Omo National Park report for the Wet season aerial survey

by

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I. Introduction

Omo National Park (ONP) is located in the Southern Nations, Nationalities and Peoples Regional State of Ethiopia. Close to the Kenyan international frontier and bordered by the Omo River, this protected area is an essential part of the Boma-Omo-Gambella Trans-boundary Ecosystem.

This National Park of 4069 Km² is composed of a mosaic of landscapes ranging from grassy and bushy plains (400 to 700 meters above see level), woody savannah hills (700 to 1200 metres above see level) and forested mountains (above 1200 meters). The four main rivers (Omo at the eastern border, Kibish at the southern border, Mui and Kuma) create perfect conditions for the Riverine Forest type habitat. Several hot and cold springs complete this attractive and complex ecosystem. This landscape heterogeneity leads to a diversification of habitats and therefore to a high wildlife biodiversity (over 300 species of birds and 57 mammals).

The protected area is not only a conservation hotspot because of its high ecological diversity (fauna and flora) but also for its complex and dynamic cultural diversity. Eight ethnic groups live in and/or around Omo National Park (Nyangatom, Mursi, Suri, Dizi, Kwegu, Mguji, Bodi and Me'en). Most of them rely partially or totally on natural resources exploitation. Access to resources is crucial for these communities who continue to have deadly conflicts to gain suitable territories and rights to use and access natural resources. Those conflicts can be very violent, have trans-border implications with other or same ethnic groups in Kenya or Sudan and shape the dynamic socio-economical structure of those communities. Therefore, the Omo National Park is a huge and dynamic ecological and ethnical system with communities having their social and economical structure closely linked with natural resources utilisation.

African Parks Ethiopia (APE) has signed, in January 2006, with the Southern Nations Nationalities and Peoples Regional State, a 25 years management contract for ONP. The aim of this management contract is to ***"establish the ONP as one of the core wildlife conservation areas within a mosaic of social and biological landscapes that would provide a mechanism for sustaining both the wildlife and cultural diversity of the Boma-Omo-Gambella Ecosystem and improve the development and the stability of the area"***.

Relatively little is known about this wild area. The last wildlife census was made by Alistair Graham in 1996 (Graham et al., 1996) and all prior studies (Lamprey 1994, Hillman 1991, Stephenson & Mizuno 1978, Brown 1969, Urban & Brown 1968) point out the lack of any reliable and long term basis information about wildlife conservation status and trends. Even if anthropological and ethnological research programs have left more documents then for the wildlife ones, most of the studies focus only on a specific ethnic group (mainly Mursi) and very few of them examine the social, cultural and economical dependence to natural resources and how the access to those resources has shaped the traditional land-owning and its past or future dynamics. The localisation of most of the communities in and around the ONP is poorly known or documented. Therefore it is essential for APE and its partners to start their commitment by a base line study of the state of the resources and its use by local communities. By its duration, the management contract signed is also an extremely good opportunity to set up a long term monitoring system in order to closely follow trends of all the dynamic systems generated by ONP particularities.

This report will focus on the results given by the first aerial survey scheduled by the assessment and monitoring of ONP and surrounding project areas. After presenting the objectives

of the study and its methodology, the report will present the first results (densities, abundance index) and maps (distribution) of wildlife and human activities observed during this aerial survey.

II. Objectives and Methodology

1) Objectives

The study aims to present, in a scientific and rigorous manner, the conservation status of most of large wild mammals and a first assessment of the human activities and land use in ONP and surrounding areas.

The aerial survey should provide an overall situation of densities and distribution of most of the large wild mammals occurring in the ONP and the surroundings areas. It should clarify the actual conservation status of those animals and the trends observed during the last surveys. Mapping the distribution of the observed animals should help managers and field conservation teams to zone the ONP into conservation priority areas and to best organise their activities. This information, linked with a better knowledge of intensity and distribution of major human activities (livestock, agriculture, villages, fires, hunting …) is essential to prepare a land use and a management plan of the protected area (including surrounding areas) and its harmonious integration in the dynamic socio-economical context.

The outputs expected in terms of data from this aerial survey are:

- Distribution maps of major human activities
- Densities of livestock
- Densities of observable mammals by plane
- Distribution maps of observable mammals

In terms of analysis, the survey should help managers and project partners to identify priority conservation species and zones. For human activities, the first survey should give a broad scale vision of wet season land utilisation by the different ethnic groups. Analysis should be made in terms of conflict for access to resources and land owning in order to help managers to better understand actual social and economical situation to be able to forecast needs and concerns that will certainly be raised by local communities. The study should help in finding a better link between resource distribution, conservation status and communities requirements within the scope to help in the process of building a land use and management plan negotiated between all stakeholders.

2) Methodology

Aerial census was chosen for its ability to survey large areas in a short period of time. Despite the fact that this technique often underestimates densities (missing observation, difficulty to keep observation strips …), it provides in a brief period a clear and broad view of distributions, and is, if the area is properly sampled, a powerful tool for mapping land use of wildlife and also human activities.

According to the objectives of the study, the surveyed area was not limited to ONP. A buffer zone of 20 km around the border of the park was made and served as limits for the flight plan. Because it is impossible to keep a safe, straight and levelled flight in high sloping areas, the mountains (West and North-Est border of ONP) and the Mursi hills were excluded from the flight

plan. Due to its crucial position for livestock inside the park, Dirga hills were included in the flight plan even though some parts are very sloppy (*Map 1*).

The employed census procedures are those described by Norton-Griffiths (Norton-Griffiths, 1978) and are accepted and used by international conservation organisation as IUCN, CITES, WCS … A high sampling effort was chosen in order to maximise the observations. Some species are known, thanks to recent informal ground and aerial surveys (Stevenson, I., com. pers.), to be in very low density and spatially scarce in the ONP or surrounding areas. Moreover, a high sampling effort will provide even more accuracy on all distribution maps (human activities and wildlife) in the way that very little information will be missed.

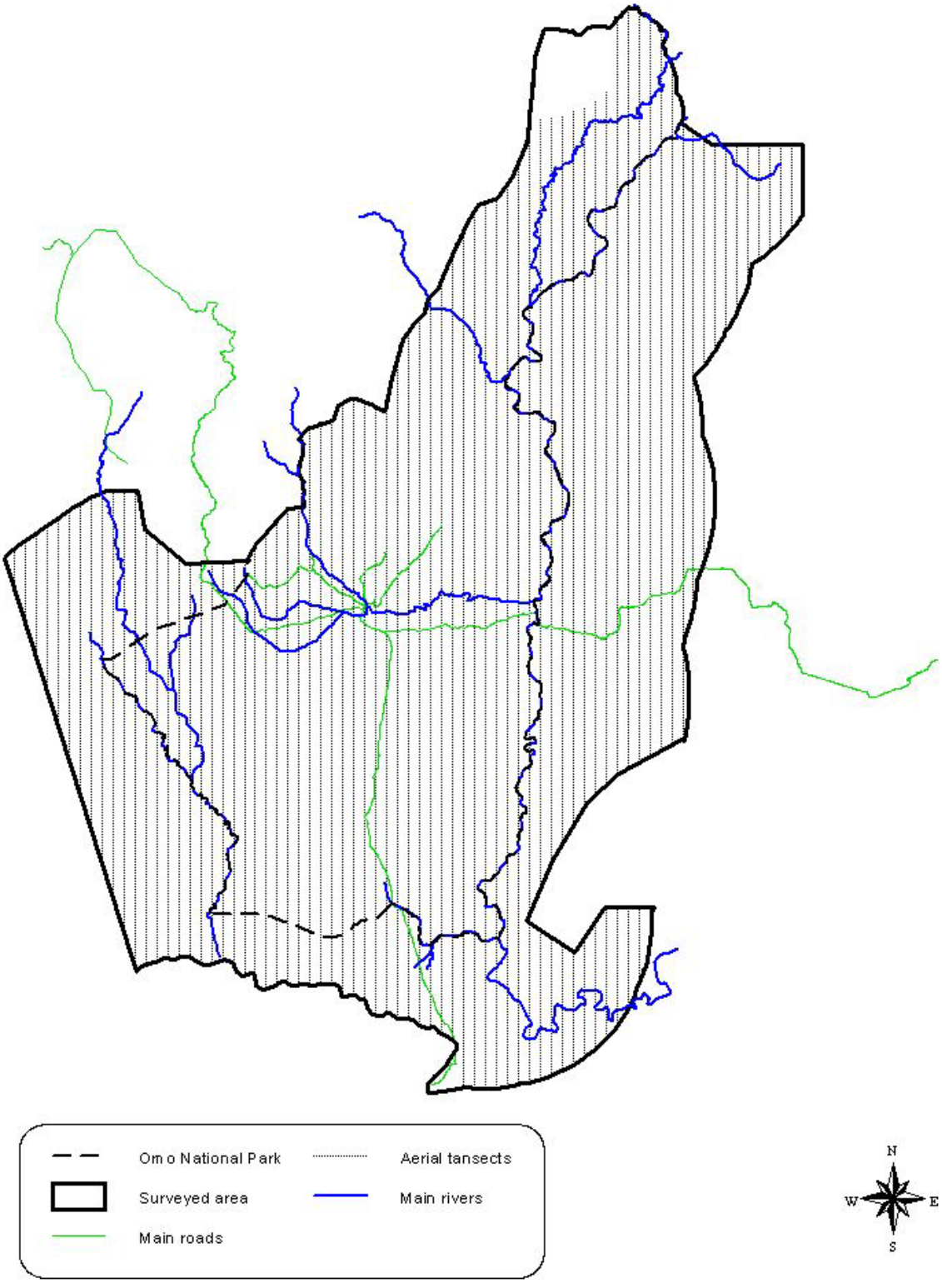
A 40% sampling effort was chosen, which was a good compromise between a full sampling effort (impossible in a such large area - 7853 km² total, 3992 km² for the buffer zone and 3861 for ONP), and a lesser sampling effort which would have led to less accuracy in distribution maps and non observation of some very rare animals. To achieve this sampling effort, transect were spaced every 1.5 km, with an observation strip of 300m each side of the plane. Normally observation strips rarely exceed 200 m to have the best visual angle so as to avoid tree canopy, to sight animals and human activities and to be sure that observers can scan equally all observation strip. In the case of ONP, most of the vegetation type of the surveyed area are either grassy plains or open wooded savannah. Except along major rivers, the vegetation is quite open and by plane, vision is easy with long sight. Surprisingly, more problems were encountered with "out of strip observation" than with "in strip observation". In the plains, observers were tempted to look very far away from their strip and were able to spot animals or human activities several kilometres away thus raising the chance of double counting. Specific attention was therefore put on the double counts and observers were asked to be very disciplined in respect to their observation strip. Some double counts were cut off the data set while in the plane (same group size, coming from the direction of the previous observation …), while other double counts were removed during the analysis of the data. Any suspicious observation was deleted from the density count and the distribution maps.

The plane flew at 100 m above ground level and at 180 km/h. While crossing hills or mountain ranges, this altitude and/or speed could vary slightly according to pilot's need to maintain safe flight. A radar altimeter (King KRA 10) helped the pilot to keep the right altitude. Before calculating densities, flight altitude was double checked by subtracting the altitude taken by the GPS and the land height given by a Digital Elevation Model (http://glcf.umiacs.umd.edu/data/srtm/) and all densities were calculated taking into account a corrected observation strip. The pilot was fully experienced for this type of flight and all members of the team were linked by an internal communication system allowing them to easy communicate while in flight.

The team was composed of :

- one pilot (Rory Mc Guinness) in charge of checking all flight parameters (100 m above ground level given by the radar altimeter, 180 Km/h, straight and levelled fly in the transect uploaded in a Garmin GPS streetpilot 3 as a route)
- one front seat observer (P.C. Renaud) in charge of data collection (observations made by the two rear seats observers, pictures of big herds, human activities and vegetation) and helping the pilot to follow the flight plan and flight parameters
- two rear seats observers (Guillaume Duboscq, Degefu T/Mariam) specially trained and tested to spot and announce properly any observation concerning wildlife and human activities.
- two reserve observers, in charge of ground support as picture counting … (Hateyesus Mathewos, Dereje W/Yohannes).

Map n°1
Omo National Park and the surveyed area



Data was collected with a Cybertracker database interface (http://www.cybertracker.co.za/) specifically designed for this operation. The database interface was loaded in a Garmin IQue M4 and all data recorded was geo-referenced via the GPS integrated in the PDA. A Nikon D100 digital camera was used for pictures of the big herds. Estimation of the size of those groups were made by the ground team. Two GPS were taken during the flight. A Garmin GPS streetpilot 3 with scheduled flight transect uploaded as a route for the pilot to easily follow them and a Garmin GPS 60 to track the plane. After each flight, the data were synchronised in the cybertracker data base, the camera downloaded and pictures given to the ground team for counting. The tracking GPS was also downloaded. Before each flight, a new virgin cybertracker was made and synchronised with the PDA. The camera and tracking GPS were emptied and the scheduled transect were uploaded in the pilot's GPS. Two flights per day were made, one in the morning from 06H00 to 09H30 and one in the afternoon from 16H00 to 18H30.

The observation strip was calibrated according to each observers eye height while seated in the plane and marked in plane's window and wings (photo below). Several flights over a line of drums, spaced by 30 meters each, were made to be sure of the calibration. Each observer was instructed to count the number of barrels (not knowing how many barrels they were supposed to count for an observation strip of 300 m) and altitude was recorded. The survey started only when the observation strip was correctly calibrated. The calibration served to recalculate the observation strip in case the flight altitude during the survey was too different from 100 m above ground level (double check with a DEM).

Four observers were chosen from a group of eight scouts specifically and intensively trained and tested to keep only the best ones. The training took 10 days and several tests were made during this period. All eight scouts were tested in animal recognition and trained in naming them in English. Full information about census techniques, objectives and data analysis were given. Techniques for rapid counting were also given and tested. Spotting capacities were tested in ground and in flight. Calibration flights served as an airsickness and concentration test. From the four selected observers, two were chosen for the plane and two were selected as reserve and for counting the pictures taken during the flight. All GIS material used during the preparation of the flight plan, the survey itself and the analysis was made with the GIS officer of the project who was also extensively trained for these specific tasks.

All data collected (Cyber tracker, GPS, pictures) was uploaded in a geo-database created specially to manage aerial surveys by Gembloux University (WASMA). Several modules were added to the original database to compute automatically most operations (flight plan, mapping, counting on photo, densities or index calculation …). All densities were calculated using the Jolly 2 formula (Jolly, 1969).

As the information collected by this aerial survey will be part of the baseline data which will contribute to a participatory process of a land use and management plan for ONP and surrounding areas, it was important to inform communities about the aim and the objectives of this aerial survey. Meetings with local chiefs were organised by AP's community team and the project manager. Leaders were invited to the Park HQ where a presentation was given explaining the purpose, value and methodologies of the aerial survey. Participants also had the opportunity to have a flight around Mui HQ at survey conditions in order to appreciate for themselves what the observation team will see during the survey from the plane.

III. Results

1) Survey data

97 transects representing **5219 km** were flown. Considering a mean **strip width of 300 m** each side of the plane and a total surveyed area (ONP and buffer zone) of **7853 km²** (**3861 km² for ONP and 3992 km² for the buffer zone**), the sampling effort was of 39.8 %. A total of 45 hours were flown for this survey (including transfer to transects, calibration and training flights).

3333 observations (**0.64 per km**) were made and **603 pictures** were taken. From this total, **1414** (**0.27 per km**) **were wildlife with 1198 of them being in the observation strip** (*table 1*). On the other hand, **1644** (**0.31 per km**) **observations are related to human activities, 55% of them being related to herding activities** (livestock, herder, herder camp or herder village observations). The split between "in" and "out" of observation strip for human activities and environmental data (river, road, escarpment, scenic …) is of less importance as most of this data will serve for mapping distribution and not for density calculation.

	Total	"in"	"out"
wildlife	***1414***	***1198***	***216***
carcasse	***3***	***2***	***1***
herding	***908***		
other human activities	***736***		
environment	***272***		
pictures	***603***		

Table 1 : Total sightings and pictures made during the survey.

2) Survey bias

All census techniques have their own bias. It is therefore essential to be fully aware of them to be able to organise the survey and train the team in accordance to bias limitation. Even with all care taken not all biases can be totally removed. In this case, data related to the condition of implementation of the survey is needed to be able to balance results. For aerial survey, major biases are linked to **distribution of animals, number of observations, vegetation, altitude of flight, calibration of observation strip and the concentration and sighting capability for both observers**.

For animal distributions and number of observations, it is essential to have a sufficient number of contacts which are well distributed in the surveyed area to avoid a high sampling error while calculating densities. Using a high sampling effort will provide greater chance to obtain a higher number of contacts. However, the probability of double counts are also enhanced and observers need to be very careful on this point and any suspicious observation removed from the dataset. Furthermore, the flight plan was designed in order to minimise the rotation time between two transects. Several very long transects, crossing nearly exclusively plains, were cut into two separate transects. None of the transects were more then 60 km in length in case of high animal densities (multiple large herds in a same area).

Having large areas of the surveyed zone nearly empty, would be hazardous for densities estimation. Therefore, the survey needs to be conducted during a period when resources (mainly

water) are as evenly distributed as possible. Furthermore, the transects need to, as far as possible, cross the main rivers and not follow them. For this survey, transects are oriented North/South as main rivers, except Omo, flow east/west. This survey was conducted towards the end of May (from the 22nd till the 30th), at the end of wet season in ONP. Moreover, for human activities, the difference in utilisation of resources in the wet season and dry season is great. May was chosen for the wet season survey when there is believed to be minimal use of resources. The second survey is scheduled for January or February during the dry season when more people are concentrated on the Omo River and there is less grazing area and water available. Thus the park is more heavily utilised. People and cattle are understood to usually move to the Omo River from October to March and to leave from April to September (Stevenson, I., com. pers.). Therefore, human activity and especially herding is, supposedly, to be at its lowest intensity during this first survey.

Flight altitude during the survey is a key point for accuracy of estimations. As observation strips are calibrated for a flight at 100 m above ground level, any changes on this altitude will modify the sampling effort with consequences to densities estimations. The radar altimeter helps the pilot to keep the right altitude. A double check was done using the altitude indicated by the GPS for any observation made and a DEM (http://glcf.umiacs.umd.edu/data/srtm/) giving the ground altitude at the same point. *Figure 1* shows the frequency of calculated altitude according to GPS and DEM. The number of observations used to draw this chart do not match the total number of observations because a same GPS point can be used for several observations (as for example several human activities in the same place). In mean, the plane flew at **99 meters** above ground level (Standard Deviation : 30.6). The minimum flight altitude was 35.6 meters and the maximum 455.7 meters corresponding most often to hill climbing and coming down. **The mean flight altitude and the frequency of distribution of recalculated flight altitude are being very close to the 100 meters expected.** WASMA geodatabase calculate densities taking into account observation strip changes.

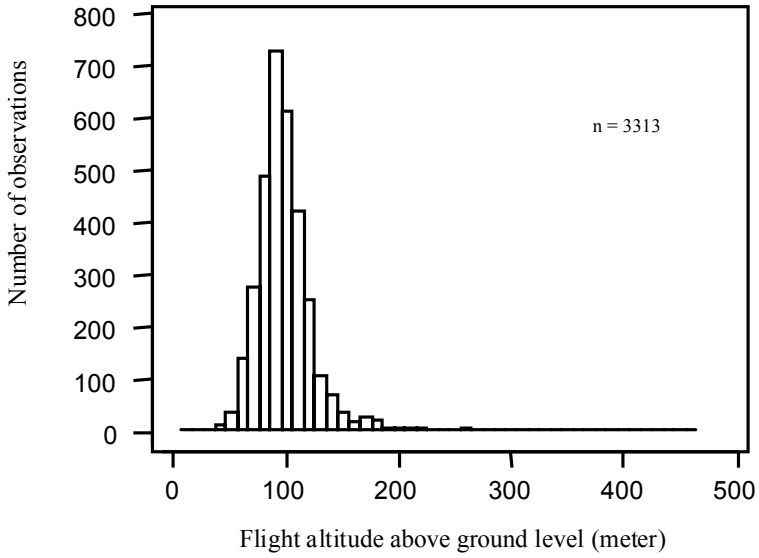


Figure 1 : frequency of flight altitude (in meter) recalculated with GPS reading and DEM for each observation (n = 3313)

Four selected observers were extensively trained and prior tests showed that they were equally capable to spot, identify and name properly the targeted observations for this aerial survey. One observer suffered from air sickness on the second morning of the survey and was immediately

changed by a reserve one. The observation strip was recalibrated and tested with the new observer who finished the survey.

As both sides recorded all observations, it is possible to test the efficiency of each scout assuming that, at the end of the survey, they had equal chances to have the same number of contacts with animals. The *figure 2* shows that left and right made approximately the same number of observations. With the exception for primates (left observer seems to be more efficient), the two observers had closely the same number of contacts. The observer bias is therefore assumed to be very low and negligible for the densities calculations. The total number of wildlife observations don't correlate with the ones given in the *table 1* because the "wild animal trails" were taken out for the *table 2*.

	left observer	right observer
large herbivore	***348***	***380***
mega herbivore	***11***	***4***
small herbivore	***160***	***163***
primate	***17***	***4***
carnivore	***17***	***11***
other	***23***	***38***
total	***576***	***600***

Table 2: Number of contacts sighted by the observers, according to wildlife type.

3) Densities and distribution

The following tables present, for all large wildlife classes (large herbivore, mega herbivore, small herbivore, carnivore, and pigs or ostrich), the estimations from the data collected during the survey. The tables quoted with an "*a*" show, **for the entire survey area**, the number of contact, number of sighted animals "in" or "out" of the observation strip and densities with 95% IC. The tables quoted "*b*" show the **densities calculated for animals sighted in ONP only and in the buffer zone only** (ONP is 3861 Km² and the buffer zone is 3992 km²). **For species having less then 30 contacts (noted, on all densities tables, with an "*"), the estimation of the sampling error is given for information, the indexes (kilometric index (KI) : number of animals per km of transect) presented in the tables quoted with an "c" are a better estimation of abundance.** Maps showing distribution of wildlife are shown in annexe.

Large herbivore

	Number contact	Number sighted "in"	"out"	Estimated pop.	Density (Km²)	Sampling error (%)	Lower limit	Upper limit
Buffalo	***36***	***269***	***61***	***675***	***0.086***	***30.7***	***468***	***882***
Eland	***46***	***764***	***375***	***1916***	***0.244***	***49.8***	***963***	***2869***
Greater kudu*	***6***	***8***	***3***	***20***	***0.003***	***66.6***	***7***	***33***
Hartbeest*	***14***	***59***	***88***	***147***	***0.019***	***46.5***	***79***	***215***
Lesser kudu	***469***	***856***	***225***	***2222***	***0.283***	***15.1***	***1887***	***2557***
Oryx*	***11***	***14***	***3***	***35***	***0.004***	***41.5***	***20***	***50***
Tiang	***71***	***870***	***1425***	***2182***	***0.278***	***58.4***	***908***	***3456***
Waterbuck	***30***	***42***	***46***	***115***	***0.015***	***27.1***	***84***	***146***
Zebra	***49***	***960***	***473***	***2408***	***0.307***	***34.5***	***1576***	***3240***

Table 3-a : population estimation for large herbivore

	Density in ONP	Density in buffer zone
Buffalo	***0.103***	***0.069***
Eland	***0.479***	***0***
Greater kudu	***0.005***	***0.001***
Hartbeest	***0.004***	***0.033***
Lesser kudu	***0.319***	***0.229***
Oryx	***0.009***	***0***
Tiang	***0.563***	***0***
Waterbuck	***0.023***	***0.004***
Zebra	***0***	***0.605***

Table 3-b : density (animal/km²) in ONP and in the buffer zone for large herbivore

	KI ONP	KI buffer zone
Buffalo	***0.0618***	***0.0416***
Eland	***0.2872***	***0***
Greater kudu	***0.0027***	***0.0004***
Hartebeest	***0.0023***	***0.0200***
Lesser kudu	***0.1916***	***0.1372***
Oryx	***0.0054***	***0***
Tiang	***0.3381***	***0***
Waterbuck	***0.0140***	***0.0023***
Zebra	***0***	***0.3629***

Table 3-c : Kilometric index (animal/km) in ONP and in the buffer zone for large herbivore

A total of 732 contacts were counted for large herbivores, **64% of them being Lesser Kudu**. Although common, Lesser Kudu are mainly distributed in the southern part of the surveyed area (*map 2*). Two main pockets of Lesser Kudu can be demarcated, one inside ONP located next to the southern part of the Omo River and the second outside the ONP, around the western part of the Kibish River. Other groups can be observed around Mui and near the northern part of Omo. Due to their habitat constrain, Lesser Kudu tend to avoid the central part of ONP (Sai plain and Ilibaï plain) except in rare cases and in areas with bush encroachment. Very few or no Lesser Kudu were found on the eastern bank of Omo River.

Tiang and **Eland** (*maps 3 and 4*) are also relatively well represented with an estimation of around 2 000 individuals each. Eland are primarily located on the two biggest plains (Saï and Lilibaï). On Saï plain, most herds were sighted in the northern part of the plain where as on Lilibaï they appeared to be more concentrated in the central part. Although the Mui River and belt of ticket should not create a big obstacle for the animals to cross, visually, the maps seems to indicate that Saï and Lilibaï plain populations are separate (10 to 15 Km) and that little individual exchange occurs. Casual ground observation indicates that there is some movement between Sai and Lilibai, not so much with Tiang but certainly with Eland and Buffalo. It is therefore confusing to see that, by air, the distribution of herds tend to show that they do not mix each other. This observation needs to be better documented as distribution maps from aerial surveys are not sufficient to verify this theory. Nevertheless, herds on Saï plain were noted to be larger in number of individuals but fewer in number of groups than on Lillibaï where big herds can be seen but in mean, they tend to be smaller (average of 35 animals per herd in Saï plain for and 23 animals in Lilibaï plain). Distribution of Tiang appear to follow quite closely that of Eland with

the exception of group size being larger on Lilibaï then on Saï Plain. It is very clear that, during the season the survey took place, Tiang were very attracted by the Lilibaï hot spring. As with Eland, Tiangs were observed on Washa plain but in low numbers.

No **Zebra** were found in ONP confirming the local extinction of this species in the National Park (*map 5*). However, outside the park, zebra was the species most represented with an estimation of 2408 (+/- 832) individuals. Three main pockets were located on the north-eastern bank of Omo River. In these three pockets, there was a very high concentration of Zebra, in a very small area. The spacing between the 3 populations ranged from 10 to 20 km. Groups of Zebra were also observed close to human settlements and in very close proximity to livestock. Information gathered indicates that the Ethnic group of Bodi do not hunt or eat Zebra which might explain the reason for the large population of Zebra in this area. One herd of zebra was sighted drinking at the Omo River. However there appears little chances that these herds could move into ONP except if they manage to cross the Omo River during the dry season. The most probable option is that those populations of zebras remain in those areas and/or move eastern rather than western.

The buffalo population estimation is quite low although widely distributed if compared to Eland and Tiang (*map 6*). Buffalo were observed up of Kuma River and on the eastern bank of Omo River. No buffalo were recorded in the western side of Dirga hills and the majority of contacts were made around Mui River and the Park headquarter. Its relatively low density (0.086 animals/km²) does not correspond with the amount of suitable habitat in ONP.

Densities of **Greater Kudu** and **Waterbuck** (*maps 7 and 8*) are very low. However the habitat and behaviour of Greater Kudu make it very difficult to spot. An aerial survey is therefore not the most appropriate technique to census them. Densities are here only given for information. To better estimate the conservation status of those species, it necessary to consider the indexes of abundance. Moreover, specific studies should be done to clarify the conservation status of Greater Kudu.

For Waterbuck, its behaviour limits its presence to very specific habitat. When calculating the density and taking into account the entire survey area, it is normal to have very low figures. Again, densities are given for information and abundance indexes provide a better picture of the population. However casual ground observations have shown that, when observing Waterbuck in its preferred habitat, this specie is relatively well represented.

The most endangered large herbivores in ONP and surrounding areas are certainly the Oryx and the Hartebeest. Their densities are very low (0.013 hartebeest/km² and 0.004 Oryx/km²). Their distribution is sparse for the Oryx and isolated to several pockets for the hartebeest (*maps 9 and 10*). Most of Hartebeest are found outside ONP, slightly east of the Zebra populations. Oryx were spotted only in ONP, mainly in Lilibaï plain although a group was sighted in Washa plain. Most contacts were individuals or very small group. Hartebeest are less present in ONP then Oryx however the remaining pockets on the eastern side of Omo River give the hartebeest potential if specific conservation actions are taken. For Oryx, the situation appears to be more problematic as no other population has been located during this aerial survey.

Mega herbivore

	Number contact	Number sighted "in"	Number sighted "out"	Estimated pop.	Density (Km²)	Sampling error (%)	Lower limit	Upper limit
Elephant*	***9***	***26***	***3***	***68***	***0.009***	***60.9***	***27***	***109***
Hippo*	***1***	***2***	***0***	***N/A***	***N/A***	***N/A***	***N/A***	***N/A***
Giraffe*	***4***	***11***	***1***	***27***	***0.003***	***67.4***	***9***	***45***

Table 4-a : population estimation for mega herbivore

	Density in ONP	Density in buffer zone
Elephant	***0.010***	***0.007***
Hippo	***0.001***	***0***
Giraffe	***0.007***	***0***

Table 4-b : density (animal/km²) in ONP and in the buffer zone for mega herbivore

	KI ONP	KI buffer zone
Elephant	***0.0058***	***0.0042***
Hippo	***0.0008***	***0***
Giraffe	***0.0043***	***0***

Table 4-c : Kilometric index (animal/km) in ONP and in the buffer zone for mega herbivore

Very few **elephants** were seen during this aerial survey (less then 30, *map 11*). Most of the contacts were solitary or small groups (3 to 5) of bulls. The only group with females and babies (15 individuals) was seen in ONP at the edge of the ticket next to southeast of Ilibai plain. All the other contacts were recorded outside ONP, on the southwest side of Kibish River. Only two very old elephant carcasses were recorded. Interestingly, one of these was seen near Kuma River where no living elephant or signs of elephant have been sighted. Elephant tracks (*map 11)* were found and concentrated on the southwest side of Kibish River as well as in the central part of Saï plain. No signs of crossing elephant were noted on the north side of Mui River. It appears that elephant routes cross ONP in the southern part indicating that migration to Kenya and/or Sudan may be a very realistic option. The northern part of ONP (after Mui River) does not seem to currently be used as part of this route or as a part of the home range of this mega herbivore. Although data from the survey appears to conclude that the conservation status of elephant is very low, the numerous tracks and elephant paths around and crossing the Kibish River indicate that a survey in a dryer period may give a better overview of the actual size of the population. During this dryer period, ONP and its numerous springs may contain the only remaining water in the region. Even so, the future of the remaining elephants is not only dependent on a sound conservation policy for ONP but should also be enlarged to all areas once migration routes are more precisely identified.

The aerial survey technique used is not appropriate for a **hippopotamus** census. The data is given only for information and should not be considered as representing the status of this species population. The hippopotamus population appear to be restricted to Omo River (*map 12*) and their density seems to be very low. A specific study (flying along the mains rivers with a light aircraft or helicopter) needs to be conducted in order to clarify conservation status of this species. Although this aerial survey cannot give a formal status of this specie, it seems clear that hippopotamus need special attention and monitoring.

Giraffe are also in a critical situation and very close to local extinction. Densities are very low and although the subspecies is not yet confirmed, it is believed to be Rothschild (*Giraffa camelopardalis rothschildi*). The population is estimated at 28 individuals, all located on the eastern side of ONP (*map 13*). The group (4 individuals) at Saï plain is regularly seen and although several pictures have been taken, the presence of a male in this group is not confirmed. This group appears to stay and move around Saï plain area only. Three groups (a solitary bull and two breeding groups with young) have been observed, mainly focused in the dense ticket area along the western side of Omo River to the southeast of Illibaï plain. Further observations indicate that those groups interact often with each other. Some babies (4) have been recorded. The sightings made during this survey clearly show that the conservation status of the Giraffe is very concerning and needs urgent attention. A specific study on this species is currently taking place in ONP.

Small herbivore

	Number contact	Number sighted "in"	Number sighted "out"	Estimated pop.	Density (Km²)	Sampling error (%)	Lower limit	Upper limit
Bushbuck	***38***	***32***	***13***	***85***	***0.011***	***28.3***	***61***	***109***
Dik dik	***88***	***121***	***20***	***316***	***0.04***	***17***	***262***	***370***
Grant's gazelle	***70***	***182***	***80***	***461***	***0.059***	***39.3***	***280***	***642***
Grim's duiker	***49***	***40***	***12***	***108***	***0.014***	***22.2***	***84***	***132***
Klipspringer*	***7***	***5***	***2***	***13***	***0.002***	***42.6***	***7***	***19***
Oribi	***52***	***42***	***20***	***113***	***0.014***	***22.6***	***87***	***139***
Reedbuck*	***20***	***15***	***9***	***43***	***0.005***	***28.7***	***31***	***55***

Table 5-a: population estimation for small herbivore

	Density in ONP	Density in buffer zone
Bushbuck	***0.012***	***0.008***
Dik dik	***0.033***	***0.044***
Grant's gazelle	***0.111***	***0.006***
Grim's duiker	***0.014***	***0.012***
Klipspringer	***0.002***	***0.001***
Oribi	***0.018***	***0.009***
Reedbuck	***0.005***	***0.004***

Table 5-b: density (animal/Km²) in ONP and in the buffer zone for small herbivore

	KI ONP	KI buffer zone
Busbuck	***0.0074***	***0.0049***
Dik-dik	***0.0198***	***0.0265***
Grant's gazel	***0.0668***	***0.0038***
Grim's duiker	***0.0082***	***0.0072***
Klipspringer	***0.0012***	***0.0008***
Oribi	***0.0109***	***0.0053***
Reedbuck	***0.0031***	***0.0026***

Table 5-c: Kilometric index (animal/km) in ONP and in the buffer zone for small herbivore

Aerial censuses often grossly underestimate densities of small herbivore due to the difficulty in sighting animals of this size from a plane. This statement is compounded for animals living in thick habitat such as **bushbuck**, **dik-dik**, **grim's duiker** (*map 14, 15 and 16*). For these species, the figures given are informative and should not be considered as a real picture of densities. Distribution maps are also difficult to interpret as they may reflect mainly the capability of observers to spot animals according to the areas. Nevertheless, it is interesting to notice that Dik-dik were hardly observed north of Mui River and Oribi were very rare in Ilibaï plain (*map 17*). Bushbuck and Grim's duiker appear to be widely distributed in the survey area and observations were recorded in appropriate habitat. It is difficult to draw a conclusion on the status of **Klipspringer** (*map 18*) and **Reedbuck** (*map 19*). All small herbivores with the exception of Grant's gazelle are equally present inside and outside ONP.

For **Grant's gazelle**, its size and habitat allow greater potential for an aerial survey to provide realistic estimations. This specie was rarely seen outside ONP with the notable exception of the area to the southwest of Kibish River. 80% of Grant's gazelle were located on Ilibaï plain, mainly to the north of Ilibaï hot springs although several large groups were recorded further south (*map 20*). The density of Grants gazelle is relatively low and may have a negative impact on some specialised carnivore population (cheetah for example).

During this survey, two contacts with an **unknown duiker** confirm the presence of a "red coated" duiker described in informal reports (*map 28*). The duiker looks larger and heavier built than a red flanked duiker. Both contacts were made in ticket habitat. After compiling information with major naturalist literature (Dorst J. & Dandelot P., 1970 ; Kingdom J., 1997) this unknown duiker may be very close to the Peter's duiker although it is quite far from its described distribution area. Ground surveys need to be conducted to identify accurately which species it is. Several households were found around the contacts. A first step may be to work with local communities and see if they can provide a good description of the animal (maybe with some skins or even live animals). Communities could also help the park team in capturing some specimens.

Carnivore

	Number contact	Number sighted "in"	Number sighted "out"	Estimated pop.	Density (Km²)	Sampling error (%)	Lower limit	Upper limit
Crocodile*	***15***	***26***	***4***	***68***	***0.009***	***51.4***	***33***	***103***
Lion*	***2***	***10***	***0***	***25***	***0.003***	***92.3***	***2***	***48***
Spotted hyenna*	***2***	***2***	***0***	***5***	***0.001***	***71.8***	***1***	***9***
Wild cats*	***4***	***5***	***0***	***13***	***0.002***	***51.8***	***6***	***20***
Jackal*	***5***	***6***	***1***	***15***	***0.002***	***53***	***7***	***23***

Table 6-a : population estimation for carnivore

	Density in ONP	Density in buffer zone
Crocodile	***0.004***	***0.013***
Lion	***0.006***	***0***
Spotted hyenna	***0.001***	***0***
Wild cats	***0.001***	***0.003***
Jackal	***0.003***	***0.001***

Table 6-b : density (animal/Km²) in ONP and in the buffer zone for carnivore

	KI ONP	KI buffer zone
Crocodile	***0.0023***	***0.0076***
Lion	***0.0039***	***0***
Spotted hyenna	***0.0008***	***0***
Wild cats	***0.0004***	***0.0015***
Jackal	***0.0019***	***0.0004***

Table 6-c : Kilometric index (animal/km) in ONP and in the buffer zone for carnivore

An aerial survey is definitely not the appropriate technique for a carnivore census. **The data presented is only informative and can not be used for any sort of conclusion.** Even distribution maps do not help to draw a conservation status for those species (*map 21, 22, 23 and 24*). For crocodile populations, aerial census with a light aircraft or helicopters following main rivers is an option (*map 25*).

Pigs and ostrich

	Number contact	Number sighted "in"	Number sighted "out"	Estimated pop.	Density (Km²)	Sampling error (%)	Lower limit	Upper limit
Bushpig*	***3***	***3***	***0***	***8***	***0.001***	***54.3***	***4***	***12***
Warthog	***36***	***84***	***29***	***223***	***0.028***	***26.7***	***163***	***283***
Ostrich*	***23***	***43***	***45***	***108***	***0.014***	***36.2***	***69***	***147***

Table 7-a : population estimation for pigs and ostrich

	Density in ONP	Density in buffer zone
Bushpig	***0.001***	***0.001***
Warthog	***0.013***	***0.040***
Ostrich	***0.027***	***0.001***

Table 7-b : density (animal/km²) in ONP and in the buffer zone for pigs and ostrich

	KI ONP	KI buffer zone
Bushpig	***0.0004***	***0.0008***
Warthog	***0.0078***	***0.0242***
Ostrich	***0.0163***	***0.0004***

Table 7-c : Kilometric index (animal/km) in ONP and in the buffer zone for pigs and ostrich

Warthog densities are relatively low and this species was never recorded in any abundance in the area. The majority of sightings were made outside ONP or around to Mui headquarter (*map 26*). Ostrich were mainly located on Saï plain (*map 27*) although some groups were found in Ilibaï and Washa plain. Most of ostriches sightings were inside ONP.

Trends

	1976*	1994	1996	2007	Trend (%)**
Buffalo	***0.606***	***0.346***	***0.283***	***0.103***	***-64%***
Eland	***0.317***	***0.160***	***0.682***	***0.479***	***-30%***
Elephant	***0.130***	***0.170***	***0.000***	***0.010***	***N/A***
Gazelle	***0.273***	***0.229***	***0.311***	***0.111***	***-64%***
Giraffe	***0.018***	***0.052***	***0.009***	***0.007***	***-19%***
Hartebeest	***0.193***	***0.132***	***0***	***0.004***	***N/A***
Lesser Kudu	***1.206***	***0.673***	***0.425***	***0.319***	***-25%***
Oryx	***0.067***	***0.034***	***0.209***	***0.009***	***-96%***
Ostrich	***0.009***	***0.035***	***0.032***	***0.027***	***-15%***
Tiang	***0.327***	***0.487***	***0.900***	***0.563***	***-37%***
Warthog	***0.026***		***0.015***	***0.013***	***-11%***
Waterbuck	***0.148***	***0.315***	***0.023***	***0.023***	***2%***
Zebra	***0.268***	***0.066***	***0***	***0***	***N/A***

Table 8 : Trends in density for ONP between 1976, 1994, 1996 and 2007. Data from 1976 come from Stephenson J. & Mizumo A., 1978. The "*" indicates that densities were found in Hillman, J.C., 1991. Data from 1994 come from Lamprey, R.H., 1994. Data from 1996 come from Alistair et al., 1996. Data for 2007 come from this survey. "**" trends from 1996 to 2007.

The densities for ONP from this survey are compared to the ones given by the last formal census conducted in 1996 (Alistair et al., 1996). Although the 1996 survey did not fly over major hills, it was observed during this survey that very little wildlife remains in the hills and it would not change drastically the 1996 estimation for the animals presented in *table 8* (Alistair et al. 1996). All major plains and ticket game trends are negative. Density is from 11 to 96% lower in 2007 then in 1996. As no distribution maps are present in the 1996 report, it is not possible to ascertain if this drop is due to loss of habitat or due to animal hunting. In the 1994 census report (Lamprey, 1994), distribution maps show that hartebeest and zebra distribution did not vary much from 2007. In 1994, Washa Plain appears to be more densely occupied by wildlife then in 2007. The declining tendency shown in table 8 follows the trend underlined in Alistair's et al. (1996) report. Oryx is the specie with the biggest drop (- 96%) pointing out once again that this species should be considered as a high priority in terms of conservation policy.

4) Human activities

Human activities are mainly analysed in term of distribution and interaction between communities and wildlife. Again, all maps can be found in annexe. Only livestock, cattle and shoat (sheep and goat are added together as it is very difficult from the air to note the difference between them), densities will be calculated in the same way as for wildlife (Jolly 2 formula). During the survey, domestic animals could be seen with herders in the bush or gathered inside bomas near or in herder camps or villages. When cattle move freely in the bush, observer counted group size as for wildlife herds, but for animals seen in bomas, it is nearly impossible to count them. Therefore, only the presence of an active herder camp or boma was noted and, when possible, a picture taken. The number of animals in the bomas was calculated by the ground team thanks to the pictures taken. As it was impossible in some areas to take a picture of every herder camp, an average herd has been calculated from the pictures for every day of flight, and the total number of domestic animals seen estimated by multiplying the average animal counted on pictures and the active camps observed.

The difference between a herder camp and a village is that a herder camp only has cattle and shows no signs of agriculture. If a village had cattle in it, then two observations were made (village + cattle) and counting was made as described above. No problems were encountered in the description of the other human activities.

Herding

In the studied area of Mursi, Nyangatom, Bodi and to a lesser extent Suri, the communities appear to have more livestock. Consequently, most herding activities are located on the eastern side of Omo River and the southern part of ONP (*map 29*). Mursi and Bodi cattle activity appear concentrated around main settlements (with a very clear delineation between the two herding activities hot spot). Nyangatom activity appears more dispersed with livestock from Kibish River to the Dirga hills. Around Kibish River, settlements seem more permanent and during the survey period livestock was mainly composed of big herds of shoats and herders were mainly women and children. However livestock observed on Dirga Hill was mainly cattle, herders were young or older men and the settlements appeared to be non permanent herder camps with all activity orientated to cattle care. The pictures taken show very clearly this switch in livestock composition and settlement type. The map with active or inactive herder camps (*map 30*) clearly shows that Nyangatom use the majority of Dirga Hills with their cattle. It also indicates that during wet season they mainly use the southern part of the hills. The presence of old or very old inactive herder camps indicates that during dry season, Nyangatom may move north with their cattle. Although cattle were mainly concentrated on the hills, some active herder camps were sighted on Ilibaï plain and vast cattle paths furrow the plain from Nyangatom main settlements to Dirga hills. Very little herds have been seen without several herders and most of them are armed with automatic weapons.

The estimations of livestock populations were 84049 cattle and 55286 shoats (*table 9-a and 9-c*). Respectively, 39467 cattle and 14759 shoats were counted in the bush and 44542 cattle and 40527 shoats were counted in bomas or herder camps. For the second estimation, the survey clearly showed three main types of livestock care while in herder camps (*table 9-c*) :

- Mursi and Bodi: On the eastern side of Omo River, Mursi and Bodi appear to keep cattle and goats together and on average, the number of cattle and goats appear to be relatively equal.
- Nyangatom on Dirga: Cattle were mainly observed in this area. Very few shoats were sighted
- Nyangatom around Kibish River: mainly shoats were observed and were focused around main settlements with very few cattle.

	Estimated pop.	Density (Km²)	Sampling error (%)	Lower limit	Upper limit
Cattle	***39467***	***5.03***	***20.7***	***31284***	***47650***
Shoat	***14759***	***1.88***	***21***	***13431***	***16087***
Donkey	***307***	***0.04***	***38.6***	***189***	***425***

Table 9-a: population estimation for livestock

	Density in ONP	Density in buffer zone
Cattle	***2.89***	***6.45***
Shoat	***0.98***	***2.75***
Donkey	***0.02***	***0.06***

Table 9-b: density (animal/Km²) in ONP and in the buffer zone for livestock

	average cattle per camp	average shoat per camp	nb. camp	estimate cattle	estimate shoat
Nyangatom in Dirga	***151***	***11***	***124***	***18724***	***1364***
Nyangatom around Kibish	***29***	***229***	***61***	***1769***	***13969***
Mursi/Bodi	***109***	***114***	***221***	***24089***	***25194***

Table 9-c: estimation of livestock in bomas or herder camp according to communities.

It is to be noted that the densities of livestock in ONP are higher then that of all wild animals. Within the total survey area, the estimation of the total population of all large wild herbivore amounts to slightly less then 10% of the population of livestock. Even within ONP, livestock is far more densely represented then wild mammals.

Nyangatom herds are the ones that are most closely in contact with wildlife as they enter deep into ONP and are settled on Dirga Hills and nearby Ilibaï plain. In the far north of ONP some settlements (believed to be Me'en people) also have their herds within the park boundary. Mursi and Bodi appear not to enter the park with their livestock at this time of year. It will be interesting to see the difference in movements of livestock during the dry season. In some areas the current density of cattle, goat and sheep appear to be causing heavy overgrazing issues. This is apparent especially around the Kibish River in the Nyangatom area where there are permanent settlements as no green grass was seen in this area during the survey even though it was at the end of a very wet rainy season. Areas of heavy erosion have also been recorded in this same area with a special attention around Omo river where heavy erosion pattern can be seen.

Land pressure due to the need to access water and grazing areas appears to be very high. This is a major issue and is very apparent with the Nyangatom who seem to have very few other options of where to water and graze their large numbers of cattle other then going north into the park or west into Suri land. This creates a knock on effect to the Suri who also need space and grass for their cattle which in turn adds pressure on the park. The so called "no-mans land" area to the southwest of the park and between the Nyangatom and the Suri needs to be investigated as it shows potential for water and grass lands and there are also signs of wildlife population (*map 31*).

Agriculture

The majority of fields and villages were observed in Suri, Dizi, Mursi and Bodi areas (*map 32*). The main agricultural activity inside the park was located north of Kuma River where several settlements (believed to be Me'en) are scattered throughout the area. Some of these settlements appear to be quite new. Fields were also sighted on Dirga Hills around herder camps but they were few in number and limited in size. On the Omo River, from Kuma River to Kibish, a lot of small settlements (4 or 5 huts maximum) were observed. All had grain storage and fields on the river bank or in the river bed. Many grain storage structures and fields were also noted and

recorded without any huts around them. Cultivation did not appear to be permanent as many of the old grain storage structures, huts and fields were often not close to active ones. With the exception of north of Kuma River, land pressure for access for agriculture does not seem to be a major problem for ONP.

Gathering and hunting

Gathering activities (honey, wood, grass …) were mainly focused around major settled areas with the exception of the north west area of ONP where a lot of signs of honey gathering were seen. Numerous human paths were sighted in this area and several groups of honey collectors or walkers were recorded. All of them were armed. No obvious signs of hunting (hunting camp, drying meat, fresh carcasses) were seen. Several shelters were observed and recorded but there were no obvious sign to confirm if they were used for hunting activity. These shelters may have been used at night by walkers crossing ONP. However this data does not confirm that communities do not hunt in or around ONP but its intensity appears to be quite low. Two old elephant carcasses and one recent buffalo carcass were found but no cause of death could be ascertained from the air. It will be interesting to observe if the hunting activity remains as discrete (by plane) during the dry season.

Overall, observations indicate that human activities have massive encroachment inside ONP and very little viable land remains outside ONP (*map 31*). In ONP, little land is free of any recorded human activity with the exception of the east side of Ilibaï Plain, the central part of Saï Plain and the very central part of Washa Plain. Nevertheless, parts of ONP remain very wild areas and are still a major biodiversity hotspot for the Boma-Omo-Gambella ecosystem that needs urgent management policy to balance biodiversity conservation and rural development. It is interesting to note that land use seems to be strongly patterned around focused activity types and also around ethnic group. There are some areas which are between two heavily used areas which look like formal land splitting between two of more communities. These appear to be some sort of "no man's land" where neither ethnic group conduct any kind of activity. This "non human activity land" is very clear between Nyangatom and Suri west of Kibish River (*map 31*). It is also apparent in the land between Mursi and Bodi and although less evident between Nyangatom and Mursi around the Omo River. As the survey didn't fly over the mountains, it was not possible to see if such divisions are also visible in the land occupied by communities living in the western side of ONP.

A second aspect of land use by human activities is that it has a direct impact on wildlife distribution. The estimations have already clearly shown that wild mammals are less numerous then domestic ones. This demographic decline is also clearly evident in the geographic mapping of wild animals home range which seem to be restricted (for the larger mammals) to the last “free of human activity" areas (*map 33*). This geographical relation is not only to be true inside the park but is also evident outside in the buffer area. The populations of zebra and hartebeest are mainly located in the "non human activity" land between Mursi and Bodi communities.

IV. Short comment on results

The results from this wet season census show a worrying but not catastrophic conservation situation. None of the species sighted in 1996 has disappeared and although zebras are locally extinct in ONP, a quite healthy population remains outside in the Tama Reserve between Mursi and Bodi. Although to a lesser extent, the same observation can be made for the hartebeest population which are in a critical situation in the park although a viable population remains outside. The two most endangered mammals are the Oryx and the Giraffe as their population is seriously low (less then 40 individuals) and no other population pocket was found in the survey area. Although the populations of Lesser Kudu, Eland, Tiang, Buffalo, Grant's gazelle and Ostrich have declined, their situation is not as critical and sound conservation action aiming to secure their actual habitat should be sufficient to raise their number.

The elephant status and situation remains unclear as very few of them have been seen however the large number of trails indicate that several herds can cross borders and range inside ONP. The dry season census should provide more information about the real status of this population. Nevertheless, a conservation plan for this species will almost certainly need trans-boundary effort.

It is important to state that an aerial survey gives valuable information for some animals but is a less effective and not the best census technique for others (mainly carnivore and small antelope). Even if no definitive conclusion can be drawn from the data and figures, it is reasonable to state that most big carnivore species may be in danger taking into account the drop in herbivore's density (see section "trends") and the presence of herders in and outside ONP. Specific studies and surveys need to be conducted to clarify their conservation status and choose the best management strategy. Some of them (cheetah for example) may be in high danger and in need of an urgent and energetic conservation plan. This point should not be neglected in the management plan.

Biological speaking, from the data analysed during this survey, at least four species need "strong conservation action" in ONP : zebra, hartebeest, oryx and giraffe. For the two first, they need to be reintroduced from the existing population outside ONP. This can form the base of a much wider community based conservation project that will include and benefit to Mursi and Bodi communities as these animals are in their "non human activity land". The reintroduction can be based on scientific data with an analysis of habitat suitability to raise the chance of success of the reintroduction scheme. For Oryx and Giraffe, the situation is different as no other populations was found. Mago National Park to the east of ONP was not part of the survey however from information coming from park staff, even if giraffe and oryx are still seen in the Mago National Park, it is doubtful that they can be used for any population reinforcement scheme. Oryx can be found in other parks of Ethiopia however if it is confirmed that the Omo giraffe are a Rothschild subspecies, it will be very difficult to find other individuals in Ethiopia. Therefore it is preferable to first consider in situ conservation action. Rhino were indigenous to Omo and as a symbolic animal, it would be interesting to consider a reintroduction scheme once the area is secured.

At the socio-economical level, land use and access to certain resources are a strong conflict starter. Access to grass for grazing appears to be crucial for Nyangatom and possibly Suri and does have a tremendous impact on ONP. **Ilibaï Plain is the actual mammal biodiversity hotspot of ONP as most wild species encountered during this survey live on this plain**. The biodiversity of Illibaï Plain is higher than Saï or Washa plain (*map 33*). Even in terms of density, Ilibaï plain is greater then the two other plains. Therefore, Ilibaï Plain is a vital and key area for the ONP ecosystem. Cattle encroachment on and around this plain should then be

managed in the best possible way and community involvement in this management should be started as soon as possible. This also applies to Dirga Hills where the situation is crucial. The same kind of management and community involvement should be conducted with Suri for Washa Plain.

An other critical issue which needs to be addressed is the erosion along the Omo River bank in Nyangatom land and the overgrazing which is having heavy ecological and sociological impact around Kibish River (*map 34*)**.** Possibly linked to that, is fire. It is startling to note that ONP has almost constant fire activity somewhere, even during the rainy season. Thus fire strategies and management should also be included in the management plan.

Because the current border of ONP does not legally protect wildlife and their distribution, it may be valuable to consider a re-demarcation of the border focusing on the actual conservation and social situation.

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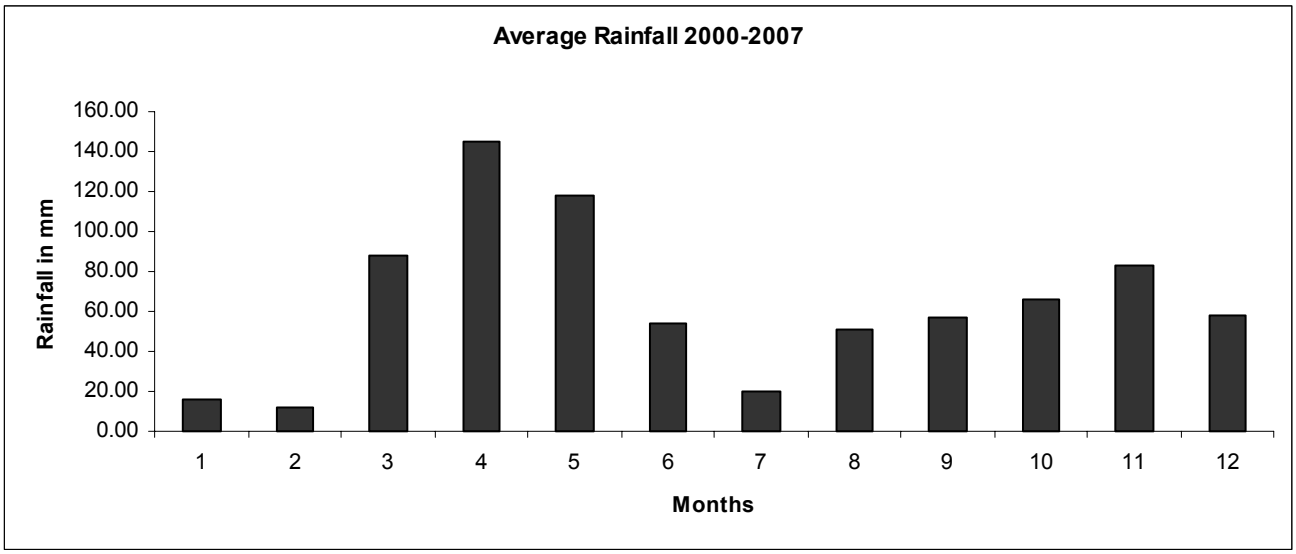
Appendices



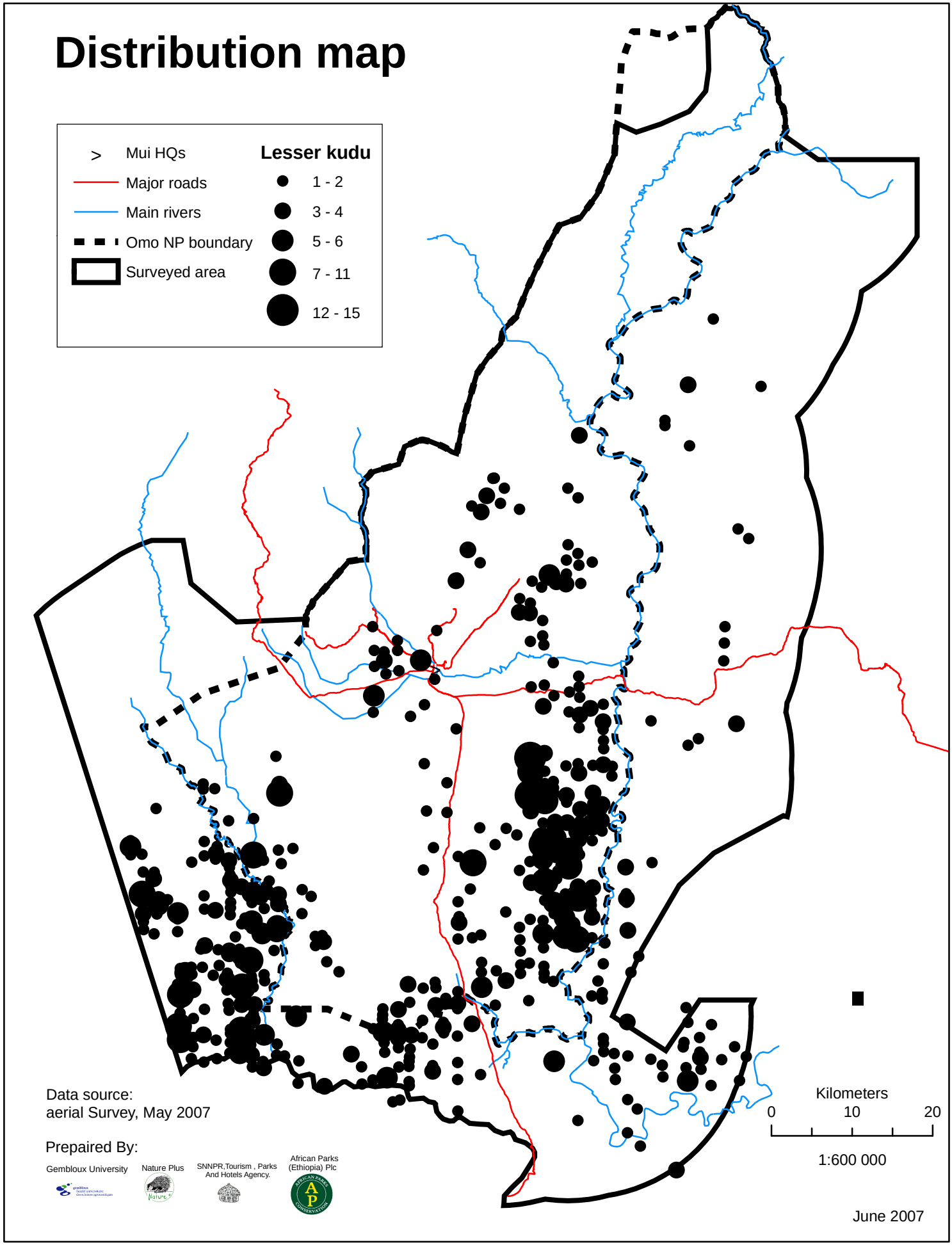
English name	Scientific name*
Ostrich	***Struthio camelus***
Baboon	***Papio anubis***
Hartebeest, lelwel	***Alcelaphus buselaphus lelwel***
African buffalo	***Syncerus caffer***
Guenther's Dddik	***Rhynchotragus guentheri***
Grimm's duiker	***Sylvicapra grimmia***
Grant's gazelle	***Gazella granti***
Defassa waterbuck	***Kobus ellipsiprymnus***
Tiang	***Damaliscus korrigum***
Common eland	***Tragelaphus oryx***
African elephant	***Loxodonta africana***
Giraffe	***Giraffa camelopardalis***
Bushbuck	***Tragelaphus scriptus***
Greater kudu	***Tragelaphus strepciceros***
Lesser kudu	***Tragelaphus imberbis***
Oribi	***Ourebia ourebi***
Oryx	***Oryx gazella***
Savanna warthog	***Phacochoerus africanus***
Spotted hyaena	***Crocute crocuta***
Lion	***Panthera leo***
hippo	***Hippopotamus amphibius***
Bushpig	***Potamochoerus porcus***
Crocodile	***Crocodylus niloticus***

*** from hillman, J.C., 1991**

Maps

1. Distribution of Lesser Kudu
2. Distribution of Tiang
3. Distribution of Eland
4. Distribution of Zebra
5. Distribution of Buffalo
6. Distribution of Greater Kudu
7. Distribution of Waterbuck
8. Distribution of Oryx
9. Distribution of Hartebeest
10. Distribution of Elephant
11. Distribution of Hippopotamus
12. Distribution of Giraffe
13. Distribution of Bushbuck
14. Distribution of Dikdik
15. Distribution of Bush-duiker
16. Distribution of Oribi
17. Distribution of Klipspringer
18. Distribution of Reedbuck
19. Distribution of Grant's Gazelle
20. Distribution of Lion
21. Distribution of Hyenna
22. Distribution of Jackal
23. Distribution of Wildcats
24. Distribution of Crocodile
25. Distribution of Warthog
26. Distribution of Ostrich
27. Distribution of unknown Duiker
28. Herding activities
29. Herder camps
30. Distribution of different human activities
31. Distribution of agricultural activities
32. Human activities and wildlife
33. Fire and erosion

Distribution map



Data source:
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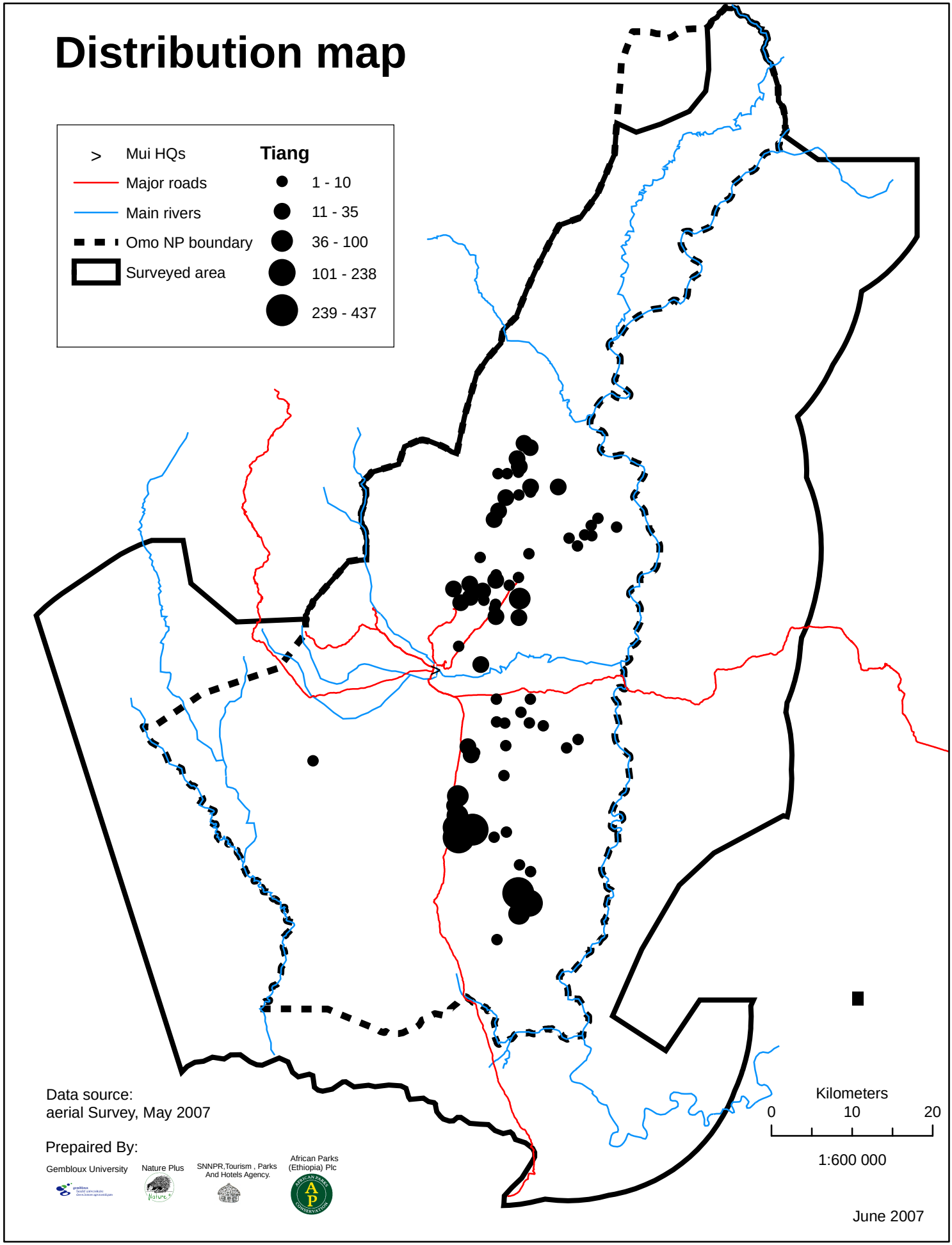
Distribution map



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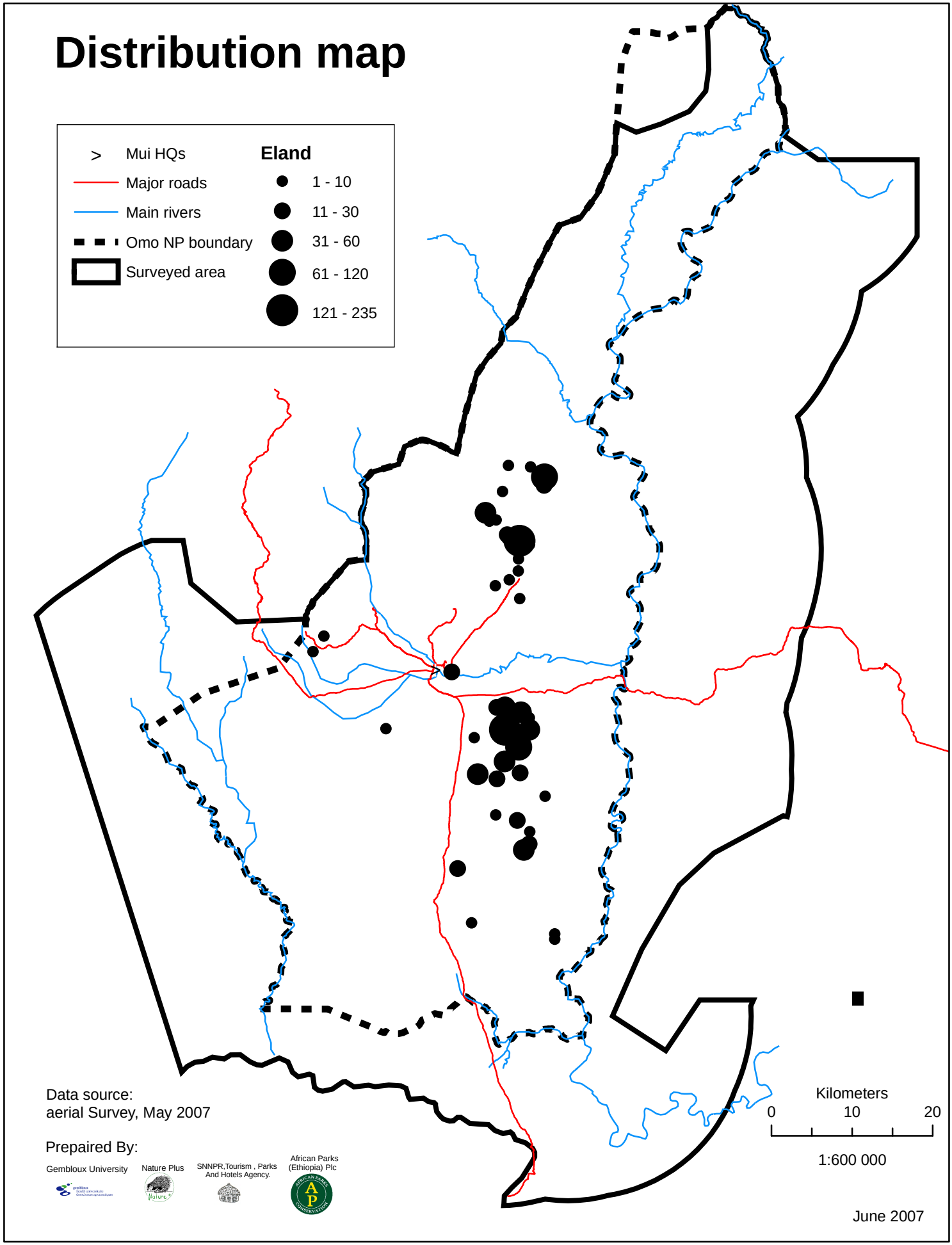

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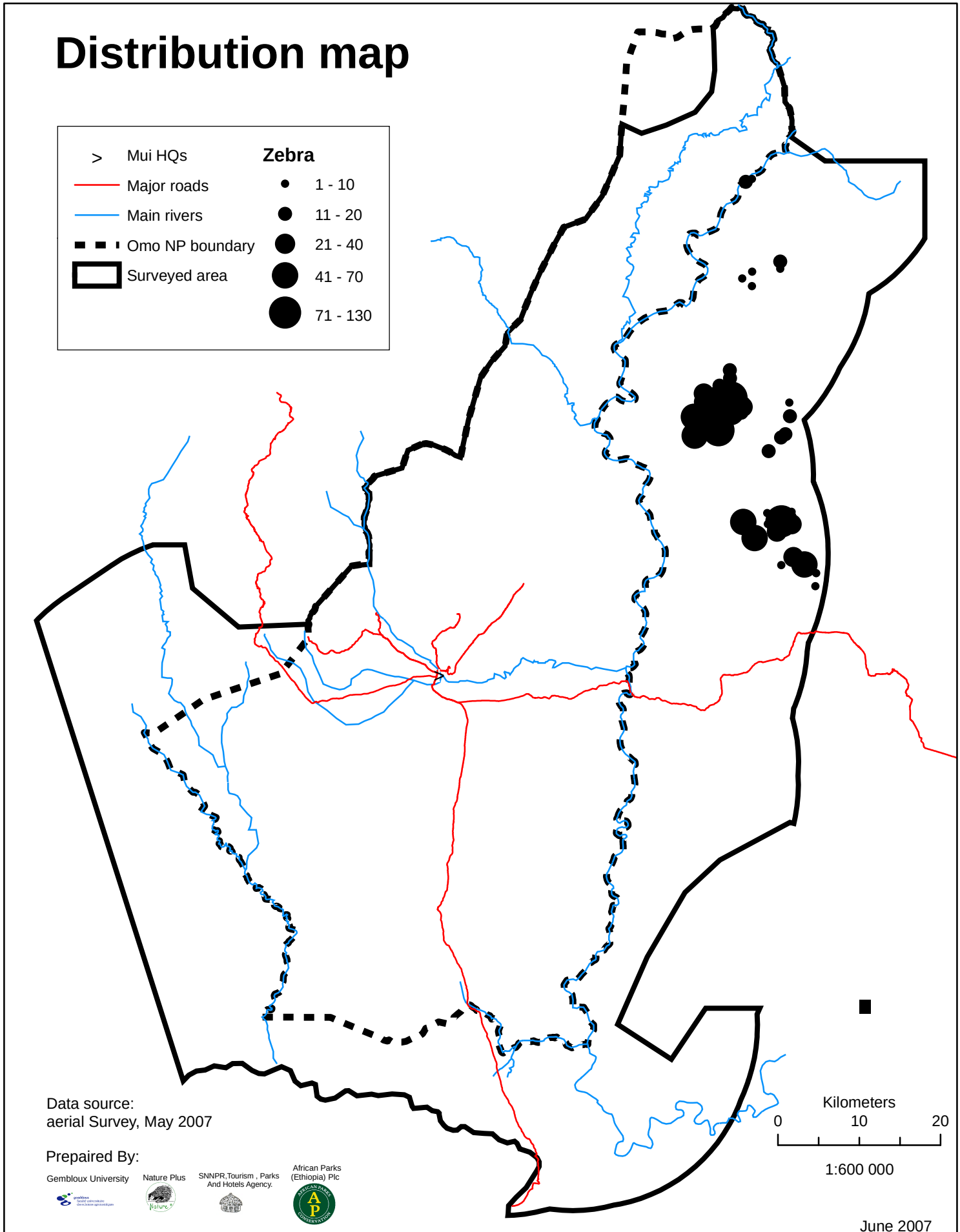
Distribution map



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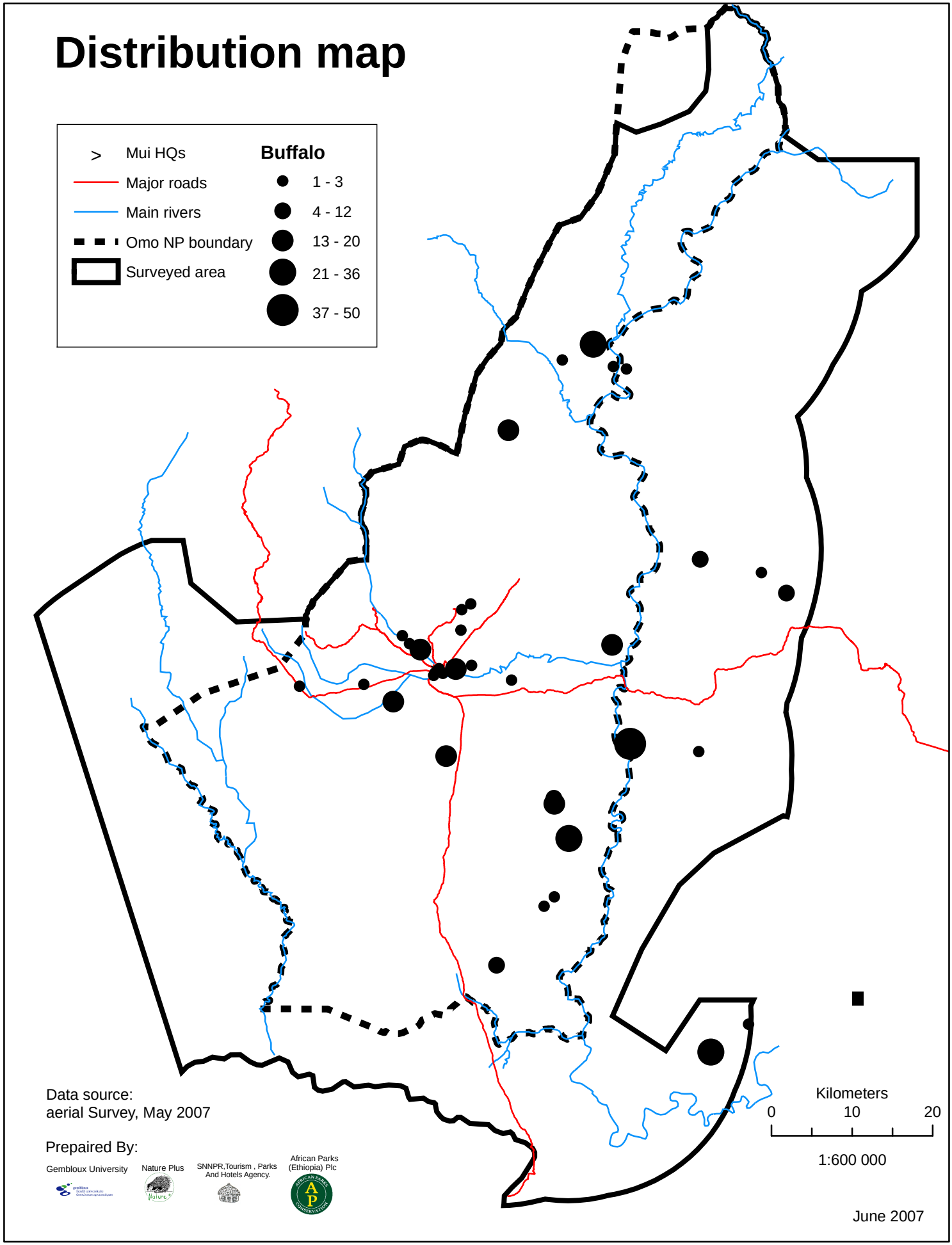

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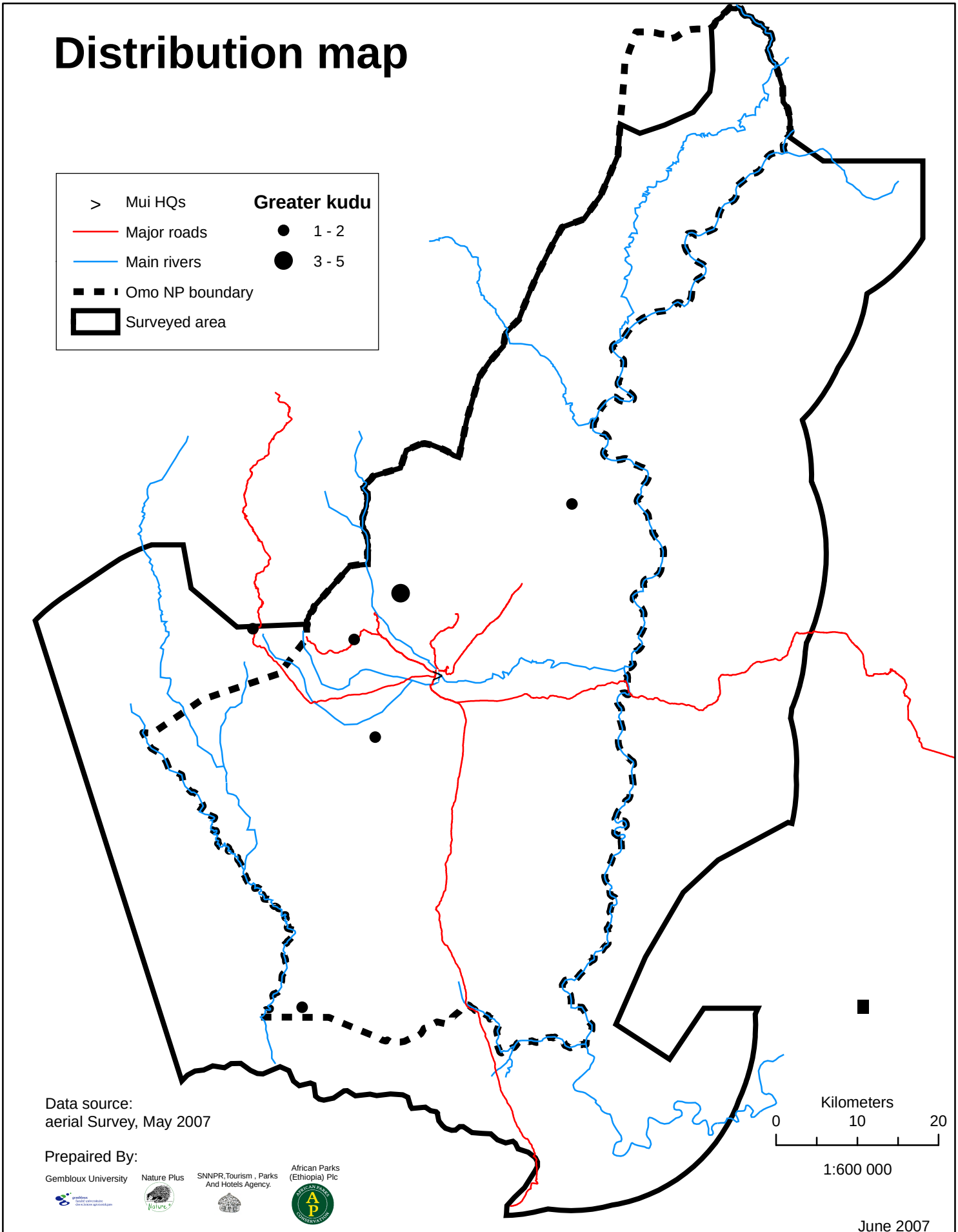

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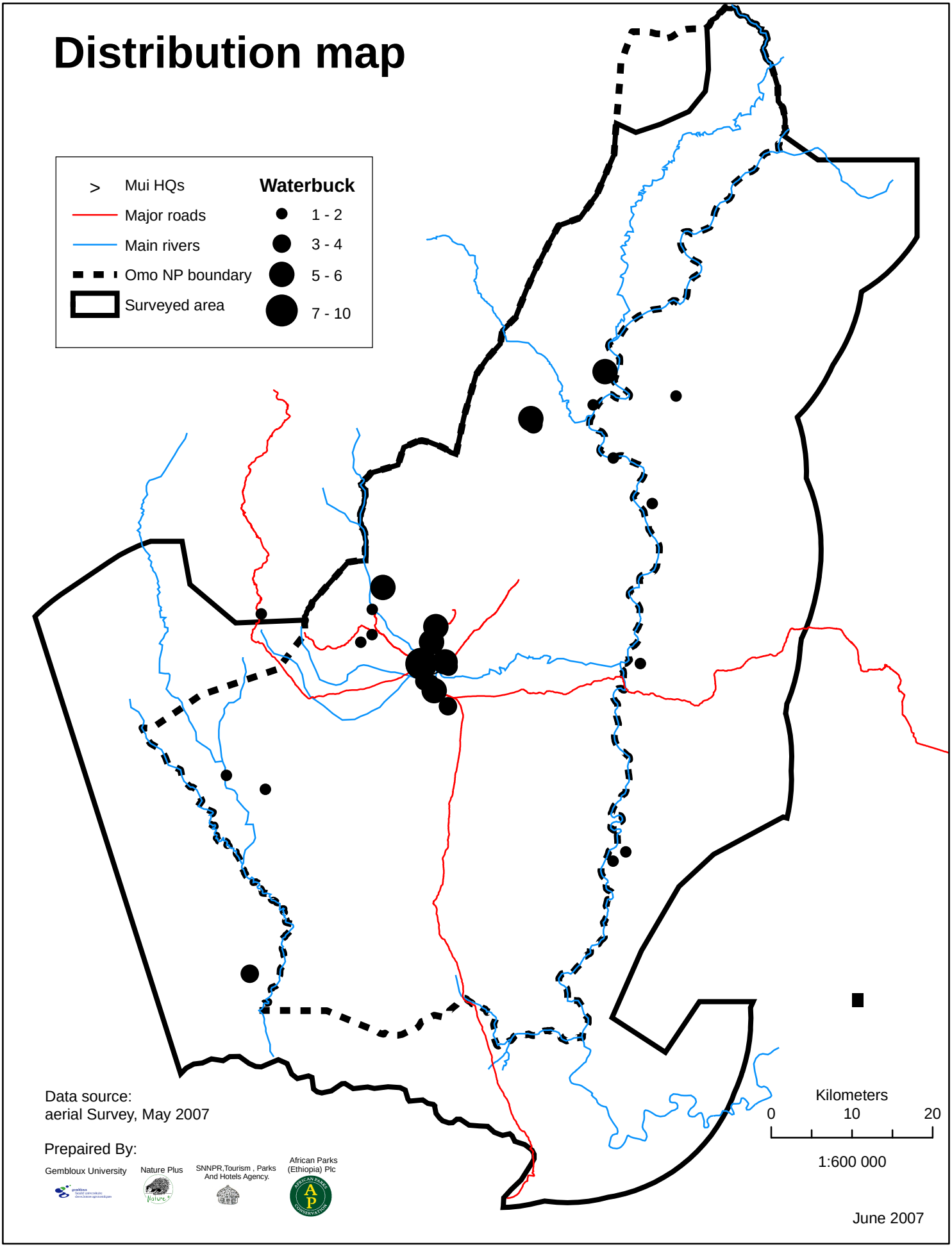

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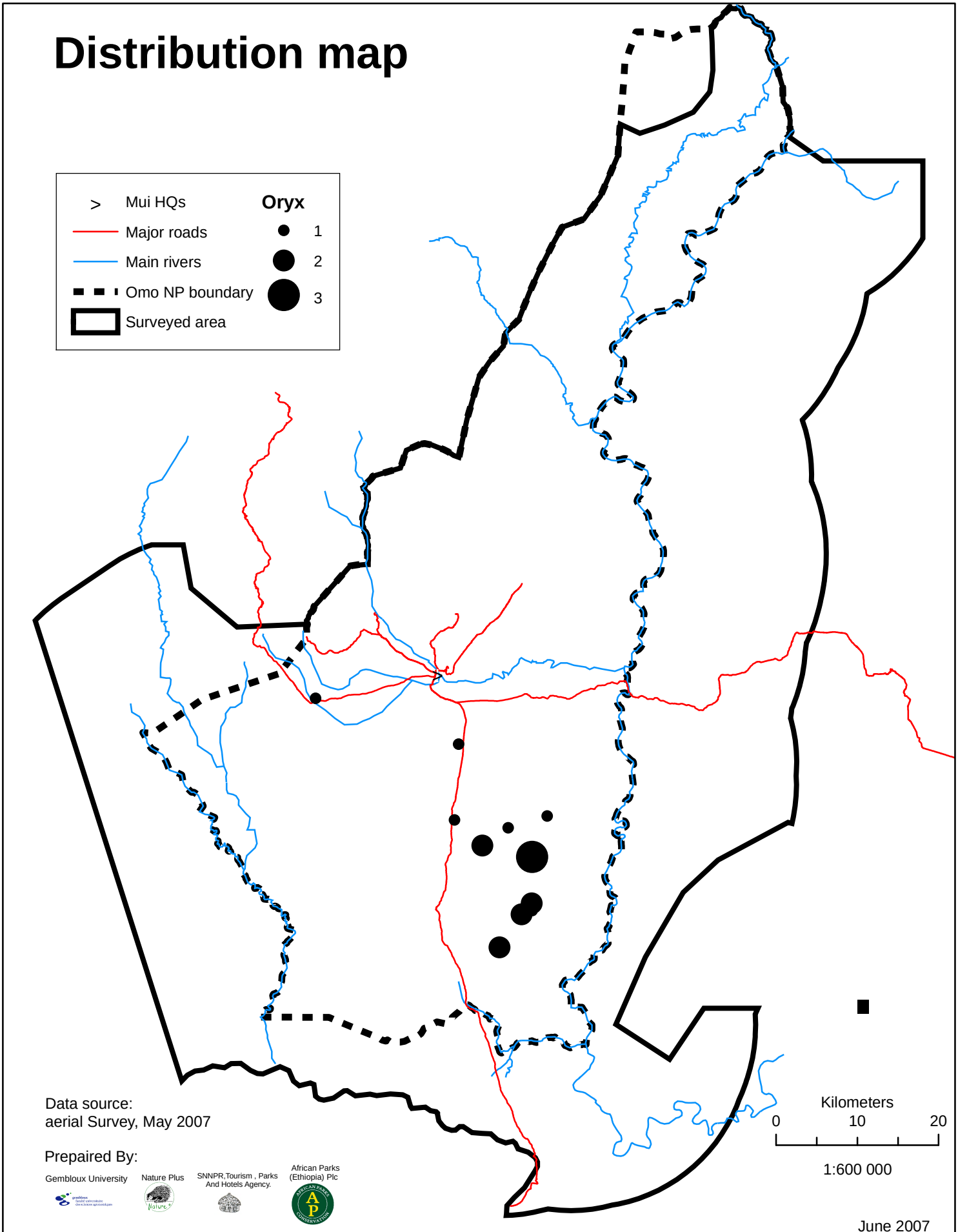

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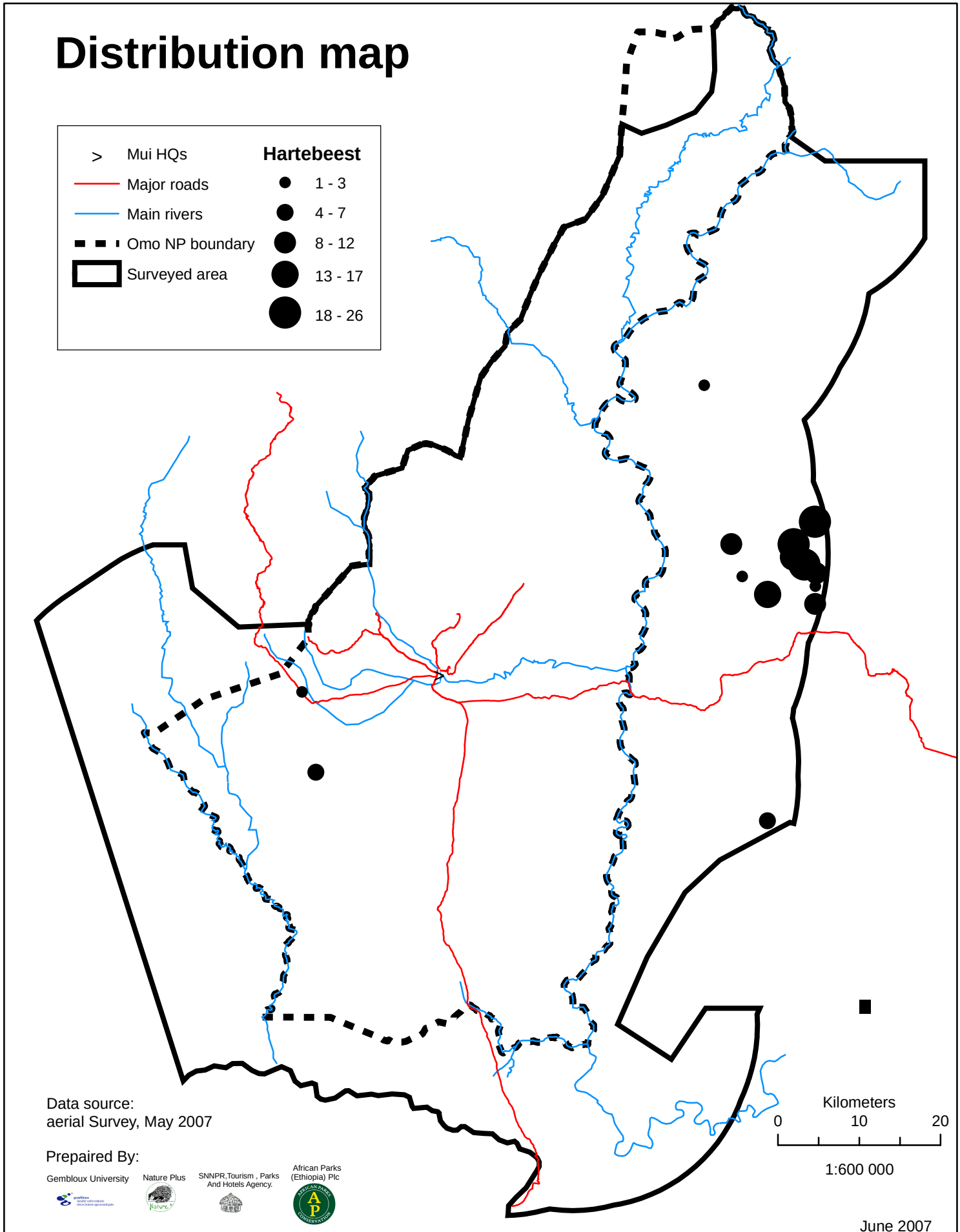

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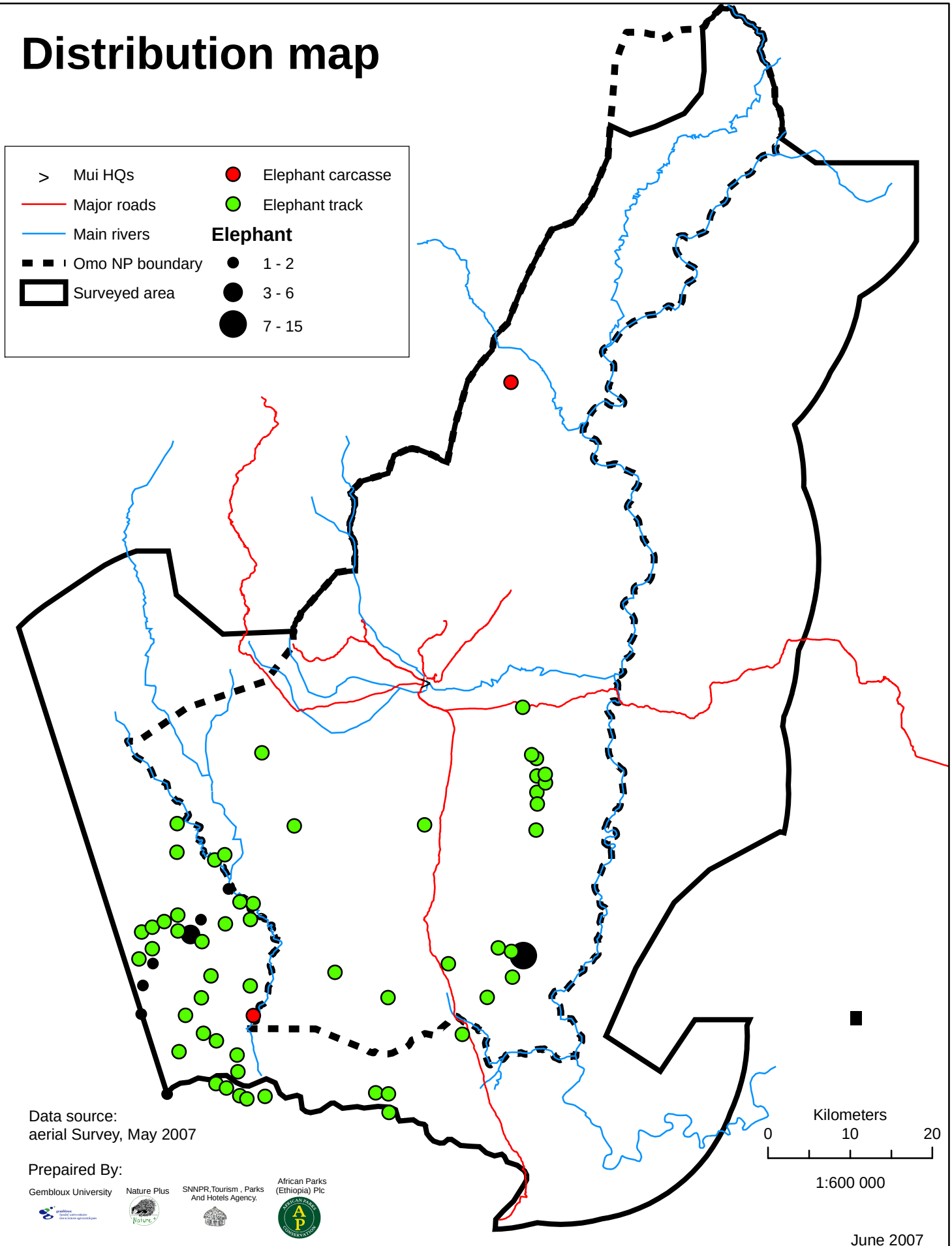

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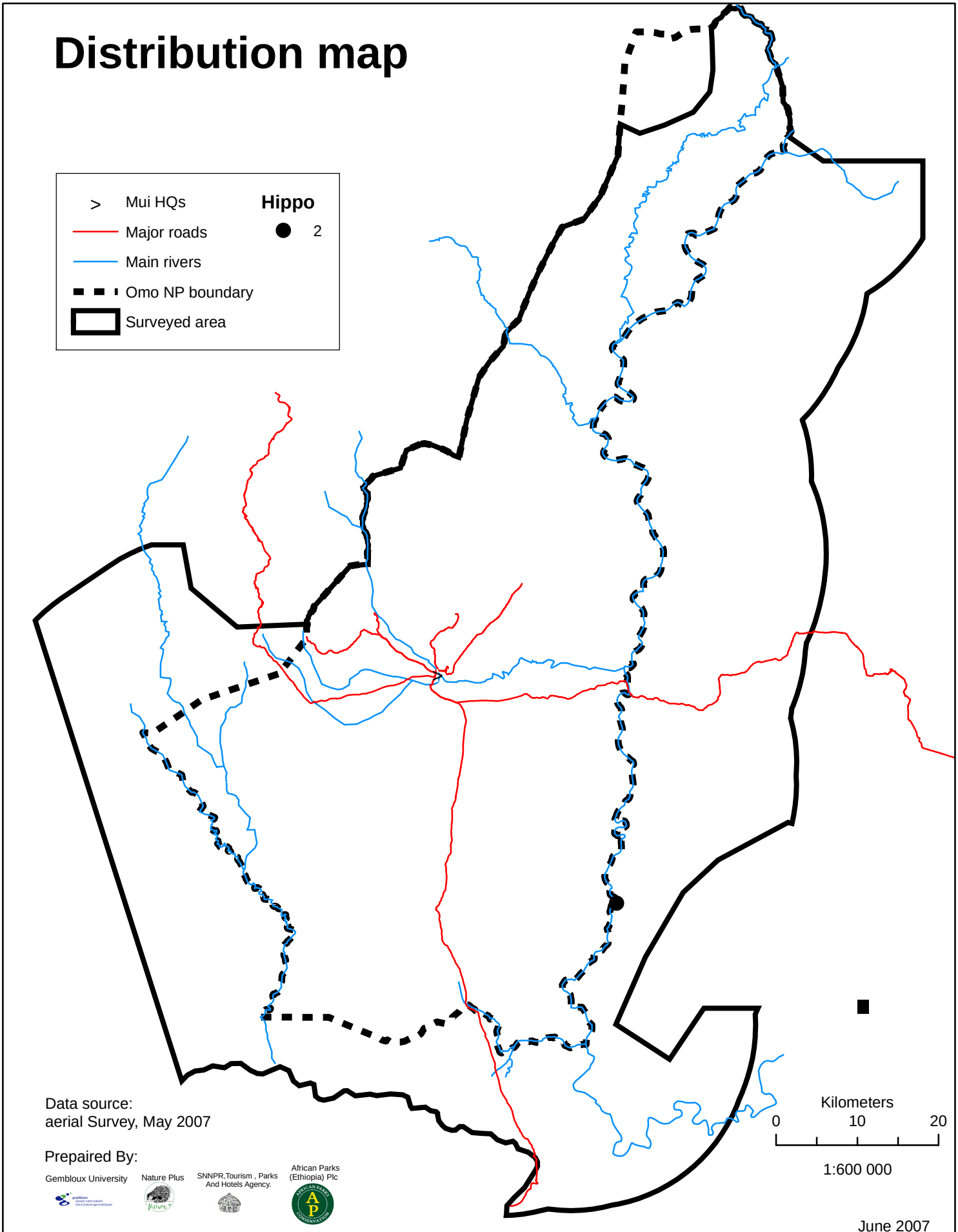

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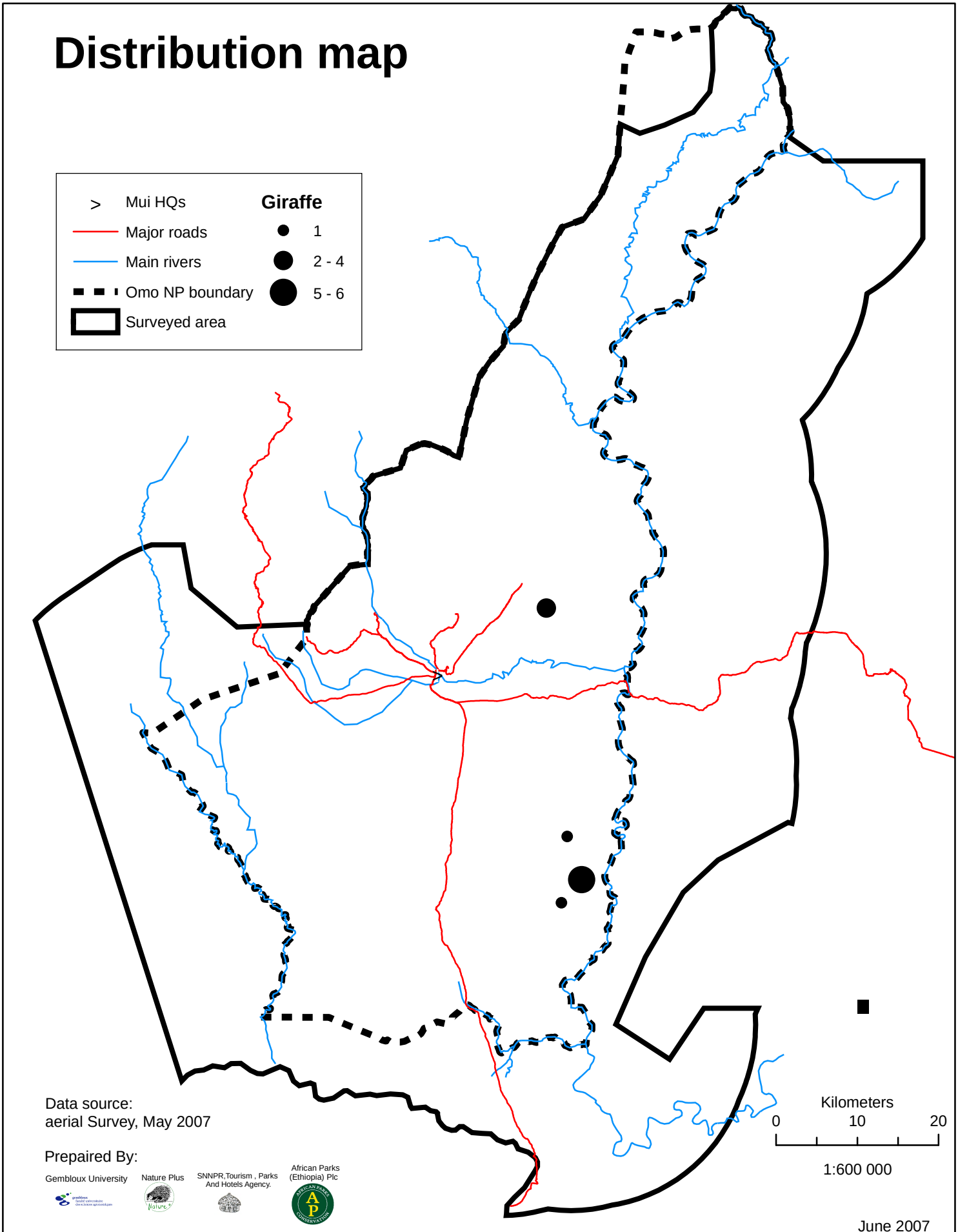

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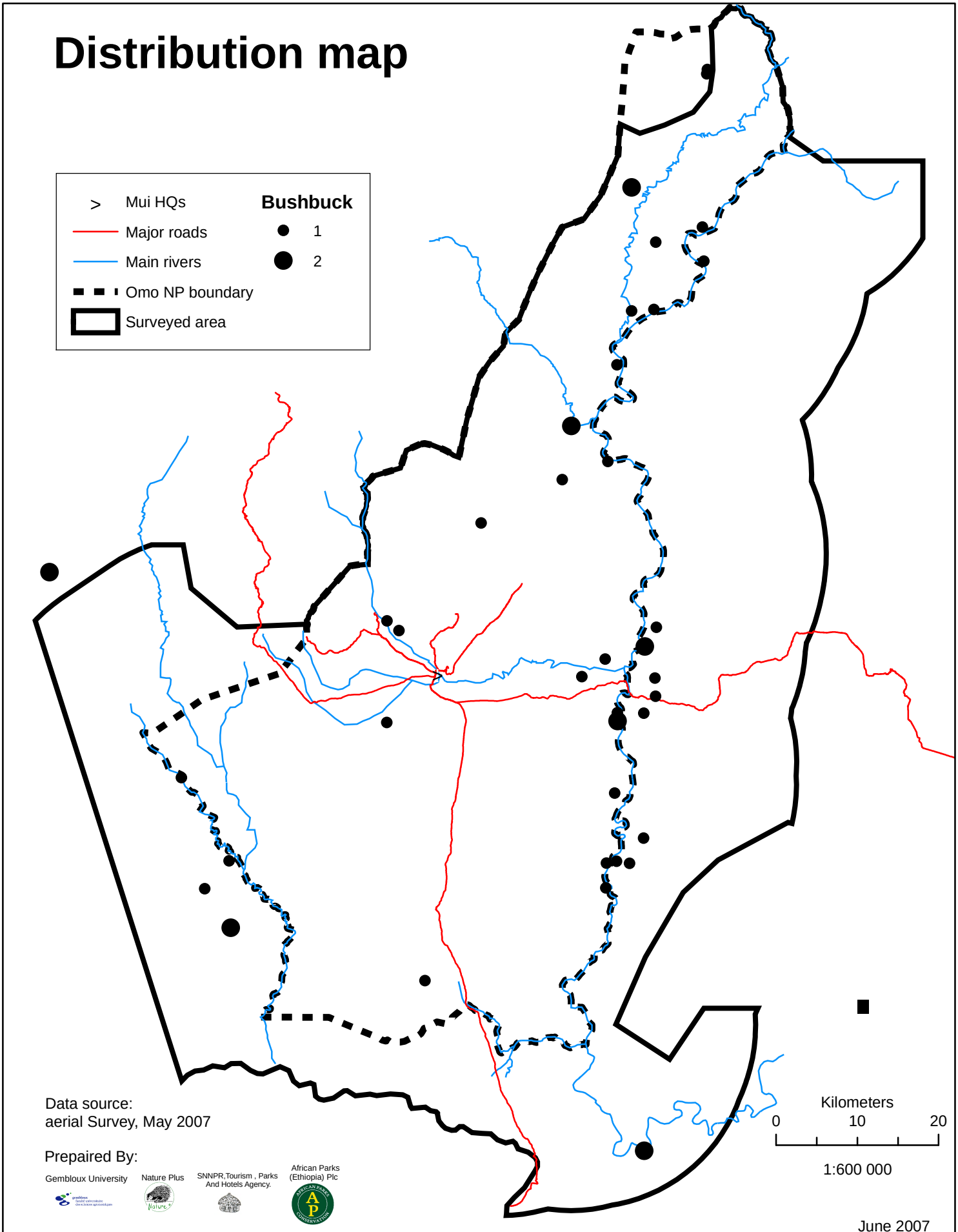

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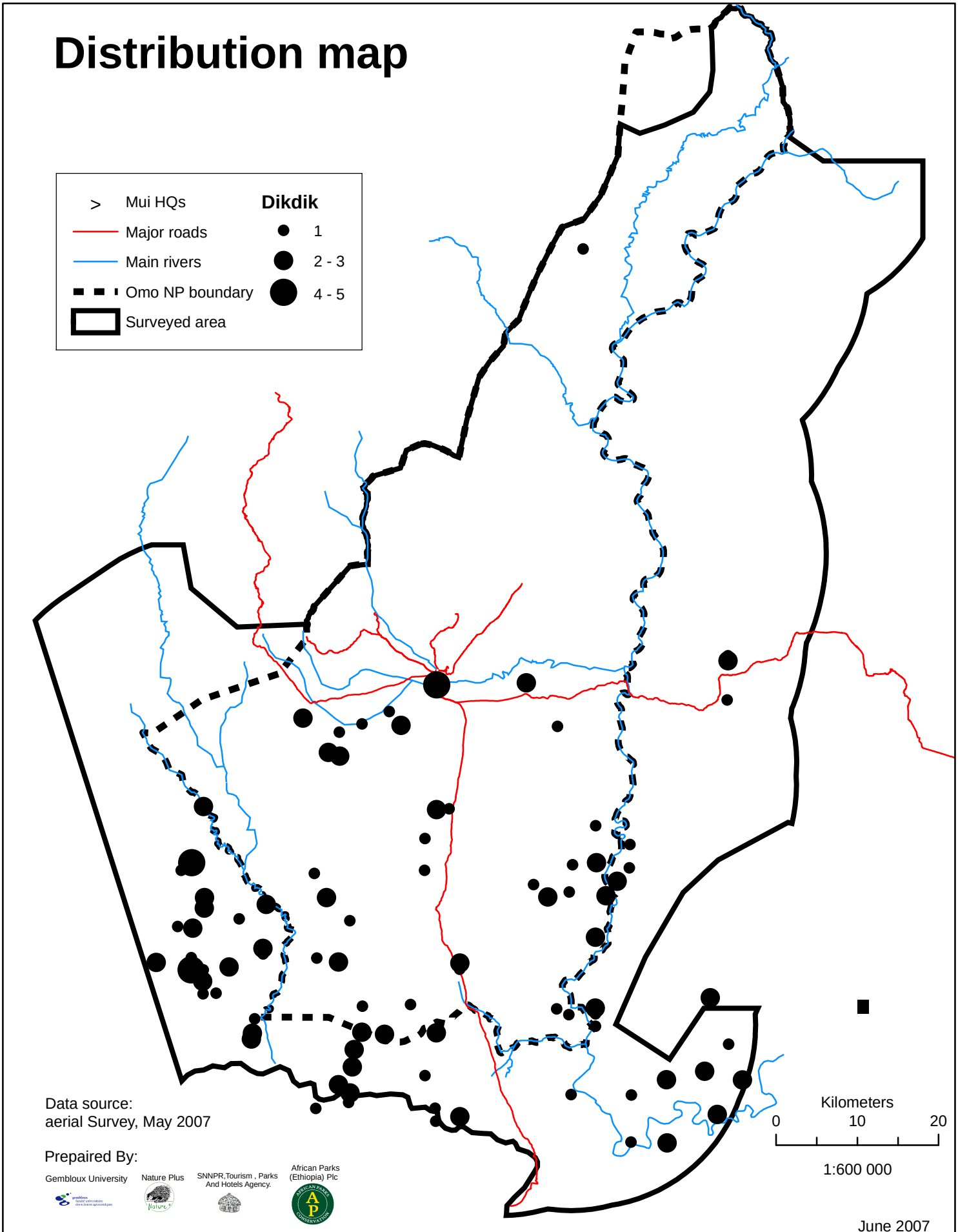

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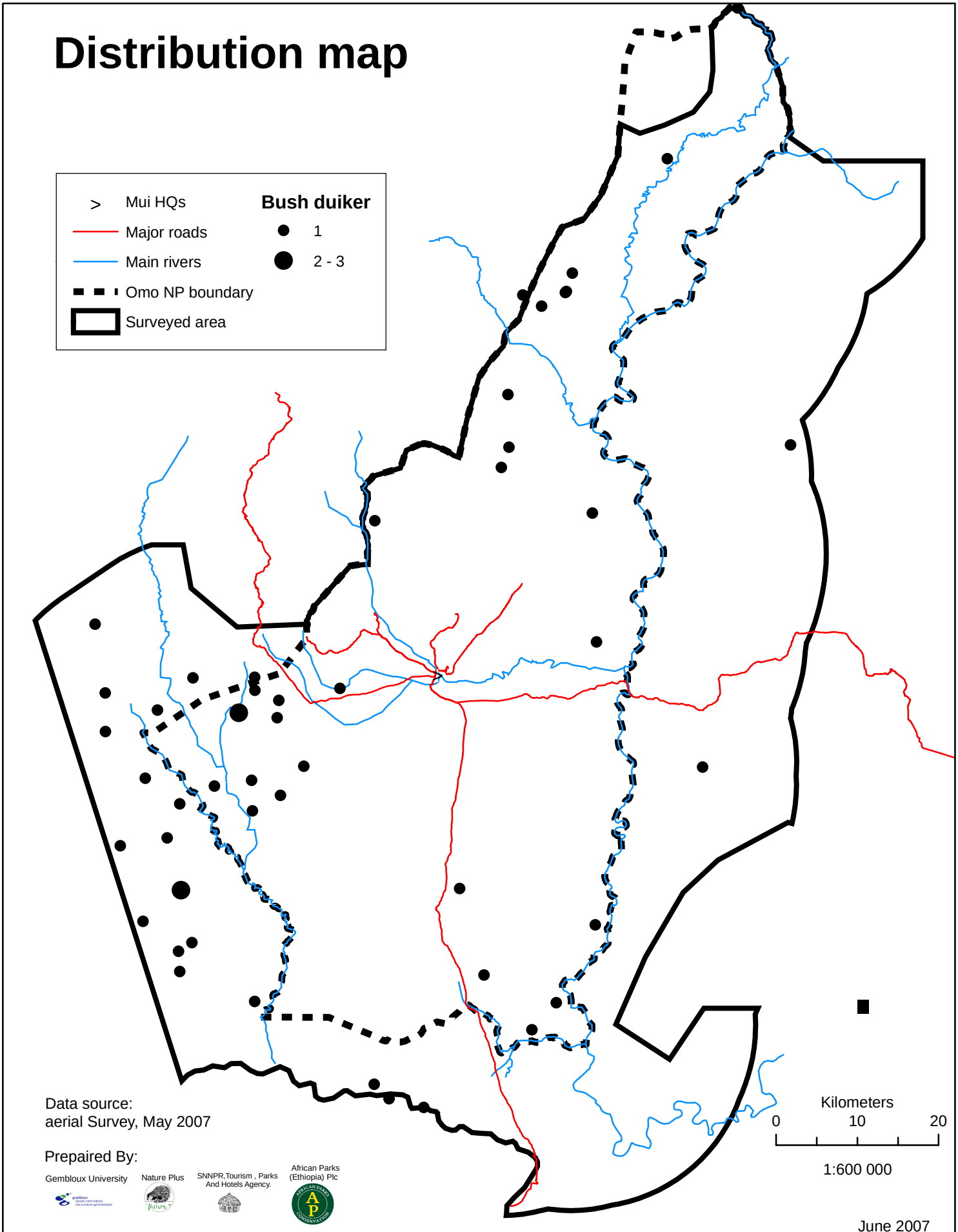

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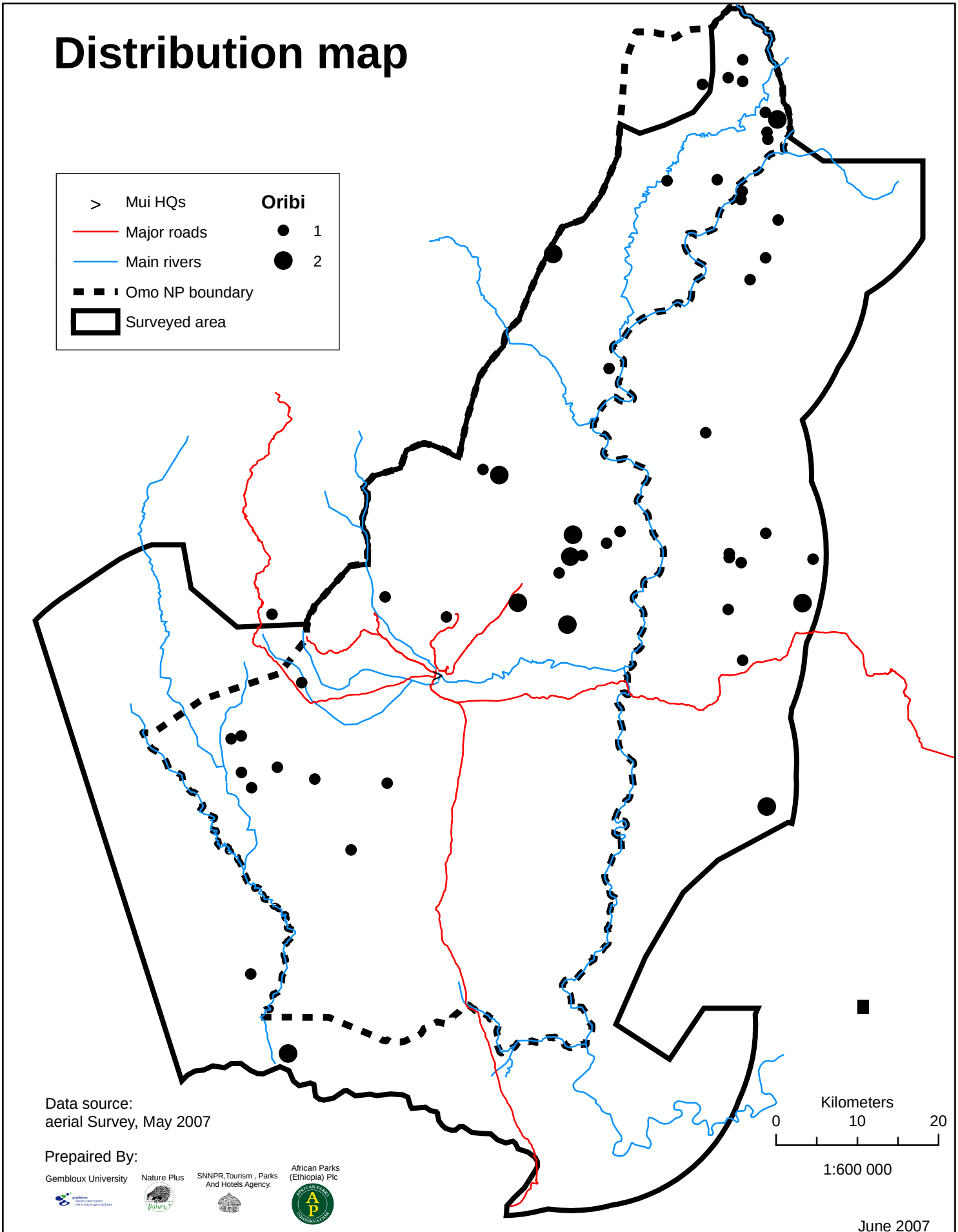

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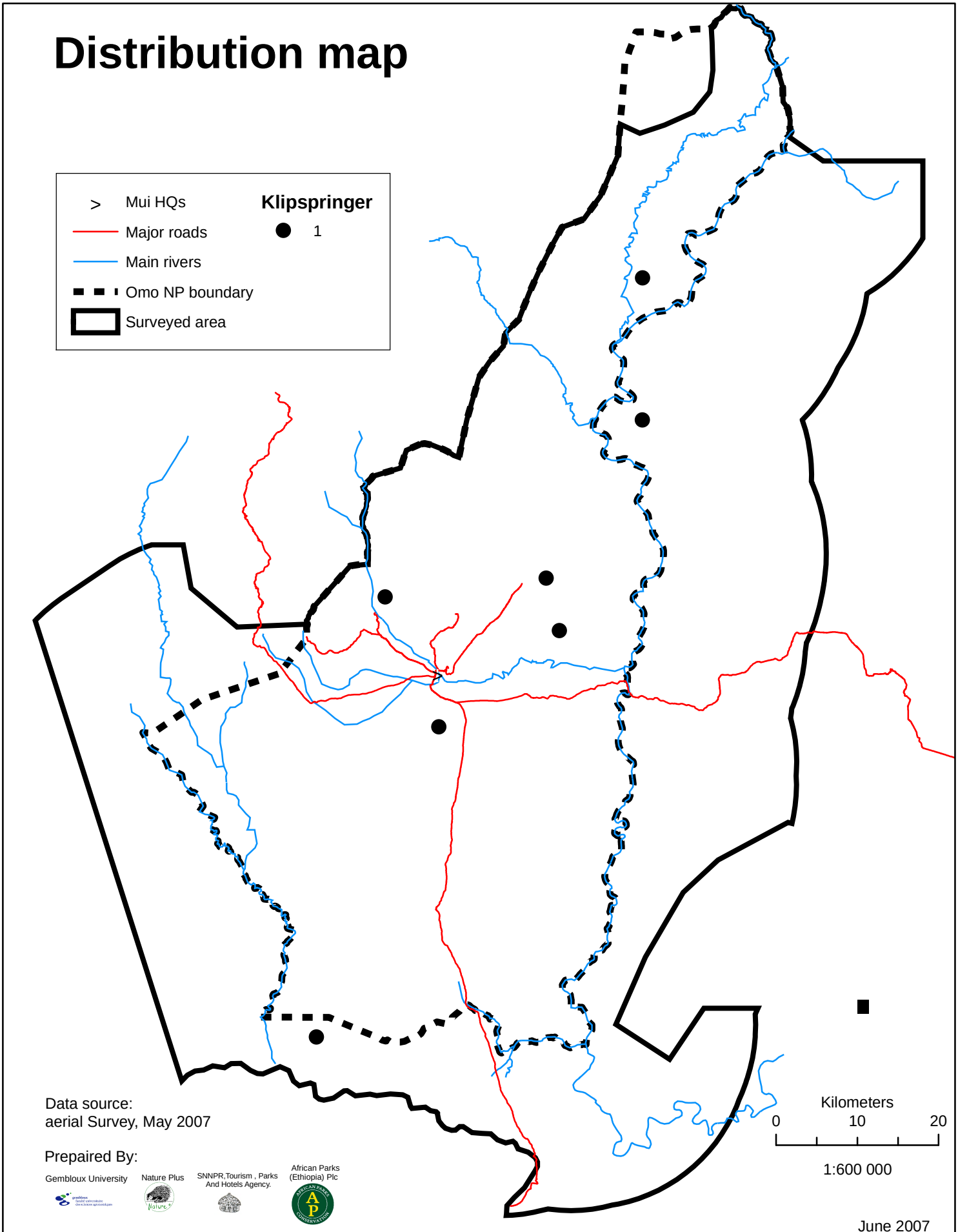

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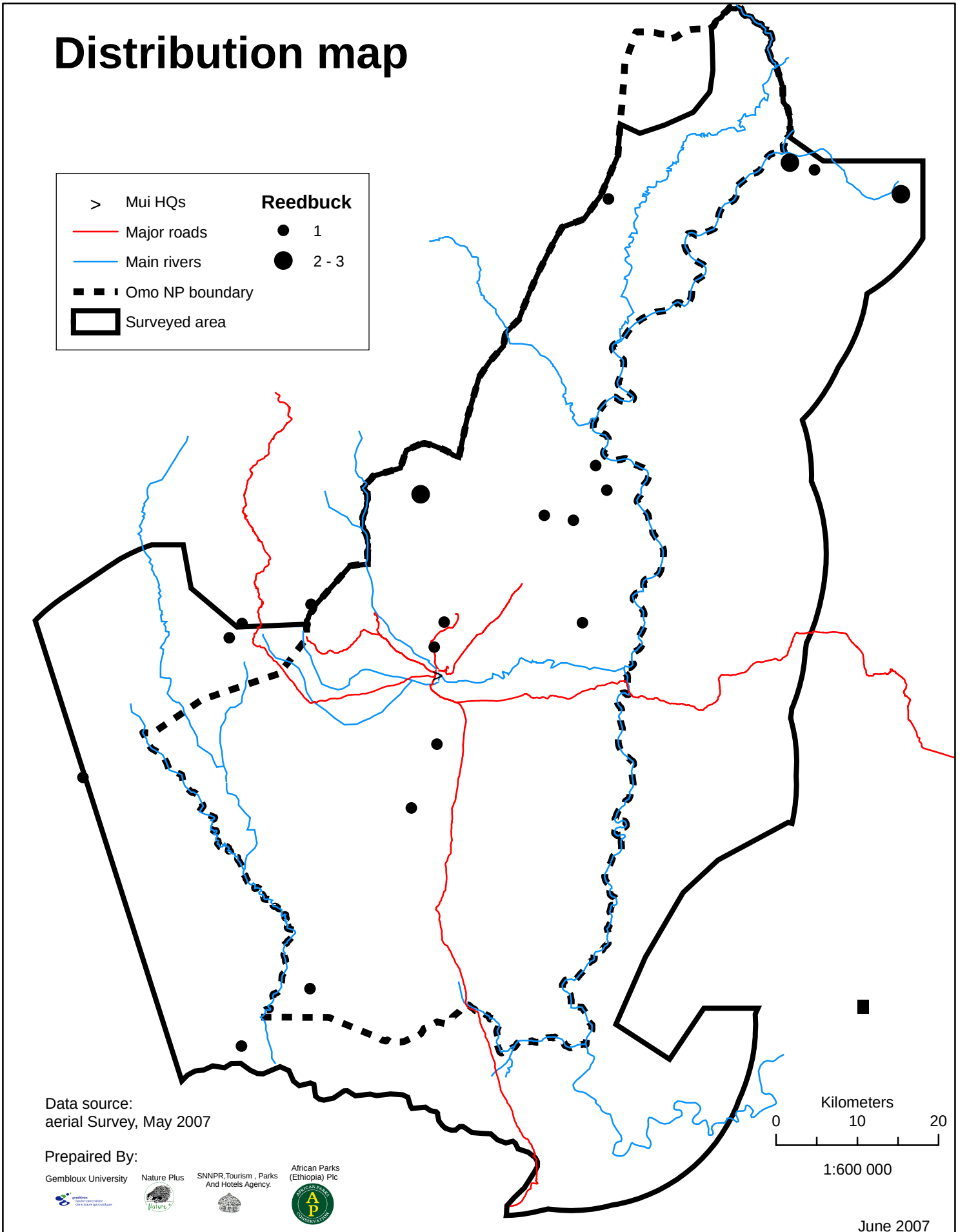

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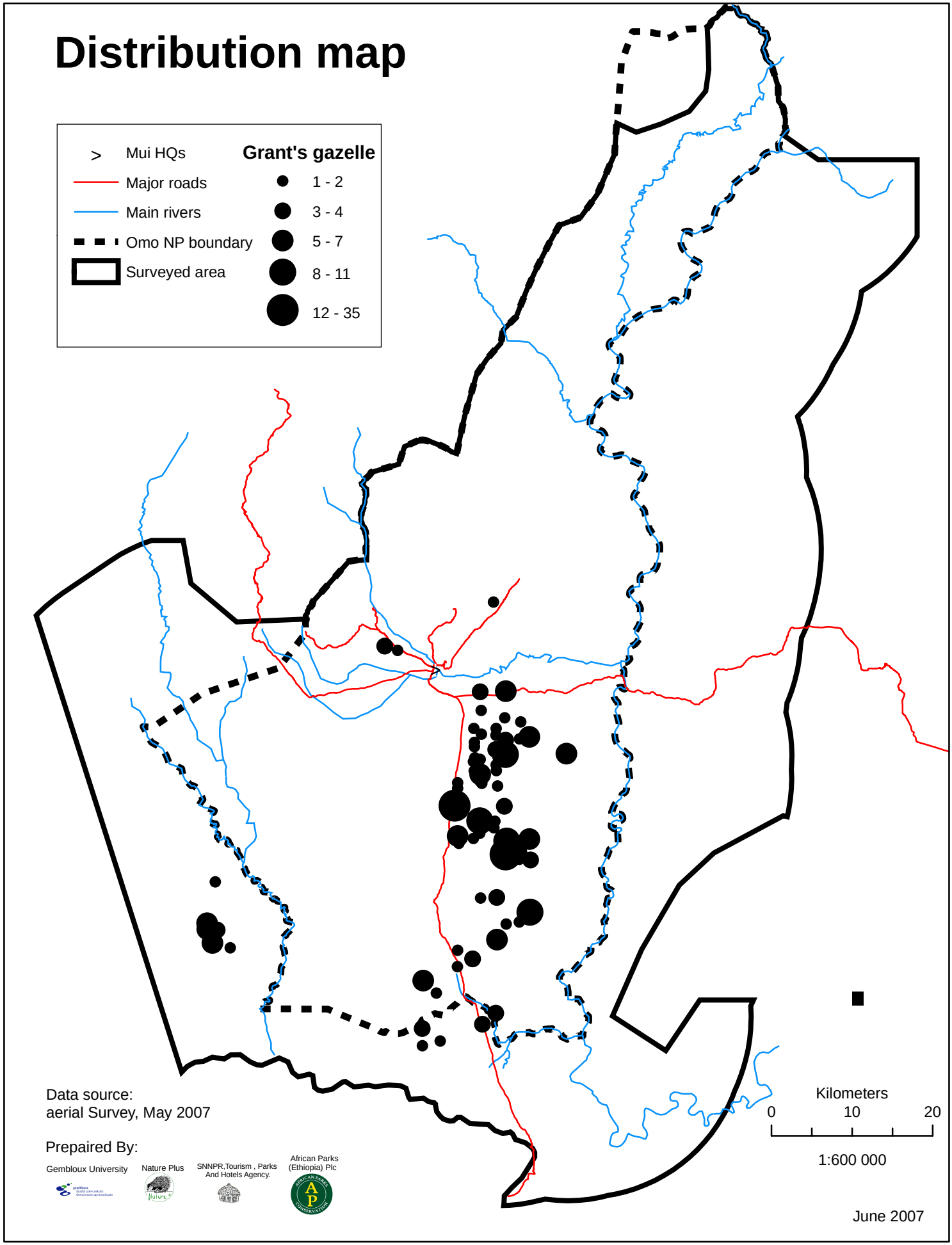

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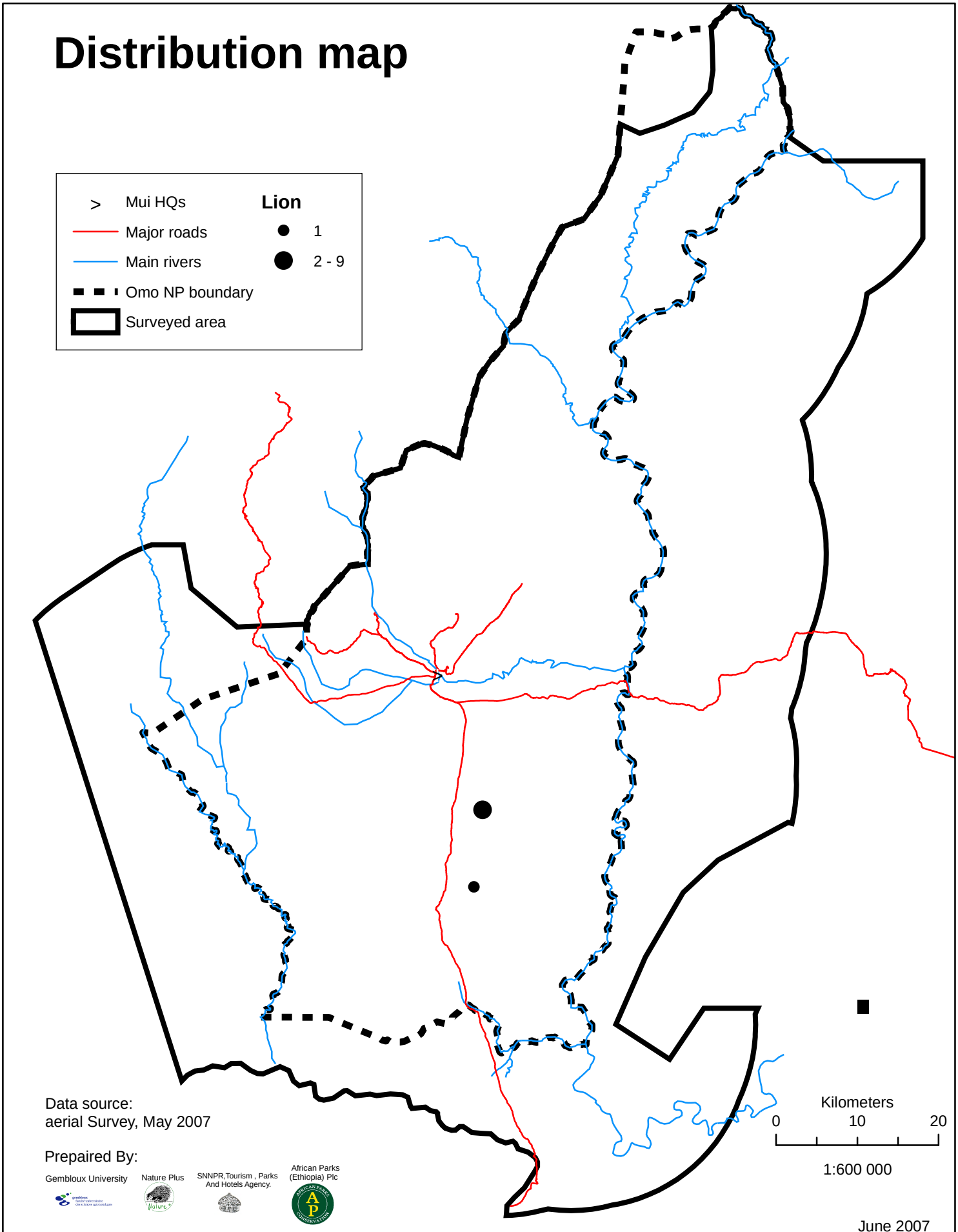

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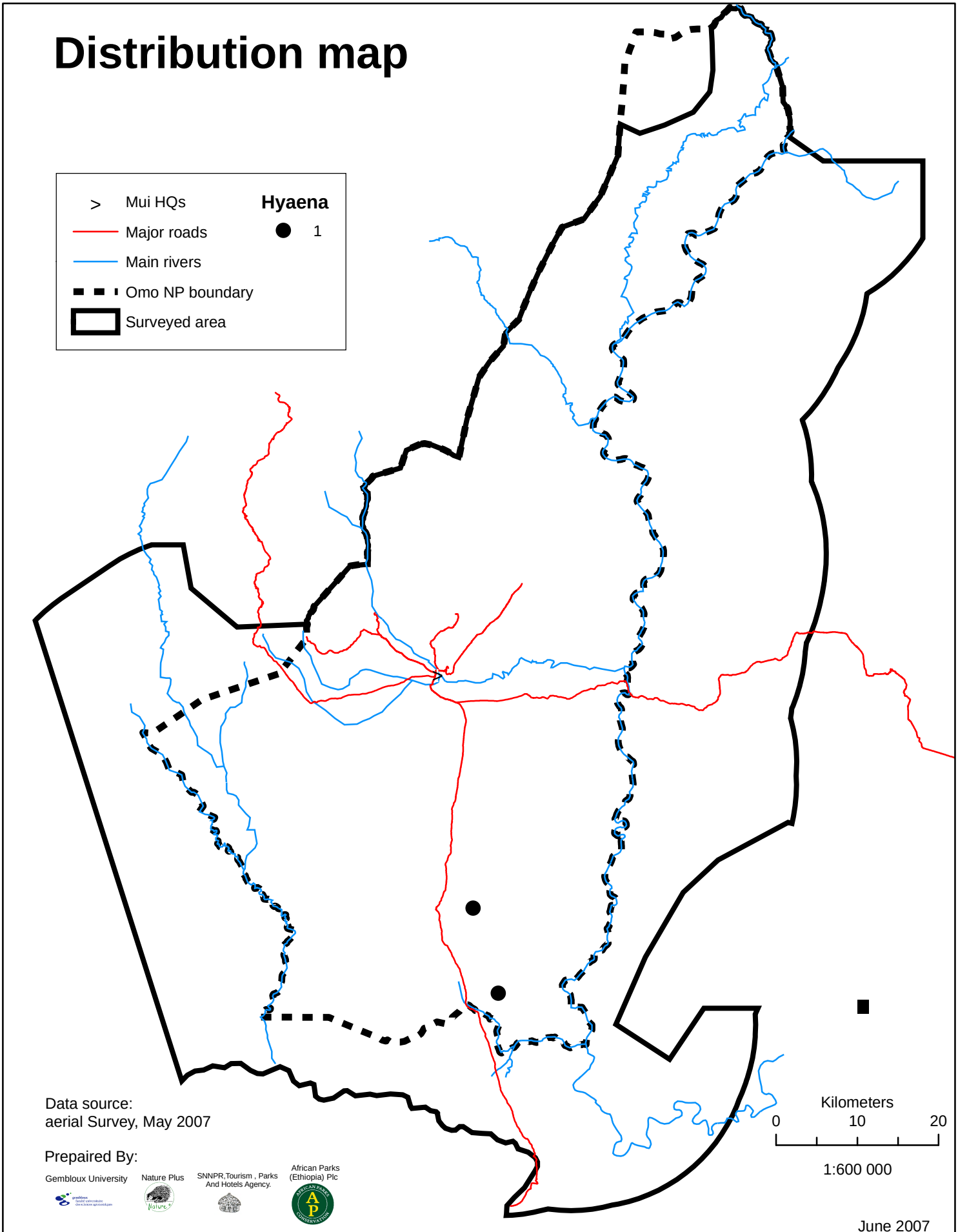

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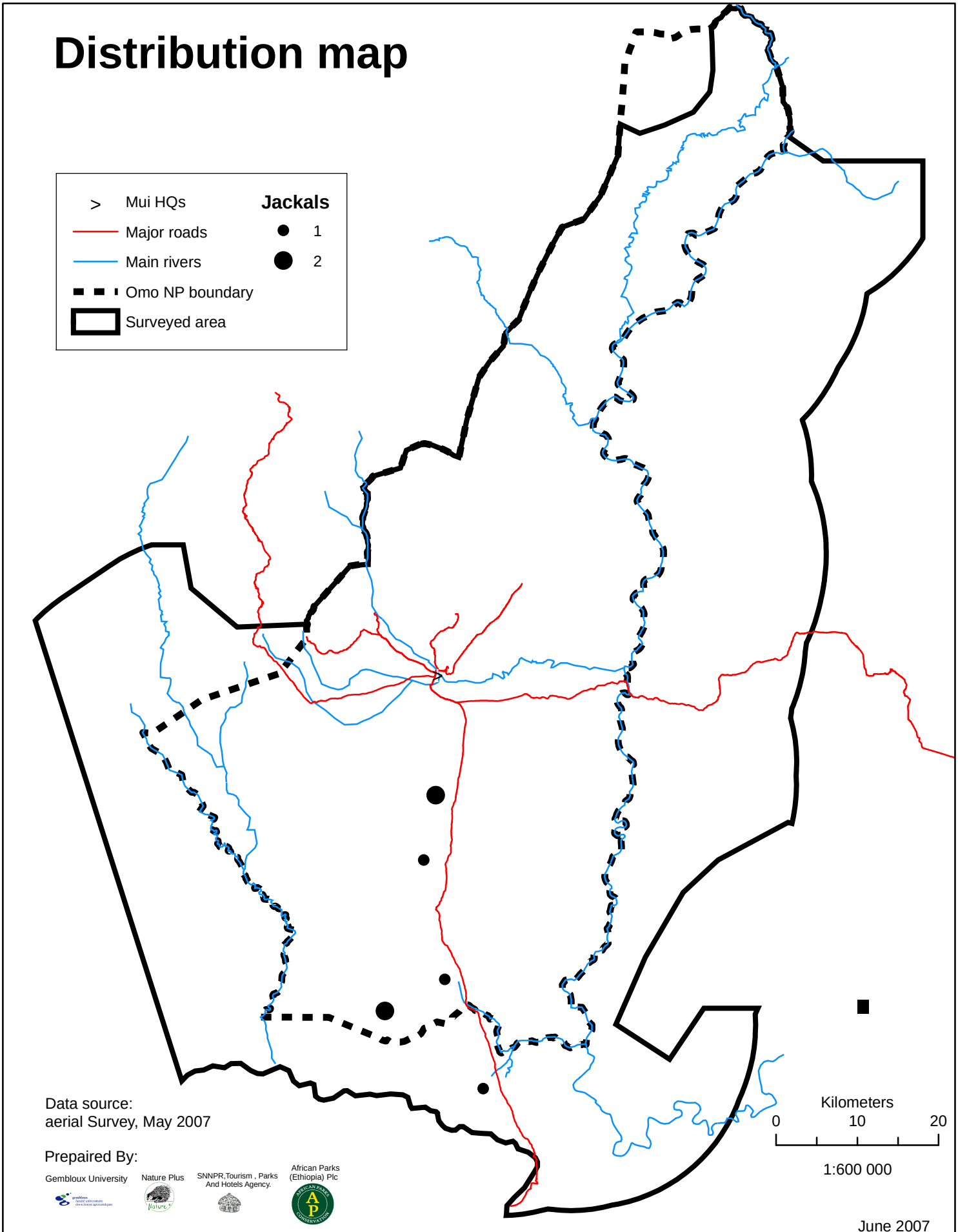

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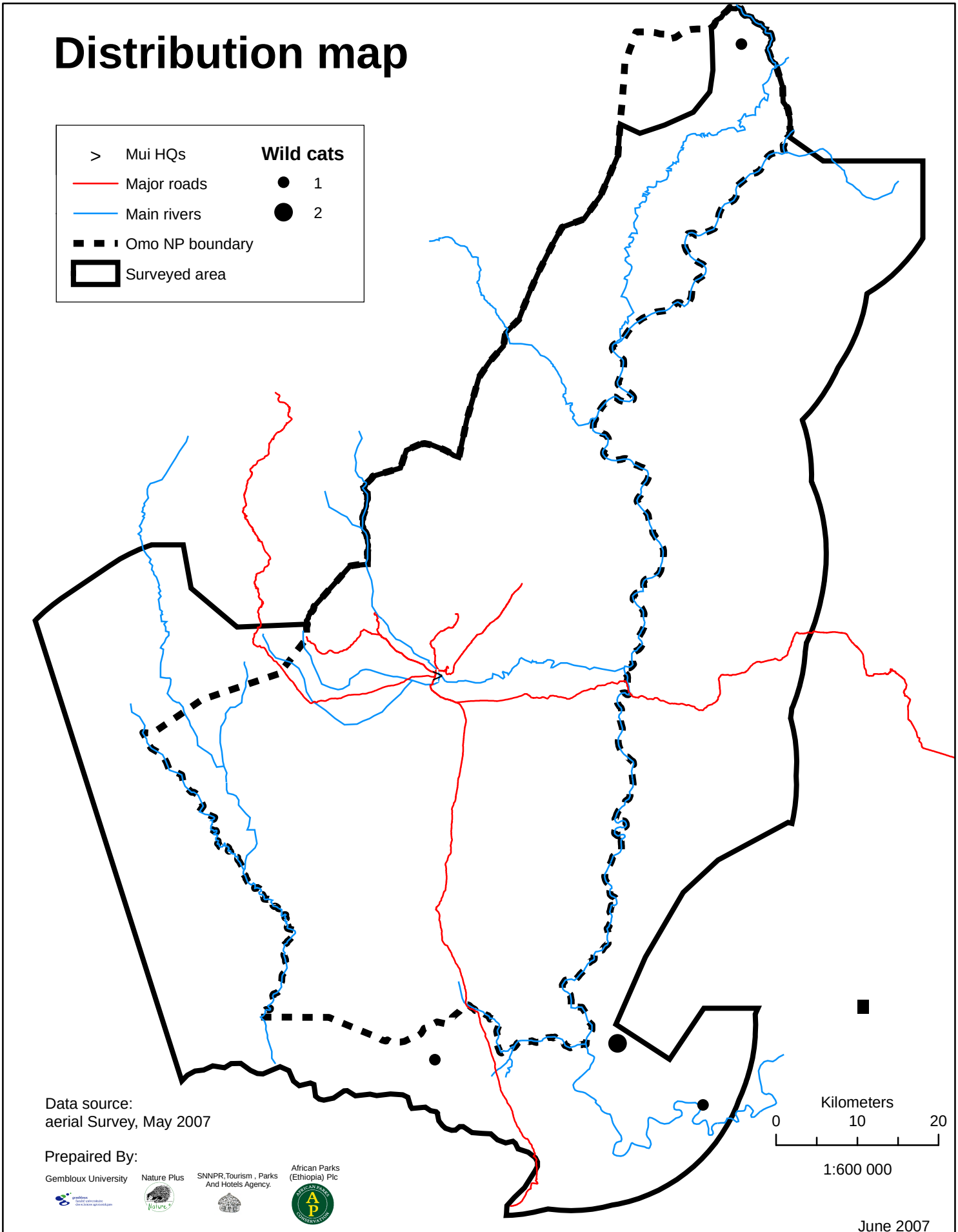

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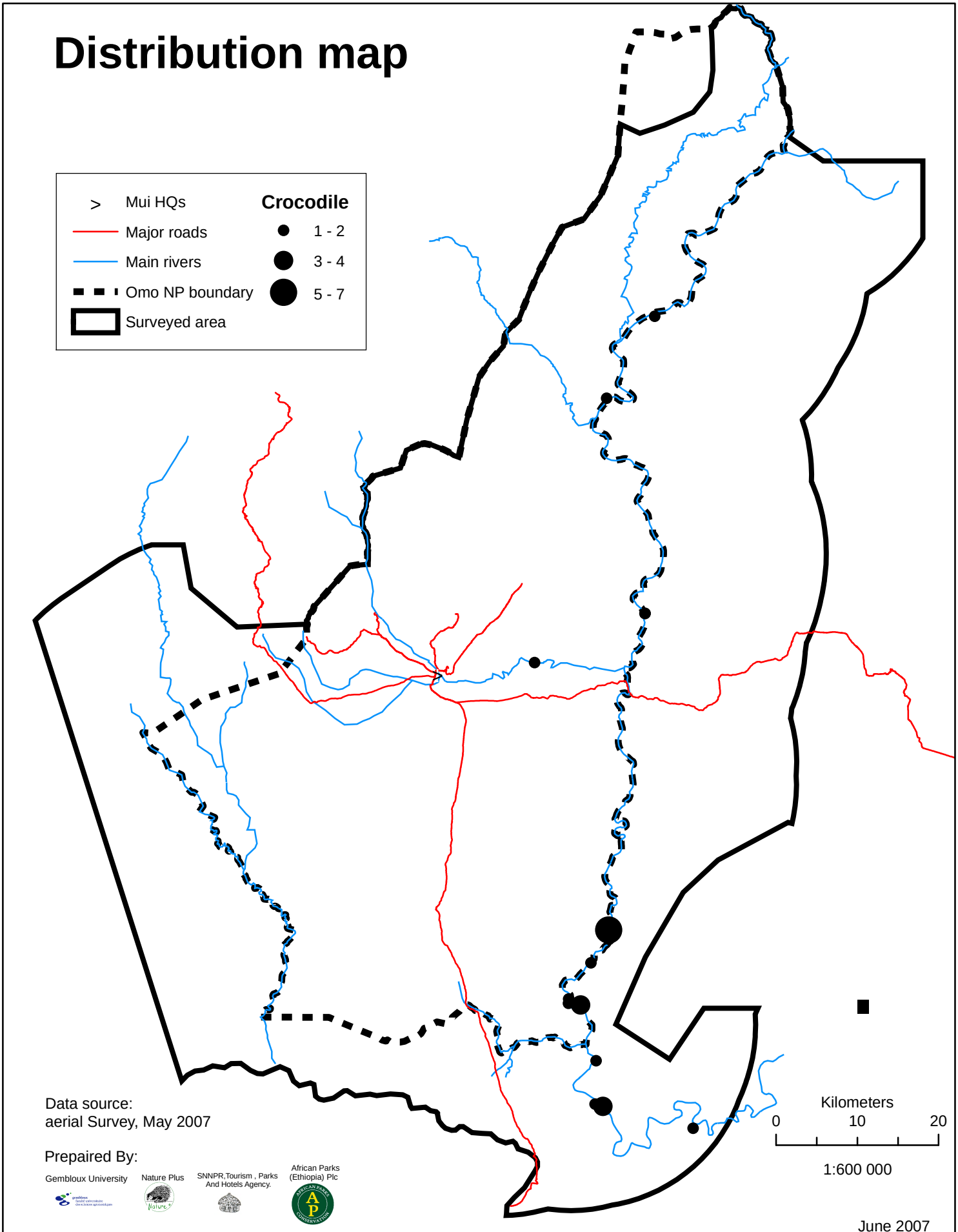

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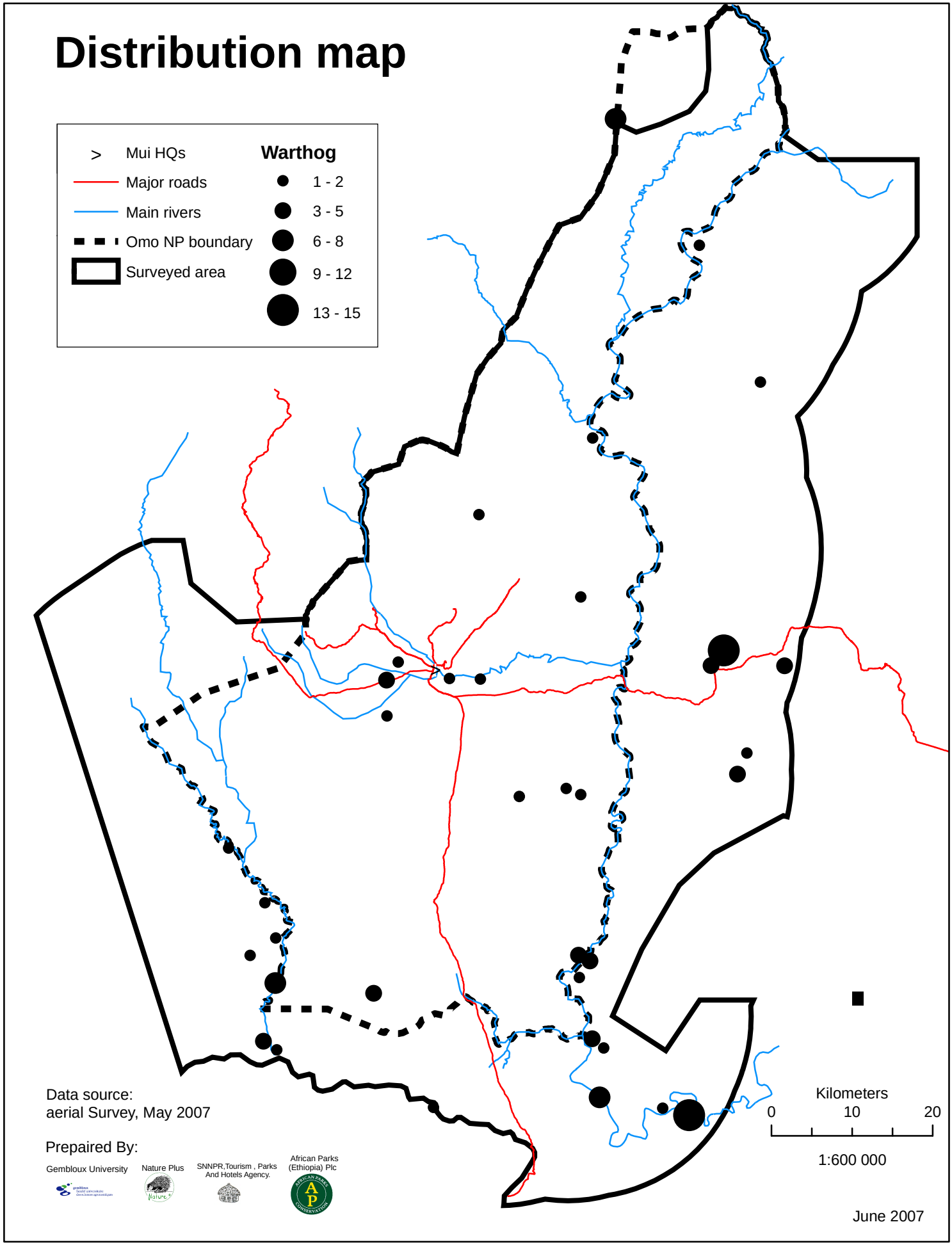

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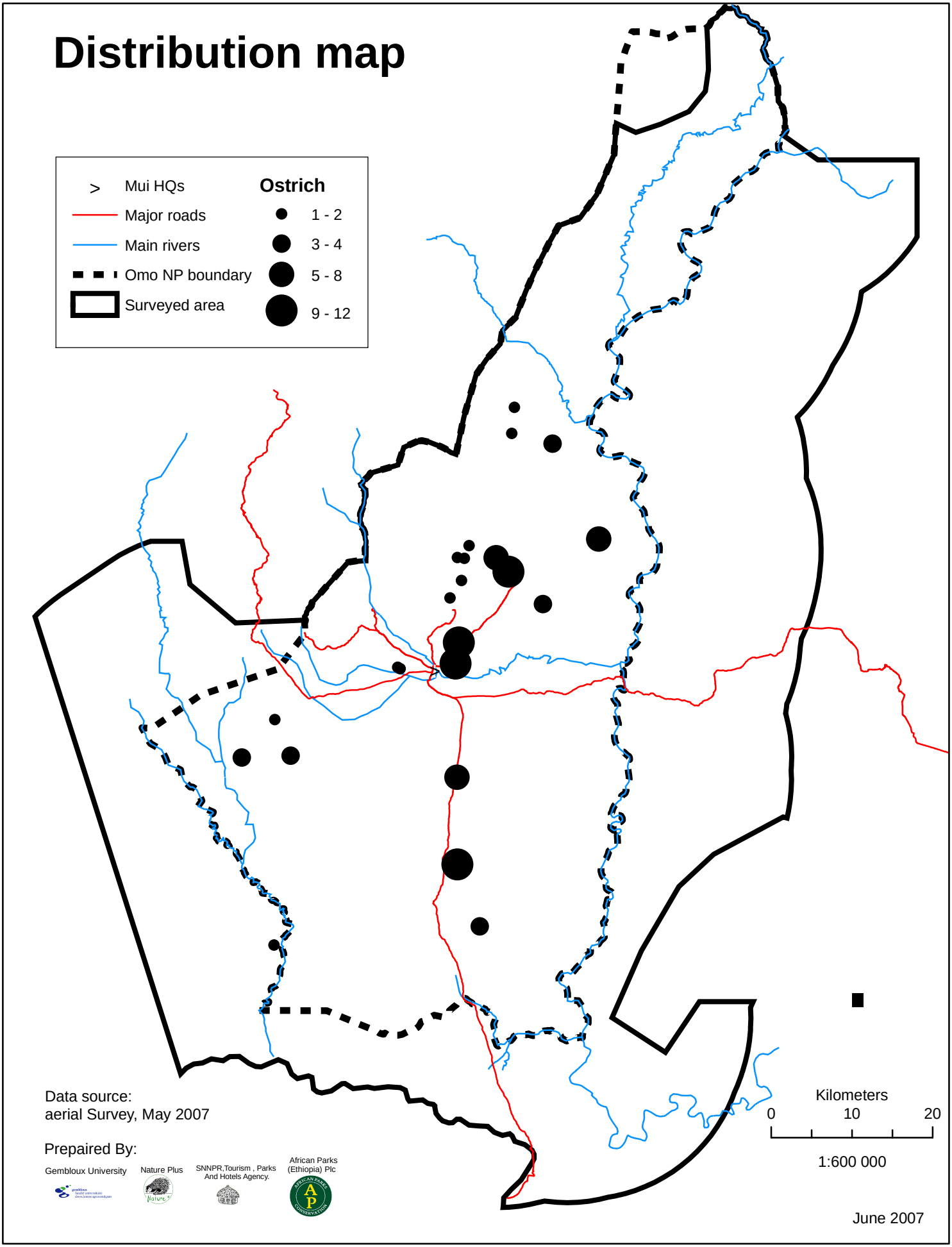

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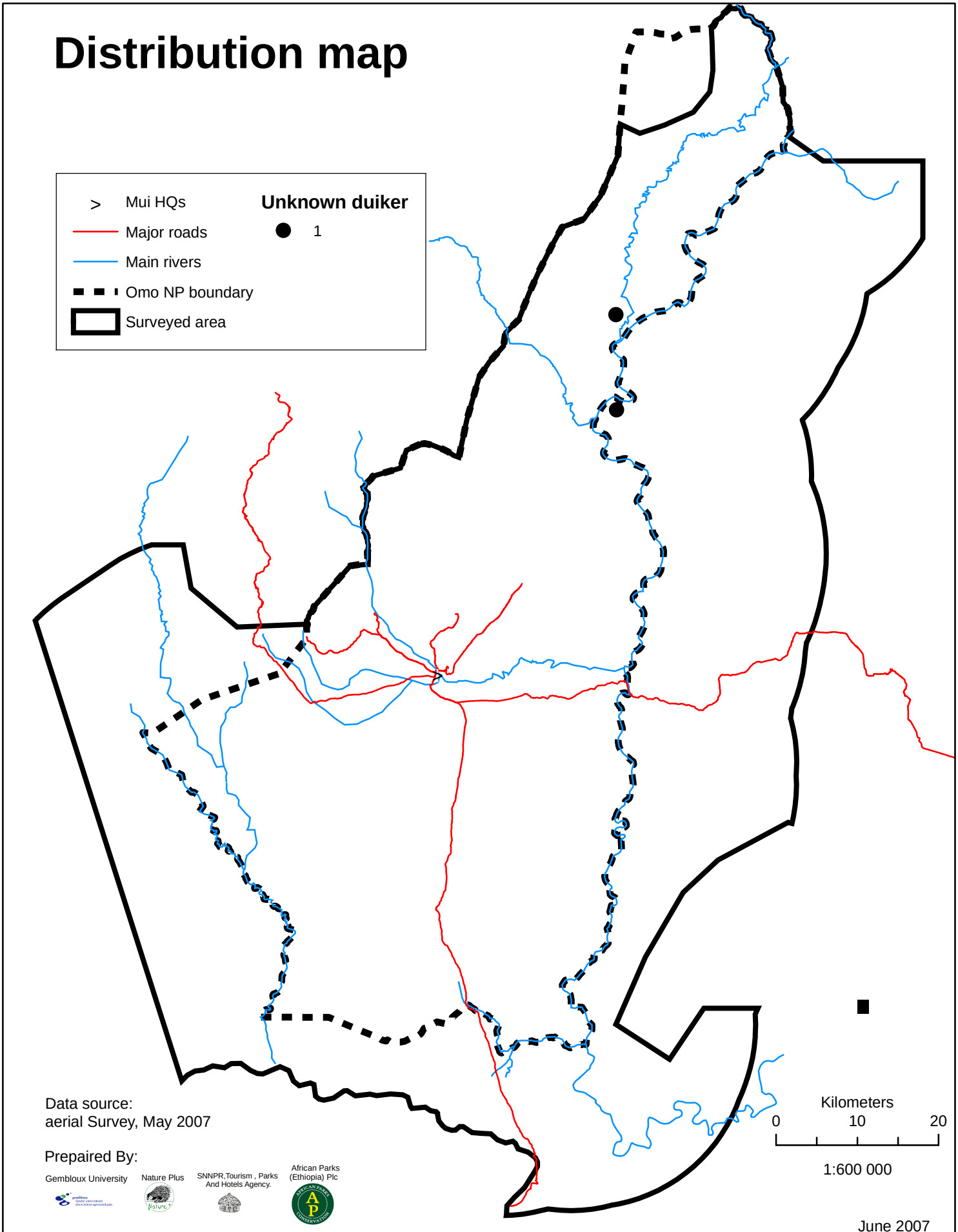
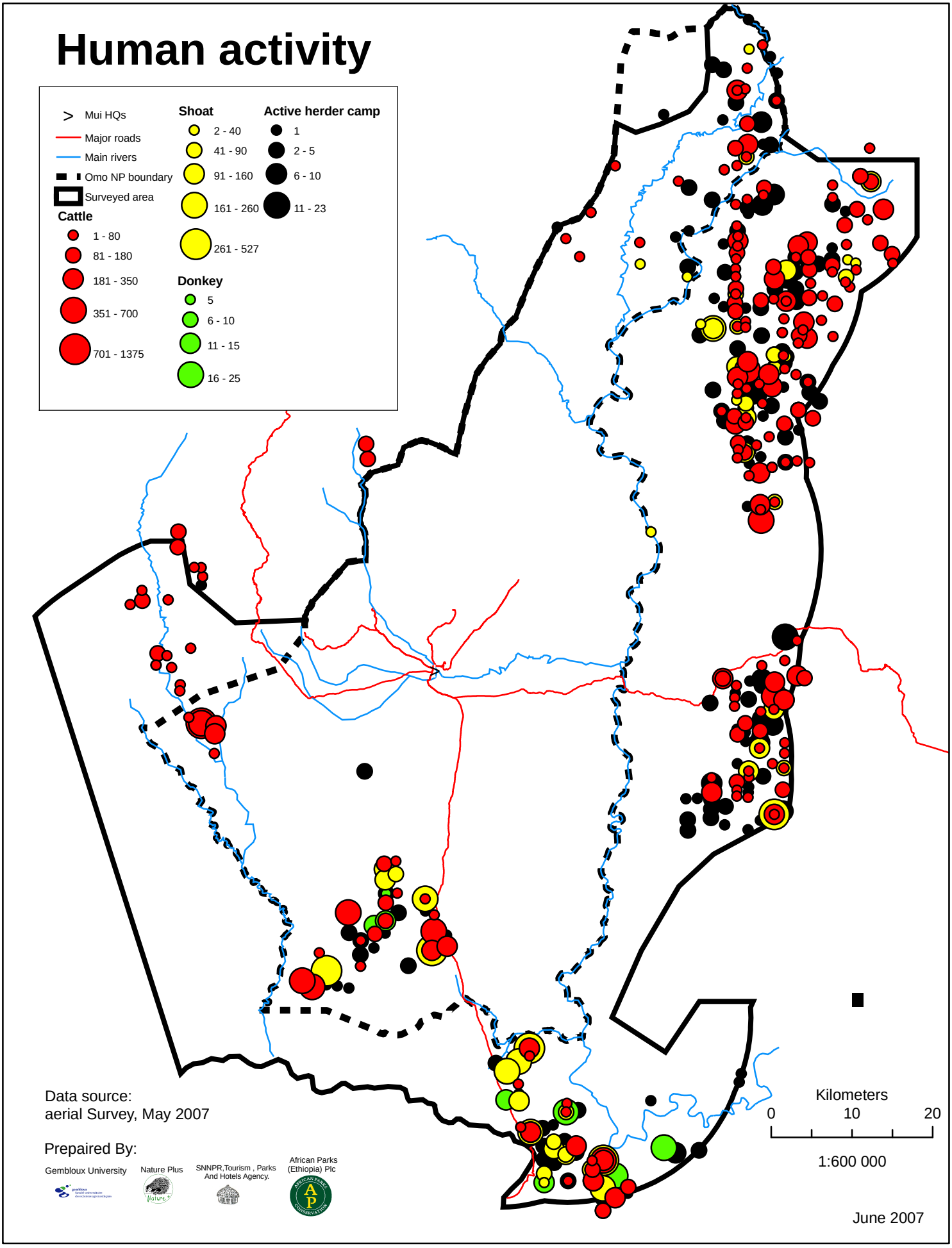


Human activity



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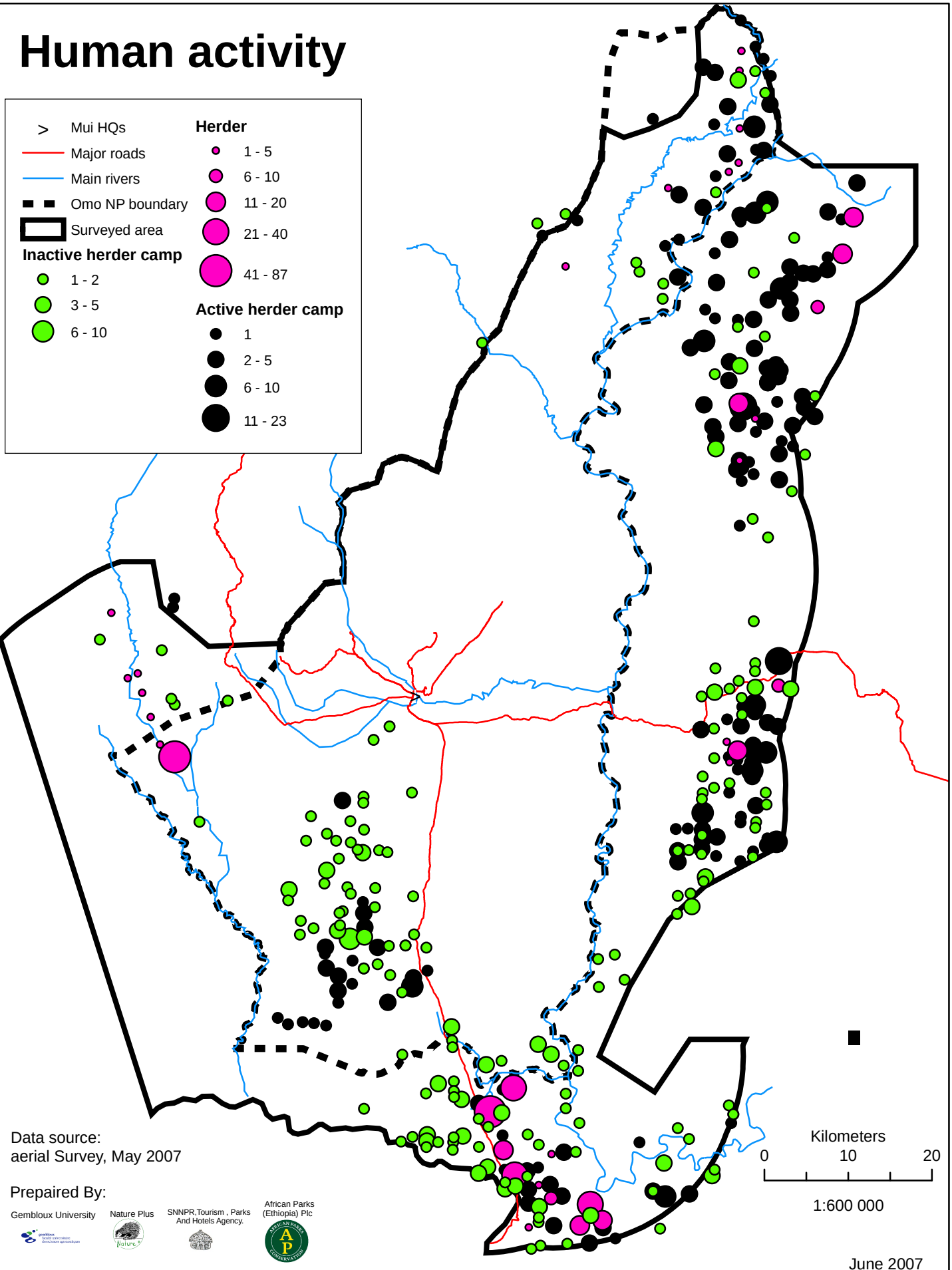

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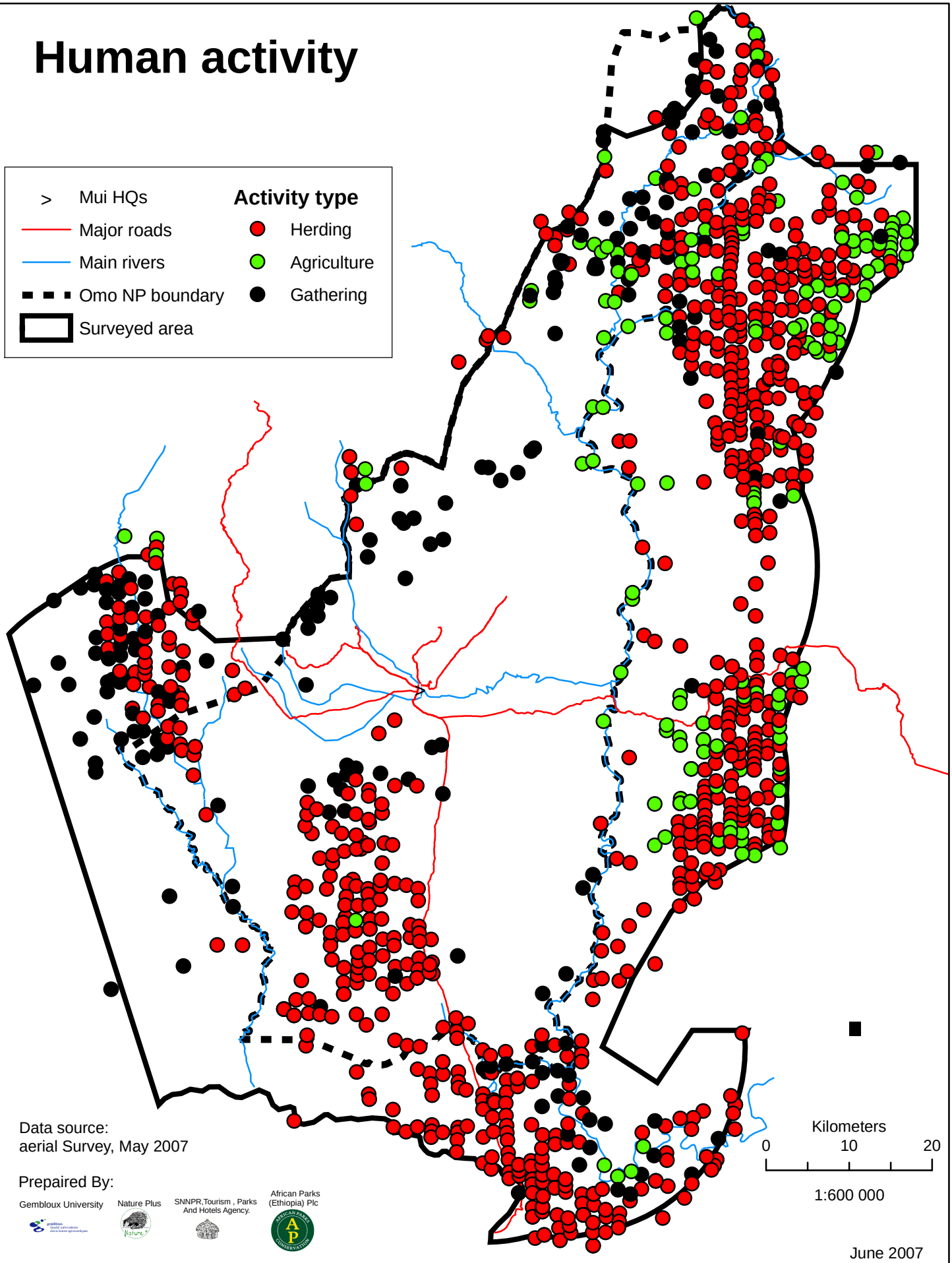

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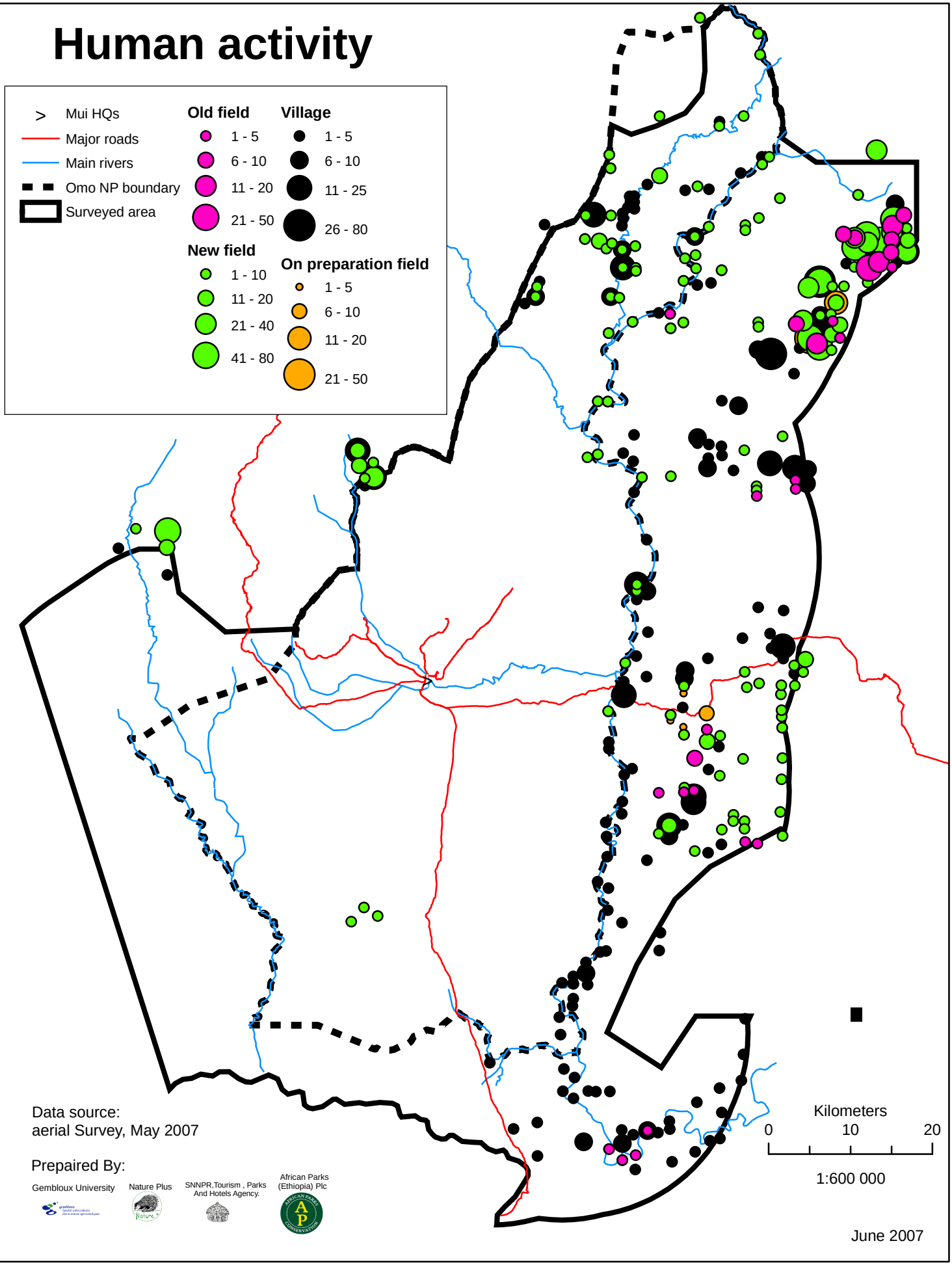

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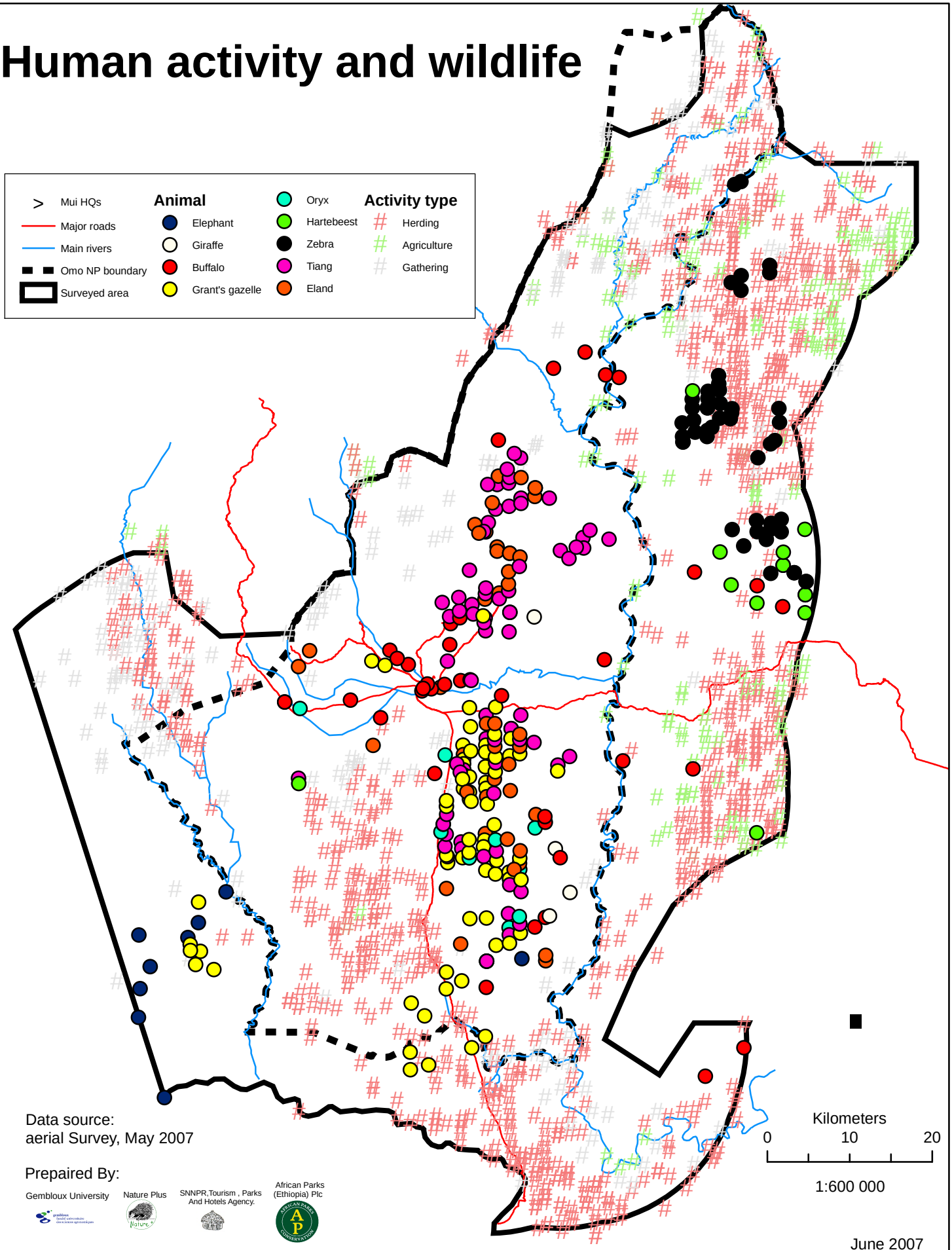
Human activity and wildlife



Human activity