Canopy Cover on Kenyan Coffee Farms

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Introduction

Coffee is one of the most important economic crops traded worldwide by developing countries (second only to oil), and being grown on over 10 million hectares in the tropics holds high potential for affecting biodiversity of birds (Donald 2004). There has been a tremendous amount of work with birds in the Caribbean, and Central and South American coffee, where it has been established that shade grown coffee has tremendous benefits for birds (Donald 2004). However, although 20% of worldwide coffee is grown in Africa, not a single study on birds in coffee from Africa has been done (FAO 2012).

For my Master's Thesis, I mist netted birds near Nyeri, Kenya to quantify the bird community to determine if patterns seen in the Neotropics hold true for eastern Africa. Essential in the design of my study was measuring canopy cover at the shade coffee farms where I mist netted. These were done under each net, holding a small densitometer to calculate the proportion of the canopy directly overhead. However, these vegetation plots made up a small percentage of the overall site they were intended to quantify cover for. As such, determining if measurements on small vegetation plots were representative of the larger landscape was important to my study. In order to understand if small scale canopy cover measurements accurately quantified larger scale patterns of tree cover, I digitized trees on 5 study sites and measured the proportion of canopy cover within 25 and 50 m buffers around vegetation plots to compare on-the-ground measurements to larger scale patterns.

Methods

From working in Kenya, I was able to verify the high accuracy of much of the data found on Google Earth satellite images by comparing individual trees located on coffee farms to those I observed in images. GoogleEarth was by far the most accurate images I could find for this region of the earth. I created polygons around all shade trees within 75 meters of 3 shade and 2 sun study sites and saved these results as a .kml (keyhole markup language) file. This file was then converted into a shape file using the .kml to shape file conversion tool in ArcGIS, defined in WGS84 (World Geodetic System) datum, and projected into UTM (Universal Transverse Mercator) Zone 37 South coordinate system. I then imported GPS points of vegetation plots from the 5 sites in a csv (comma separated value) file into ArcGIS, defined them in WGS84 datum (which the GPS used to collect them was in at the time of collection), and projected them into UTM Zone 37 South. I created both 25 m and 50 m buffers around each sites points (each site is composed of 2 lanes of plots), and erased the canopy cover from within each of these buffered sites. I then calculated the area of each buffered plot and subtracted it from the area of buffered plots with the canopy cover erased. This gave me the area of each plot covered by canopy, which I then divided by the total buffer area to give me the proportion of canopy cover in each site.

Lastly, I compared these results to the average canopy covers we calculated from ground observations to assess their accuracy.

Figure 1. Locator map of study site (marked with the red star) in central Kenya.

Results

Digitizing the canopy cover from GoogleEarth appeared to be relatively accurate and easy because of the high resolution of the images. Converting the .kml file to a shape file did not appear to distort or alter the shape of polygons in any way, and all points appeared to project in the relative location to polygons as they had in GoogleEarth. Results from the proportion of canopy cover calculated in both the 25 and 50 m buffers of the vegetation plots were quite similar to results from ground-based surveys (within ±7% for most shade coffee plots and slightly higher for sun coffee plots). One shade site (Kihuri 2) appeared to have results that differed more than normal from ground-based measurements. This was likely due to many of the overhead trees being dead when surveyed in the field, yielding much smaller canopy cover measurements than images of full-canopied trees (which were likely taken at an earlier date before trees started dying) showed. This bias disappeared at the larger scale radius, likely because this scale captured a larger scale with a more accurate sampling of proportions of tree cover and coffee on the landscape than the 25 m radius.

Figure 2. Sample of the imagery available from GoogleEarth for our study site, along with an example of digitized tree canopy perimeters.

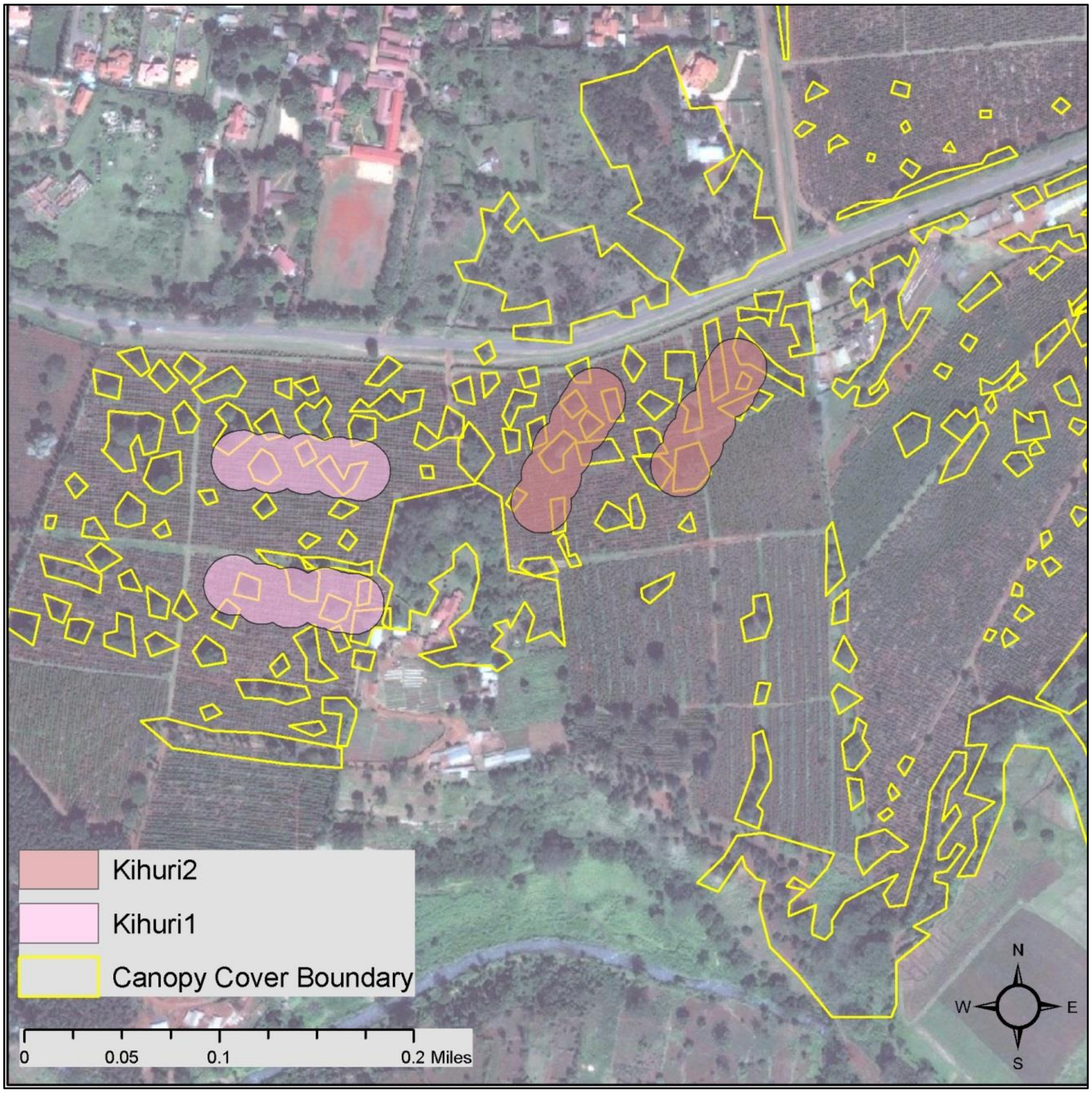

Figure 3. Detailed map showing a close-up view of 2 shade sites (each with 2 lanes of vegetation plots, labeled Kihuri2 and Kihuri1), with digitized canopy cover layered underneath.

Table 1. Comparison of percent canopy cover in shade and sun coffee farms estimated from 25 and 50m buffers and ground-based vegetation surveys.

50m buffer							
Coffee Type	**Site**	**Total Buffer Area (m^2)**	**Buffer without Canopy Cover (m^2)**	**Area of Canopy (m^2)**	**GIS Calculation of % Canopy Cover**	**Observed % Canopy Cover**	**% Difference in Cover**
Shade	Kihuri1	35472.9	25755.4	9717.5	0.27	0.35	0.08
Shade	Kihuri2	34026.2	23625.4	10400.8	0.31	0.23	-0.07
Shade	Jungle1	35253.8	28120.1	7133.7	0.20	0.27	0.07
Sun	Jungle 2	45655.4	38202.9	7452.5	0.16	0.02	-0.14
Sun	Kimathi5	34994.4	25696	9298.4	0.27	0.15	-0.11
25m buffer							
Coffee Type	**Site**	**Total Buffer Area (m^2)**	**Buffer without Canopy Cover (m^2)**	**Area of Canopy (m^2)**	**GIS Calculation of % Canopy Cover**	**Observed % Canopy Cover**	**% Difference in Cover**
Shade	Kihuri1	13489.2	9665.6	3823.6	0.28	0.35	0.07
Shade	Kihuri2	13089	7772	5317	0.41	0.23	-0.17
Shade	Jungle1	13457	10542.5	2914.5	0.22	0.27	0.06
Sun	Jungle2	18438	16138.2	2299.8	0.12	0.02	-0.11
Sun	Kimathi5	14587.8	11217.9	3369.9	0.23	0.15	-0.08

Discussion

Results from the digitized canopy cover within 25 and 50 m buffers compared very closely to results from small scale vegetation plots at coffee sites. Most shade sites were within 7% of ground-based observations, and sun sites were generally within 10-14%. Sun sites were likely slightly higher because nets were located against forest fragments (shade sites were located in the middle of coffee). As such, buffers around several vegetation plots near forest edges included forest that ground based measurements did not include. These results would likely be more accurate if only nets >25m from forest edges were included when using 25 m buffers (and the same for 50 m buffers). These results confirm that the ground-based vegetation measurements in my thesis are likely quite representative of the site as whole, validating canopy data that suggests canopy cover pattern at a site level actually negatively affect bird diversity on coffee farms in east Kenya. This is in striking contrast to over a dozen studies published from other areas of the Neotropics, suggesting shade coffee in east Africa may function very differently for birds than it does in other areas of the world.

Conclusion

It appears canopy cover measurements done on a small scale are applicable to much larger areas of coffee farms. In my thesis, I extrapolate bird abundance to the "site" scale. This analysis confirms I can also extrapolate canopy cover (one of the most important variables predicting bird abundance) to the site level as well, helping validate my thesis conclusion that canopy cover actually has a negative effect on bird abundance in coffee farms.

Acknowledgments

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References

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