Quantifying Wildlife Conservation Effects of a Community Wildlife Management Area near Tarangire National Park, Tanzania, East Africa

Derek E. Lee and Monica L. Bond

Wild Nature Institute, P.O. Box 165, Hanover, NH 03755 USA

Abstract

In Tanzania, community-based natural resource management occurs through the creation of Wildlife Management Areas (WMAs). WMAs are community-based conservation and development areas, with several villages setting aside land for wildlife conservation. The ecological success or failure of WMAs for wildlife conservation has yet to be quantified. We used 4 years of distance sampling surveys conducted 6 times per year for wild and domestic ungulates to quantify wildlife and livestock density before and after the establishment and implementation of management efforts at Randilen WMA relative to adjacent unprotected land of similar habitat quality. We documented significantly higher resident wildlife densities (giraffe and dik-dik) and lower cattle densities in the WMA, relative to unprotected land, indicating short-term ecological success. Continued monitoring is necessary to determine longer-term effects, and to evaluate management decisions.

Keywords: before-after-control-impact, community-based natural resource management, environmental assessment, wildlife management area, wildlife monitoring.

Introduction

Community-based natural resource management (CBNRM), based on the devolution of management and user resource rights to local communities, is promoted as a conservation tool to balance human well-being with biodiversity protection, and has become a dominant paradigm of natural resource conservation and economic development (Western and Wright 1994, Borgerhoff Mulder and Coppolillo 2005, Nelson 2010). Yet the success record of CBNRM is mixed, with many documented ecological and economic failures (Kellert et al. 2000, Blaikie 2006, Singleton 2009, Brooks et al. 2012, Measham and Lumbashi 2013, Salerno et al. 2015). Unfortunately, the ecological success or failure of CBNRM projects is rarely rigorously assessed. In a recent meta-analysis published in the Proceeding of the National Academy of Sciences, only 13% of 159 CBNRM projects included quantification of ecological outcome (Brooks et al. 2012).

In Tanzania, CBNRM efforts to decentralize wildlife management to local communities occurs through the creation of Wildlife Management Areas (WMAs). WMAs are community-based conservation and development areas, with several villages setting aside land for wildlife conservation in return for the majority of the tourism revenues from these areas (URT 1998, 2012, Nelson 2010). There have been social and economic critiques of WMAs, such as onerous bureaucratic demands, continued governmental control over revenue collection, the large role played by outside conservation organizations, and economic and human rights failures (Goldman 2003, Igoe and Croucher 2007, Benjaminsen et al. 2013). However, the ecological value or success of WMAs for wildlife conservation has yet to be quantified.

In this study, we used 4 years of surveys for wild and domestic ungulates to quantify wildlife and livestock density before and after the establishment and implementation of management efforts at Randilen WMA, in comparison with adjacent unprotected land of similar habitat quality in northern Tanzania, East Africa (**Fig. 1**). This study design with before-after-control-impact (BACI) data provides the greatest basis for inference in environmental impact evaluation (Green 1979, Stewart-Oaten et al. 1986, Underwood 1992). We hypothesized higher resident wildlife densities and lower livestock densities in WMAs, relative to unprotected lands would indicate ecologically successful implementation of the WMA management plans. Alternatively, if we reveal no detectable difference between WMA and unprotected land, then we can conclude WMAs were ecologically ineffective and protective measures should be augmented, or different management activities implemented.

Study Area

The Tarangire Ecosystem (TE) is a savanna-woodland ecosystem and a global hotspot of large-mammal diversity (Bourliere and Hadley 1970, Bolger et al. 2008). The TE is in the eastern branch of the Great Rift Valley and encompasses roughly 30,000 km^2 (Borner 1985, Prins 1987). The TE is defined by the migratory ranges of eastern white-bearded wildebeest (*Connochaetes taurinus*) and Burchell's zebra (*Equus quagga*) from their dry-season refuge along the perennial Tarangire River north to Lake Natron, and southeast to the Simanjiro plains (Lamprey 1964, Kahurananga and Silkiluwasha 1997, Foley and Faust 2010).

Mean total annual rainfall was 650 mm for years 1980–2009, coefficient of variation = 42.6%, range = 312 to 1,398 mm (Foley and Faust 2010). There are 3 precipitation seasons per year (short rains = Oct–Jan, long rains = Feb–May, and dry season = Jun–Sep). Average monthly precipitation by season was: short rains = 63 mm, long rains = 100 mm, dry = 1 mm (Foley and Faust 2010).

Methods

Before-After-Control-Impact (BACI) sampling is widely used in investigations of environmental impacts on abundance or density of a population. The principle is that an anthropogenic "impact" location will experience a different pattern of change from before to after the impact, compared with natural change in the control location (Underwood 1992).

We conducted 24 distance-sampling surveys from January 2012 to Oct 2015 in Randilen WMA and adjacent Lolkisale Game Controlled Area (LGCA). In 2014, Randilen WMA was established and active management began soon thereafter. We analyzed ungulate populations for significant differences in density after active management began in the Randilen WMA relative to LGCA (**Fig. 1**). LGCA is an essentially unmanaged area adjacent to Randilen WMA which we used as a comparison site to determine whether and how ungulate population densities varied in the absence of WMA management. Our ecological criteria for success was the significant increase in ungulate wildlife populations and decrease in livestock in the WMA after beginning active management operations.

We surveyed according to a robust design sampling framework (Pollock 1982) with 3 sampling occasions per year near the end of each precipitation season (February, June, and October). Each sampling occasion was composed of 2 back-to-back sampling events during which we drove all fixed-route transects (dirt tracks) in the study area, for a total of 6 sampling events per year. Driving speed was maintained between 15 and 20 kph on all transects, and all survey teams included the same two dedicated observers and a driver. Each track segment was sampled only 1 time in a given event.

We collected distance data for all ungulates visible along both sides of the track out to 500 m. Distance data records the group size and perpendicular distance from the transect to each group of animals when first detected. When a group or singleton was sighted, we halted the vehicle and recorded the perpendicular distance from the track to the animal(s) measured with a laser rangefinder (Bushnell Arc 1000), the total number of individuals, and the GPS position of the vehicle. If the sighting was a cluster of animals, distance was measured as the perpendicular distance from the track to the approximate middle of the group.

Distance data were analyzed with program DISTANCE 6.0 (Thomas et al. 2010) to estimate density of animals in each site while accounting for variation in detectability according to distance from the road transect. We analyzed distance data following recommendations in Buckland et al. (2005). We considered all roads surveyed within a site during a single sampling event as a single transect, and each of the survey events were treated as replicate samples. We discarded the farthest 15% of observations. We plotted frequency histograms of perpendicular distances and fitted models to the histogram based on the key function and series expansion approach. We fit uniform, half-normal, and hazard-rate key functions with cosine and simple polynomial series expansions. We fit the key function models and associated series expansions to the data and used corrected Akaike information criterion (AIC_c) to select the best detection function model. We assessed goodness-of-fit of the top model using chi-square and Cramer von Misses tests. We regressed the logarithm of cluster size against the detection probability and adjusted detectability based on the expected cluster size. We estimated year- and site-specific density using the top-ranked model for each site.

Results

We collected sufficient distance sampling observations for analysis of cows (*Bos taurus*), shoats (sheep *Ovis aries* and goats *Capra aegagrus*), impala (*Aepyceros melampus*), giraffe (*Giraffa camelopardalis*), dik dik (*Madoqua kirkii*), and zebra (*Equus quagga*). This enabled us to measure population densities of representative samples of a resident large- and small-bodied browsers (giraffe and dik-dik), a resident mixed-feeder (impala), and a migratory grazer (zebra). Annual densities of livestock and resident wildlife species showed good cohesion (similarity) between control and impact sites before the establishment of RWMA in 2014 (**Fig. 2**), indicating that our study design should be able to discern any effect of WMA protections and management.

We found significantly higher densities of two resident wildlife species (dik-dik and giraffe) and significant declines in livestock density (cows) in Randilen WMA relative to LGCA, after implementation of WMA management activities in 2014. Cow densities were higher inside Randilen WMA in 2014 due to a short-term invasion of cattle from outside the area. By 2015, the situation had reversed itself and cow density was lower inside the WMA relative to outside in LGCA. One resident ungulate (impala) and one migratory species (zebra) showed good cohesion between Randilen WMA and LGCA, but no impact was detected after the establishment and management of Randilen WMA (**Fig. 2**).

Discussion

Since their inception, the performance of community-based conservation efforts has been debated and policies promoting CBNRM have faced opposition (Naughton-Treves et al.

2005, Roe 2008). Nevertheless, quantitative evidence suggests positive social and ecological outcomes can result from CBNRM projects (Tallis et al. 2008, Brooks et al. 2012). Our data have clearly demonstrated that WMA establishment and management as practiced in Randilen WMA had positive ecological outcomes for some resident wildlife species over the short term period of this study. We assert that density is an appropriate criteria for assessing the performance of WMAs, particularly when nearby unmanaged areas of similar habitat quality are assessed simultaneously for comparison.

The rapid change in resident wildlife densities following WMA establishment could be due to redistribution or less hiding behaviour following the reduction of livestock density. Negative correlations between livestock and wildlife density have previously been found in East African savannahs (Prins 1992, Bonnington et al. 2007). However, Kinnaird and O'Brien (2012) suggest that despite potential negative effects of livestock on wildlife density, both can co-exist at relatively high densities given protection from illegal hunting and increasing people's tolerance of wildlife.

Despite the apparent positive conservation outcome, our results do not imply that current efforts are sufficient to sustain this WMA in the longer term. Using our methods, populations of livestock and resident ungulates can be continuously assessed, and any conservation or management actions can be easily evaluated. The high variability of wildlife densities over time requires regular long-term monitoring (Link et al. 1994).

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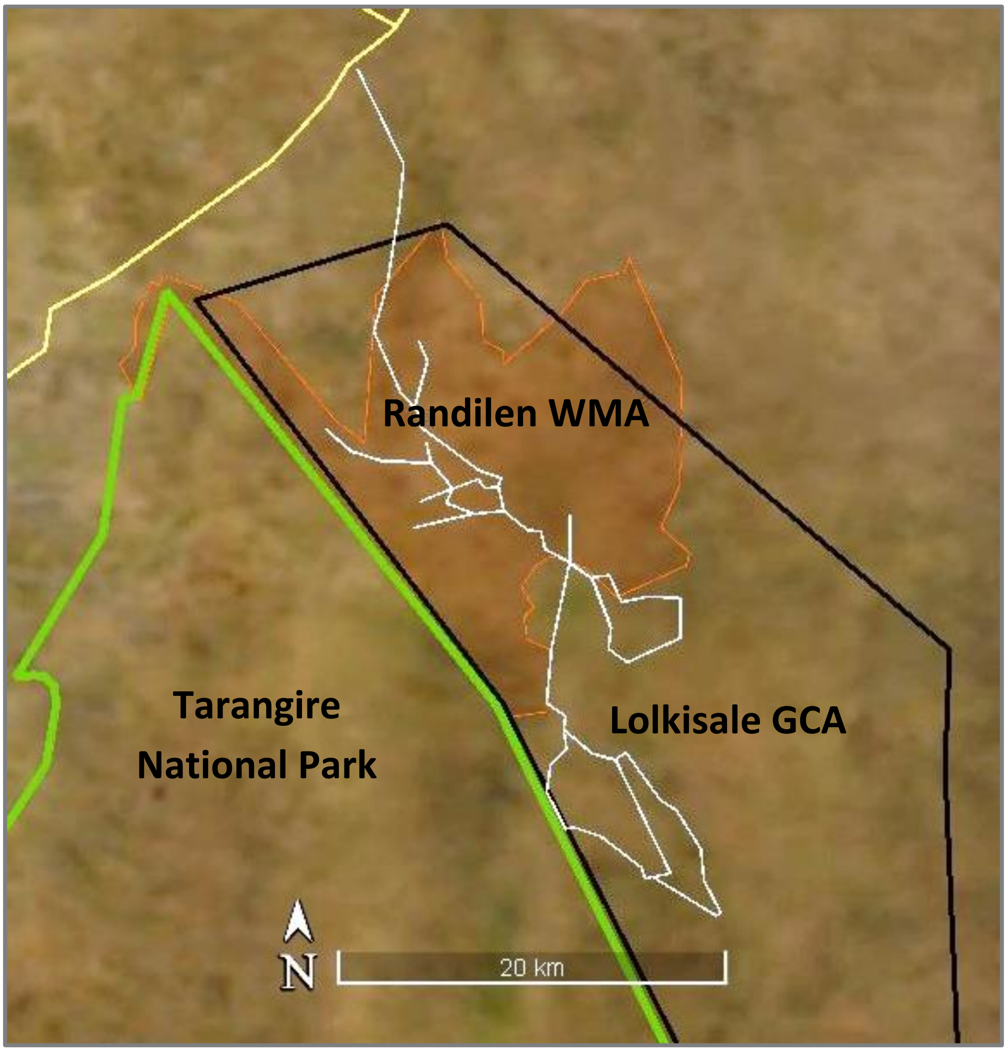
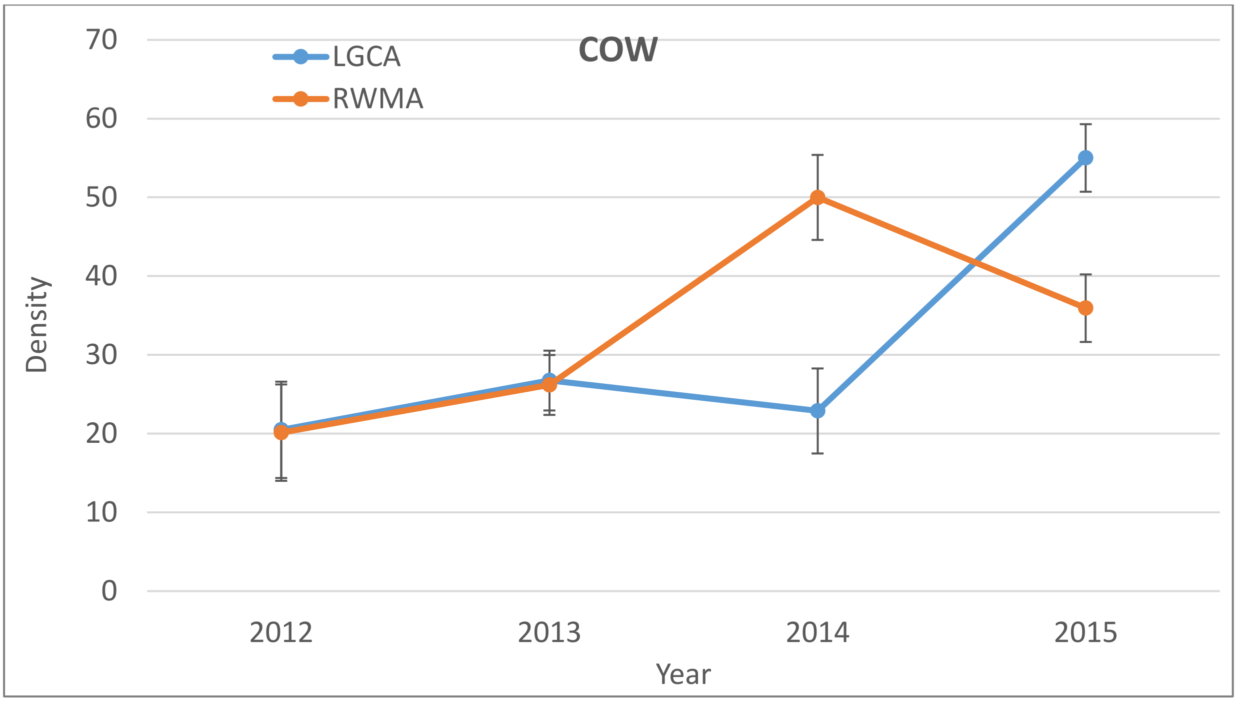
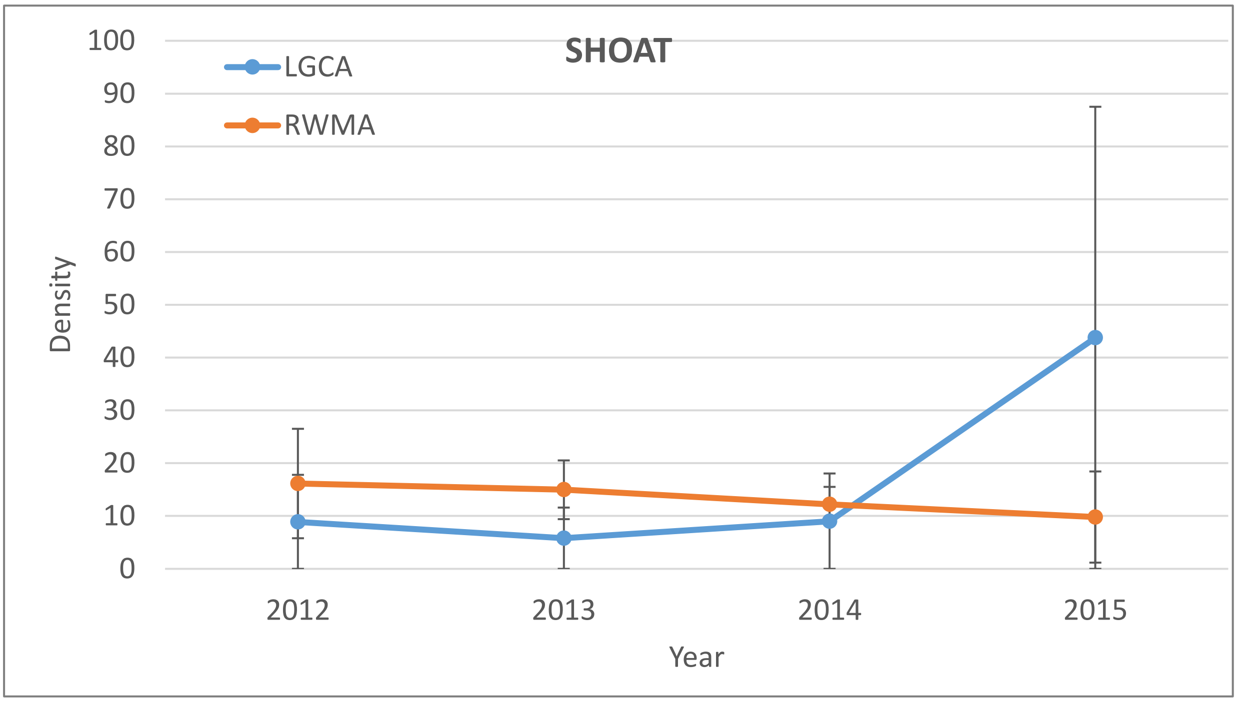


Fig. 1. Study area map of Randilen Wildlife Management Area (orange outline and filled area), Lolkisale Game Controlled Area (black outline, excluding Randilen WMA), and Tarangire National Park (green outline). White lines are survey tracks, yellow lines are tarmac roads.


COW
LGCA
RWMA
Density
70
60
50
40
30
20
10
0
2012
2013
2014
2015
Year


SHOAT
LGCA
RWMA
Density
100
90
80
70
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50
40
30
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10
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2012
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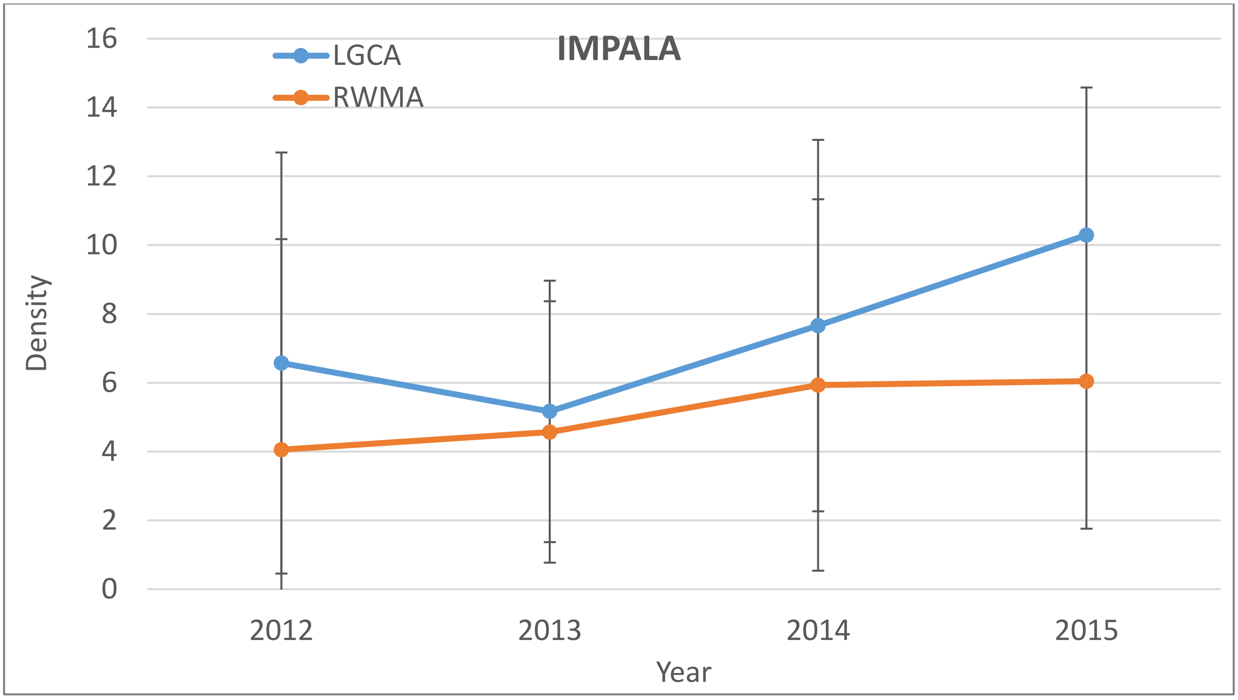
2014
2015
Year


IMPALA
LGCA
RWMA
Density
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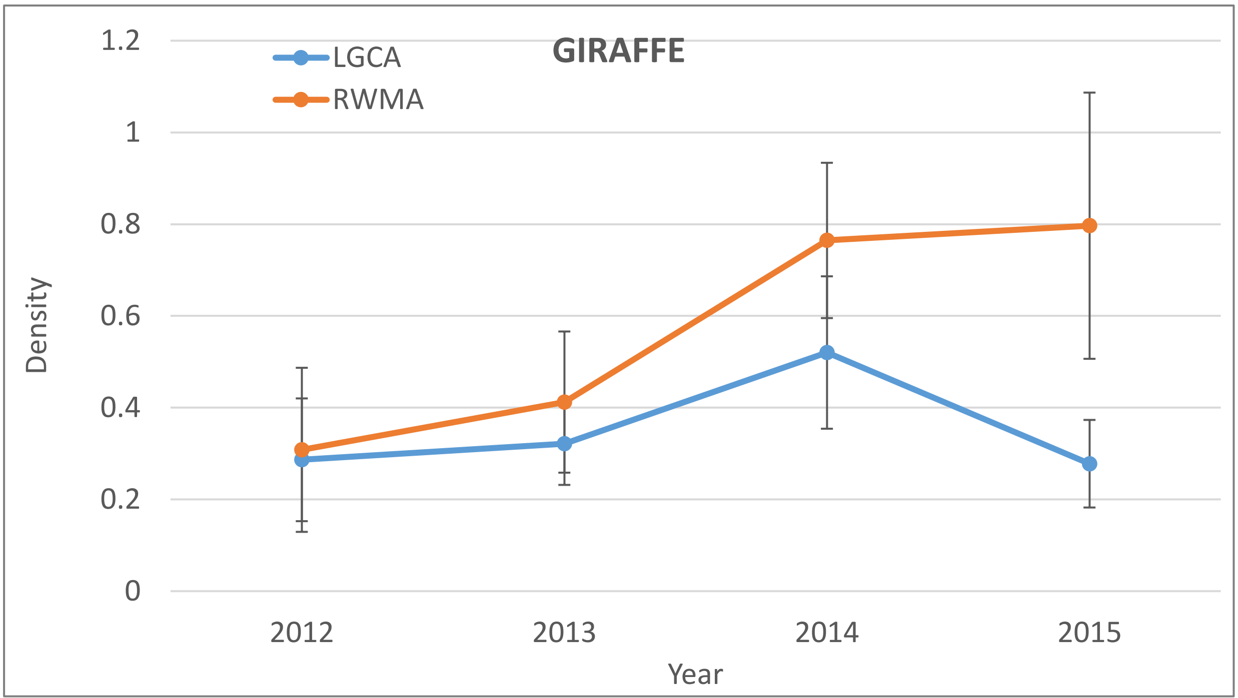
14
12
10
8
6
4
2
0
2012
2013
2014
2015
Year


GIRAFFE
LGCA
RWMA
Density
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0.8
0.6
0.4
0.2
0
2012
2013
2014
2015
Year

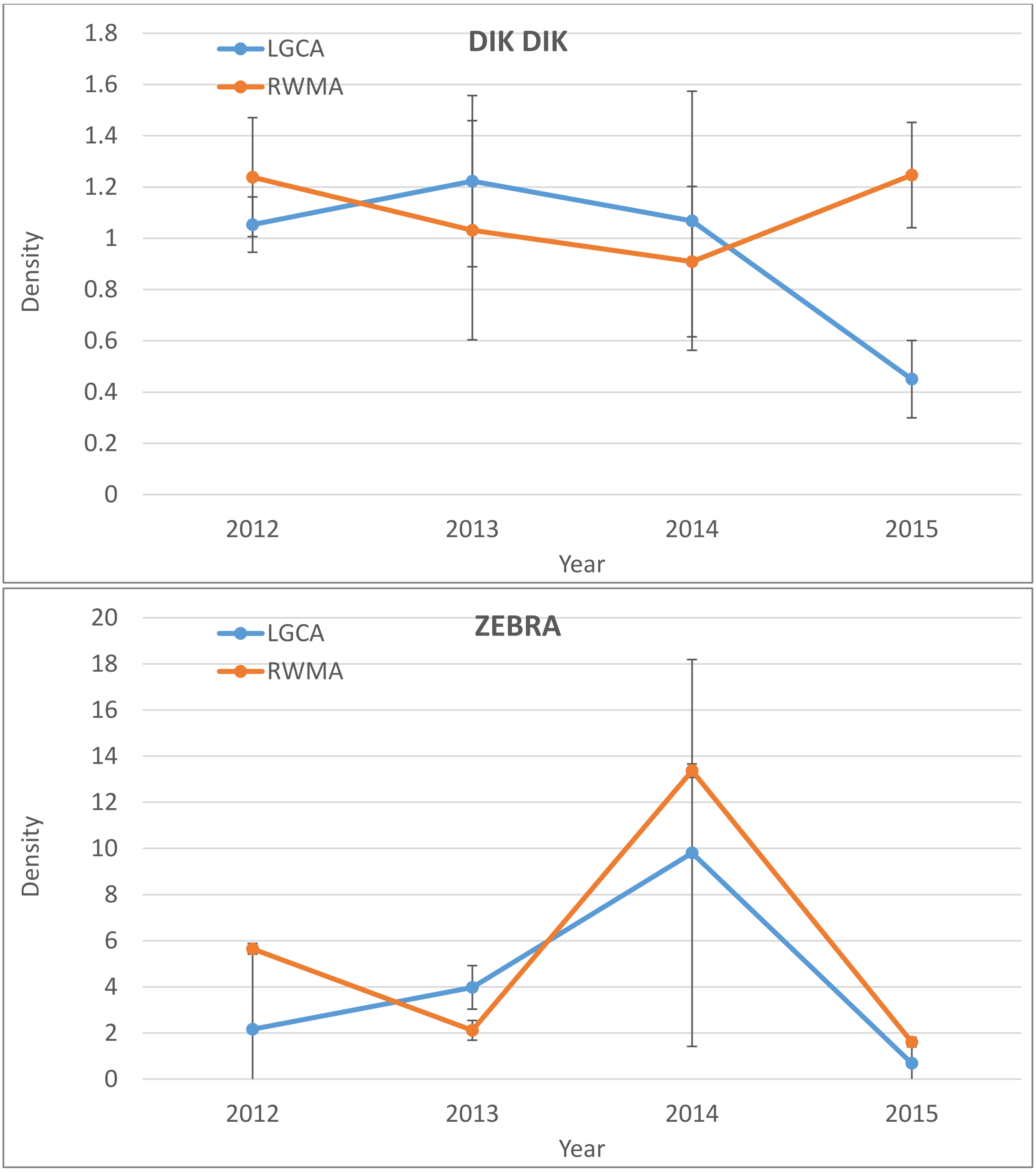

Fig. 2. Mean annual densities (#/km^2) of livestock and wildlife species in Randilen Wildlife management Area (RWMA) and adjacent Lolkisale Game Controlled Area (LGCA) from 2012 to 2015. RWMA was established and management activities began in 2014.