RESEARCH ARTICLE

Spatial response of the globally-endangered Sokoke Pipit (*Anthus sokokensis* van Someren, 1921) to habitat modification in an Eastern Arc Coastal Forest [version 1; peer review: 1 approved with reservations, 1 not approved]

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Abstract

The Arabuko-Sokoke forest is the largest relic of a formerly larger contiguous East African coastal forest. It forms part of the Eastern Arc Forest system which is a global biodiversity hotspot with considerable species endemism. As one of the most important bird habitats in Africa, it hosts nine globally-threatened and four regionally threatened species. Despite such conservation significance, the forest is undergoing rapid modification and habitat loss mainly from anthropogenic pressures, with negative impacts on sensitive species such as the Sokoke Pipit (*Anthus sokokensis*). This study examined impacts of change in habitat quality on the species' population and spatial occurrence within three blocks of *Brachystegia* woodland in the forest. Over a three week period, six 1-km transects were used to estimate the species' population in relation to major habitat quality variables. Sokoke Pipits occurred at an overall mean density of 0.72 ± 0.15 birds/ha with an estimated population of 5,544 in the *Brachystegia* woodland. Tree logging intensity was the key cause of the degradation of the Sokoke Pipit's critical habitat, which affected its density ($R^2 = 0.663$, $\beta = -0.814$, $p = 0.048$). The species also preferred sites covered with deep floor litter ($R^2 = 0.769$, $\beta = 0.877$, $p = 0.021$) even in areas with low tree canopy height, but showed no clumped distribution ($\chi^2_{(2, 0.05)} = 2.061$). Sites with intensive elephant activity, which leads to tree felling and clearing of the understorey, had low Sokoke Pipit densities. We conclude that although human-driven tree removal is a major driver of degradation of the Sokoke Pipit's critical habitat, elephant activity may be an important additional factor in this process. Long term conservation strategies for the species will require stricter control of logging but management of the population and

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dispersal of elephants across the forest, especially in *Brachystegia* woodland, may also be helpful.

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Introduction

Tropical forests constitute the most important habitats for biodiversity because despite covering less than 7% of the global land surface, they host at least half of all terrestrial species on earth¹. However, these habitats also face the greatest threat from human exploitation, destruction or modification with an estimated loss rate of c. 10% every decade especially in areas without formal protection^{1,2}. Birds are among the most affected by forest destruction and habitat loss, particularly forest-dependent species^{3,4} which may respond to such perturbations in such spatially distinct patterns as to make them suitable for monitoring the quality of the forest habitat and its suitability for other taxa⁵.

Sokoke Pipit⁶ is a forest-floor insectivore of the East African coastal forests of Kenya and Tanzania^{7–9}. This globally-endangered species¹⁰ is generally restricted to the woodland habitat dominated by *Brachystegia* tree species (Leguminosae)^{9,11} where it feeds on arthropods on the ground or in the understorey^{9,12–14}. It mainly occurs in parts of the woodland with deep floor litter and a fairly closed tree canopy⁹.

The species has been more frequently encountered in the coastal forests of Kenya than those of Tanzania, with the most common sites being in the Arabuko-Sokoke forest, hereafter ASF and the Dakatcha Woodland. The main threat to the species is the modification and reduction of its suitable habitat^{12,14}, especially the removal of *Brachystegia* trees, a process to which it is very sensitive⁹.

This study aimed to assess the Sokoke Pipit's response to change and modification of its habitat by comparing its estimated densities across three zones of its *Brachystegia* woodland stronghold in ASF. Although there have been extensive previous studies on the forest's biodiversity in general^{15,16}; on other forest-dependent bird species^{17,19,20} and one on forest disturbance¹¹ no study has been conducted to directly investigate the link between Sokoke Pipit population or distribution and modification of its habitat. Musila *et al.* examined¹⁴ the species' general habitat requirements within *Brachystegia* woodland, but did not specifically examine its demographic and spatial response to change in structural habitat quality. Our study thus aimed at filling these gaps as well as providing updates on the species' current population estimate over the past decade since the study by Musila *et al.*¹⁴ in 2001. In that earlier study species density was estimated at 2.8 ha⁻¹ and 0.7 ha⁻¹, in the undisturbed and disturbed areas of the *Brachystegia* forest respectively, and overall population at 13,000 for the whole forest.

Materials and methods

Study area

The ASF is located between 39°40'E–39°50'E longitude and 3°10'S–3°30'S latitude, within the Malindi and Kilifi Districts along Kenya's north coast (18 km south of Malindi) see [Figure 1](#). Its altitude ranges from 60 to 200 m above sea level²⁰, and mean annual rainfall from 600 mm in the northwest to 1100 mm in the northeast, with the rainy season falling between late March and May, the short rains occurring from November to December

Figure 1. Map of study area. The figure shows the map of Arabuko-Sokoke forest indicating the main blocks in *Brachystegia* woodland where surveys were conducted (Jilore, Narasha and Kararacha) and the six transects used (two in each block). Numbers 1, 2, 3.... are transect numbers in the blocks (Map adapted from Davis, 2005)²⁰.

and dry season from June to October and December to February¹¹. Mean monthly temperatures range from 26 to 31°C. The forest is one of the few remaining indigenous forests in Kenya, and one of the largest fragments of an earlier, much larger coastal forest that once covered much of the East African coast²¹. It covers 41,600 ha¹⁸ including 4,300 ha which is formally protected as a nature reserve^{9,20}.

The ASF constitutes one of the Eastern Arc Coastal biodiversity hot spots²² and is one of the most significant Important Bird Areas in Kenya based on BirdLife International protocols^{9,15}. It hosts at least 230 bird species including five globally-endangered species (Sokoke Pipit *Anthus sokokensis*, Spotted Ground Thrush *Zoothera guttata*, Sokoke Scops Owl *Otus ireneae*, Clarke's Weaver *Ploceus golangi* and Amani Sunbird *Anthreptes pallidigaster*); four near-threatened species (East Coast Akalat *Sheppardia gunningi*, Plain-backed Sunbird *Anthreptes reichenowi*, Fischer's Turaco *Tauraco fischeri* and Southern-banded Snake Eagle *Circaetus fasciolatus*); and eight regionally-vulnerable species^{9,10,18}. Among these are five species endemic to the East African Coastal Forests Endemic Bird Area: Sokoke Pipit, Clarke's Weaver, Amani Sunbird, Fischer's Turaco and Sokoke Scops Owl^{9,14,16}. These features make ASF the second most important forest for bird conservation in mainland Africa⁴. In addition there are three endangered mammals including the African elephant (*Loxodonta africana*), an endangered amphibian *Mertensophryne micranotis* and the rare lizard *Gastropholis prasina* as well as at least 50 globally rare plant taxa⁹.

The ASF consists of three main forest plant community zones: *Brachystegia* woodland which runs in a central strip, a relatively open habitat dominated by *Brachystegia spiciformis* trees growing in low density mainly on whitish-leached sandy soils covers some 7,700 ha of largely open understorey with little or no undergrowth²⁴; mixed forest with a diversity of relatively densely populated, tall and undifferentiated trees covering an area of about 7,000 ha; and *Cyanometra* forest with a variegated thicket, which covers about 23,500 ha, grows in the western part of the forest on red Magarini sands and is dominated by *Cyanometra webberi*, *Manilkara sulcata*, *Oldfieldia somalensis* and *Brachystegia huillensis*^{9,11,25}. The rest consists of plantation forest and open gaps (Figure 1).

The forest is surrounded by small-scale agricultural land and settlement by a growing population of adjacent communities whose relatively low income levels are partly responsible for their increasing dependence on forest products for many of their needs^{9,26,27}. According to current strategic forest management plan estimates, there are almost 60 villages scattered around the forest that utilize natural products directly derived from the forest^{9,18,25}.

The main forms of human activities that impact on the forest habitat include illegal logging, honey harvesting, game snaring, cattle grazing and the creation of numerous tracks used by tree poachers into and out of the forest²⁵. Further impact on the habitat is caused by the foraging behaviour of the resident population of African elephants, which has increased from an estimated mean value of 141 individuals in 1996^{28,29} to between 180–227 in the period from 2002–2006^{29,30}. We were not able to obtain any official figures since 2006.

This study was conducted in the forest woodland zone dominated by *Brachystegia spiciformis* trees, to examine the response of the Sokoke Pipit population to human-induced habitat modification, particularly the removal of trees and other habitat degradation effects. The response to such variables was assessed in terms of the species' density, encounter rates and distribution. Accordingly, we expected the species' density and distribution to reflect corresponding spatial patterns in logging intensity.

Sampling strategy

The survey was carried out over 28 days between November 2011 and February 2012 within three blocks in the *Brachystegia* woodland stratified as follows: the main forest reserve block in the north-east, centered around Narasha (generally regarded as the most highly disturbed area from earlier intensive lumbering which continued until the early 1980s); the southern block of regenerating forest (a reserve regarded as less disturbed) in the Kararacha area; and the smaller strip on the outer north-western part of the forest around the Jilore village, which is considered more disturbed than Kararacha but slightly less so than Narasha (Figure 1). This classification is based on the methodology of Oyugi *et al.*¹¹. Two 1-km transects were laid randomly in each block. Randomization was achieved by selecting the third track that branched to the left of the main forest track each time^{31,32}. When such a track was too short to cover one whole kilometer of forest as was in the case in the Jilore zone, a track was selected to run parallel to the main forest track but maintaining at least 250 m from the main track and the forest edge. In addition, bird surveys were conducted by starting from a different end of the transect each successive time³¹. Sampling independence for bird detection was ensured by maintaining at least 1 km from neighboring transects. Bird surveys, vegetation sampling and habitat assessment for tree logging intensity were assessed on separate days.

Bird survey

Sokoke Pipit survey was the main objective of the study but we also recorded other birds encountered along the transects. The survey was conducted using Distance protocol, as described by Buckland *et al.*³³ starting from 6.00 am to 9.00 am along the randomly selected 1-km transects in each forest block. Transect widths were fixed at 60 meters and birds were counted by moving slowly and recording all sightings and calls^{5,31}. Surveyors worked in pairs, one observing with a pair of Bushnell XLT binoculars with 8×32 magnification and the other recording any encounters as they walked along the transect. Only positively identified Sokoke Pipit individuals or clusters were recorded. Perpendicular distance of each encounter from the transect centre was also determined, using a Nikon NKU 8371 rangefinder and recorded [see Buckland *et al.*³³ and Fewster *et al.*³⁴]. To reduce biases associated with double counting, birds flying from behind the surveyors were ignored and a distance of no less than 1 km was maintained between transects³¹. For clusters of birds, the perpendicular distance measured was to the centre of the point where the individual cluster was originally detected^{31,33}.

Vegetation sampling

Vegetation parameters were assessed within ten 10 × 10 m quadrats along the same transects used for birds. The quadrats were established on alternate sides of the transects at 100-m intervals

and within them estimates of percent canopy height, using a Nikon NKU 8371 rangefinder, and canopy cover from three different points along a diagonal line down the quadrat (each corner and the centre) were scored. Canopy cover percent was scored within three defined ranges as < 33%; 34–66%; or > 66%). Live woody stems were also counted in each quadrat to gauge the understorey woody vegetation density. These were scored in three size classes of small (10–30 cm); medium sized (31–60); cm and large (above 60 cm) measured using a standard tape measure at breast height. In addition, logging intensity was assessed in each of the quadrats by counting all cut stems of trees of similar diameter size using the categories above¹¹.

Floor litter sampling

In each of the quadrats along transects used for vegetation sampling, forest floor litter depth was assessed at three points along a diagonal running from one corner to another through the quadrat centre³². The depth of litter was determined using a straight, stiff thin metallic rod driven vertically and gently downward until it touched the firm forest floor beneath the litter, and then read off against a standard 30 cm ruler. Litter cover was assessed by dividing the 10 × 10 m quadrats into 25 smaller grids of 2 × 2 m quadrats by use of a standard meter rule and tape measure then ascertaining the percentage category in each 2 × 2 square before averaging the total out of 25.

Data analyses

Because of the relatively small number of replicates in the study (two transect runs for birds and one set of habitat variable samples) preliminary data exploration showed departure from normal distribution. As such, all count data such as for live stems and cut tree stumps were transformed by logarithm and ratio or scale data such as by arc-sine before analyses proceeded^{31,35}. Sokoke Pipit densities were determined per hectare using DISTANCE v 6 software³³ while their encounter rates were also calculated from the relationship $R_E = n/L_i$ where R_E = encounter rate; n = mean abundance of Sokoke Pipits along the transect; and L_i = total length of transect in kilometers. Due to high variance in detection of Sokoke Pipit in the Jilore block compared to Kararacha and Narasha (Table 1), which was likely a result of differences in understorey structural characteristics, Multiple Covariate Distance Sampling (MCDS) was preferable to Conventional Distance Sampling in estimating Sokoke Pipit density even with the relatively small sample size as the mean cluster sizes were quite constant at two individuals per sighting^{36,37}. We selected the cosine adjusted half-normal detection functional model with the lowest value based on Akaike Information Criterion in the

density estimations³⁷. Species richness for all birds was evaluated as the total cumulative number of different species recorded in each transect during all the bird sampling sessions. Bird diversity was worked out using the reciprocal of Simpson's index of the form: $1/S = 1/[(\sum n(n-1)/N(N-1)]$ where S = Simpson's Index, n = the total number of organisms of a particular species and N = the total number of organisms of all species. Simpson's index of diversity was chosen as it is suitably robust for non-numerous replicate sampling such as was the case in the study^{32,35}.

The mean number of live stems and tree stumps/cut stems were derived from all stems counted in the three size classes in all quadrats in transects and transformed into densities per hectare. Percent canopy cover scores were coded such that open canopy, moderately open canopy and closed canopy scored 1, 2 and 3, respectively. These were then transformed to ratios scaled with '3' as the maximum. Canopy height, floor litter cover and litter depth measurements were averaged from all quadrats in all transects.

Due to high preliminary-test covariance amongst the various size classes of live tree stems and tree stump counts, the size classes were pooled together into 'total live stems' and 'total stems cut' for subsequent analyses. For habitat variables that showed particularly strong correlations to bird variables, simple linear regression was performed to test the actual correlations and relative strengths of predictability. Differences of means of the key habitat (independent) variables were compared on the spatial scale by one-way Analysis of Variance (ANOVA) using the forest blocks as the categorical treatment effects on the bird (response) variables. The relationships between the independent and response variables (ANOVA and regressions) were analyzed in SPSS version 18.

Results

In all surveys, a total of 308 birds were encountered, distributed across 55 species belonging to 25 families. This included three of the globally-endangered species: Sokoke Pipit, Clarke's Weaver and Amani Sunbird; two globally near-threatened species: East Coast Akalat and Plain-backed Sunbird; and one regionally-vulnerable species: Little Yellow Flycatcher *Erythrocerus holochlorus* (Supplementary Table 1). There were 17 encounters of Sokoke Pipit with an overall abundance of 30 individuals. The Sokoke Pipit occurred at a mean overall density of 0.72 birds/ha across the blocks surveyed, with a projected overall population estimated at 5,544 individuals (Table 1). The density was higher in the moderate to high disturbance Brachystegia forest zone represented by Jilore and Kararacha blocks (0.89 birds ha⁻¹) compared to the more

Table 1. Density per hectare of Sokoke Pipit in the three blocks surveyed in the *Brachystegia* woodland of the Arabuko-Sokoke forest. AIC = Akaike Information Criterion with right-truncated distances and cosine adjustment function.

Forest block/area	Area (ha)	Disturbance level	Density/ha	AIC	Estimated population	Standard error
Kararacha	2700	Undisturbed	0.79	27.3	2133	184
Jilore	400	Moderate	0.99	59.7	396.8	100
Narasha	4600	High	0.71	14.9	3266	104
Overall	7700	N/A	0.72	98.6	5544	826

disturbed Narasha block ($0.71 \text{ birds ha}^{-1}$). Nevertheless, there was no significant evidence of clumped distribution of the species across the blocks ($\chi^2_{(2, 0.05)} = 2.061$).

Similarly, the species had the highest encounter rate in Jilore (4 km^{-1}) while Kararacha had $2.0 \text{ birds km}^{-1}$ and Narasha $1.5 \text{ birds km}^{-1}$. The mean cluster size observed for Sokoke Pipit was 2 birds. For all birds, Kararacha had the highest species diversity ($1/S = 0.69$) followed by Narasha ($1/S = 0.721$) then the Jilore area ($1/S = 0.724$), S being the reciprocal of Simpson's diversity index. Jilore was the most bird species-rich (38 species) followed by Narasha (35 species) and then Kararacha (34 species).

Floor litter was deepest in the Kararacha block ($2.52 \pm 0.83 \text{ cm}$) followed by the Jilore block ($2.21 \pm 0.73 \text{ cm}$) and Narasha (1.75 ± 0.58), $F = 6.839$, $p = 0.002$ (see Figure 2). Mean litter cover was generally within the middle category (33–66%) in the Kararacha and Jilore blocks and below the lower category (0–33%) in the Narasha block ($F = 9.937$, $p < 0.001$).

Other significant spatial variations in means of habitat variables were observed in overall tree removal (total cut stems), removal of small poles (small-sized trees), and density of live mid-sized trees and removal of mid-sized trees (Table 2). Thus overall tree removal rate was highest in the Kararacha block and lowest in Narasha

Figure 2. Comparison of litter depths across the forest blocks. The figure shows the comparative depths of forest floor litter across the three forest blocks with the deepest litter in Kararacha and the least in Narasha. The figures represent mean values of litter depth across booth transects in each block. Error bars denote 95% confidence intervals.

Table 2. One-way ANOVA results for significant variations in means of key habitat parameters amongst the forest blocks surveyed. Tree removal and live tree figures are given in densities per hectare.

Parameter	Forest block	N	Mean (ha^{-1})	Standard error	F statistic	p ($p < 0.05$)
Overall tree removal	Kararacha	20	140.0	1.40	10.62	< 0.001
	Jilore area		35.0	0.07		
	Narasha		10.0	0.01		
Small-sized tree removal	Kararacha	20	105	0.84	6.18	0.004
	Jilore area		35.0	0.11		
	Narasha		11.0	0.01		
Mid-sized tree removal	Kararacha	20	25.0	0.03	4.48	0.016
	Jilore area		20.0	0.04		
	Narasha		20.5	0.01		
Mid-sized live trees	Kararacha	20	200.5	4.01	6.28	< 0.001
	Jilore area		65.0	0.52		
	Narasha		175.4	03.33		

both for small poles and large mature trees. The same pattern was observed for the density of mid-sized live woody vegetation.

Overall, the *Brachystegia* habitat was dominated by small-sized trees of 30 cm diameter at breast height (dbh) or less especially in the Jilore area (Table 3). These were also the most intensely logged tree sizes with most of them cut in the Kararacha block (Table 2).

Sokoke Pipit abundance was strongly correlated to forest floor litter depth ($R^2 = 0.719$, $\beta = 0.848$, $p = 0.033$) and floor litter cover ($R^2 = 0.769$, $\beta = 0.877$, $p = 0.021$) although litter depth was the better predictor of the species' abundance (Figure 3), with a predictive equation:

$$\text{Sokoke Pipit abundance} = 0.727 + 0.485 * \text{Mean litter depth}$$

Furthermore, litter depth was positively correlated to logging intensity of small trees ($R = 0.787$, $p = 0.063$) suggesting that pruning of small trees in the forest by tree poachers might be a significant

source of forest floor litter. Sokoke Pipit density appeared adversely affected by overall logging intensity ($R^2 = 0.663$, $\beta = -0.814$, $p = 0.048$) see Figure 4. However, there was no significant effect of percent canopy cover ($R = 0.5798$, $p = 0.228$) or canopy height ($R = 0.174$, $p = 0.742$) on Sokoke Pipit density.

Arabuko-Sokoke forest ecological data: Sokoke Pipit abundance, vegetation survey results, floor litter measures and elephant damage in three forest blocks

4 Data Files

<http://dx.doi.org/10.6084/m9.figshare.924690>

Discussion

The density of the Sokoke Pipit from this study are lower than the values from studies in the same habitat about a decade ago in which the undisturbed *Brachystegia* forest had 2.8 birds ha⁻¹ and disturbed zones had 0.9 birds ha⁻¹¹⁴. The same applies for the previous estimated total population of 13,000 birds. This is because of the

Table 3. A comparison of vegetation density and logging intensity per hectare across the *Brachystegia* woodland habitat. Vegetation density is expressed as mean number of live woody stems and logging intensity as mean number of cut stems.

Block	Live woody stem			Total	Cut stems			Total
	<30 cm	31–60 cm	> 60 cm		<30 cm	31–61 cm	>60 cm	
Kararacha	750	200	180	1130	105	25	10	140
Jilore area	980	65	180	1225	35	20	0	35
Narasha	785	175	150	1110	0	20.5	10	10
Total	2515	440	510	3465	140	65.5	20	185

Figure 3. Relationship between litter depth and Sokoke Pipit abundance. The scatter plot illustrates an overall positive influence of litter depth on abundance and distribution of Sokoke Pipit across the three forest blocks. Abundance is expressed in density per hectare and mean litter depth determined in centimeters.

Figure 4. Impact of logging pressure on Sokoke Pipit abundance. The figure shows the net impact of tree removal intensity on Sokoke Pipit abundance in the forest. The Sokoke Pipit was encountered less often in areas with high tree loss, which represents degradation of its habitat through understory opening, reduced forest floor litter and possible exposure to predation.

continued degradation and modification of the species' habitat in the *Brachystegia spiciformis* zone through disturbance, especially in the form of tree cover loss, which has continued over the past decade as observed by many investigators^{9,11,15,17–20,38}. Human activity and related encroachment effects are strongly presumed by all these investigators as the sole and direct source of the disturbance. The results of the present study confirm this but suggest that other complementary causes could be responsible for this habitat degradation processes.

To put this into perspective, it is important to understand the current general categorization of two main regions within the study area (the woodland dominated by *Brachystegia spiciformis*) as used by ecologists and forest managers. The first region is the middle section known as Narasha, which is generally characterized as “disturbed” while the second region is Kararacha to the south east, which is characterized as “undisturbed”^{11,18–20}. The Jilore region, which is located to the far northwesterly end of the ASF across the larger *Cyanometra* forest stand, is rarely studied and is generally uncharacterized using such criteria even though it harbours *Brachystegia* tree stands. These regions are labelled solely on the basis of the comparative intensities of decades of intensive selective logging, which was spurred by high demand for valuable timber species, leading to loss of much of the primary indigenous stands of *Brachystegia* trees during the forest's pre-protection era^{11,18}. The effect of this logging impacted the *Brachystegia* forest so heavily that it is yet to recover its original near-pristine forest status. It is this readily apparent scar of differential or selective “disturbance” between these regions that still guides most scientific habitat stratification in comparative study design. But this characterization is driven by such visible vegetation structural evidence as comparative densities, extent of spatial cover or openness of the understory^{11,17,20,26} rather than the more functional and ecologically

consequential processes and dimensions such as species or community dynamics, inter-trophic interactions, effect of anthropogenic encroachment, forest management systems or even climate change.

For instance, not only is earlier intensive deforestation still discernible in the structure of much of the forest, but in addition human populations around the forest have grown steadily and rapidly over the years^{9,18}. The increasing dependence of these adjacent communities on forest products have resulted in significant negative ecological impacts on the forest's biodiversity^{9,14,17,20}. In addition, forest management intervention methods by the Kenya Forest Service (KFS) and Kenya Wildlife Service (KWS), have been in place for more than three decades since the era of official intensive logging began and this has further influenced overall ecological processes in the forest including the increasing population of elephants^{18,25}. Partly due to this forest surveillance, much of the illegal logging in the ASF is now predominantly focused on smaller trees or poles that are easier to cut and remove from the forest. Thus, effective characterization of the forest into spatial zones should therefore account for both structural and functional elements in the ASF.

In this study, the main driver of Sokoke Pipit habitat degradation was tree removal that results in opening up the understory, a process that may expose individuals to the risk of predation through increased edge^{39,40}, reduction in patch substrate^{14,26} or change in micro-climate³⁹. One of the main reasons for lower logging rates in Narasha is that it is closest to the KWS and KFS stations and thus enjoys higher levels of surveillance against tree poaching compared to Kararacha and Jilore where logging rates were higher. These patterns conform to patterns observed by Ngala and Jackson from surveys carried out in 2009 and 2010^{25,41}. Secondly, it is the region with the highest elephant activity³⁸ which is a further deterrent to illegal loggers.

However, the effect of tree removal on Sokoke Pipit abundance was offset by the positive influence of forest floor litter cover and depth. Floor litter harbors much of the arthropod and other invertebrate biomass on which many insectivorous birds such as Sokoke Pipit depend^{15,42}. Secondly, the process of removing small trees appeared to be a significant additional source of floor litter, due to cumulative layers of discarded leaves and twigs left behind by tree poachers during pole harvesting, in addition to the slow rate of decomposition of organic matter typical of many forests along the eastern coast of Africa^{43,44}.

The Jilore block's predominance in Sokoke Pipit encounter rates, in spite of its proximity to human settlements and farmland, may in part be due to its comparatively small size and low canopy with an understorey dominated by small regenerating trees (Table 3). Harvesting of small trees for poles, which was highest in this block might also contribute to litter density that is conducive for harboring the Sokoke Pipit's arthropod prey. On the other hand, the Kararacha block's high Sokoke Pipit abundance (Table 1) in spite of high logging rates indicates that human-driven selective tree removal is not the sole determinant of Sokoke Pipit population abundance or distribution across the *Brachystegia* habitat. For Narasha block, low litter depth coupled with lower percent canopy cover and low overall tree density due to poor regeneration all contributed to relative non-suitability for the Sokoke Pipit, despite apparent intensive surveillance against tree logging due to its proximity to the KWS and KFS stations. This is in contrast to Kararacha block's comparative habitat suitability with respect to these variables is evidenced not only by higher a Sokoke Pipit density but also greater overall birds species richness despite a comparatively higher degree of logging pressure targeting small poles.

Evidence of the role of elephants in modifying the forest habitat is borne by our numerous direct chance observations across the study area, particularly in the Narasha block during which we made frequent sightings of trees felled or broken and the ground dug up by elephants. Analyses of data (see Data File) from these incidental observations was not attempted since counts were made only for the Narasha and Kararacha blocks. However, the spatial distribution of elephant damage noted here is consistent with similar earlier studies and observations conducted by ASFMT¹⁸, Ngala⁴¹ and Banks *et al.*³⁸, all of which recorded the highest elephant activity intensity in Narasha. Such intensive activity results in more open canopy, exposed understorey and an increased area of edge habitat that may limit the dispersal capability of species that avoid crossing gaps, or may increase rates of general or nest predation^{45,46}.

Two main reasons support the contribution of elephants to habitat modification in the ASF's *Brachystegia* woodland. First, the forest is estimated to hold between 126 and 184 individuals, giving a density of 0.44 animals km⁻²^{129,30}. Not only does this make the ASF the 7th highest elephant density site of all 30 elephant habitats across Kenya²⁹ but is also fast approaching the 0.5 km⁻² recommended maximum carrying capacity, to ensure stability and sustainability of the vegetation in the habitat⁴⁷. This density is a conservative estimate as it represents a projection for the whole forest; considering that the elephants seem to favour the *Brachystegia* forest zone³⁸, the

carrying capacity will likely be exceeded much sooner than for the ASF overall, with negative consequences for the Sokoke pipit for which this is a critical habitat.

Secondly, the forest management has began erecting an electric fence, in 2006, which already covers a substantial portion of the forest boundary for the purpose of keeping the animals within the forest to reduce conflicts with forest-adjacent farmers who have previously incurred heavy crop losses to the elephants. This physical barrier to dispersal has had the effect of nearly doubling elephant density in the forest, further stretching the carrying capacity and worsening the habitat degradation process⁴⁷. The pressure is particularly high in the ASF due to its small size in comparison to other elephant sites in Kenya³⁰ and given the peri-urban nature of the forest with its surrounding agricultural land and human settlements¹⁸.

In addition, the *Brachystegia* vegetation zone of the ASF has the lowest vegetation regeneration rates along the entire eastern coast of Africa due to soil with a functionally poor structure²⁴, low nutrient content, low moisture level and limited micro-organism activity that is necessary for nutrient cycling^{11,44}.

Thus, in terms of forest habitat health, in addition to human-driven tree removal the high elephant density and the restrictive nature of the electric fence are compounded by the slow forest regeneration rate, which may aggravate the role of elephants as drivers and accelerators of overall habitat change in the *Brachystegia* woodland. In many sections along the transects in the Narasha area, the frequency of elephant-felled trees outnumbered those cut down by humans. Without implementing measures to regulate the elephant population and movement in *Brachystegia* woodland concurrently with a halt in illegal logging in the forest, the rate of tree removal is likely to increase in the medium term with serious ramifications for the Sokoke Pipit and other forest-dependent species.

Conclusions

The Sokoke Pipit's favoured habitat is an open understory with deep litter cover, often but not always with dense vegetation. Its density and estimated population in *Brachystegia* woodland is lower than it was a little more than a decade ago, suggesting increased pressure on the species' habitat through increased loss or continued modification. The main cause of this habitat degradation is still illegal logging. Habitat degradation may be further accelerated by elephant-mediated habitat damage through tree felling, as evidenced by several incidental observations during the study, and consistent with findings of other recent studies though more in-depth studies on this are needed to underpin its scale and impact patterns on Sokoke pipit and forest specialist birds. Tree poachers mainly target small trees/poles which are taken mainly from parts of the forest farthest away from patrol bases and with minimal elephant numbers, from where they are easily carried out of the forest. A sound long-term conservation strategy would involve significantly reversing tree logging trends through increased surveillance; effectively managing local elephant populations and their movement; and stepping up habitat restoration through reforestation of heavily damaged Sokoke Pipit sites.

The deterring effect of proximity of Narasha to the KWS and KFS stations indicates the potential benefits of increased patrol and surveillance as an immediate check on habitat destruction by humans not only in the *Brachystegia* woodland zone but also throughout the forest.

Data availability

figshare: Arabuko-Sokoke forest ecological data: Sokoke Pipit abundance, vegetation survey results, floor litter measures and elephant damage in three forest blocks, <http://dx.doi.org/10.6084/m9.figshare.924690>⁴⁸.

Author contributions

NO conceived the study and designed the experiments, NO prepared the first draft of the manuscript while NO, DN and AM were all involved in the process of project planning, logistical arrangements, data collation, data summary and revision of the initial project report. They all agreed to the final content of the manuscript.

Competing interests

No competing interests were disclosed.

Grant information

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The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Supplementary materials

Supplementary Table 1. Checklist of all birds observed across the *Brachystegia* woodland blocks of forest surveyed in Arabuko-Sokoke forest. The checklist is in phylogenetic order grouping birds by family, scientific and common name following Bird Committee of the east African Natural History Society⁴⁹.

No.	Family	Scientific Name	Common Name
1	Accipitridae	<i>Accipiter tachiro</i>	African Goshawk
		<i>Polyboroides typus</i>	African Harrier Hawk
		<i>Accipiter minullus</i>	Little Sparrowhawk
2	Columbidae	<i>Turtur chalcospilos</i>	Emerald-spotted Wood Dove
		<i>Streptopelia semitorquata</i>	Red-eyed Dove
		<i>Turtur tympanistria</i>	Tambourine Dove
3	Cuculidae	<i>Chrysococcyx klaas</i>	Klaas Cuckoo
		<i>Pachycoccyx audeberti</i>	Thick-billed Cuckoo
		<i>Centropus superciliosus</i>	White-browed Coucal
4	Caprimulgidae	<i>Caprimulgus pectoralis</i>	Fiery-necked Nightjar
5	Phoeniculidae	<i>Rhinopomastus cyanomelas</i>	Common Scimitarbill
		<i>Phoeniculus purpureus</i>	Green Wood Hoopoe
6	Bucerotidae	<i>Bycanistes bucinator</i>	Trumpeter Hornbill
7	Lybiidae	<i>Stactolaema olivacea</i>	Green Barbet
8	Indicatoridae	<i>Indicator variegatus</i>	Scaly-throated Honeyguide
9	Picidae	<i>Dendrocopos minor</i>	Little-spotted Woodpecker
		<i>Campethera mombassica</i>	Mombasa Woodpecker
10	Platysteridae	<i>Batis mixta</i>	Forest Batis
		<i>Batis soror</i>	Pale Batis

No.	Family	Scientific Name	Common Name
11	Malaconotidae	<i>Dryoscopus cubla</i>	Black-backed Puffback
		<i>Telophorus viridis</i>	Four-coloured Bush-shrike
		<i>Laniarius aethiopicus</i>	Tropical Boubou
12	Prionopidae	<i>Prionops retzii</i>	Retz Helmetshrike
13	Timaliidae	<i>Prionops scopifrons</i>	Chestnut-fronted Helmetshrike
14	Oriolidae	<i>Oriolus larvatus</i>	Black-headed Oriole
		<i>Oriolus oriolus</i>	Eastern Golden Oriole
		<i>Oriolus oriolus</i>	Eurasian Golden Oriole
15	Dicruridae	<i>Dicrurus adsimilis</i>	Common Drongo
16	Monarchidae	<i>Trochocercus cyanomelas</i>	Blue-mantled Crested Flycatcher
		<i>Erythrocerus holochlorus</i>	Little Yellow Flycatcher
17	Cisticolidae	<i>Apalis melanocephala</i>	Black-headed Apalis
		<i>Camaroptera brevicaudata</i>	Grey-backed Camaroptera
		<i>Prinia subflava</i>	Tawny-flanked Prinia
18	Pycnonotidae	<i>Nicator gularis</i>	Eastern Nicator
		<i>Phyllastrephus fischeri</i>	Fischer's Greenbul
		<i>Phyllastrephus strepitans</i>	Northern Brownbul
		<i>Phyllastrephus debilis</i>	Tiny Greenbul
		<i>Chlorocichla flaviventris</i>	Yellow-bellied Greenbul
		<i>Andropadus importunus</i>	Zanzibar (Sombre) Greenbul
19	Sturnidae	<i>Lamprolornis corruscus</i>	Black-bellied starling
20	Turdidae	<i>Cercotrichas quadrivirgata</i>	Eastern Bearded Scrub Robin
		<i>Neocossyphus rufus</i>	Red-tailed Ant Thrush
21	Muscicapidae	<i>Muscicapa caerulea</i>	Ashy Flycatcher
		<i>Sheppardia gunningi</i>	East Coast Akalat
		<i>Bradornis pallidus</i>	Pale Flycatcher
22	Musophagidae	<i>Tauraco fischeri</i>	Fischer's Turaco
23	Nectariniidae	<i>Anthreptes pallidigaster</i>	Amani Sunbird
		<i>Hedydipna collaris</i>	Collared Sunbird
		<i>Cyanomitra olivacea</i>	Olive Sunbird
		<i>Anthreptes reichenowi</i>	Plain-backed Sunbird
24	Ploceidae	<i>Ploceus golandi</i>	Clarke's Weaver
		<i>Ploceus bicolor</i>	Dark-backed Weaver
25	Motacillidae	<i>Anthus sokokensis</i>	Sokoke Pipit

References

- Gardner TA, Barlow J, Chazdon R, *et al.*: **Prospects for tropical forest biodiversity in a human-modified world.** *Ecol Lett.* 2009; **12**(6): 561–582.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Whitmore TC: **Tropical forest disturbance, disappearance, and species loss.** in Laurence WF and Bierregaard RO. (Eds) *Tropical Forest Remnants*, Chicago University Press, Chicago. 1997.
[Reference Source](#)
- Collar NJ, Crosby MJ, Stattersfield AJ: **Birds to watch 2: The world list of Threatened birds.** BirdLife International, Cambridge, UK. 1994.
[Reference Source](#)
- Stattersfield AJ, Crosby MJ, Long AJ, *et al.*: **Endemic bird areas of the world: priorities for bird conservation.** BirdLife International, Cambridge, UK. 1998.
[Reference Source](#)
- Bennun LA, Howell K: Bird sampling techniques. In: *African Forest Biodiversity*:

- A Field Survey Manual for Vertebrates.** G. Davies (Ed). Earthwatch Institute (Europe), Cambridge, UK. 2002; 131–161.
[Reference Source](#)
6. Van Someren VGL: *Eremomela badiceps turneri*, subsp. nov. *Bulletin of the British Ornithologists' Club*. 1920; 40: 92.
 7. Burgess ND, Cutts CJ, Huxham M: **New records of the Sokoke Pipit *Anthus sokokensis* from Kiono Forest Reserve, Bagamoyo District, northeastern Tanzania.** *Scopus*. 1991; 15: 56–57.
 8. Dowsett RJ, Forbes-Watson AD: **Checklist of birds of the Afrotropical and Malagasy regions.** Liège, Belgium: Tauraco Press. 1993.
[Reference Source](#)
 9. **9 BirdLife International.** Species factsheet: *Anthus sokokensis*. 2013.
[Reference Source](#)
 10. International Union for Conservation of Nature: **IUCN Red List of threatened species.** Version 2012. 2013.
[Reference Source](#)
 11. Oyugi JO, Brown J, Whelan CJ: **Effects of human disturbance on composition and structure of *Brachystegia* woodland in Arabuko-Sokoke Forest, Kenya.** *Afr J Ecol*. 2007; 46(3): 374–383.
[Publisher Full Text](#)
 12. Fry CH, Pearson DJ, Taylor PB: **Motacillidae: Wagtails, Pipits and Longclaws.** In: Keith S, Urban EK and Fry CH (Eds). *The birds of Africa Vol. IV*. Academic Press Ltd. London (1992).
 13. Mlingwa COF: **A note on the rediscovery of the Sokoke Pipit *Anthus sokokensis* in the Pugu Hills, Tanzania.** *Bird Cons Int*. 1996; 6: 293–294.
[Publisher Full Text](#)
 14. Musila F, Bennun LA, Karanja W: **The Sokoke Pipit *Anthus sokokensis*, in Arabuko-Sokoke Forest, Kenya: population estimates and response to habitat disturbance.** *Ostr Suppl*. 2001; 198: 97–204.
 15. Bennun LA, Njoroge P: **Important Bird Areas in Kenya.** East African Natural History Society, Nairobi. 1999.
[Reference Source](#)
 16. Waiyaki EM, Bennun LA: **The avifauna of coastal forests in southern Kenya: status and conservation.** *Ostrich*. 1999; 71: 247–256.
[Publisher Full Text](#)
 17. Matiku PM, Bennun LA, Nemeth E: **Distribution and population size of the threatened East Coast Akalat in Arabuko-Sokoke Forest, Kenya.** *Ostrich*. 2000; 71(1-2): 282–285.
[Publisher Full Text](#)
 18. Arabuko-Sokoke Forest Management Team: **Arabuko-Sokoke Strategic Forest Management Plan 2002–2027.** Birdlife International, UK. Accessed on 21/03/2012. 2002.
 19. Oyugi JO, Brown JS, Whelan CJ: **Foraging behavior and coexistence of two sunbird species in a Kenyan woodland.** *Biotrop*. 2011; 2: 1–8.
[Publisher Full Text](#)
 20. Davis JA: **Density and population estimates of Amani Sunbird *Antheptes pallidigaster* in Kenya's Arabuko-Sokoke Forest.** *Bird Cons Int*. 2005; 15: 53–62.
[Reference Source](#)
 21. Burgess ND, Doggart N, Doddy K, *et al.*: **New information on the lowland coastal forests of eastern Africa.** *Ory*. 2003; 37: 280–281.
[Reference Source](#)
 22. Gordon I, Burgess N, Luke Q, *et al.*: **Final project report of the Critical Ecosystem Partnership Fund on the Easter Arc Mountains and coastal forests of Kenya and Tanzania: ecosystem profile.** Conservation International, Cambridge. 2003.
[Reference Source](#)
 23. Collar NJ, Stuart SN: **Key forests for threatened birds in Africa.** ICPB Monograph No. 3. ICPB, Cambridge. 1988.
[Reference Source](#)
 24. UNESCO: **The Eastern Arc Coastal Forests: Arabuko-Sokoke forest and Shimba Hills National Reserve.** UNESCO World Heritage Centre. Fontenoy, France. 2013.
[Reference Source](#)
 25. Ngala D, Jackson C: **Monitoring Important Bird Areas in the Arabuko-Sokoke Forest.** Friends of Arabuko-Sokoke Forest. Malindi, Kenya. 2010.
[Reference Source](#)
 26. Fanshawe JH: **The effects of selective logging on the bird community of Arabuko-Sokoke forest.** Unpublished PhD thesis, University of Oxford, UK. 1995.
[Reference Source](#)
 27. Kenya Commission on Revenue Allocation: **County Fact Sheet: Kilifi County.** Government of Kenya. Nairobi. 2012.
 28. Muoria PK: **Ecological correlates of crop raiding by elephants and baboons: a case study in Arabuko-Sokoke Forest, Kenya.** Unpublished PhD thesis. Kenyatta University, Kenya. 2001.
[Reference Source](#)
 29. Omondi P, Litoroh M, Kock R, *et al.*: **Conservation and Management Strategy for the Elephant in Kenya (2012–2021).** Kenya Wildlife Service. Nairobi. 2012.
[Reference Source](#)
 30. International Union for Conservation of Nature: **Elephant Database: Kenya 2012 (Africa Analysis).** 2012.
[Reference Source](#)
 31. Bibby C, Jones M, Marsden S: **Bird Surveys: Expedition Field Techniques.** London: Expedition Advisory Centre (Royal Geographical Society). 1998; 143.
[Reference Source](#)
 32. Sutherland WJ Ed: **Ecological census techniques: A handbook.** Cambridge University Press, Cambridge. 1996.
[Reference Source](#)
 33. Buckland ST, Anderson DR, Burnham KP, *et al.*: **Distance Sampling. Estimating the Abundance of Biological Populations.** Chapman and Hall, London. 1993.
[Reference Source](#)
 34. Fewster RM, Buckland ST, Burnham KP, *et al.*: **Estimating the encounter rate variance in Distance sampling.** *Biometrics*. 2009; 65(1): 225–236.
[PubMed Abstract](#) | [Publisher Full Text](#)
 35. Zar JH: **Biostatistical Analysis.** 4th ed. Prentice Hall, New Jersey. 1999.
[Reference Source](#)
 36. Marques TA, Thomas L, Steven GF, *et al.*: **IMPROVING Estimates of bird density using multiple covariate distance sampling.** *The Auk*. 2007; 124(4): 1229–1243.
[Publisher Full Text](#)
 37. Buckland ST, Anderson DR, Burnham KP, *et al.*: **Advanced distance sampling: estimating abundance of biological populations.** Oxford University Press, Oxford, UK. 2004; 400.
[Reference Source](#)
 38. Banks J, Jackson C, Hannon L, *et al.*: **The cascading effects of elephant presence/absence on arthropods and an Afro-tropical thrush in Arabuko-Sokoke forest, Kenya.** *Afr J Ecol*. 2010; 48(4): 1030–1038.
[Publisher Full Text](#)
 39. Lindenmayer DB, Fischer J: **Habitat fragmentation and landscape change: an ecological and conservation synthesis.** Island Press. Washington. 2006.
[Publisher Full Text](#)
 40. Newmark WD, Stanley TR: **Habitat fragmentation reduces nest survival in an Afrotropical bird community in a biodiversity hotspot.** *Proc Nat Acad Sci U S A*. 2011; 108(28): 11488–11493.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 41. Ngala D: **Monitoring tree poaching & elephants in Arabuko-Sokoke Forest with Kenya Forest Service.** Unpublished technical report of Friends of Arabuko-Sokoke Forest. Malindi, Kenya. 2009.
[Reference Source](#)
 42. Lange CN: **Environmental factors influencing land snail diversity patterns in Arabuko Sokoke forest, Kenya.** *Afr J Ecol*. 2004; 41(4): 352–355.
[Publisher Full Text](#)
 43. Van-Aarde RJ, Ferreira FM, Kritzing J, *et al.*: **An evaluation of habitat rehabilitation on coastal dune forests in northern KwaZulu-Natal, South Africa.** *Rest Ecol*. 1996; 4(4): 334–345.
[Publisher Full Text](#)
 44. Backéus I, Pettersson B, Strömquist L, *et al.*: **Tree communities and structural dynamics in Miombo (*Brachystegia-Julbernardia*) woodland, Tanzania.** *For Ecol Manag*. 2006; 230(1–3): 171–178.
[Publisher Full Text](#)
 45. Bender DJ, Contreras TA, Fahrig L: **Habitat loss and population decline: a meta-analysis of the patch size effect.** *Ecology*. 1998; 79(2): 517–533.
[Publisher Full Text](#)
 46. Newmark WD: **Tropical Forest Fragmentation and the Local Extinction of Understory Birds in the Eastern Usambara Mountains, Tanzania.** *Cons Biol*. 2005; 5(1): 67–78.
[Publisher Full Text](#)
 47. Jachmann H, Croes T: **Elephant effects on woodlands and a suggested optimum elephant density at the Nazinga Game Ranch, Burkina Faso.** Unpublished technical Report No LAEBRA 1989/142 of Association de Développement de l'Élevage de la Faune Africaine. Ougadougou, Burkina Faso. 1989.
[Reference Source](#)
 48. Nickson EO, Ngala D, Mwalimu A: **Arabuko-Sokoke forest ecological data: Sokoke Pipit abundance, vegetation survey results, floor litter measures and elephant damage in three forest blocks.** *figshare*. 2014.
[Data Source](#)
 49. Bird Committee of East African Natural History of Society. **Checklist of the Birds of Kenya**, 4th Ed. EANH, Nairobi. 2009.

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John Banks

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This article addresses the links between habitat condition and an endangered bird species in an important forest reserve (ASF) in eastern Kenya. It addresses an important topic, especially given ongoing anthropogenic pressures on this and similar types of forest reserves in eastern Kenya and throughout the tropics. Despite the rather small temporal and spatial extent of the study, it should make an important contribution to bird and forest conservation. There are a number of issues with the methods and analysis that need to be clarified/addressed however; furthermore, some of the conclusions overreach the data collected, while other important results are given less emphasis that they warrant. Below are more specific comments by section:

Abstract:

The conclusion that human-driven tree removal is an important contributor to the degradation of ASF is reasonable given the data reported in the article. Elephant damage, while clearly likely a very big contributor to habitat modification in ASF, was not the focus of the study (the authors state clearly in the Discussion that elephant damage was not systematically quantified, and thus no data were analyzed) – and thus should only be mentioned in passing here – if at all.

Introduction:

More information about the life history ecology of *A. sokokensis* would provide welcome context here. A bit more detail about breeding sites as well as dispersal behavior etc. would be helpful – and especially why these and other aspects render the Pipit a good indicator species/proxy for habitat condition. This could be revisited in the Discussion as links are made between habitat conditions and occurrence of the bird (where you discuss the underlying mechanisms for why it thrives in some parts of ASF and not others, and why it's abundance correlate strongly with some types of disturbance and not others). Again, you reference other studies that have explored other species in ASF and forest disturbance, but do not really explicitly state why the Pipit is a particularly important indicator of forest condition.

Methods:

- Bird Survey: As described, all sightings and calls were recorded and incorporated into distance analysis – but it is not clear here whether or not distances to both auditory and visual encounters were measured the same way (i.e., with the rangefinder). Please clarify.
- Floor litter sampling: Not clear here whether or not litter cover was recorded as a continuous or categorical variable (percentage). If not, please describe percentage “categories” used.

Results:

- Mean litter depth graph (Figure 2) and accompanying text reports the means and sd but no post-hoc comparison test (e.g. Tukey HSD) – need to report the stats on which differences were/were not significant.
- Figure 3 – you indicate litter depth was better predictor of bird abundance than litter cover, but r-squared is higher for litter cover. Need to clarify (and also indicate why you chose only to shown depth values in Figure 3).
- The linear equation can be put in Figure 3 caption (not necessary to include in text).
- Figure 4 – stats aren’t presented here; also, the caption states that tree loss and leaf litter are inversely correlated – this might be taken to mean, given discussion (below) about pruning, that there could be a poaching threshold below which poaching may pay dividends to Pipits (and above which Pipits are negatively affected). This warrants further exploration/elaboration.
- The pruning result is arguably the most important one here – this suggests an intriguing trade-off between poaching and bird conservation (in particular, the suggestion that pruning by poachers may bolster Pipit populations – or at the very least mitigate against other aspects of habitat degradation). Worth highlighting this more in Discussion.

Discussion :

- Last sentence on p. 7 suggests causality (“That is because...”) – but your data only support correlation (one can imagine that there may have been other extrinsic or intrinsic drivers of population decline).
- P. 8: discussion of classification of habitat types in ASF is certainly interesting, but could be made much more succinct in keeping with focus of this paper.
- P. 9, top: first paragraph could be expanded – as noted before, tradeoff between poaching/pruning and Pipit abundance is worth exploring in more depth. Could your results be taken as a prescription for understory pruning as a conservation tool for the Sokoke Pipit or other threatened species? More detail here would be welcome (and also in Conclusion); in subsequent paragraph about Pipit foraging behavior and specific relationship to understory vegetation at varying heights could be incorporated into this discussion. Is there any info about optimal perch height for foraging or for flying through the understory? Linking to results of other studies in ASF, is there potential for positive correlations with optimal habitat conditions for the other important bird species in ASF in order to make more general conclusions about management?

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 12 Apr 2014

Nickson Otieno, National Museums of Kenya, Kenya

Dear Dr. John Banks,

Thank you for your useful comments on our manuscript. We have attempted to address your concerns about the manuscript in the following ways:

Introduction:

- We have now added more information about the habits of the Sokoke Pipit, although we have also indicated that no comprehensive previous studies are known of the species' live history traits, especially breeding records. We have also added that the specialist attributes of the species, especially as the key forest-floor specialist of the interior Brachystegia forest, make it a good candidate for monitoring habitat quality of the Brachystegia understory.

Methods:

- Only once was an encounter of the Pipit based on a call only, and in this case the abundance was assumed to be that of 1 bird and perpendicular distance determined for its approximate location as for the other cases.
- Litter cover was recorded as percentages of cover in three main categories: fully covered (67-100%); moderately covered (34-66%) and not little or no cover (0-33%). Scoring these respectively as 3, 2 and 1 on a scale of 1 to 3, each was then divided by "3" to derive a cover score that were finally arcsined transformed towards normality of distribution.

Results:

- We have now reported the post hoc Tukey test results statistics for the significant difference in forest floor litter depth across the three blocks.
- For figure 3 (now figure 4) we have now presented the figure with fresh partial regressions of both the mean litter depth and the arcsines of mean litter cover percent against Sokoke pipit densities per transect. Accordingly, we have revised the legend of this figure to reflect these changes. We have also made the correction in the text of the results section, in which the regression stats for how Sokoke Pipit density varied with litter depth and litter cover were initially written in reversed order.
- The regression equation between Sokoke Pipit density and litter depth is now transferred from results text body to the caption of figure 4 (formerly figure 3).

- Actual figures and statistics on logging rate were presented already in Table 2.

Discussion:

- We have now revised the statement that the lower density of the S. Pipit recorded in the study, in comparison to the earlier survey, was "*because of*" continued habitat to read "*attributable to*" instead.
- The part of the discussion which details the ASF zonation and characterization is now cut down to the essential facts directly relevant to the study.
- We have expounded from discussion through to conclusion on the issue of the apparent tradeoff between leaf litter from trees pruned by poachers and the quality of Sokoke Pipit habitat, stressing that while such compensatory effects may be beneficial, it might be unwise to recommend understory pruning of young trees, as this might further degrade habitat for S. Pipit and other understory species. Instead, work should be stepped up towards preserving dead wood and controlling forest fires that would reduce forest litter. We have also put recommended conservation measures for the species' habitat in perspective of recommendations from previous studies in ASF.

Competing Interests: No competing interests to declare

Reviewer Report 14 March 2014

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Jeremy Lindsay

A Rocha International, Cambridge, UK

Overall comments:

This is an important survey, and I support the collection of these results, but not the way they are currently presented and interpreted. The presentation has been compromised by poor attention to methods. This raises concerns about errors in the analysis and that conclusions are not assured. The small sample size involved also raises concerns about the robustness of the conclusions. Given the very large population decline being described it is important to ensure that the conclusions are supported by the data. As it stands a lot more caution needs to be attached to this work - results might be suggestive of a decline that needs more serious investigation rather than this being proven.

Furthermore, explanation of the declines is not always clear – the overall tone of the discussion is that disturbance has harmed the pipit even though some evidence suggests the pipits benefit from disturbance. No data are presented to demonstrate that disturbance has increased over the course of the decline.

I think the authors could do with a good session with a qualified statistician to first straighten out the analyses, and then review their conclusions. And I would urge them to do this as the conclusions could be important for the conservation of this species.

Abstract:

- 5 globally threatened and 4 near-threatened, not 9 threatened. The Methods section states it correctly.

Introduction:

- Birds in general are not most sensitive to forest change, but certain groups are good indicator species.
- Avoid reference to BirdLife factsheets if possible, good as they are - the original source is preferable.
- The title of the article by Musila *et al.* (2001) certainly implies they studied response to habitat change. Make clear that you are not studying change – it is not a before and after study. You are substituting space for time. The title also implies you have studied change over time (modification).

Materials and methods:

- Change “BirdLife protocols” to “BirdLife criteria”.
- The second paragraph is largely not needed as it is unrelated to the pipits, and can be referenced elsewhere.
- Third paragraph, change “community zones” to “communities”.
- Paragraph four – insert a quick statement about the amount of forest in the surrounding landscape (i.e. almost none!)
- How do honey harvesting and game snaring affect the habitat? Do they cut trees to harvest honey? But what about snaring?

Sampling strategy:

- You use the term “lumbering”. If this is to denote commercial logging as opposed to illegal logging might be better to make this clear.
- The positioning of transects is very unclear. Are you saying that you used existing paths as transects? Or were the paths only used to locate a starting point?
- You also need to say why you used existing paths as transects when you have already said

that the habitat has a relatively open understory and is therefore presumably easy to move through.

- Looking at the map, the transect look very straight which suggests they were not on existing tracks.
- Do you think the 3rd track on the left really is unbiased since more heavily disturbed areas are likely to have a higher density of tracks, which means your sample in more disturbed areas will always tend to be nearer your point of entry and likely therefore to be the more disturbed parts of the patch. I think you need to be clear about this.
- You say you ensured at least 1 km separation between transects but don't say how you actually did this given that the transect selection is described as random.

Bird Survey:

- Distance sampling (as cited) does not specify a fixed width to the transect. It is called "variable distance" sampling. You may specify a cut off beyond which you don't bother recording observations. Is that what you mean?
- Doubling counting of birds on different transects is only a problem if the movement of the bird between the two was caused by the observers.
- Presumably you recorded cluster size? It isn't mentioned.
- Did you walk transects more than once? This is implied in the paragraph on sampling strategy but no information is given about how many times here or there.

Vegetation sampling:

- How did you measure % canopy height with rangefinder? How many readings did you take and how do you express this as a percentage? Percentage of plot covered by different height classes? If you measured straight up this tends to underestimate height because of the number of occasions that the laser hits lower branches and because you only read from the underside of the canopy. If you measured from the distance then you needed to measure angle too?
- Was the stem size you measured the circumference or the DBH. You say you used an ordinary tape measure. Why do you say this - you can still use this to record diameter. Are the size classes given circumferences or diameters?
- You say you recorded cut stems in "similar" size classes to the live stems. What do you mean? The same? If not the same say why and how the classes differed. Obviously you can't usually measure a cut stem at breast height so need to say so and how you dealt with this. In that sentence about cut stems you also refer to diameter - so does that mean the other measurement earlier were diameters?

Floor Litter Sampling:

- "Litter cover was assessed by dividing the 10 × 10 m quadrats into 25 smaller grids of 2 × 2 m quadrats by use of a standard meter rule and tape measure then ascertaining the percentage category in each 2 × 2 square before averaging the total out of 25" This is an awkward sentence. Did you ascertain the percentage cover in each 2x2 square and then record the

average value for all 25 squares?

Data analyses:

- Try to avoid starting section/paragraph/sentence with “because”.
- OK, so here you state the number of visits – this is in the wrong section.
- You shouldn't be expecting normal distribution in bird count data or counts of trees in stem size classes, regardless of samples sizes. Counts are discrete integers whereas a normal distribution assumes all possible values could be observed (i.e. fractional values). This means that log-transforming the count data to cope with the apparent skew in the data is incorrect. Count data in natural populations are nearly always heavily skewed – for birds there are always lots of low counts (and often many zero counts) and for trees there are (nearly) always lots of small trees compared to big trees. Bird count data often follow a poisson distribution. Having said all that there shouldn't be any transformations undertaken of the bird data (the distances) prior to analysis in Distance. You are not analysing the counts but the distances and in this case you certainly won't have a normal distribution – at best a half normal.
- The distribution of predictor variables like stem density is not important and don't need transforming for a regression. But if you are analysing stem density by forest block then stem density becomes the response variable and you do need to worry about its distribution.
- When you analyse using regression the densities arising from the Distance analysis *then* you need to worry about the distribution. And in this case you may need to transform the densities to approximate normality.
- For calculation of the encounter rate, “n” is not “mean abundance”, it is the “number of detections”. You are using the number of detection to try and work out the abundance.
- Explanation of choosing MCDS isn't clear. If cluster size was entered as a covariate because cluster size affected detectability then that makes sense, but you state that cluster size varied little implying it wasn't an issue. But you do seem to say that encounter rate varied a lot from one site to another. But you've not made it clear why MCDS would help cope with this (actually I don't think it would).
- “We selected the cosine adjusted half-normal detection functional model with the lowest value based on Akaike Information Criterion in the density estimations” would read better as: “We selected the cosine adjusted half-normal detection function based on it having the lowest AIC value”. However, you ought to assess model fit on more than just AIC. Did you have to pool data? Or truncate data? What other models did you consider?
- “Bird diversity was worked out using the reciprocal of Simpson's...” better worded as “Bird diversity was estimated using the reciprocal of Simpson's...”
- It is not clear the level at which stem densities were calculated – for each transect? Same goes for the other veg measurements.

- IT is not clear what you did to canopy cover: converted the values to ordinal scale then converted this to a ratio. Ratio of what to what? Doesn't this imply a closer numeric relationship between the classes than you really measured?
- Presumably the high variance in stem densities was because of the very small plot size relative to mean stem density – 0.1 ha is quite a small area to sample for trees in any forest.
- *"simple linear regression"* - It is not clear what this means. Do you mean univariate tests where you only consider one predictor variable at a time? If so, then you really ought to consider multivariate tests.
- *"Differences of means of the key habitat (independent) variables were compared on the spatial scale by one-way Analysis of Variance (ANOVA) using the forest blocks as the categorical treatment effects on the bird (response) variables."* I don't understand this sentence so please rephrase. Are you saying you used ANOVA to test for differences in the habitat variables between the different forest blocks? Not sure how the "bird (response) variables" also fit in here.

Results:

- No need to report on other birds species. The paper is about the pipit. You can mention that pipits surveyed as part of survey of all species but the other species data are few and add little.
- *"There were 17 encounters of Sokoke Pipit with an overall abundance of 30 individuals"* Confusing. You encountered pipits on 17 occasions comprising 30 individuals. Abundance is what you are trying to estimate from these encounters. You could put mean group size in brackets here to clarify further).
- Jilore and Kararacha are described as "moderate to highly disturbed" in contrast to Narasha which is "more disturbed". Not clear which is actually the more disturbed. Table suggests the former are less disturbed.
- You report results of a chi sq test of clumpedness but don't explain this in methods.
- Can you report 95% confidence intervals instead of standard errors in table 1. Makes it much easier to interpret the results.
- Table 1 says you right-truncated the data – presumably you mean in Distance. This is not mentioned in Methods. Perhaps relates to earlier confusion about appearing to use fixed width transects at 60m.
- Table 1 AIC presumably refers to the value returned by distance. This serves no purpose in this table as you cannot compare AIC values for the different forest blocks as they are computed from different data. AIC values can only be compared where the data are the same.
- Is degradation confounded with edge effect (Jilore)?

- Figure 2 - there should be no line connecting the three sites because there are no intermediate locations to be represented by positions along the line. They are discrete sites. Would be better to have a box and whisker plot for this figure.
- Fig 2 - it is hard to believe from this plot that litter depth does vary significantly between the blocks despite the reported very low p value!
- Table 2 should say stems per hectare, not densities per hectare.
- Having said stems size classes were pooled earlier on, table 2 reports results of them unpooled.
- Why can't Fig 4 be shown as scatter plot like Fig 3? There appears to be no relationship in Fig 4 between logging and pipits. Two unlogged sites have both high and low pipet density and the logged site had intermediate pipit density.
- Good to include the raw Distance data – that's commendable. Would be also good to have a plot showing the Distance histogram and selected model to demonstrate how suitable the selected model was.
- The analysis really lacks a coherent conclusion as there was no attempt to combine the predictor variables in a single analysis. Admittedly this may not be possible with so few replicates but there may be other ways to cut the data to improve this.

Discussion:

- A good edit for language is required, in the discussion especially.
- There are long sections about forest disturbance and history that do not arise from the results of the survey. These should be moved to the introduction by way of describing the site and why the survey might be needed or removed.
- Not sure that the impact of logging on the pipits is proven from the presentation given. Fig 4 is not convincing as it stands. In fact the opposite seems to be argued for in places – logging leads to more litter which is good for pipits.
- The article needs a good reference to back up the idea that leaf litter from felled trees persists for any length of time. Usually if a tree is felled the leaves dry up attached to the branches and don't fall off as they would naturally. Logging may lead to there being more dead wood rotting on the forest floor though.
- The elephant issue is important as fenced population must be having an impact. My understanding was that the fence was now complete.
- There is no real discussion of comparison with former surveys. Decline is rather simply attributed to habitat degradation without comparing the habitat in current survey with the habitat before.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 01 Apr 2014

Nickson Otieno, National Museums of Kenya, Kenya

Dear Dr. Lindsell,

We highly appreciate your review comments on our article, particularly the accompanying detailed suggestions for revision. We have now gone through the comments and revised the article accordingly by addressing the concerns as outlined below, and hope that our treatment meets with your expectations.

Thanks,

Nickson E. Otieno (for the co-authors)

Revisions by the authors in detail:

Abstract

- We have now corrected the proportion of globally threatened and near-threatened species.

Introduction

- We have clearly specified that the group of birds useful for monitoring forest health are the forest-dependent ones.
- We have now minimized repeat references to BirdLife Fact sheets.
- We have clarified that our study, in contrast to that of Musila *et al.* which examined species' response to habitat change, dealt also with spatial variations in habitat structural quality, and that the results provide an update in the spatial and temporal dimensions of the habitat effects on the species.

Materials and methods:

- We have changed *BirdLife protocols* to *BirdLife criteria* as suggested.
- We have retained paragraph two, as we feel it presents a suitable background the forest as a significant national and global habitat for many forest-dependent species of which SP is one. But we have eliminated the part outlining other taxa found in the forest.
- We have changes *community zones* to *communities* as suggested.

- We have included a statement about the absence of any forest fragment within the agricultural zone outside the main forest blocks.
- We have clarified that honey harvesters and game hunters damage the forest habitat by clearing vegetation to make paths, burning vegetation to access hives. Creation of such openings further accelerated anthropogenic impacts on the forest habitat, which affects forest-interior species like SP.

Sampling strategy

- Lumbering: we have clarified that this was officially sanctioned commercial logging, in the era before forest protection was actively enforced.

Transect positioning

- We did not use existing paths, as you rightly point out, the habitat was penetrable enough for survey walking, and the paths were only use for purposes of location the starting points of transects.
- On the map the transects look straight but in actual fact they were not necessarily so. The illustrations representing the transects on the map show only the straight lines joining the starting and ending points of transects. We have included this clarification in the main text.
- Using the 3rd track to select the start of transects was considered sound enough as a way of randomizing transects across the blocks because despite there being differences in disturbance levels across the blocks, presence of the paths did not differ significantly across them (see results, final paragraph) in frequency and thus was unlikely to be a significant source of bias. The “3rd track” tool was thus just a way of systematizing transect randomization to minimize spatial bias. It is this systematization scheme that ensured that if we could not maintain at least 1 km between adjacent transects, we continued searching till we found a transect starting point that fulfilled both conditions. So the abundance of tracks in the forest indeed assisted in some way.

Bird survey

- We have specified that we used Distance sampling but “fixed” our maximum transect width to 60m, beyond which, even in a forest that is not exactly too thick, it makes it subjective to accurately detect all individuals or clusters of a species as sensitive, silent and camouflaged as the SP. For this reason we also made truncation of our distance values on the programme itself by a general value of 5m.
- It is also clearly mentioned that we recorded SP individuals “and clusters” because there were incidents in which only single individuals were detected/encountered.
- We have added that bird transects were run twice each on different days.

Vegetation sampling

- It is canopy cover that was determined into % and not canopy heights. The canopy heights were determined using a range finder not from the within each transect quadrat but from an open area, either on a track or a deforested area, and using the range finder to obtain the observer distance from the tallest crown tree and then measuring to the crown height then using triangulation to determine crown height and adding eye-level height.
- We have clarified that live stems and cut tree stumps were measured in terms of circumference (not diameter) size classes. Only live stems were measured at breast height.

Floor litter sampling

- The sampling description is now made clearer.

Data analysis

- The count data that was log transformed initially were those of other counted things as only live stems and logged-out tree stumps. Bird data was only transformed from encounter rates (abundance) for purposes of regression against litter depth.
- By “transformed into densities per hectare” with regard to stem densities, we actually means “expressed as densities per hectare”. We have now reflected this in the data analysis section text. The initial transformation by logarithm was for the purpose of comparing these variables between blocks.
- We have clarified that SP encounter rates were worked out from total number of detections divided by survey effort, which was 2 km of transect in each forest block, surveyed twice each. Accordingly, we have reworked the encounter rates and corrected the values.
- It was our feeling that the rather small sample size of pipit detections was related to disturbance effects on the Pipit habitat within the *brachysetgia* forest. Having shown that disturbance as a parameter itself varies across the three segments of Brachystegia forest, we felt that it would significantly influence detection of the pipits. One evidence of the variant disturbance across the blocks was the mean sighting/detection distance, which also ended up corresponding to the forest disturbance levels of the blocks. Therefore MCDS was employed by using disturbance levels as factor covariates thus reducing the variance (and possible low confidence) in the density estimates that would be expected if CDS were to be used.
- In determining the densities using Distance, data were pooled for the various blocks into a global analysis, factoring in the block factor covariates. But the densities were also worked for the individual blocks. For the global analyses, we have also replaced the standard errors of density estimate on table 1 with 95% confidence intervals.
- We have also included a description of how the model of fit was selected for distance estimation, and how data was truncated for analysis.

- Vegetation assessment variables analysis were treated at the transect and block levels.
- Percent canopy cover scores were coded such that open canopy, moderately open canopy and closed canopy scored 1, 2 and 3, respectively. These were then transformed to ratios scaled with '3' as the maximum. So the ratio was cover score:3. Transformation of the ratios using ArcSine ensured that there would be no close relationship between the ratios representing the cover scores than was actually measured.
- By simple linear regression, we mean "neither logistic nor loglinear". Multivariate was the method, through which for instance were selected litter depth as a better predictor of pipit abundance than litter cover as we had stated in the results section.
- Although 10 x 10 m quadrats could be small for sampling forest trees, our analyses of vegetation measurements were done at the transect level which integrated 10 of the quadrats of each transect thereby reporting results per ha rather than 0.1 ha.
- The statement on ANOVA means that means were compared across the blocks. We have revised the statement to read: "Means of habitat variables were compared across the blocks using one-way ANOVA"

Results

- The section mentioning other bird species has been removed in the revised version of results.
- Jilore and Narasha blocks are described as less disturbed as compared to the more disturbed Narasha block.
- We have included in the data analysis section the use of the chi test for S Pipit distribution.
- It is possible that edge effects could be linked to effects of degradation in Jilore block. However, as we did not investigate extent or effects of edge effect, our main view about the high detection of S Pipit in that block is related to lack of massive destruction by elephants and comparatively reduced human traffic over the past few years due to the enclosing electric fence barrier.
- AIC values have been removed from Table 1.
- Figure 2 is now reproduced in box and whisker form to more distinctly show variation in litter depth across the blocks.
- Table 2 actually presents the tree stem data pooled into size classes (small sized = >30cm, mid-sized = 31-60cm and large = >60cm)
- Figure 4 is not presented as a scatterplot because the logging data used to produce it

are those of total trees stems cut, as the figure shows (human removal) without inclusion of trees removed or felled by elephants. In the discussion, we clearly showed that impact on Sokoke pipit due to habitat degradation was both a function of stem cutting as well as elephant tree removal. Furthermore, the figure as presented is intended to demonstrate that a slight increase in tree cutting/removal can correspond to a drastic impact on the Pipit abundance. Accordingly Narasha with low logging rate also had low pipit encounter rates, because the habitat degradation in that block is due to the numerous elephants rather than from human-mediated logging (stem cutting). We have updated the legend for Fig 4 to reflect this clarification.

Discussion

- It is our view that the section that deals with description of many authors' characterization of Arabuko Sokoke forest as a way of delineating it in terms of disturbance zones, provides a good setting in which we present our own characterization based on actual observed attributes which are in addition to, rather than restricted to, spatial variations in tree logging patterns. For instance, no other researcher has ever appeared to notice the possible relationship between the elephant feeding habits and forest habitat impacts. Putting this section in the introduction would imply that it is common documented knowledge, which it is not. We have however removed the first paragraph of that section, which might have been the more redundant of earlier descriptions under "Materials and methods".
- We were not able to find any study linking Sokoke Pipit needs with habitat variables ever since Musila *et al* did so in 2000, which is why we did not have much such discussion in our paper. We mentioned however that since the Musila *et al* study, there has been a decline in Pipit density, presumably due to habitat degradation that has continued since then. This is clearly outlined in the first paragraph of discussion. Oyugi, Fanshawe, Banks, Davis *et al*. all studied habitat of the *Brachystegia* forest, but in reference to other species mostly of the forest canopy and thus not directly comparable to the Sokoke Pipit.
- The impact of tree loss is proven as the main cause of Sokoke Pipit habitat in terms of abundance and distribution and as we argue in the discussion, trees are lost not only through logging by human (fig 4) but also by elephant tree damage. Augmentation of leaf litter (important for pipit) from pruning poached poles in the forest was neither evident throughout the study area nor considered the main driver of Pipit abundance and distribution. It was only associated to areas where logging intensity targeted small trees (human-induced removal). Again, human-induced tree removal was not the only driver of S pipit demographics.

Competing Interests: No competing interests

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