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RESEARCH ARTICLE

Population Status of Chimpanzees in the Masito-Ugalla Ecosystem, Tanzania

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More than 75 percent of Tanzania's chimpanzees live at low densities on land outside national parks. Chimpanzees are one of the key conservation targets in the region and long-term monitoring of these populations is essential for assessing the overall status of ecosystem health and the success of implemented conservation strategies. We aimed to assess change in chimpanzee density within the Masito-Ugalla Ecosystem (MUE) by comparing results of re-walking the same line transects in 2007 and 2014. We further used published remote sensing data derived from Landsat satellites to assess forest cover change within a 5 km buffer of these transects over that same period. We detected no statistically significant decline in chimpanzee density across the surveyed areas of MUE between 2007 and 2014, although the overall mean density of chimpanzees declined from 0.09 individuals/km^2 in 2007 to 0.05 individuals/km^2 in 2014. Whether this change is biologically meaningful cannot be determined due to small sample sizes and large, entirely overlapping error margins. It is therefore possible that the MUE chimpanzee population has been stable over this period and indeed in some areas (Issa Valley, Mkanga, Kamkulu) even showed an increase in chimpanzee density. Variation in chimpanzee habitat preference for ranging or nesting could explain variation in density at some of the survey sites between 2007 and 2014. We also found a relationship between increasing habitat loss and lower mean chimpanzee density. Future surveys will need to ensure a larger sample size, broader geographic effort, and random survey design, to more precisely determine trends in MUE chimpanzee density and population size over time. Am. J. Primatol. © 2015 Wiley Periodicals, Inc.

Key words: chimpanzee; density; survey; remote sensing; masito-ugalla; tanzania

INTRODUCTION

Chimpanzees (*Pan troglodytes*) have been classified as an endangered species since 1996 (IUCN) and are threatened across their geographic range [but see Oates, 2006]. Over the last four decades, researchers and conservationists alike have described the impact on wild chimpanzee populations of habitat destruction [Junker et al., 2012; Lehmann et al., 2010; Young et al., 2013], human introduced [Köndgen et al., 2008; Leendertz et al., 2004; Ryan & Walsh, 2011] and natural [Keele et al., 2009; Kaiser et al., 2010; Rudicell et al., 2010] disease, and poaching [McLennan et al., 2012; Ohashi & Matsuzawa, 2011; Reynolds, 1992; Sugiyama & Soumah, 1988].

Tanzania, home to the two longest-running studies of chimpanzees [Gombe Stream National Park—Pusey et al., 2007; Mahale Mountains National Park—Nishida, 2011], hosts between two and three thousand chimpanzees, all within three regions in the western part of the country [Plumptre et al., 2010]. About a quarter of these chimpanzees live in tropical forests within the boundaries of the two aforementioned national parks. However, the rest are distributed across approximately 30,000 km^2 of land outside of national parks, comprising mostly (>80%) miombo woodland [Moyer et al., 2006]. These extra-park savanna-woodland chimpanzees occur naturally at extremely low densities. Specifically, a recent survey across the Masito-Ugalla Ecosystem (MUE) in 2012 combined genetic censusing techniques with traditional transect methods and reported a density of 0.10 individuals/km^2 (95%CI: 0.09–0.13)

Conflicts of interest: None.

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[Piel & Stewart, 2013], far lower than most other chimpanzee communities. The low densities pose a significant logistical challenge to those trying to monitor changes in population size and distribution over time [Moyer et al., 2006; Piel et al., 2015]. As a result, conservation organizations, and local stakeholders have divided the western region into contiguous, geographically separate areas (Masito, Ugalla) to help focus their efforts in censusing chimpanzee sub-populations and establishing geographically specific conservation strategies. This work is described in detail in collaboratively conceived conservation action plans [Lasch et al., 2011].

Monitoring these apes is critical given the nature of the threats facing much of Tanzania's wildlife. Specifically, numerous recent reports show that while the primary threat to chimpanzees is habitat loss caused by human settlement expansion and conversion to agriculture, annual burning, logging, and poaching are also playing a role [Davenport et al., 2010; Plumptre et al., 2010; Piel & Stewart, 2013, 2014; Piel et al., 2015] and conservationists have focused on establishing priority areas based on remaining chimpanzee habitat. In western Tanzania, human incursion into the Masito area is mostly for conversion of forest into oil palm plantations, but also for slash and burn agriculture [Pintea et al., 2002,2012]. This conversion is particularly concerning for conservationists given the known negative impacts of oil palm habitat conversion, from the loss in biodiversity to increases in habitat fragmentation and pollution [Fitzherbert et al., 2008; Swarna Nantha & Tisdell, 2008].

When results from monitoring studies are combined with data on forest-cover loss over time, the intensity of human threats on wildlife abundance, distribution, and behavior are clear [Newmark et al., 1994; Banda et al., 2006; Pintea, 2007]. Conservationists can then adapt subsequent conservation strategies and actions to directly address these threats [Mulder et al., 2007]. Accordingly, we recently conducted a survey of five previously surveyed areas across the MUE in western Tanzania. Our primary goal was to compare results from a similar survey conducted in 2007 [Jane Goodall Institute, 2007]. We predicted that overall chimpanzee population density would have declined over the seven years between surveys in response to increased human pressure. We also predicted that the largest declines in density would occur nearest to the largest human settlements in the Masito region, whereas the more remote Ugalla areas would show stable densities.

METHODS

Survey Areas

MUE is a 5,756 km^2 region in western Tanzania, bordered to the north by the Malagarasi river, to the east by the Ugalla river, to the south by the Lugufu river, and to the west by the coastal villages along Lake Tanganyika. MUE forms part of the Greater Mahale Ecosystem of contiguous chimpanzee habitat to (and including) Mahale National Park in the south (see Fig. 1). MUE habitat consists of broad valleys separated by steep mountains and flat plateaus ranging from 900 to 1800 m above sea level. Vegetation is dominated by miombo woodland (86%)—*Brachystegia* and *Julbernardia* (Fabaceae) species—although it also includes swamp, wet, and dry grassland, as well as evergreen gallery and thicket riverine forests (3%; vegetation types are described in Table I). For the purposes of this study we used only "open" (woodland, swamp, grassland, rocky-outcrop) and "closed" (evergreen and thicket forests) vegetation types for analysis. There are two distinct seasons: wet (November–April) and dry (May–October), with annual rainfall between 900 and 1400 mm [Piel et al., 2015]. Chimpanzees use this heterogeneous habitat differentially, with more nests [Stewart & Pruetz, 2013] and observations [Russak, 2014] occurring in gallery forest than in other vegetation types.

Such heterogenous use of the landscape can skew chimpanzee population size estimates when one extrapolates chimpanzee density to the whole region. A more accurate assessment of chimpanzee population size in the region might be determined if one extrapolates only to the area of suitable chimpanzee habitat within the region. To assess what proportion of the MUE represented environments suitable for chimpanzee occupation, we chose Mahalanobis distances (M-distance) as the modeling algorithm [Moyer et al., 2006; Calenge et al., 2008]. M-distance requires chimpanzee presence data only and is ideal for GIS mapping where habitat variables are highly auto-correlated [Jennes, 2003]. In our case, we used the algorithm to identify which areas within the MUE best predict where chimpanzee nests were observed.

In collaboration with The Jane Goodall Institute (JGI), Tanzania Wildlife Research Institute, and district wildlife and forest officers from Mpanda and Kigoma districts, the Tanzanian Institute for Resource Assessment (IRA) designed and led the original (2007) survey [Jane Goodall Institute, 2007]. IRA researchers selected six survey sites non-randomly based on known chimpanzee presence. Where possible, they walked four radial transects of 5 km length following cardinal directions from the central campsite at each site (they walked 20 transects in total, as two sites comprised only two transects each). Such non-randomly selected transects are not ideal for estimating overall population size across MUE, however, these data do allow for comparison over time.

To control for regional variation in chimpanzee density we repeated identical surveys at five of the

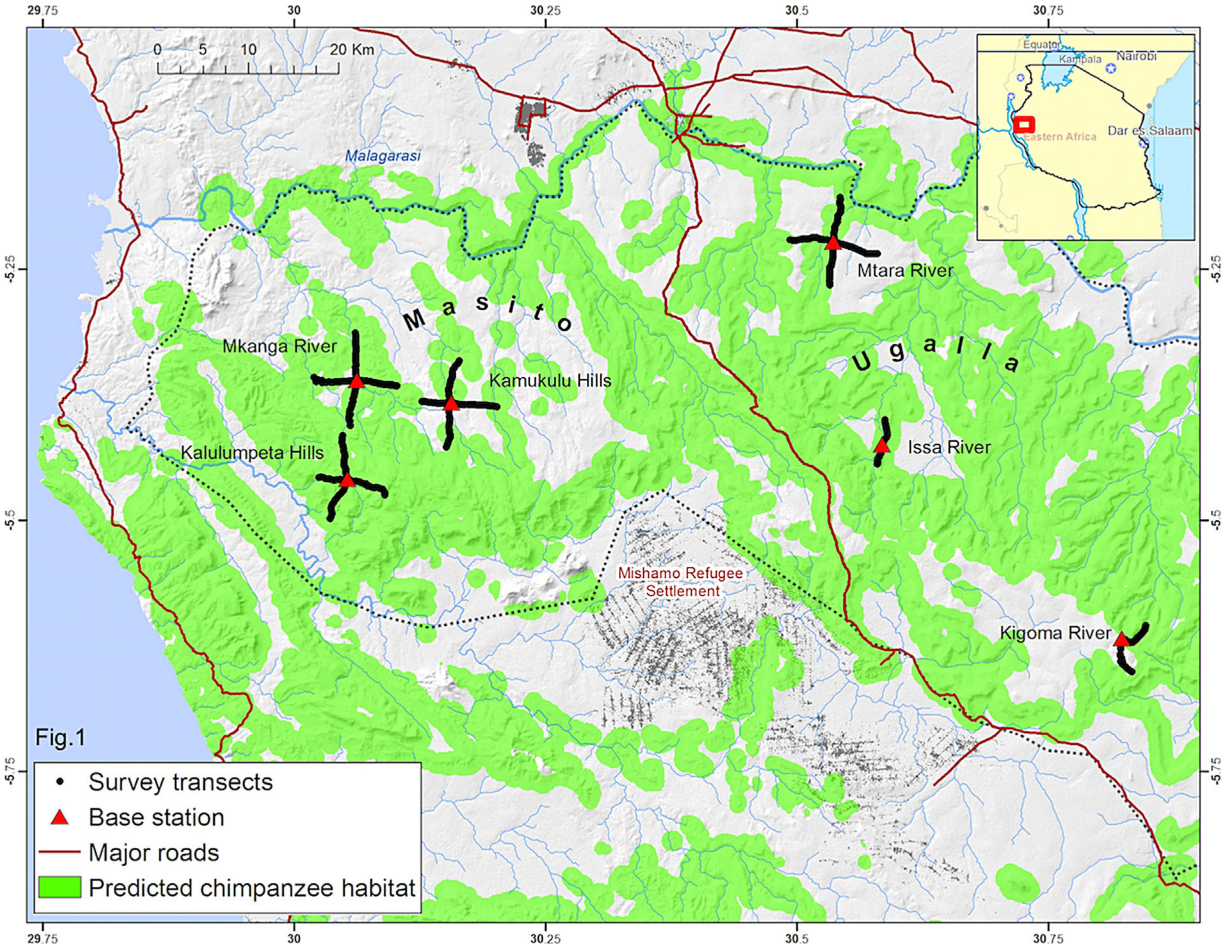

Figure 1. Map of western Tanzania with Masito, Ugalla, and transect locations labeled. Shaded green areas represent predicted chimpanzee habitat.

six sites in 2014 (two in Ugalla and three in Masito,16 transects in total). We conducted 2007 and 2014 surveys during the wet seasons, with 2007 transects walked in October-November (early rains) and 2014 transects walked in January-February (late rains).

Data Collection and Nest Encounters

To determine chimpanzee density from nest counts, we used standard line transect methods to first estimate densities of chimpanzee nests and then converted these to densities of individuals [Plumptre & Reynolds, 1996]. This method relies on the fact that chimpanzees, like all great apes, construct nightly nests. We decided to use nest counts instead of direct encounters with chimpanzees given the low density of chimpanzees across MUE and overall rarity of actual encounters.

On each transect, we recorded data on paper (2007) or on tablet computers (2014), equipped with forms that we had designed on Open Data Kit software. We recorded all direct (sightings) and indirect (print, nest, feces) evidence of chimpanzees, noting GPS waypoint, vegetation (open or closed, see Table I), number (of animals for direct encounters only), age classification (of nest) and perpendicular distance to the transect. We categorized nest state of decay as the following: (1) fresh feces underneath, leaves green and nest structure intact; (2) some leaves brown, but nest structure intact; (3) nest rotting and structure disintegrating; and (4) only the frame and <5% of leaves remaining. We considered nests decayed from age 4, following Plumptre and Reynolds [1996]; therefore we used only nests of age 1 to 3 for analyses.

We analyzed both 2007 and 2014 datasets identically for comparative purposes. We compared transect lengths by measuring transect lines using publicly available high-resolution imagery from Google Earth. Transect lengths walked in 2014 differed slightly in some cases from 2007 (Table II). On the transect, we measured the perpendicular distance from each nest or animal to the transect line [sensu Buckland et al., 2010] and entered data into DISTANCE 6.0 [Buckland et al., 2001] to calculate the Effective Strip Width (ESW), and from the total area

TABLE I. The Vegetation Types that Characterize the Habitat.

Vegetation type	Category	Description
Gallery forest	Closed	Evergreen (riverine) forest with open understory, typically beside seasonal watercourses.
Thicket forest	Closed	Dense growth of shrubbery or small trees, usually connecting patches of gallery forest
Woodland	Open	Deciduous (predominantly miombo) trees and shrubs with grass understory and discontinuous canopy.
Dry grassland	Open	Short grasses with some shrubs in valley lowlands or plateaus.
Wet grassland (swamps)	Open	Tall grasses up to three meters. Seasonally inundated (swamp-like) with very low density of trees/shrubs.
Rocky outcrop	Open	Landscape consisting of exposed bedrock and boulders with low density of trees/shrubs.

surveyed, obtain a nest density estimate (nests/km^2). Several models can be used for nest density estimation, and we selected the model that yielded the lowest Akaike's Information Criterion value as recommended by previous studies (Thomas et al., 2010). We stratified by vegetation type to calculate ESW separately for open or closed vegetation types (Table I). This stratification is necessary given the dramatic difference in visibility and decay rate between nests built in each vegetation type. This analysis therefore yields a nest density estimate for open and closed vegetation, in addition to a global nest density estimate that controls for survey effort in each vegetation type. We also calculated global nest density manually by controlling for the amount of available open versus closed vegetation across the ecosystem.

We used an available nest production rate of 1.1 per day [Plumptre & Reynolds, 1996] for both survey years. Unlike previous studies that used a nest decay rate of 97 days, we used a nest decay rate specific to each vegetation type: woodland (open) = 139.2 days versus gallery forest (closed) = 118 days, described in Stewart et al. [2011]. We thus calculated the number of individuals per km^2 by correcting for the time for nests to decay to age 4, and nest production rate, using the formula below [Plumptre & Reynolds, 1996]:

Density of chimpanzees = Density of nests / (production rate x mean time to decay)

Finally, we converted chimpanzee density (number of individuals/km^2) to estimated population size by multiplying this density estimate by either the total area of the MUE (5756 km^2) or by the area of suitable chimpanzee habitat. Because of small sample sizes we used nonparametric statistics, including Spearman rank correlations, and conducted all analyses manually, assessing significance at $P < 0.05$ and using critical values tables for small sample sizes [Brown & Hollander, 1977].

Forest Cover Change

To assess whether a loss in forest and woodland habitats might explain any variation found in chimpanzee density between the survey periods, we analyzed the total amount of forest and woodland lost in each survey area each year between 2008 and 2012. We first created a 5-km buffer for each transect using ArcGIS 10.2 software. We then estimated the total area of forest and woodland loss within 5-km buffers for each transect. We used forest loss data derived from Landsat satellite imagery [Hansen et al., 2014].

All research complied with protocols approved by the Tanzania Wildlife Research Institute and adhered to the legal requirements of Tanzania and the American Society of Primatologists Principles for the Ethical Treatment of Non-Human Primates.

RESULTS

We walked 16 transects (12 in Masito, 4 in Ugalla), covering a total of 70.30 km in 2007 and

TABLE II. Transect Lengths and Habitat Proportions for each Transect Walked in 2007 and 2014.

		2007 Transects				2014 Transects			
		Lengths (km)#				Lengths (km)#			
Region	Survey area (abbreviated)	Open	Closed	Total	Nests	Open	Closed	Total	Nests
Ugalla	Kigoma	9.50	0.47	9.97	25	8.18	0.47	8.64	3
	Issa	4.97	0.00	4.97	33	4.97	0.00	4.97	11
Masito	Mkanga	17.97	1.86	19.83	37	15.61	1.76	17.37	8
	Kamukulu	16.33	1.48	17.81	13	16.33	1.48	17.81	2
	Kalululempeta	16.22	1.50	17.72	28	15.77	1.50	17.27	2
	TOTAL	64.99	5.31	70.30	136	60.86	5.21	66.07	26

66.07 km in 2014 (Table II). In both surveys, we documented chimpanzee nests at all survey sites, even when we removed age 4 nests from the dataset. When we partitioned transects into open and closed vegetation, we found that ~92% of transects were in open vegetation, versus ~8% in closed vegetation in both 2007 and 2014 (Table II).

Using the values that DISTANCE provided for ESWs for each vegetation type, we calculated the number of individual chimpanzees per km^2 to be over 26× higher in closed than in open vegetation in 2007, and over 7× higher in 2014 (Table III). Given that the percentage of closed vegetation on the surveyed transects (7.9%) was higher than the percentage of closed vegetation across the ecosystem (3%), we report overall density taking into account proportion of vegetation types along transects (see below) and also across the ecosystem. For the latter, we calculated an overall population density of 0.09 individuals/km^2 in 2007 and 0.05 individuals/km^2 in 2014 (Table III). From these more recent figures, we can estimate the population size for chimpanzees living in suitable habitat (~135 chimpanzees in 2699 km^2) and across the entire ecosystem (~288 chimpanzees in 5,756 km^2). However, these estimates have large error margins (Table IV).

Further, we calculated the 2007 chimpanzee density on the surveyed transects to be 0.12 individuals/km^2, compared to 0.06 individuals/km^2 in 2014 (Table III). We found no significant difference when we compared densities between years across five transect areas (Wilcoxon matched pairs signed ranks test, $W = 6$, N = 5, two-tailed, $P = 0.406$, two-tailed). We also found no significant difference when we compared chimpanzee density between years across transects, ($W = 18.5$, $N = 11$, two-tailed, $P = 0.120$). The lack of a significant decline overall reflects the observation that changes in density were not consistent across each transect area. Instead, Issa, Kamukulu Hills, and Mkanga river all exhibited an increase in density, while Kigoma River and Kalulumpeta Hills exhibited declines (Fig. 2).

Given that we conducted the 2007 surveys in the early wet season, versus the 2014 survey which we conducted in the late wet season, it is possible that changes in nesting site preferences of chimpanzees in response to vegetation changes from the early to late wet season explain the lower mean density in 2014. To test whether variation in nesting preferences explained the difference between 2007 and 2014 chimpanzee densities, we compared the total number of nests observed (per km^2 to control for different ESWs) in closed versus open vegetation between 2007 and 2014. We found a smaller number of nests/km^2 in 2014 (44.1 nests/km^2) compared to 2007 (60.2 nests/km^2) in closed vegetation and a greater number in open vegetation (0.45 nests/km^2 in 2014, 0.42 nests/km^2 in 2007). Nevertheless, if vegetation changes from the early to late wet season influence chimpanzee use of closed versus open habitats for nesting, we would expect to see a similar pattern across all survey areas. We therefore compared chimpanzee densities across surveyed areas in closed versus open vegetation. Kalulumpeta Hills and Kigoma River showed declines in chimpanzee density in open vegetation as well as closed, while Mkanga and Kamukulu Hills showed an increase in density in closed vegetation in 2014 (Fig. 2). A comparison of density on transects revealed that researchers located fewer nests in closed vegetation in 2014, although this trend was not significant (Wilcoxon matched pairs signed ranks test, $W = 3$, $N = 6$, one-tailed, $P = 0.067$). We also found no difference in density in open vegetation between 2007 and 2014 ($W = 17$, $N = 10$, one-tailed, $P = 0.161$).

Habitat loss

We found that areas within five kilometers of the MUE line transects lost a total of 1,134Ha of forest and woodland habitat between 2008 and 2012. To assess whether a loss in habitat may explain some of the variation in chimpanzee density between the survey periods, we correlated the amount of total habitat (all vegetation types combined) loss with change in chimpanzee density between 2007 and 2014. Across transect areas, chimpanzee density seemed to decrease with increasing habitat loss, although the correlation was not significant (Fig. 3;

TABLE III. Density Estimates (With 95% Confidence Intervals - CI) Compared Across Vegetation Types and Globally for our Re-Analysis of 2007 Data Reported in JGI (2007) Using Updated Nest Decay Rates and Re-Walked Transects in 2014.

	Chimpanzee density (individuals/km2)			
	2007		2014	
Vegetation	Mean	95%CI	Mean	95%CI
Open	0.05	0.02–0.12	0.04	0.01–0.27
Closed	1.34	0.47–3.83	0.29	0.12–0.70
Overall (controlling for 7.9% forest on transects)	0.12	0.06–0.23	0.06	0.02–0.23
Overall (controlling for 3% forest across MUE)	0.09	0.03–0.23	0.05	0.01–0.30

TABLE IV. A Comparison of MUE Chimpanzee Population Sizes From Various Studies With Mean Density and 95% Confident Intervals (CI). The 2012 Survey Focused on Chimpanzee Habitat Across the Greater Mahale Ecosystem (GME).

	Chimpanzee density (indivs/km^2)		Estimated population size				
	Mean	95%CI or range*	Total MUE landscape		Suitable predicted habitat		
Census (survey year)			Mean	95%CI	Mean	95%CI	Reference
Re-walked MUE (2014)	0.05	0.01-0–30	288	58–1728	135	27–810	This study
Re-analysed MUE (2007)	0.09	0.03–0.23	518	173–1324	243	81–621	This study/ [JGI, 2007]
GME MUE survey (2012)	0.10	0.09–0.13	576	493–733	243	231–344	[Piel & Stewart, 2013]
Historical surveys comparison (2006)	Ugalla: 0.08 Masito: 0.2	0.03–0.14* 0.16–0.71*	270 481	101–469 385–1709	133 211	49–230 169–748	[Moyer et al., 2006]

Spearman rank correlation, $r_s = -0.80$, $n = 5$, $P = 0.067$).

DISCUSSION

Overall we found no significant decline in chimpanzee density between 2007 and 2014 across the surveyed areas of the MUE in western Tanzania. Although estimated chimpanzee density in 2014 was almost half the 2007 value, the confidence intervals surrounding these estimates overlap almost entirely. Large confidence intervals in both the 2007 and 2014 data sets reflect the limited number ($N = 20$) and length (total of <100 kilometers walked) of transects, and limited sightings of nests ($N = 202$ in 2007; $N = 32$ in 2014) across an area estimated at >5,500 km^2. Given these large error margins, it is impossible to say with confidence whether chimpanzees have declined over the last seven years. Our 2007 estimate is consistent with historical reports of chimpanzee density in the region. Except for one of the earliest studies in the mid 1950s in one high-density chimpanzee area of Kasakati in Masito, where researchers reported densities at 0.46–0.71 [Suzuki, 1969], all previous (transect) survey work across Tanzania has resulted in values repeatedly and consistently between ~ 0.01 and 0.14 individuals/km^2 [reviewed in Moyer et al., 2006; see also Table IV]. The current figures are also consistent with a recent (2012) survey across the country, in which Piel and Stewart [2013] combined a genetic census with line transects to assess chimpanzee population densities. They reported a population density of 0.10 individuals/km^2 in suitable

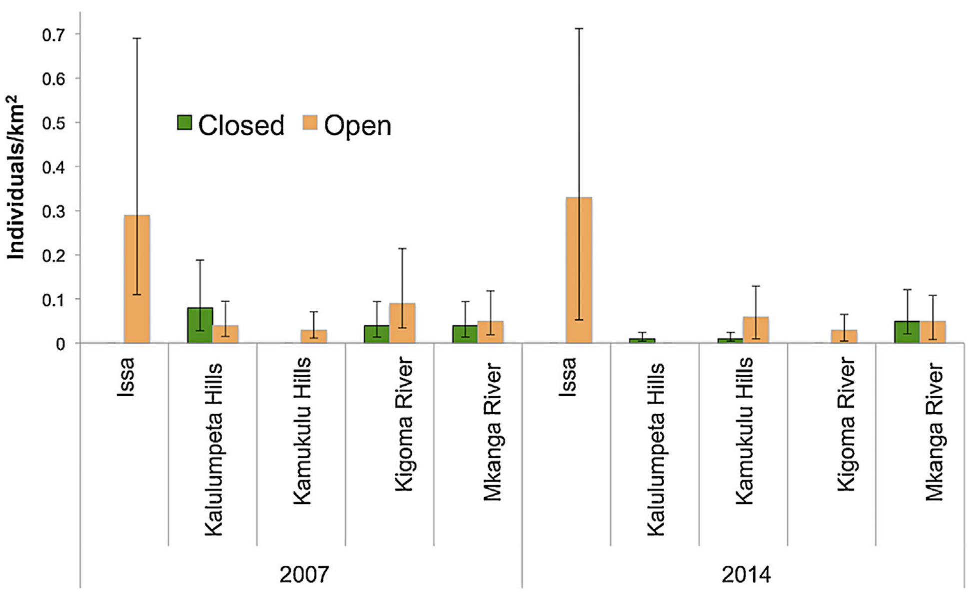

Figure 2. Chimpanzee density within each vegetation type—open (orange) and closed (green)—and compared across years in each area surveyed. Density figures and 95% confidence intervals were calculated by DISTANCE.

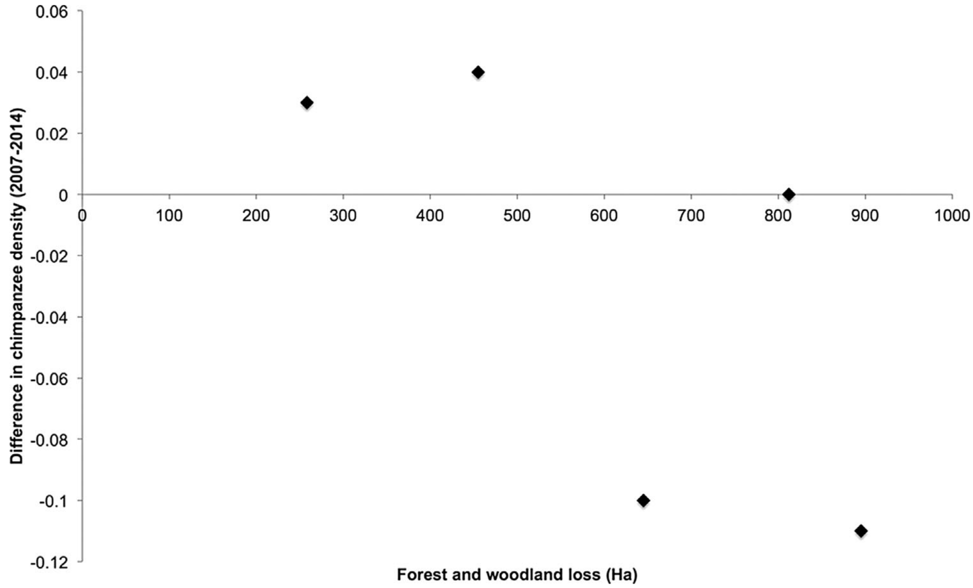

Figure 3. Forest loss and difference in chimpanzee density between 2007 and 2014.

chimpanzee habitat in MUE (Table IV). Nonetheless, the difference in number of nests encountered and mean density between 2007 and 2014 estimates suggest that, although not statistically detectable in this study, there may be an overall decline. Such a decline could result from temporal differences in survey period and human disturbance.

Temporal Differences in Survey Period

The savanna woodlands of western Tanzania are characterized by dramatic seasonality. In the heterogeneous MUE habitat, chimpanzees nest disproportionately more frequently in forest areas [Stewart & Pruetz, 2013], in addition to selectively nesting on woodland slopes [Hernandez-Aguilar, 2009]. However, the extent to which chimpanzees select closed or open vegetation for nesting changes seasonally. In the dry season, chimpanzees avoid nesting in open and preferentially select closed vegetation, probably because of the seasonal loss of foliage in (open) woodland vegetation [Stewart, 2011; Stewart & Pruetz, 2013].

We attempted to control for possible seasonal effects by conducting both surveys in the wet season, although the 2014 survey occurred during the latter part of the wet season, when chimpanzees would likely be nesting in woodlands. The 2007 survey occurred in the early wet season, when chimpanzees nest more often in the evergreen forests. Given that 92% of the survey effort was conducted in woodland, it is possible that such nesting site preferences might influence the number of nests observed on our line transects. The overall number of chimpanzee nests per km^2 in closed versus open vegetation was greater in 2007 than 2014, and there was some, albeit weak, evidence for more nests per km^2 in forest in 2007 than 2014, suggesting that chimpanzee seasonal use of vegetation for nesting may have influenced observed differences in global chimpanzee density across years.

Human Disturbance

Although we cannot be fully confident of the pattern, there was some evidence that the amount of deforestation since 2008 related to declines in chimpanzee density across the five survey areas. This correlation is expected given the relationship between forest loss and great ape decline across their geographic range in Africa [see Junker et al., 2012], and Tanzania is probably no exception. Human settlement and agriculture expansion along with other threats such as illegal timber harvesting and fires continue to threaten Tanzania's chimpanzee habitat [Fisher et al., 2011; Mwampamba, 2007] with a particular impact on evergreen forests [Pintea, 2007; Pfeifer et al., 2012]. In an arid landscape like western Tanzania, evergreen forests and woodland slopes are important refuges for chimpanzees, providing key food sources and nesting trees at various times of year [Hernandez-Aguilar et al., 2013; unpublished data]. A reduction in forest abundance likely threatens chimpanzee viability across Tanzania [Lasch et al., 2011; Plumptre et al., 2010; Piel & Stewart, 2014].

RECOMMENDATIONS FOR FUTURE SURVEYS AND CONSERVATION ACTIONS

In assessing change in chimpanzee presence over time, historical data can be useful. However, given the differences we identified above in survey design, we should be cautious when extrapolating these densities to the wider MUE. To obtain more representative densities, we recommend more extensive spatial and temporal coverage, especially more and longer transects that reduce error margins [Buckland et al., 2010; Kühl et al., 2008; Thomas et al., 2010]. Future surveys should also include a greater proportion of gallery forest. In a heterogeneous landscape like MUE, Moyer et al. [2006] pro-] promote the use of transects that "zig-zag" across forests, for example, as a means of increasing coverage of this rare vegetation class. We further recommend that transects are placed randomly across the landscape and are walked during each season at the same time in the rain cycle (e.g. early or late) to control for seasonal differences in chimpanzee nesting behaviour. Finally, the current study made some key assumptions that could be remedied in subsequent work. First, we have used the same nest decay rate for both the 2007 and 2014 data sets, which may also influence subsequent density estimates. Matthewson and colleagues [2008] provide an excellent analysis of the numerous factors that affect orang-utan (*Pongo pygmaeus*) nest decay rates, including rainfall, tree type and size, as well as nesting height (e.g. higher nests decayed more quickly than lower ones). While nest-decay studies are often too time-intensive to conduct at all survey sites, future surveys could incorporate data on nesting tree species and nest height in an initial attempt to better compare nesting characteristics as a proxy for variation in decay rate. Marked nest transects [Spehar & Marshall, 2010] also address some of these issues, but are often logistically impractical.

There are already various strategies employed to address the threats to MUE [Jane Goodall Institute, 2009; Lasch et al., 2011]. For example, JGI has recently facilitated village land use plans developed by the local communities and worked together with district governments, Tanzania National Parks (TANAPA), local communities and other non-government organizations to establish Local Area Forest Reserves that cover all the general land in the MUE. Additionally, it is now well established that researcher presence deters illegal human activity [Campbell et al., 2011; Laurance, 2013; Pusey et al., 2007; Piel et al., 2015] and long-term research projects may help mitigate these threats. Therefore there is a need to use the results and recommendations from this study to design a comprehensive survey approach that would allow continuous evaluation of the success of ongoing conservation efforts in the region.

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