Conservation of transboundary migratory mammals: the case of white eared kob in Ethiopia and South Sudan landscape

Principal investigator: Cherie Enawgaw Beyene

Abstract

Migratory species in particular mammals are in sharp decline across the globe. In 2007, world second largest migratory animals consisting of larger proportion of white eared kob (Kobus kob leucotis) with other many large mammals were reported crossing the border of Ethiopia from Southern Sudan surviving the two decade of civil war in the region. While mass migration of mammals in the Boma-Jonglei Ecosystem is known from 1970 and 1980 studies, it was believed these migrations were thought to be decimated by civil war. Little is known how such large population of wildlife survive; it is likely that the area was dominated by Sudan People's Liberation Army (SPLA) little affected by large public. While this is good news, changes made in Social structure and human development following the independence of south Sudan may threat such spectacular migration. In both countries, foreign investment for large scale agriculture and Construction of Dam for hydroelectric power plant is increasing. Without considering critical habitat and migration corridors, such development may case a quick collapse due to uncontrolled human impact. In March 2013, supported by Conservation of Migratory Species (CMS) we collared 18 white eared kob providing a very useful information on the movement pattern and corridors of the white eared kob over 230km air distance landscape between Ethiopia and south Sudan (85,000 km2 area as combined home range). So far the GPS coordinates (fixes every 4 hrs) is downloaded from web site from the programmed satellite collars. The current field work is planned for collecting ground truthing data which will be used for habitat classification from 2 m resolution satellite image by ERDASS imagine software to develop habitat suitability map for the species. The map will be developed by using logistic regression as implemented in R based from GPS fixes of collared animals in relation to different environmental factors including Land cover types, slope and elevation. Migration corridors will be developed from least cost path model and direct GPS fixes. The field work is also vital to determine reproductive pattern from transect sampling and intensity of bush meet hunting both from questionnaire survey and indirect clues of hunting.

Introduction

Migratory mammals of the world are sharply declining in number and range during the last few decades. Much is known about migration of large ungulate herds in protected areas with the Serengeti wildebeest (*Connochaetes taurinus*) migration being the most famous one. However, little is known on the long dispersal routes and habitat requirements of the migratory animals outside protected areas while expanding human activities including agriculture, human settlement and other infrastructures are increasingly disrupting the migratory corridors. The technological advancement in satellite collars and spatial analysis tools in Geographic information system, increasing availability of high resolution satellite images provide a novel opportunity to understand ecological circumstances of long distance migration and to design effective conservation management plans to save long distance migratory mammals from vanishing. Recently, a survey by WCS in 2007 highlighted that in Southern Sudan nearly a million of individuals mainly composed of white eared kob (Kobus kob leucotis) with other many large mammals were confirmed to survive the two decades of civil war. During the survey, such large wildlife population were observed while migrating to the Ethiopian border. This project aims to study the migration corridors, habitat requirements and environmental factors that urge the annual migrations. This will provide an important baseline data set in the conservation of such spectacular migratory animal that represent the world second largest migratory animals.

Migration, predictable seasonal movement of individuals between two separate geographic areas, one area usually being where they breed and back, is necessary for existence of many important wildlife species. The reason of migration is mainly associated with changes in spatial patterns of rainfall, which in turn affects the availability of food and nutrient quality (Wilmshurst et al., 1999; Wolanski et al., 1999). Large mammals such as the wildebeest or bison live in herds that are too large to depend on a single location for food in particular in the dry season when grass is scarce. Additional factors including escaping harsh climate, minimizing risk of predation, avoiding competition with resident individuals increase survival and reproduction (Fryxell & Sinclair, 1988; Nicholson et al., 1997; Boone et al., 2006). Over the past 4 decades however, many long distance migrations have been disrupted due to anthropogenic barriers, habitat loss and excessive hunting and human induced behavioral effects on the species (Thirgood et al., 2004; Sawyer et al., 2005; Harris et al., 2009; Beckmann et al., 2012) which has caused rapid population collapse in many migratory populations (Homewood et al., 2001; Ottichilo et al., 2001; Bolger et al., 2008; Harris et al.,

2009). A 90% population decline was reported from several migratory ungulate species of Africa (Braack, 1973; Whyte & Joubert, 1988; Gasaway et al., 1996; Berry, 1997; Skinner & Chimimba, 2005). In central Asia the number of migratory saiga has dropped by over 95%, from over one million to fewer than 50,000 (Berger et al., 2008). European breeding birds (i.e., those species that breed in Europe but winter in sub-Saharan Africa) have suffered severe population decline (Sanderson et al., 2006). Migration also contributes to the normal cycle of the ecosystem by consuming herbaceous vegetation and redistributing nutrients via their urine and dung (Lundberg & Moberg, 2003). This has indirect effects on ecosystem processes (e.g. increasing grassland production and raising nitrogen mineralization) (Frank, 1998), and therefore losing migrations may result in ecosystem alterations and possibly collapse.

The best-known phenomenon of long distance migration in Africa is the migration of 1.3 million wildebeest and 0.6 million zebra, Equus burchelli, and gazelle, Gazella thomsoni (Pennycuick, 1975; Maddock, 1979). Many other migrations are however poorly known (Wilcove, 2008; Harris et al., 2009) with the human population increase across the region making the conservation of many migratory species exceptionally difficult (Berger, 2004; Bolger et al., 2008). The need for effective conservation of migration routes of mammals necessitates a more complete understanding of the biology of this complex behavior of the species, habitat requirement and dispersal corridors of migration (Monteith et al., 2011). Long distance migratory species are also vulnerable to climate change (Monteith et al., 2011). Climate change can affect migration by changing the timing of migration (Lehikoinen et al., 2004) and changes in population distribution (MacLeod et al., 2005). The long-term changes in the timing of autumn migration in birds for instance are found to affect the annual cycle of migration that limits the reproductive period (Tryjanowski et al., 2002; Jenni & Kery, 2003; Stern, 2007).

Study area

The study will be carried out in 85,000 km2 area landscape in Ethiopia and Sothern Sudan (Fig 1). This study area is designed from the combined home range of the collared individuals with 40 km buffer. Gambella National Park with size of 4775 Km2 in Ethiopia and Boma national park in southern Sudan are within the designed study area.

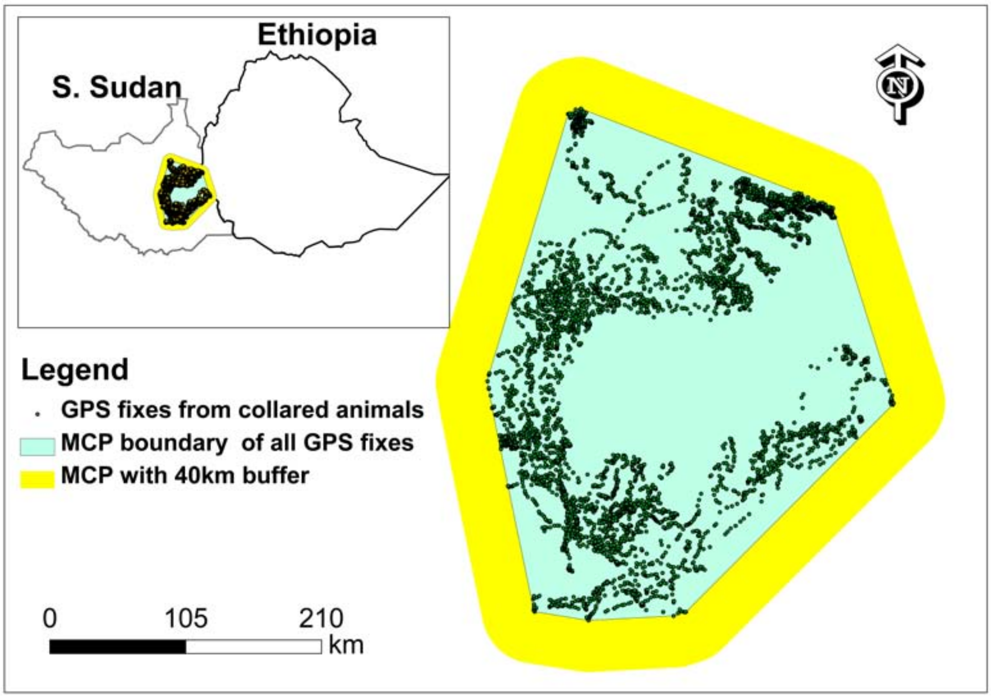

Fig 1. Study area (85,000 km^2) based on 40km buffer of the MCP home range of all combined collared individuals

Collaring White-eared Kob

In March 2013, 18 white eared kobs were collared capturing by animals by net and darted from helicopter in Ethiopia. It was carried out safely and no animal was wounded during this practice.

Movement pattern and migration routes from satellite collars

Seince march, the GPS fixes taken in 4hrs interval are continuously transferred to our data base from the sattelite collars which we hope to for the next three years. During migration, individuals moved at different speed. When forage is abundant, migrants move less than when it is sparse (Mduma et al., 1999). I will compare the step lengths (straight-line distance between successive GPS locations) of the migrating individuals across the different habitat classes (mentioned as bellow) and at different periods of the year by using spatial libraries in the free R language environment (net squared displacement). This data will provide details of movement pattern, migration corridors and habitat requirements in the migration process.

Environmental factors driving the long distance migration

I will develop habitat models that explain the seasonal migration of animals by using Normalized Difference Vegetation Index (NDVI) data acquired by the moderate-resolution imaging spectro-radiometer (MODIS) on board of the TERRA satellite which represents vegetation productivity differences across the landscape (Mueller et al., 2008). For each of the months of the year, I will consider to obtain NDVI composite at 500-m resolution. Monthly rain fall variation in the locality between the two countries will be assessed from the monthly rain fall variation acquired from direct measure of rain fall and the climate layer with a spatial resolution of about one square kilometre obtained from Global Climate Data (Hijmans et al., 2005; WorldClim;http://www.worldclim.org/; Fig 2).

While detailed analysis is yet to be made, from preliminary analysis, Kobs migrated to Ethiopia in the dry season (low rain fall) and moved back to southern Sudan which is rainy season in the area (Fig 2). Most migrations including the great Africa migration of wildebeest is in contrary to this phenomenon. They follow rain seasons across the landscape to find out fresh grass. I want to find out the effects of this rainfall on the landscape land cover that matters the habitat requirements of the white eared kob.

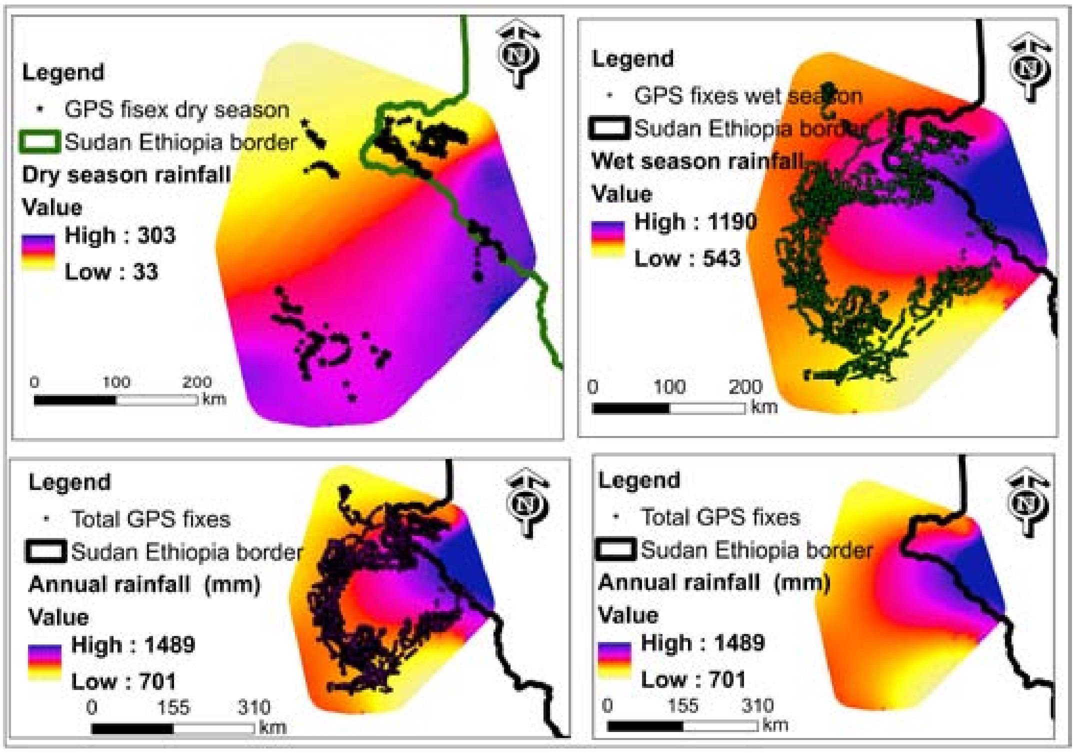

Fig 2. The association of white eared kob movement pattern with rain fall intensity in Ethiopia-south Sudan landscape

Vegetation mapping and land-use cover change

I will prepare land use cover raster map (forest, pasture, bush land, agriculture, shrub, water, human settlement and Erica) as an input for developing habitat suitability maps by using maximum likelihood classification algorithm in ERDAS Imagine from 2 meter resolution SPOT satellite image retrieved in 2013. The degrees of the slope and elevation will be derived by using Surface analysis of GIS from 90m resolution Digital Elevation Model (DEM) in ArcGIS 10 Spatial Analyst. Land use cover change will be carried out by comparing the vegetation changes dated back in 1972 to the recent days. Land cover types of the different years will be developed by supervised classification of ERDASS imagine based on ground truthing data, both from random locations and predetermined locations found vague from the satellite image (Fig 3).

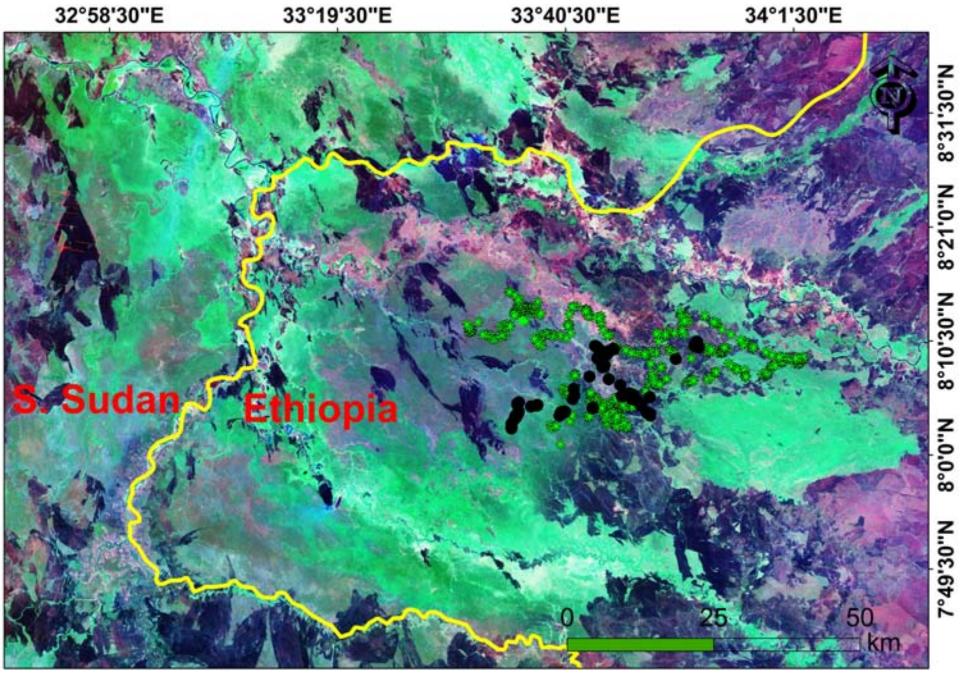

Fig 3. Landsat image to be used for habitat classification

Habitat suitability modelling

I will develop the habitat suitability map by using generalised logistic mixed models on GPS locations obtained from the collared animals. As fixed effects in the candidate models I will include the range of different variables such are habitat classes, slope and elevation. Candidate models will be compared based on differences in AIC value and AIC weights. For transferring the model to a map I will do the following. In ArcGIS 10, I we will enter the parameter estimates from the best model into the Spatial analyst raster calculator. This procedure allocates a value for the logarithm of the odds (i.e., logit) of GPS fixes in all pixels in the map. The logit value will subsequently be converted to probability through the formula p=exp(logit value)/1+exp(logit value) also in the Spatial analyst raster calculator. Potential corridors in between fragmented populations will be established from source population by using spatial analyst tool from cost values derived from habitat suitability models (1-Habitat suitability map).

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