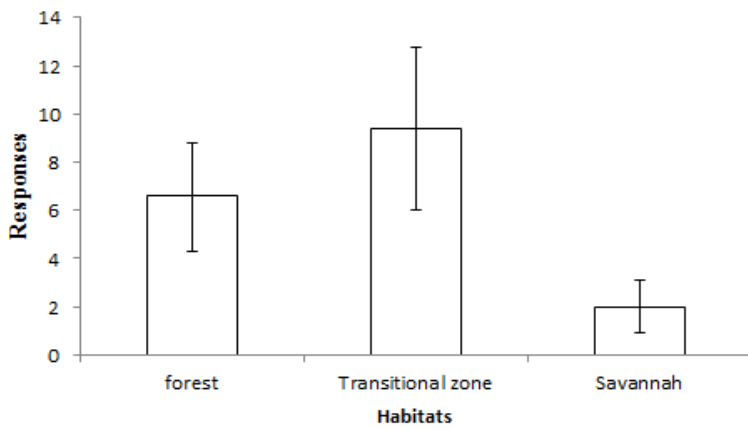
431 **Figure 6:** Conditional modes of the intercept (+/- 95% CI) for the random effect of transect  
432 nested in study site extracted from the minimum adequate GLMM explaining Wood Warbler  
433 presence. Study site abbreviations are NAT: Nacthigal, BAT: Batschenga and NTUI: Ntui.

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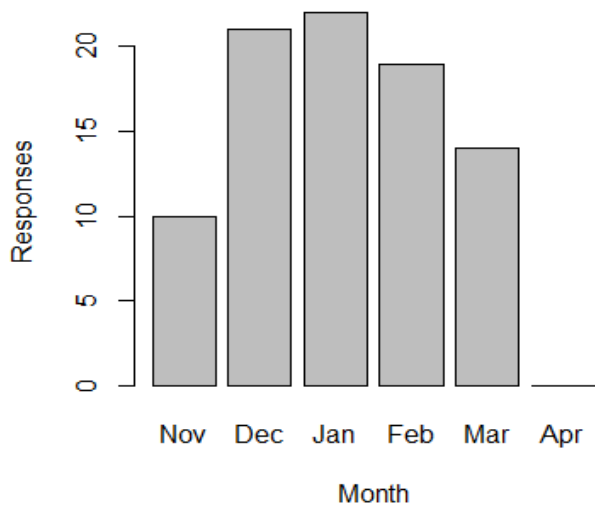
435 **FIGURES**



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 437 **Figure 1:** Map of study area and study site in Centre Region of Cameroon.  
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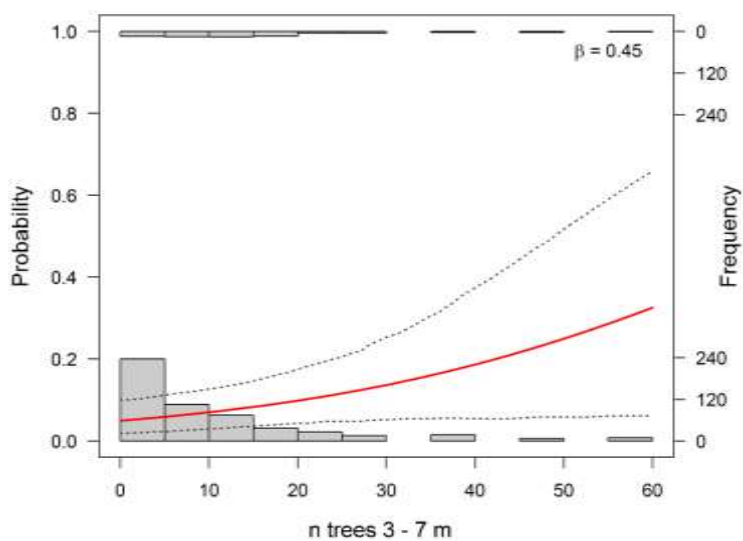
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 440 **Figure 2:** Average number of responses per habitat  
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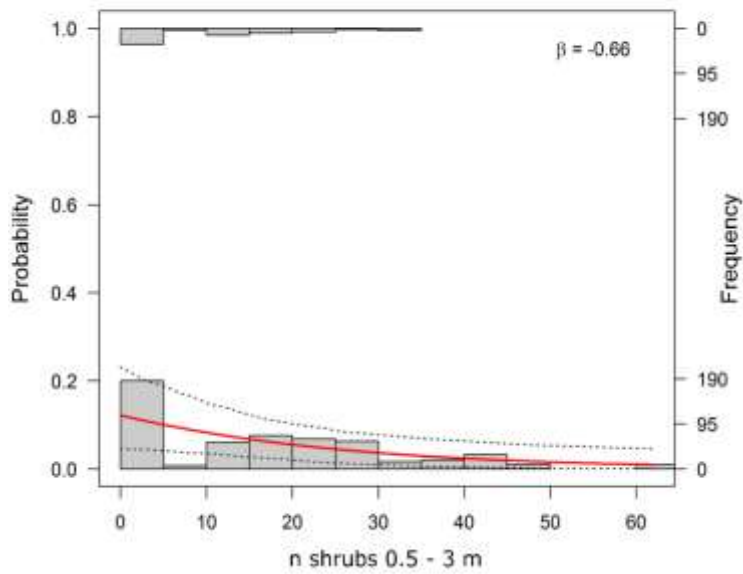
443 **Figure 3:** Number of responses recorded per month surveyed

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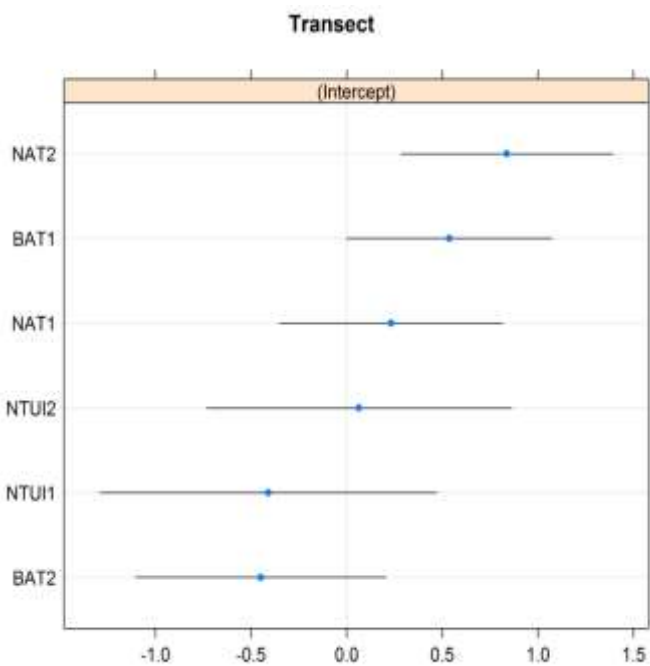
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446 **Figure 4:** Fitted values (red line +/- 95% CI) from the top GLMM explaining Wood Warbler  
 447 presence showing the effect of  $n$  trees 3-7 m on Wood Warbler presence at a survey point.  
 448 The histograms show the frequency of presence/absence for a given value on the x-axis.



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**Figure 5:** Fitted values (red line +/- 95% CI) from the top GLMM explaining Wood Warbler presence showing the effect of n shrubs 0.5 - 3 m on Wood Warbler presence at a survey point. The histograms show the frequency of presence/absence for a given value on the x-axis.



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**Figure 6:** Conditional modes of the intercept (+/- 95% CI) for the random effect of transect nested in study site extracted from the minimum adequate GLMM explaining Wood Warbler presence. Study site abbreviations are NAT: Nacthigal, BAT: Batschenga and NTUI: Ntui.