High Survival and Percentages of Giraffe Calves Signal Areas in Need of Protection

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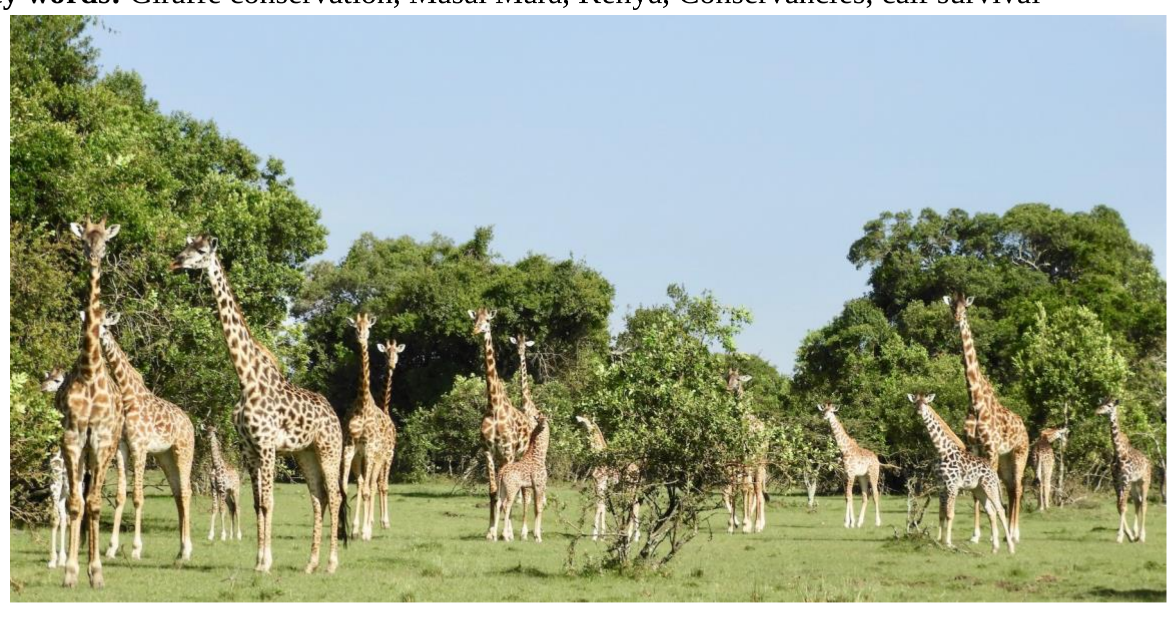
Abstract. We surveyed endangered Masai giraffes (*Giraffa camelopardalis tippelskirchi*) at Oloirien Group Ranch (OGR) and Oloisukut Conservancy (OC) in Kenya to determine their conservation potential. Here, Maasai settlements, livestock, and predator control result in lion densities less than half that of adjacent protected areas. Using surveys and photographic mark-recapture (PMR), we annually calculated percentages of newborn (< 4 mos) and older giraffe calves (4-12 mos). We used Cormack-Jolly-Seber models to estimate annual survival of giraffes at OGR from 2014 to 2022. Giraffe survival for all ages and sexes was estimated at 0.85, higher than in reserves where lions are protected. There were no significant differences in calf percentages at OC and OGR, 23.6 ± 6.7% (N=8). In 2021 and 2022, OGR calf percentages were > 30%, similar to areas without lions. At OGR, 65% of female giraffes were observed multiple years, including calves transitioning to adulthood. One female of 232 was recorded at both sites. OGR females frequented the Mara Triangle Conservancy (MTC) and are a source of giraffes for that protected area. Our findings show that savanna-grasslands external to protected areas where lion densities are low are critical for giraffe conservation. OGR needs a giraffe conservancy, now.

Key words: Giraffe conservation, Masai Mara, Kenya, Conservancies, calf survival



INTRODUCTION

We predict that grazing lands in the Greater Maasai Mara Ecosystem (GMME) of Kenya (see Li et al., 2020) outside of protected areas, where lion numbers are reduced and native savanna-grasslands remain, are of critical importance to the recovery of endangered giraffes. We compare giraffe calf percentages at two locations on the Siria Plateau and estimate calf survival at one site to assess the conservation value of these human-dominated savanna grasslands for giraffe conservation.

In 2019, the International Union for Conservation of Nature (IUCN) listed Masai giraffes (*Giraffa camelopardalis tippelskirchi*) as endangered after populations had declined by half in three decades (Bolger et al., 2019). Giraffes declined for a variety of interrelated reasons including, habitat loss, fragmentation, and degradation, human population expansion (Wells et al., 1992), poaching, disease, war, and civil unrest (Giraffe Conservation Foundation, 2021). Furthermore, giraffe calf survival is highly sensitive to predation pressure, especially from lions (Lee et al. 2016; Muller, 2018; Bond et al., 2021b). Source and sink dynamics also play a role in giraffe viability (Lee et al., 2016) and sources, places where survival is relatively high, must be identified.

In 2014, community-based giraffe monitoring at OGR (Figure 1) suggested that the Siria Plateau might be a source of giraffes for Rift Valley protected areas. During wildlife surveys, giraffe calves, especially newborns, were observed more frequently on the plateau than in the Mara Triangle Conservancy (MTC), or the Maasai Mara National Reserve (Becker, 2017). This prompted the hypothesis that calf survival was high on the plateau hallmarking a source of giraffes. However, this idea conflicted with Lee and Bolger (2017a) who claimed that protected areas were sources of giraffes, while areas outside of national parks were sinks - areas of low survival. Later, Lee et al. (2021b) discovered areas outside of national parks that had higher giraffe calf survival than inside national parks.

Lion Predation. Conservation areas in the Rift Valley protect iconic African predators (lions, cheetahs, hyenas, and leopards) for tourism income. In contrast, on the Siria Plateau, lions, the main predators of giraffe calves (Strauss & Packer, 2012, Dagg & Foster, 1982), are frequently translocated back to the Rift Valley, or euthanized. According to the Kenya Wildlife Service, lion abundance on the Siria Plateau is low, around half that of the reserves and conservancies in the Rift Valley. When we conducted giraffe surveys, mean lion density in MTC and MMNR was 17.3 ± 3 lions/100km^2 (Mara Predator Conservation Programme (MPCP, 2020). Thus, lion density on the Siria Plateau was ~ 8 lions/100km^2 and limited to the eastern edge of the plateau (MPCP, 2020). High giraffe calf percentages were expected on the Siria Plateau due to higher calf survival resulting from lower lion numbers.

Benefits of Human Shielding and Livestock Browsing. In addition to fewer lions, Maasai settlements and people are ubiquitous on the plateau resulting in human shielding (Berger, 2007). Predators avoid areas inhabited by people, "shielding" prey species (Berger, 2007; Bond et al., 2020, 2021b). Furthermore, at OGR and Oloisukut Conservancy (OC), browsing by domestic and wild ungulates have created dense thickets of short trees where giraffe calves can feed and hide (see DuToit et al., 1990; Google maps, 2022). These two factors can favor high calf survival on the Siria Plateau.

Female Groups, Site Fidelity, and Overlap Hypothesis. Given that OGR and OC are located adjacent to each other (Figure 1), giraffes may form a fluid metapopulation such the same females use both sites. However, it is equally plausible that female giraffes will show little overlap due to site fidelity (Karsch et al., 2016) and intense female bonding (Bond et al., 2021). This would increase the conservation value of local areas that attract female giraffes. We compare overlap of individual female giraffes to determine if one or two subpopulations are represented by the two sites.

Human Dimensions of Giraffe Conservation on the Siria Plateau. Given that local decisions about conservation depend greatly on local people (Ole Seno, 1998; Lamprey & Reid, 2004; Ogutu et al., 2016; Tiller, 2017), we provide an overview of local capacity for, and interest in, giraffe and wildlife conservation. We expand on these themes in results and discussion informed by our experiences and publications (Becker, 2017; Naiyainoi et al., 2021).

The Maasai community at Oloisukut began community-based conservation in 2006, and formed a conservancy in 2010. OC covers 13,335 ha and is composed of 51 private parcels and ~200 members. The main goal of OC is to "improve the livelihoods of the members through conservation-based enterprise while safeguarding the integrity of the larger Mara-Serengeti Ecosystem for current and future generations (Odeck, 2016)".

In contrast, even by 2010, OGR had no community-based conservation program and had not privatized communal lands. In 2011, Life Net Nature (LNN), a conservation charity, was invited by a local Maasai elder to start a community-based conservation project at OGR. LNN assisted Maasai in forming a community-based organization, Maasai Moran Conservation and Walking Safaris (MMCWS), with aims to monitor wildlife and advocate for conservancies. MMCWS became the ‘eyes and ears’ on the ground for human-wildlife interactions. They hosted visitors at their campsite, selected students for scholarships, patrolled community lands, and monitored nearby Masai giraffe populations. They worked in partnership with local authorities to assist wildlife that were injured or in need of assistance. Additionally, MMCWS took 200 heads-of-households to visit Maasai-owned conservancies to discuss the pros and cons, and ways of forming conservancies (Becker, 2017).

In 2018, MMCWS joined the Maasai Mara Wildlife Conservancies Association (MMWCA), a Kenyan organization working to conserve wildlife. In 2019, OGR privatized land holdings, a concept alien to most local Maasai (Ole Seno,1998), but that afforded more autonomy over small parcels of land. Early in 2022, MMWCA and MMCWS, established the 6,475-ha Oloirien-Nyakweri Conservancy uniting a set of new land owners to protect forests used by elephants when birthing. Now MMCWS is advocating for a giraffe conservancy. That will involve a different set of landowners and different funding sources (Naiyianoi et al., 2021).

MATERIALS & METHODS

Study Areas. Data were collected at the two sites, OGR and OC, located on the Siria Plateau in western Kenya, from 2014-2022, and 2019-2020, respectively. The Siria Plateau is on the western edge of the Rift Valley, ~ 300 m above and adjacent to the Mara Triangle Conservancy (MTC), Masai Mara National Reserve (MMNR), and other conservancies (Figure 1). OC's eastern boundary is the Mara River (Odeck, 2016), while ORG's is the Oloololo escarpment (Figure 1). OC shares a southern boundary with OGR, and the OGR giraffe study area is only 5 km south. Vegetation is similar at the two sites consisting of patchy savannah woodlands grazed by Maasai livestock (Ole Seno, 1998; Odeck 2016).

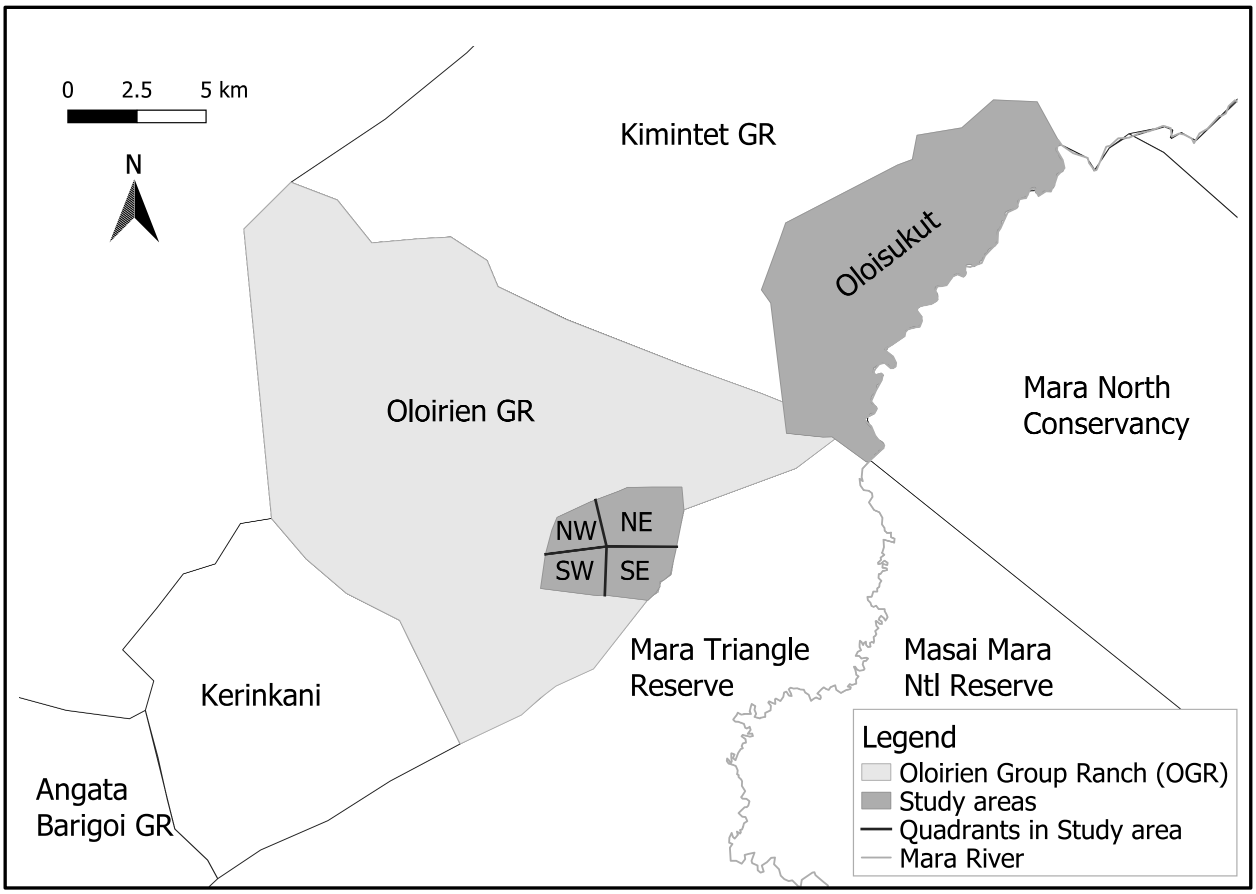


Figure 1. Locations of the giraffe monitoring area at Oloirien Group Ranch and Oloisukut Conservancy on the Siria Plateau with linkages to protected areas in the Rift Valley of Kenya. Note location of Mara River and the closeness of the two study areas on the Siria Plateau.

Giraffe Counts. At OGR, giraffe counts were completed from July 2014 to the end of 2022. Annual surveys, duplicated within a 10-day period, were completed July to October in 2014-19 and 2021. Starting March 2019, giraffes were surveyed monthly at OGR. Giraffe metrics at OGR were estimated by two methods: 1) surveys made on foot, for which error due to double counting and turnover were possible, and 2) by photographic mark-recapture (PMR) where such errors were eliminated. Double counting results in an overestimate of giraffes in a given survey, while missing individuals due to their coming and going from the survey area, or turnover, results in and underestimate. Comparing results from the two methods should reveal the type of error influencing data from surveys.

Giraffes at OC were systematically sampled annually, once in November 2019 and again in September 2020. For this paper, only PMR results were used to derive statistics for OC.

Photographic Mark-Recapture (PMR). At both study sites, the right sides of individual giraffes were photographed (marked), and when photographed again (recaptured), individuals were confirmed as alive and present at a given location. PMR results were used to estimate calf percentages and calf survival. At OC, the conservancy was divided into four blocks, and a team of three people (driver, recorder, and photographer) travelled through the blocks taking photographs of the right side of each giraffe encountered. Surveys lasted 3-5 days, until the team felt they had a complete sample of the giraffes within the conservancy.

In 2014, 2017, 2019, 2020, 2021, and 2022, photographs of the right sides of individual giraffes were taken at OGR and used for PMR evaluation. In other years, only observational data were collected. At OGR, giraffes were surveyed in a 1600-ha study area divided into four quadrants: NE, NW, SE, SW (Figure 1). Starting in the morning (0700-0800), teams of up to four observers walked predetermined GPS transects in each quadrant. Detection widths were ~150 m resulting in 300-m swaths (belt transects) systematically covering each quadrant. When a giraffe group was encountered, observers recorded a GPS location, counted the total number of giraffes, recorded the sexes and ages of giraffes, and attempted to photograph the right sides of all giraffes.

Photo Matching and Aging**.** Photographs from both sites were processed with Wild-ID software version 1.0.0 (Bolger et al., 2012). Based on spot patterns, the program provided a set of 20 possible matches that were visually rejected or accepted by P. Campbell to derive a set of verified individual giraffes at each location. Giraffes were categorized into four age classes: newborn calf (0–3 mo), older calf (>3–12 mo), subadult (>1–5y), and adult (>5 y) based on physical characteristics, including height, presence of umbilical cord (newborns), relative length of the neck and legs, coat colour and texture (reddish and fluffy in calves), and ossicone (horn) characteristics (Strauss, 2014). Adult female ossicones are thin and tufted, while adult males typically have thicker ossicones that bald on top as a result of frequent necking and horn-knocking with other males (Dagg & Foster, 1976). Penile sheaths were notable on males of all ages, especially in photographs.

Statistical Analyses. We completed statistical analyses in Excel and JMP 15.0.2 (SAS, 2020) with alpha set at 0.05. Means are presented with standard deviations. We estimated apparent annual survival for all identified giraffes from 2014 to 2022 using the full photographic mark-recapture dataset in RMark (Laake 2022), the R implementation of program MARK (White & Burnham 1999). Given the photographic mark-recapture dataset consists of "live" recaptures, we used Cormack-Jolly-Seber (CJS) models to disentangle the relative effects of age and sex on survival in addition to estimating whether survival and recapture probability varied with time or remained constant from 2014 to 2022 (Table 3). After running a set of candidate models, we used survival estimates from the model with the lowest Akaike's Information Criteria with correction for small sample sizes (AICc) score (Burnham & Anderson 2002). We conducted all survival analyses in program R v.4.2.1 (R Core Team 2022).

Community dynamics and land use changes at OGR. Local attitudes about giraffe conservation were determined during formal surveys (Naiyianoi, 2021) and informal discussions with local community members. Given that RKN and MMCWS members speak Maasai and communicate in culturally appropriate ways, they were the main sources of information about local attitudes. Incidents of human-wildlife conflict on the plateau were recorded by MMCWS and LNN teams during giraffe surveys. Becker (CDB) and Nagut (RKN) personally witnessed land-use changes in and around the giraffe-monitoring area from 2011 to present, and Kadane (LAK) since 2015. Google Earth images from 2009 to 2023 and GIS evaluation by McKay (KM) in 2021 were used to summarize land-use changes including those resulting and pending from privatization of lands implemented in 2019.

RESULTS

PMR Counts and Calf Percentages. Based on six years of PMR analyses, 265 individual giraffes were identified at OGR. Two PMR samples from OC resulted in the identification of 190 different giraffes. Six giraffes occurred in both samples, five males and one female.

Estimates of calf percentages based on PMR varied by year (Table 1). Although OGR had a higher mean percentage of newborn giraffe calves, 6.6 ± 2.2% (N = 6 y), than OC, 1.5 ± 2.1% (N = 2 y), the percentages were not statistically different. Likewise, the mean percentage of older calves was not statistically different for the two sites (Table 1). Thus, the two sites had an annual mean percentage of newborn giraffes of 5.5 ± 3.9 (N = 8). The mean annual percentage of all calves on the plateau was 23.6 ± 6.7% (N = 8).

Table 1. Giraffe calf percentages at Oloirien Group Ranch (OGR) and Oloisukut Conservancy (OC) on the Siria Plateau of Kenya. Calf percentages are based on photographic samples of individually identified giraffes. Lions are protected at OC but not at OGR.

Study Site	Year	Management	% Newborn Calves	% Older Calves	Total (N)
OGR	2014	None	3	14	99
OGR	2017	None	5	7	56
OGR	2019	None	7	16	93
OGR	2020	None	5	22	115
OGR	2021	None	13	18	126
OGR	2022	None	8	23	103
Oloisukut	2019	Conservancy	3	22	136
Oloisukut	2020	Conservancy	0	23	107
Means	**N=8**	**Siria Plateau**	**5.5 ± 3.9**	**18.1 ± 5.6**	

Calf survival at OGR. The CJS model from the survival analysis with the lowest AICc score (constant survival and time-dependent recapture probability; Table 2) revealed that giraffe survival at OGR was 0.85 and constant from 2014 to 2022. Notably, this model ranked higher than other candidate models that included effects of age, sex, or both. Recapture probability was lowest during 2015, 2016, and 2018, the years lacking a dedicated PMR effort.

Table 2. Candidate CJS models for giraffe photographic mark-recapture data from 2014 to 2022 with model results ranked by delta AICc. "Phi" represents survival and "p" represents recapture probability.

Candidate models	Number of parameters estimated	AICc	DeltaAICc	Weight	Deviance
Phi(~1)p(~time)	9	278.57	0	0.99	119.25
Phi(~time + Sex)p(~time)	17	289.27	10.7	0.005	110.84
Phi(~time + Sex + Age)p(~time)	18	290.92	12.35	0.002	109.95
Phi(~time)p(~time)	16	292.27	13.7	0.001	116.34
Phi(~time + Age)p(~time)	17	293.06	14.49	7.07E-06	114.63
Phi(~time + Sex)p(~1)	10	330.81	52.24	4.50E-12	169.21
Phi(~time + Sex + Age)p(~1)	11	331.33	52.75	3.47E-12	167.42
Phi(~time)p(~1)	9	334.14	55.57	8.50E-13	174.82
Phi(~time + Age)p(~1)	10	334.87	56.3	5.91E-13	173.27
Phi(~1)p(~1)	2	339.14	60.57	6.98E-14	194.94

Female Site Fidelity. Based on PMR, at least 144 different female giraffes used the OGR study area from 2014 to 2022. Of these, 35% were detected only in one year, 19% were re-photographed (detected in two years), 18% in three years, 15% in four other years, and 5% in all six years. Thus, 65% of the females were found in the giraffe-monitoring area at OGR in multiple years. Females identified as calves at OGR in 2014 and 2017 were later recaptured as adults in 7 out of 13 known cases over the 8-year period. Of the female giraffes identified at OGR and the 89 females photographed at OC, only one female was documented at both sites.

Comparing Counts and Calf Percentages by Method at OGR. On average PMR at OGR resulted in 99 individual giraffes, nearly twice the average of 50 based on annual surveys.

Based on PMR, giraffe calf percentages averaged 23.5 ± 7.7% (N = 6 y) similar to the mean from annual observational surveys (23.0 ± 9.2%; N = 7 y) (Figure 2). The mean of means for monthly surveys was 19.7 ± 6.5% (N = 4 y), and not statistically different.

Annual estimates of calf percentages differed by method in some years (Figure 2). Monthly surveys and PMR had similar percentages of giraffe calves in 2019 and 2020, but differed from each other in 2021 and 2022. PMR indicated that the percentage of giraffe calves increased after 2017, but annual and monthly counts suggest declines (Figure 2). Calf percentages based on PMR were > 30% in 2021 and 2022, while percentages based on observational surveys were half that.

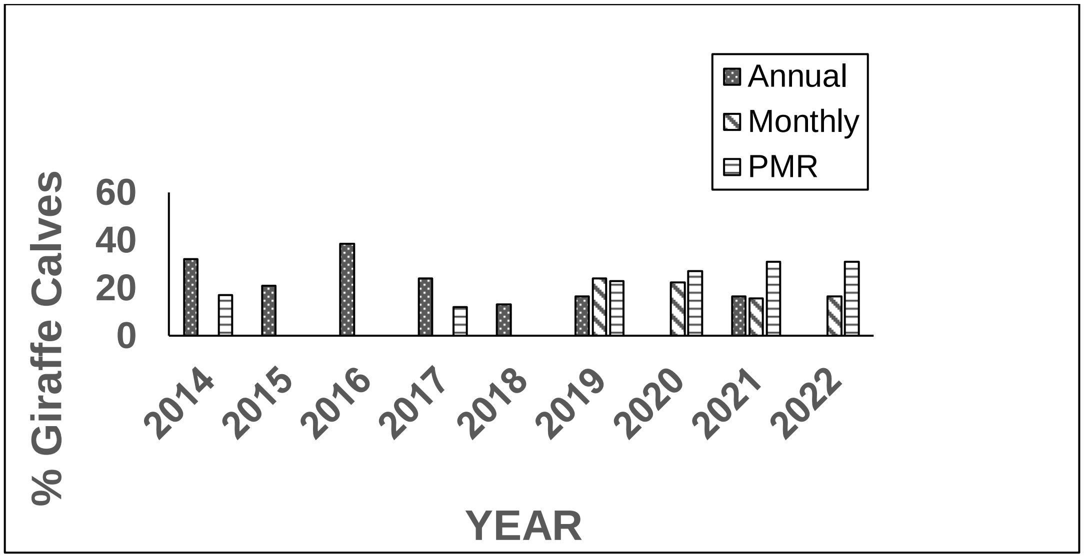


Figure 2. Mean percentage of giraffe calves (0-12 months) estimated by three survey methods at Oloirien Group Ranch, Transmara, Kenya 2014-2022. PMR (photo, mark, recapture) used photographs to identify individual giraffes, were annually compiled, thus a single value. Annual survey histograms are the mean of two surveys done within a 10-day period (SDs ranged from 0.7 to 11.3%, see supplemental materials online). Monthly surveys are a mean of 10-12 surveys per year (SDs ranged from 5.5 to 8.2, see supplemental materials).

Land-Use Trends and Human-Giraffe Conflicts at OGR. From 2011 to 2022, land cleared for agriculture on the Siria Plateau steadily increased in and around the OGR giraffe monitoring area (Google Earth). Tourism infrastructure was slower to grow there. For example, Mara West with its small dirt road was the only tourist lodge in or near the OGR study area until 2015. In 2015 Angama Lodge was built and a new road was added. Rare flights to Ol Kurruk airstrip became a daily phenomenon. Even more impactful and dramatic were changes in land use that began in 2019 when OGR privatized their communal land.

During privatization, most heads of households at OGR were allocated 16 ha, after which, land speculation began. Concurrent with the rapid allocation of privatized parcels, land enclosures began, including the use of electric fencing within and around the giraffe monitoring area. Fencing diverted and excluded giraffes and other wildlife from most of the SE quadrant of the giraffe-monitoring area, while agricultural expansion steadily decreased habitat in the SW quadrant. In August 2021, annual surveys found no giraffes in the SW or SE quadrants, and in

2022, 60% of 10 monthly surveys conducted that year found no giraffes in the SE and SW quadrants. GIS mapping by McKay in 2021 (Figure 3) found that current and planned fencing, and other land-use changes, including additional crop fields have or will destroy giraffe habitat, excluding them from more than 42% of the giraffe-monitoring area, a loss of 672 ha.

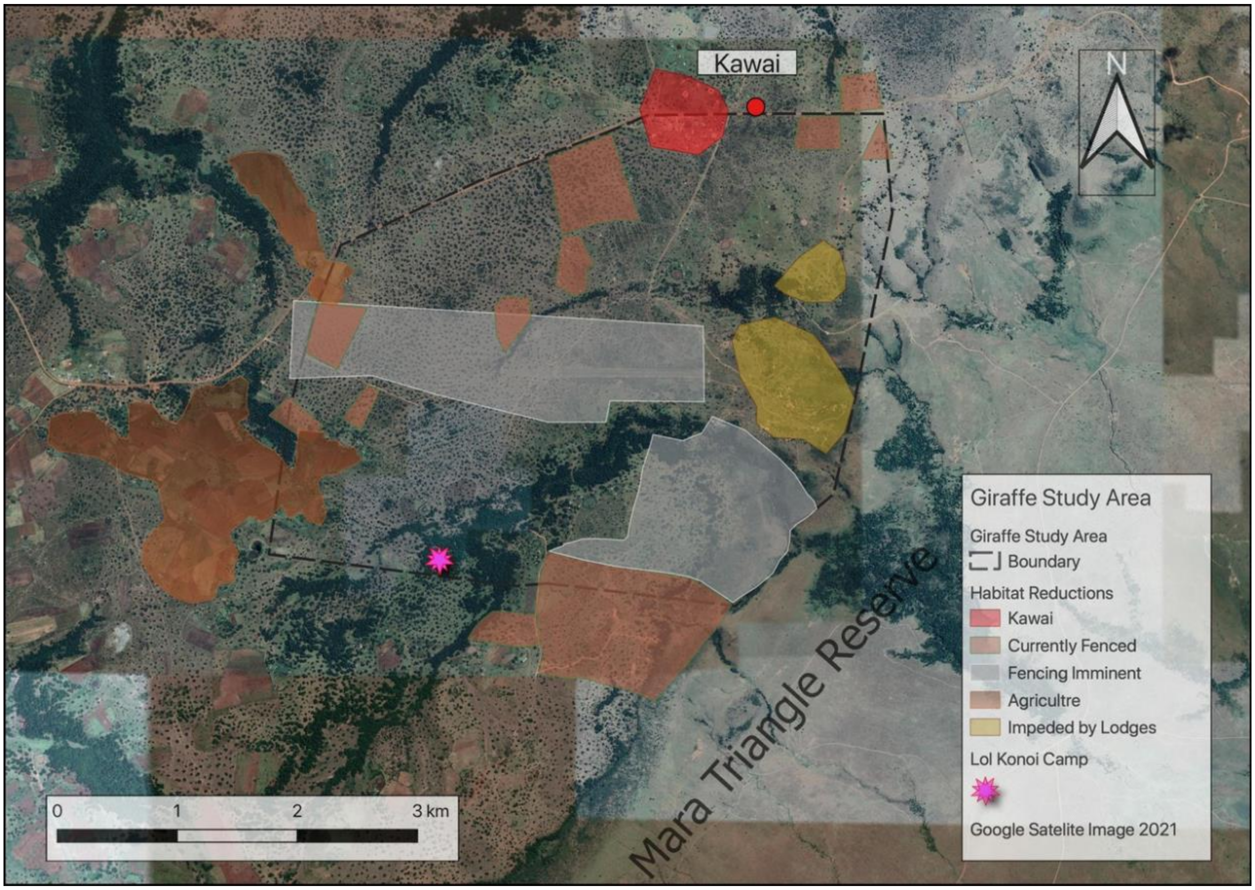


Figure 3. GIS map showing that ~42% of the savannah-grassland habitat within the 16 Km^2 giraffe study area at Oloirien Group Ranch, Transmara, Kenya is currently destroyed, off limits, or planned in a way that will exclude giraffes. Proposed fencing of the airstrip and elite properties will result in major habitat losses for giraffes.

Once privatization was implemented, wealthy elite Kenyans quickly purchased parcels from the new Maasai landowners. Most purchases focussed on consolidating land along the edge of the Oloololo escarpment overlooking the MTC (Figure 3), a prime lodge location for tourism. Developers, politically powerful property holders, and foreign lodge owners also proposed expansion of the airstrip including fencing to "protect wildlife". This would exclude wildlife from ~243 ha of savanna-grasslands currently used by two giraffe nursery groups (Figure 3). One famous non-Maasai consolidated 136 ha overlooking the MTC in the southern part of the giraffe monitoring area and constructed a third tourist lodge. He also added a new access road lined with above-ground electrical poles and wires bisecting the SW and SE quadrants of the giraffe monitoring area. Next, he fenced the plateau side of his property, while leaving the eastern escarpment open to the MTC (Figure 3). The new fence helps keep Maasai livestock off his land, but prevents wildlife from moving between MTC and the Siria Plateau. In August 2021, we noted large dents on both sides of the fence, presumably from wildlife. Later that year, an adult female zebra died from exhaustion trying to get past the new fence to access MTC (Tajewuo, pers. comm., 2021).

From August 2014 to the end of 2022, giraffe-monitoring teams documented nine incidents of human-giraffe conflict at OGR, two resulting in giraffe deaths. Snaring and spearing of giraffes (75% of incidents) were related to conflicts over crops, two cased requiring attention by the Mara Veterinary Unit with giraffes involved making recoveries (Limo, pers. comm., 2015). In 2020, an adult male giraffe died from entanglement in an electric fence. In October 2021, female giraffe 045, studied since 2014, was killed for no obvious reason. Finally, early in 2022, a pregnant giraffe died when she became entangled in fencing material, before the fence was built.

DISCUSSION

Giraffe Calf Percentages and Survival at OGR: Implications for Conservation.

Based on PMR at OGR and OC, average percentages of giraffe calves were relatively high on the Siria Plateau (Muller, 2018). In fact, the most recent annual giraffe calf percentages at OGR were > 30%, on par with areas in Kenya where predation by lions is absent (Muller, 2018). Likewise, annual survival of newborn giraffes at OGR, 85%, was substantially higher than the 30 - 70% reported for protected areas in Tanzania (Lee et al., 2016). The top-performing CJS model in our survival analysis suggests that giraffe survival at OGR does not vary notably through time, between age classes, or between sexes, all factors known to influence survival in mammals (Arso Civil et al., 2019). High survival independent of time, age, and sex points to a potential survival benefit for giraffes occupying OGR and underscores the conservation value of the Siria Plateau's savanna-grassland areas for giraffes.

Lower lion densities on the Siria Plateau likely explain the high survival and high percentages of newborn and older calf giraffes at OGR and OC (Muller, 2018; Bond et al., 2021a, 2021b), but other factors may also play a role. The presence of Maasai and their domestic animals may contribute to higher giraffe calf survival, because people and their infrastructure shield ungulates from predators (Berger, 2007; Lee, 2018). Bond et al. (2021b) also found that proximity to settlements was related with higher giraffe calf survival in Tanzania. Secondly, domestic livestock may divert predation from newborn giraffes (Lee et al., 2016). Likewise, giraffe calves, and pregnant and lactating females may benefit from the browsing by sheep and goats, as it in short-statured woody plants with high protein new leaves (DuToit et al., 1990; Bronson, 1985). At OGR, giraffes not only fed in heavily browsed "acacia" thickets, but females left their calves in kindergarten groupings there. In contrast with the Siria Plateau, the Rift Valley protected areas have less woody cover (Reid et al., 2003), with the exception of riparian areas where predators often lurk (Dybas, 2011). Calf survival remains to be determined for protected areas in the Rift Valley of Kenya, but is likely similar to Tanzania - lower than on the Siria Plateau at OC and OGR.

Giraffe Movements and Site Fidelity.

Based on observations and PMR we know that giraffe females from the Siria Plateau move to and from Rift Valley protected areas. PMR evidence suggests that OGR females mainly use the MTC southeast of the Mara River, while OC females use conservancies to the north of the Mara River (Figure 1). High lion densities in the Rift Valley reserves may drive pregnant and lactating female giraffes to the Siria Plateau to birth and nurse calves. In August 2021, citizen science teams at OGR followed two giraffe nursery groups in the NE and NW quadrants of the monitoring area. Newborn giraffe calves were found in kindergarten groups (Pratt & Anderson, 1985) tended by various adults, including an adult male at times, similar to reports by Saito and Idani (2018). In January 2022, MMCWS found a giraffe nursery group traveling down the Oloololo escarpment to MTC accompanied by a young male calf, estimated to be only around eight months old.

More efforts to follow giraffe nursery groups on the Siria Plateau could determine to what extent calves accompany adults into the Rift Valley reserves. Follows of mother-infant pairs and nursery groups may reveal behavioural mechanisms underlying traditions of habitat use by female giraffes (See Saito & Idani, 2016). Bond et al. (2020) found that sociality among female giraffes correlated with better adult female survival, and that like elephants, older females were a repository of spatial information. For this reason and others, the loss of adult female 045 in 2021, may have harmed the functioning of OGR's giraffe nursery groups.

The fact that only one female was found at both OC and OGR suggests that female giraffes on the Siria Plateau are not a fluid overlapping metapopulation, but instead are distinct female groups contributing young to different protected areas. Likewise, PMR results confirmed that female giraffe calves at OGR return to their nursery areas as adults, indicating site fidelity.

Sources of Error in Methods. Given that giraffes give birth in all months of the year, and calves remain in natal herds for more than a year (Dagg & Foster, 1976), the percentages of calves would not be greatly influenced by timing of surveys (Bonefant, 2005; Bond et al 2021b). Likewise, detection bias (Mackenzie, 2002) was opposite of our hypothesis. Calf detection on the Siria Plateau, due to extensive woody cover and thickets should be lower than in the Serengeti - Mara ecosystem where open grasslands dominate the landscape (Reid et al., 2003; see also Google Maps, 2023).

PMR was more accurate for estimating numbers and demographics of giraffes than observational surveys because, for one, it eliminated error due to turnover of individuals. Turnover was determined to be a source of error because our observational survey estimates were on average lower than PMR estimates.

One incongruence in results was that observational surveys suggested a recent decline in the percentage of giraffe calves, while PMR indicated an increase. Variation in aging giraffes by different observers may be a factor, such that older calves were counted as subadults or visa versa. PMR was done by only one person making it the more consistent and reliable data source.

However, in the field, PMR can miss individuals when they fail to present right sides for photographs, or run away before being photographed. Such individuals would have been counted, and survey tallies could yield lower calf percentages in that manner.

Human Habitat Modification and Human-Giraffe Conflicts. Since 2010, the conversion of native habitats to agriculture in the Transmara district of Kenya has increased by more than 42.5% (Tiller, 2017), and habitat loss had been going on well before that due to Kenya's high population growth (Ole Seno, 1998). The clearing of native tropical forests and ploughing of grasslands have reduced water flow in rivers, resulted in losses of wildlife, and have caused a decline in the quality of nature-based tourism; with similar trends documented for the entire GMME (Lamprey & Reid, 2004). These regional trends were exemplified in and around the giraffe monitoring area at OGR (Figure 3), and explain increasing fatalities of giraffes there. Giraffes are experiencing more harm from electrical fencing associated with land privatization. High calf survival may does not necessarily confer a high quality of life for young giraffes at OGR, but allows calves to escape lion predation until they are larger and predation becomes less of a threat.

Given plans to expand the airport and the new lodge, increased traffic from tourism at OGR where the giraffe nurseries range may become too much of a disturbance for the female giraffes. On the contrary, female nursery groups may adjust and continue to benefit from human shielding and low lion abundance at OGR (Berger, 2007; Muller, 2018).

Conclusion

Giraffe calf survival and percentages on the Siria Plateau were higher than in many East African protected areas, especially where lions are protected (Bond et al., 2021b; Muller, 2018). Unlike at OC which is a functional conservancy, giraffes at OGR lack any formal protection, and threats have increased with land privatization. Now is the time to protect an important source of giraffes for the MTC by making a conservancy for them at OGR.

If compensated, local Maasai landowners say they are willing to protect giraffe nursery habitats and keep corridors open to the MTC (Naiyianoi et al., 2021). Funding for a conservancy could be derived from: 1) targeted profit sharing by the Mara Triangle Conservancy, 2) carbon-credit payments, 3) profit sharing by lodges operating on OGR properties near giraffe nurseries, and 4) funding from local, regional, national, and international conservation organizations. A fair and workable system of compensation to OGR landowners for stewardship of giraffe nurseries will contribute to the recovery of endangered giraffes.

Giraffes require large areas and diverse habitats to meet their survival and reproductive needs (Bronson, 1985), and population viability increasingly depends on properties adjacent to protected areas (Lamprey & Reid, 2004; King et al., 2015). Throughout Africa, declining numbers of giraffe reflect poor survival, poor reproductive rates, or both (Bronson, 1985; Owen-Smith & Mason, 2005). The viability of any mammal population relies on sufficient habitat and resources to sustain pregnant and lactating females, newborn offspring and juveniles (Millar, 1977; Bronson, 1985; Ciechanowski et al., 2017), and a pool of genetically diverse and healthy adults (Dale et al., 2011; Karsch et al., 2016; Allen et al., 2016). Our results confirm that high giraffe calf survival occurs outside of reserves, likely contributes to maintaining populations inside protected areas, and requires collaboration by local landowners to sustain.

ACKNOWLEDGEMENTS

CDB, LAK, and RKN thank the MMCWS giraffe team—Nyaru Letoto, David Kapio, Joshua Sereny, Wuantai Munke, Nancy Lepore, and Dickson Mures, Life Net Nature citizen-scientists, and Primate Global for giraffe monitoring at OGR. RKN thanks Rangers Joshua Kakesio, Koikoti Jackson, Moses Meisi, Johnstone Sakambei, and Letara Konchellar. The Giraffe Conservation Foundation provided CDB with an equipment grant to implement giraffe monitoring at OGR in 2014. CDB and LAK thank the Ole Nagut family for hosting LNN teams at Lol Konoi Giraffe Camp. KLD thanks Oloisukut Conservancy for supporting giraffe data collection and dissemination. Student interns, Loise Kuria, Jackline Kosgey, and Julius Leto helped collect and establish the Oloisukut giraffe database. Benard Sankale and Leonard Kinanta also assisted along with Jackson ole Mpario, founder of OC. Dr. Susan Schmidt did fine edits of the manuscript.

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Appendix 1. Supplemental Material for Figure 2

Mean giraffe calf percentages at Oloirien Group Ranch (OGR) on the Siria Plateau of Kenya as determined by three methods: duplicated annual surveys, monthly single surveys, and annually compiled photographs. Aggregate means in bold.

Survey Type	Years	N	Mean Calf% of Total	S. D.
Annual	2014	2	32	7.1
Annual	2015	2	21	1.4
Annual	2016	2	38.5	0.7
Annual	2017	2	24	11.3
Annual	2018	2	13	2.8
Annual	2019	2	16.5	4.9
Annual	2021	2	16.5	4.2
Mean Annual		**12**	**23.0**	**9.2**
Monthly	2019	10	24. 1	5. 8
Monthly	2020	10	22. 2	5. 5
Monthly	2021	12	15.7	6.5
Monthly	2022	10	16.5	8.2
Mean Monthly			**19.7**	**6.5**
Mean PMR	2014-2022	6	**23.5**	**7.7**