Zoning planning for the

Itombwe Natural Reserve

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Executive Summary

This report makes an assessment of the boundary delimitation and proposed draft zoning plan for the Itombwe Reserve, Democratic Republic of Congo and compares it with recent biodiversity information generated by the Wildlife Conservation Society for this massif. By modeling the distribution of species that are threatened (IUCN Redlist: CR, EN or VU) or endemic to the Albertine Rift we generate maps of the areas of importance for conservation of large and small mammals, birds, amphibians and plants. We also compile sightings of large mammals that have been made over the past 15 years by WCS surveys to assess important areas for this group.

The report identifies three key areas which are important for conservation and yet which have been omitted from the current zoning plans. One area in particular in the north east of the reserve is likely to be so important that it deserves a separate *Core Protected Area* designation as it contains at least 20 endemic or threatened species (IUCN red listed as CR, EN or VU) that are likely to only occur here and nowhere else in the Reserve. Whether this can be achieved will depend on the local community and how settled this area is currently but we propose this here as an objective to try and aim for. Two other areas are important for great apes and elephants respectively.

We propose Land Use Zones that should be discussed with local communities for zoning the *Sustainable Use Zone* that has been proposed. If planned well this land use zoning could help create important corridor areas or larger blocks of habitat for species conservation, particularly if zones are developed which have minimal impact on the habitat such as *Sustainable Hunting Zones*. We also define what activities might be allowed in these zones. It is important that there is agreement on such zones before the local communities are approached so that the zoning plan for the reserve doesn't contain a large number of differing zones because different zoning systems have been proposed in different villages.

We propose next steps in the process that require agreement between the conservation partners on the *Land Use Zones* and then testing of these zones with selected villages to allow changes to be made before moving ahead with the full zoning plan.

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Acknowledgements

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Introduction

The Itombwe Natural reserve in the East of the Democratic Republic of Congo (DRC) is one of the most important sites in the Albertine Rift for biodiversity conservation. The Albertine Rift has more endemic and threatened vertebrate species than any other ecoregion in Africa and as a result is recognized as part of the Eastern Afromontane Biodiversity hotspot (Plumptre *et al.* 2004, 2007). This makes Itombwe massif one of the richest sites in Africa and also the World and it is therefore critical that conservation efforts here try to ensure the conservation of all the endemic and threatened species to be found here. Previous work has highlighted the global importance of Itombwe for species conservation (Prigogine 1971-84; 1985; Wilson & Catsis, 1990; Omari *et al.* 1999) and in particular amphibian conservation (Laurent, 1964; Evans *et al.* 2008; Greenbaum & Kusamba 2012).

Itombwe has several species that are unique to this massif; notably the Itombwe nightjar (*Caprimulgus prigoginei*), Itombwe Puddle Frog (*Phrynobatrachus asper*), Itombwe Golden frog (*Chrysobatrachus cupreonitens*) and Itombwe clawed toad (*Xenopus itombwensis*). Additional species have been sighted here and only at one other site outside this massif: the Congo bay owl (*Phodilus prigoginei*), and at least four amphibian species. The massif is known to be rich in species and surveys by the Wildlife Conservation Society (WCS) together with Centre de Recherche en Sciences Naturelles (CRSN), The Chicago Field Museum and the Trento Science Museum are discovering several new species, particularly new amphibians and possibly reptiles also. These are in the process of being examined and described.

The Itombwe process has generated different maps (scenarios) since 2006 as data and meetings with stakeholders were carried out. The current scenario V (Figure1) shows the main settlements in and around Itombwe reserve.

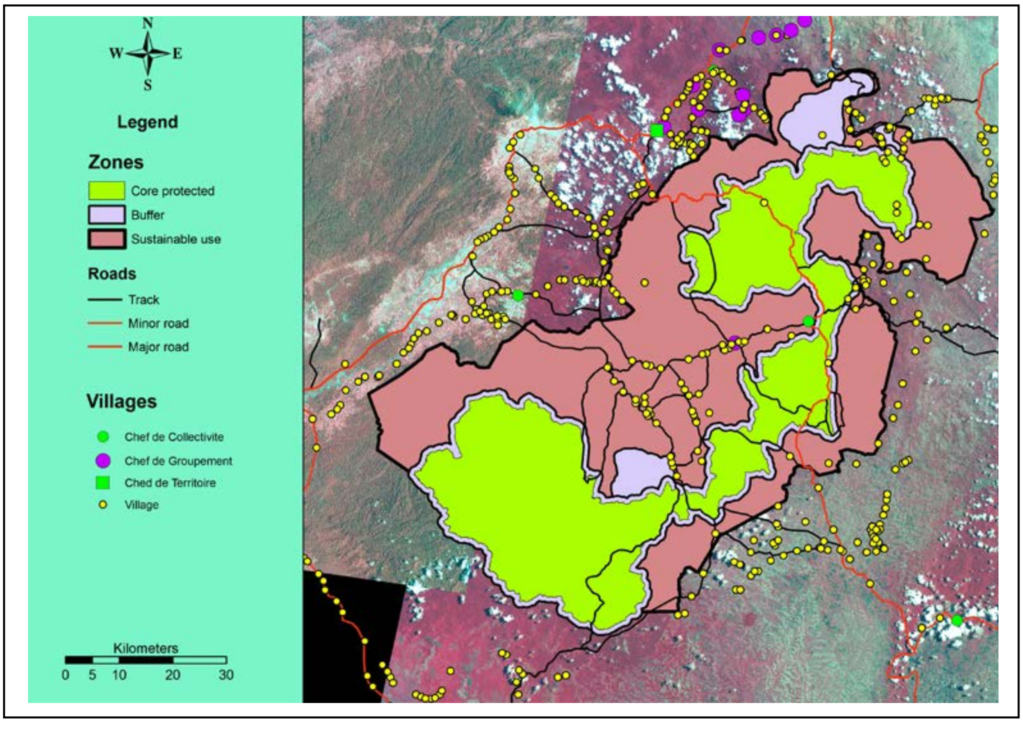


Figure 1. The Proposed Itombwe Reserve (Scenario V) with the location of human settlements and roads/tracks.

Thirty three threatened vertebrate species are known from the Itombwe Massif (table 1). Most reptiles have not been assessed yet by the IUCN redlist and so no threatened species are listed for the massif.

Table 1. List of known threatened vertebrate species for the Itombwe massif

Mammals

1. Chimpanzee (*Pan troglodytes*) EN
2. Grauer's gorilla (*Gorilla beringei graueri*) EN
3. Red Colobus (*Procolobus rufomitratus*) EN
4. Rahm's Brush Furred Rat (*Lophuromys rahmi*) EN
5. L'hoest's monkey (*Cercopithecus lhoesti*) VU
6. African Spot-necked Otter (*Lutra maculicollis*) VU
7. African Elephant (*Loxodonta africana*) VU
8. Schaller's Mouse Shrew (*Myosorex schalleri*) DD*
9. Grauer's Montane Shrew (*Paracrocidura graueri*) DD*

Birds

10. Congo Bay Owl (*Phodilus prigoginei*) EN *
11. Itombwe Nightjar (*Caprimulgus prigoginei*) EN *
12. Yellow-crested Helmet Shrike (*Prionops alberti*) VU *
13. Albertine Owlet (*Glaucidium albertinum*) VU *
14. African Green Broadbill (*Pseudocalyptomena graueri*) VU*
15. Rockefeller's Sunbird (*Nectarinia rockefelleri*) VU*
16. Shelley's Crimson-wing (*Cryptospiza shelleyi*) VU*

Amphibians

17. Itombwe massif clawed frog (*Xenopus itombwensis*) CR*
18. Luvubu Reed Frog (*Hyperolius leleupi*) EN*
19. White-striped Reed Frog (*Hyperolius leucotaenius)* EN*
20. Painted African Frog (*Callixalus pictus*) VU*
21. Ahl's Reed Frog (*Hyperolius castaneus*) VU*
22. Goldbelly Reed Frog (*Hyperolius chrysogaster*) VU*
23. Rugegewald River Frog (*Phrynobatrachus acutirostris*) VU*
24. Visoke River Frog (*Phrynobatrachus bequaerti*) VU*
25. Rwanda River Frog (*Phrynobatrachus versicolor*) VU*
26. Itombwe Screeching Frog (*Arthroleptis hematogaster*) Data deficient*
27. Mwana Screeching Frog (*Arthroleptis vercammeni*) Data deficient*
28. Mukuzira Long-fingered Frog (*Cardioglossa cyaneospila*) Data deficient*
29. Itombwe Golden Frog (*Chrysobatrachus cupreonitens*) Data deficient*
30. No common name (*Hyperolius diaphanous*) Data deficient*
31. Mokanga Forest Treefrog (*Leptopelis fiziensis*) Data deficient
32. Itombwe Puddle Frog (*Phrynobatrachus asper*) Data deficient*

* = Endemic species to Albertine Rift

In addition the Itombwe duiker (*Cephalophus hypoxanthus*) has been proposed as a separate species by Groves and Grubb (2011) separating it from Weyn's duiker. If accepted this duiker would be a species confined to the Itombwe massif. Several plant species are also likely to be unique to the massif but we have not compiled all the data yet on these species.

It is clear therefore that Itombwe is an important site for the conservation of threatened species and therefore conservation planning for the site should aim to ensure the long term conservation of these species. Itombwe is being established with the local communities as a Natural Reserve and will contain many people within its boundaries. It is therefore critical that a zoning approach is used to identify and conserve areas important for wildlife conservation as as well as areas important for the improvement of the livelihoods of the people living within the reserve. This report aims to assess how zoning should be undertaken in the reserve to ensure that the conservation and livelihood needs are both met.

Zoning of protected areas

The International Union for the Conservation of Nature (IUCN) identifies six main types of protected area (Table 2) and Itombwe will fall within one of the last two categories (Dudley & Stolton, 2008). Category V is defined as *a protected area where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.* Category VI sites are *protected areas that conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area* (Dudley, 2008). In a comparison of the two categories Dudley (2008) suggests that *Category V applies to areas where landscapes have been transformed as a result of long-term interactions with humans; category VI areas remain as predominantly natural ecosystems. The emphasis in category VI is therefore more on the protection of natural ecosystems and ecological processes, through nature protection and promotion of the sustainable use of natural resources.* Using these definitions and the clarification of the difference between category V and VI we would propose that the Itombwe Natural Reserve best fits within category VI.

Table 2. IUCN Protected area categories.

Areas managed mainly for:

I. Strict protection
   a. Ia) Strict nature reserve and
   b. Ib)Wilderness area
II. Ecosystem conservation and protection (i.e., National park)
III. Conservation of natural features (i.e., Natural monument)
IV. Conservation through active management (i.e., Habitat/species management area)
V. Landscape/seascape conservation and recreation (i.e., Protected landscape/seascape)
VI. Sustainable use of natural resources (i.e., Managed resource protected area)

IUCN does not give any specific guidelines for zoning protected areas but accepts that this can happen under its guidelines for specific activities such as tourism (Eagles *et al.* 2002) but recommends that less than 25% of the protected area be assigned to a different zone if the protected area is to retain its designation (Dudley 2008). This is referred to as the 'Seventy five percent rule'. However, protected areas can contain different protected area categories within zones (Dudley 2008). In the case of Itombwe it could be category VI for the most part but contain a category II Core Protected Area for instance. IUCN recognizes hard or soft zones as follows:

IUCN recommends that multiple categories can be reported within a single large protected area when certain conditions are met. These conditions reflect the permanence and objectives of the zoning system. Two alternative scenarios are:
● ***"Hard" zone:*** *zones can be assigned to an IUCN category when they: (a) are clearly mapped; (b) are recognised by legal or other effective means; and (c) have distinct and unambiguous management aims that can be assigned to a particular protected area category (the 75 percent rule is not relevant);*
● ***"Soft" zone:*** *zones are not assigned to an IUCN category when they: (a) are subject to regular review, such as through a management planning process; (b) are not recognised by legal or other effective means; and (c) do not correspond to a particular protected area category (the 75 percent rule applies to defining the overall category for the protected area).*

To be clear, separate categorization of zones is possible when primary legislation describes and delineates zones within a protected area and not when primary legislation simply allows for zoning in a protected area, such as through a management planning process. IUCN recommends in most cases that assigning different categories to zones in protected areas is not necessary but may be relevant in larger protected areas where individual zones are themselves substantial protected areas in their own right.

Given these two definitions of zones there needs to be some discussion of the Core protected zone category within Itombwe as it may be useful to give it a separate category of protected area to strengthen its protection. However, under the new Conservation Act in the DRC it is recognized that most protected areas should have zones to minimize conflicts with local communities. IUCN gives a flow chart to work through that is useful to decide whether a zoning within a protected area should classify as a separate protected area category (figure 2).

The aim of zoning protected areas is defined well by Rotich (2012):

> *Zoning refers to what can and cannot occur in different areas of the protected areas in terms of natural resources management, cultural resource management, human use and benefit, visitor use and experience, access, facilities and Protected Area development, maintenance and operations. Through management zoning the limits of acceptable use and development in the Protected Area are established. Often, when there is not enough information about the area, zoning is an action that occurs during the implementation of the management plan. It allows areas to be set aside for particular activities such as protection of key habitats or nursery areas and breeding sites, research, education, anchoring, fishing and tourism. Zoning helps to reduce or eliminate conflict between different users of the Protected Areas, to improve the quality of activities such as tourism,*

and to facilitate compliance. Zoning is a widely accepted method to keep people out of the most sensitive, ecologically valuable, or recovering areas, and to limit the impact of visitors.

The zones reflect the intended land use, existing patterns of use, the degree of human use desired, and the level of management and development required. Zoning can ameliorate incompatible land uses in given areas, while allowing for sustainable resource extraction that benefits local communities they consistently attempt to determine where resources will be extracted or preserved and who will claim authority and access to these areas. It is designed to allocate geographical areas for specific levels and intensities of human activities and of conservation. Zoning can also be temporal, that is an area set aside for different uses at different times, within the course of the day, over the week or seasonally (Eagles, et al., 2002).

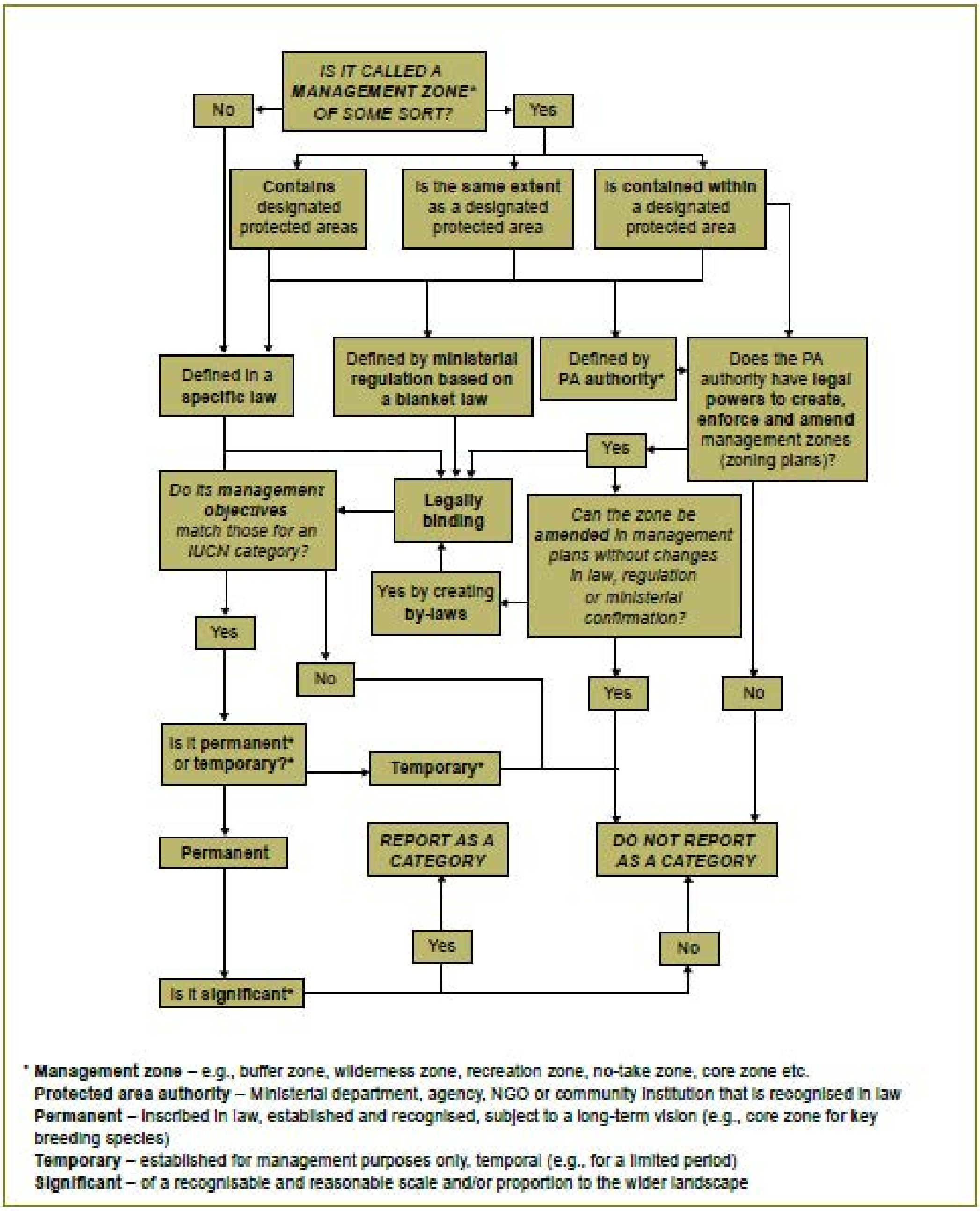


Figure 2. Flow chart that can be used to assess whether zones should be given a separate protected area category (from Dudley 2008).

Zoning categories that have been used in different protected areas are many and not standardized between sites. Rotich (2012) identified 20 main classes of zones which have been used and include designations such as 'core conservation zone'; 'wilderness zone'; 'intensive use zone'; 'development enclaves'; 'buffer zone'; and 'cultural zone'. Zoning is usually a management tool that is developed at a site and as a result can be very site specific. For instance the Uganda Wildlife Authority usually designates several zones within its national park and wildlife reserve management plans such as 'tourism areas', 'core wilderness areas', 'community resource access areas', and 'research areas'. Similarly the Uganda National Forestry Authority undertook an analysis of all of its large Central Forest Reserves in the mid 1990s to identify three main zones: 'Nature Reserve'; 'Buffer area' and 'Sustainable harvesting area'.
The main issue in developing zoning is to use scientific and expert knowledge to identify:

a) where different zones should be established and
b) what activities can be undertaken in each zone

Ensuring that zoning is based on sound science is important if the zones are to have greatest impact for conservation of the biodiversity of a site and conservation planning can often improve zoning if it has not used scientific and expert knowledge (Hull *et al.* 2011).

Zoning to date in the Itombwe Natural Reserve

The Itombwe Natural Reserve has undergone a complex history of establishment. Surveys of the Itombwe Massif by scientists in the mid 1900s (Prigogine 1985; Laurent 1964) and conservation practitioners in the 1990s (Wilson & Catsis, 1990; Doumenge, 1998; Doumenge & Schilter, 1997; Omari *et al.* 1999) identified the importance of the massif for biodiversity conservation. However, the presence of people in the massif made it difficult to establish a protected area. Based upon the information ICCN had from all of these surveys and studies, the Minister of Environment signed an 'Arreté' in 2006 to establish the Itombwe Natural Reserve. This was unfortunate as it was created with little consultation with local communities and at the same time it did not identify the boundaries of the reserve, although a crude map was attached to show roughly where it should be. This led to a lot of friction with local communities forming their own local NGOs to fight the establishment of the Reserve, and with Rainforest Foundation, arguing for the rights of these groups to annul the arête that had established the reserve. Using a conflict resolution approach, supported by USAID (Kujirakwinja *et al.* 2010), WCS brought together the conflicting parties and after several meetings it was agreed that the International NGOs (WCS, WWF and Rainforest Foundation) together with local NGOs (AfriCapacity and RACCOMI) would work with the communities in the Itombwe Reserve to identify where they would accept the boundaries of the reserve and to work with them to develop a zoning plan for the reserve.

In the mid 2000s WWF undertook a socioeconomic survey of the people living in the proposed Itombwe Natural Reserve which assessed how people used the forest and this was used to identify how many communities were in the proposed reserve area (Bisidi *et al.* 2008). At the same time during the 2000s WCS undertook several surveys of parts of the massif and compiled the biodiversity data from these surveys and previous ones made in the 1990s and proposed a very draft zoning plan for the Itombwe Reserve based upon these results (Plumptre *et al.* 2009). It was recommended, however, that more detailed planning be made to further develop the zoning.

Since 2009 a joint process of all of the named NGOs (above) and the local communities has been taking place to determine where local communities are willing to establish the boundary of the Itombwe Reserve. By working with these people it has been possible to increase the reserve size to conserve some of the unique and important habitats for conservation and by an iterative process to develop an accurate map of the reserve with GPS readings for all key points along the boundaries (figure 3). A draft zoning plan has been proposed when consultations have been made with communities but it has always been agreed that the first step would be to finalise the boundaries and then to work with them on the detailed zoning of the reserve. At present three key zones have been proposed in the zoning plan (figure 4):

1. Core protected area
2. Buffer zone – an area within 2km of the core protected area zone
3. Sustainable use zone

The zoning plan produced to date has taken into account the known sightings of large mammal species, particularly apes and elephants, and also the known distribution of people in the reserve. While a good start to the zoning process WCS believes that more thinking about the zoning is needed before everyone starts working with the communities and starts to develop land use plans around their villages. In particular there is a need to identify the critical areas for conservation of the threatened species identified in Table 1. This report aims to elaborate on some of the thinking WCS has been doing as well as update the biological information we have been collecting for the reserve.

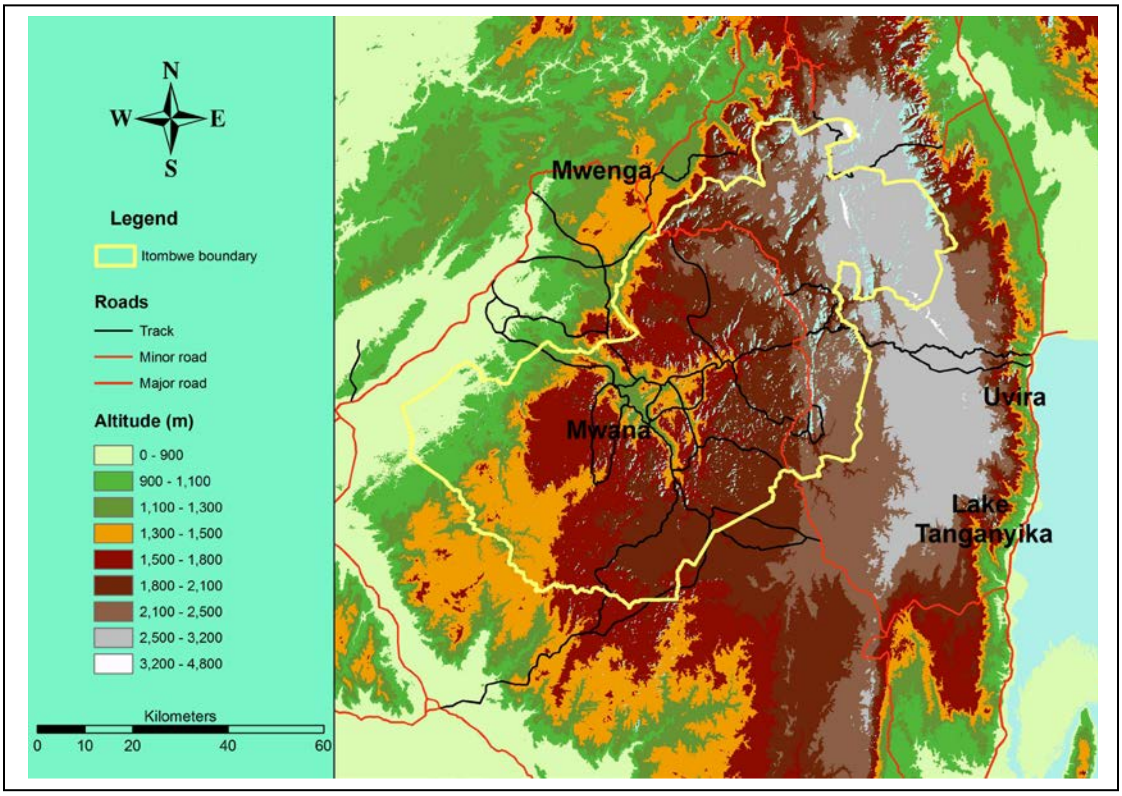


Figure 3. Scenario V of the Itombwe delimitation process identifying the likely final boundaries and the altitude variation within the reserve.

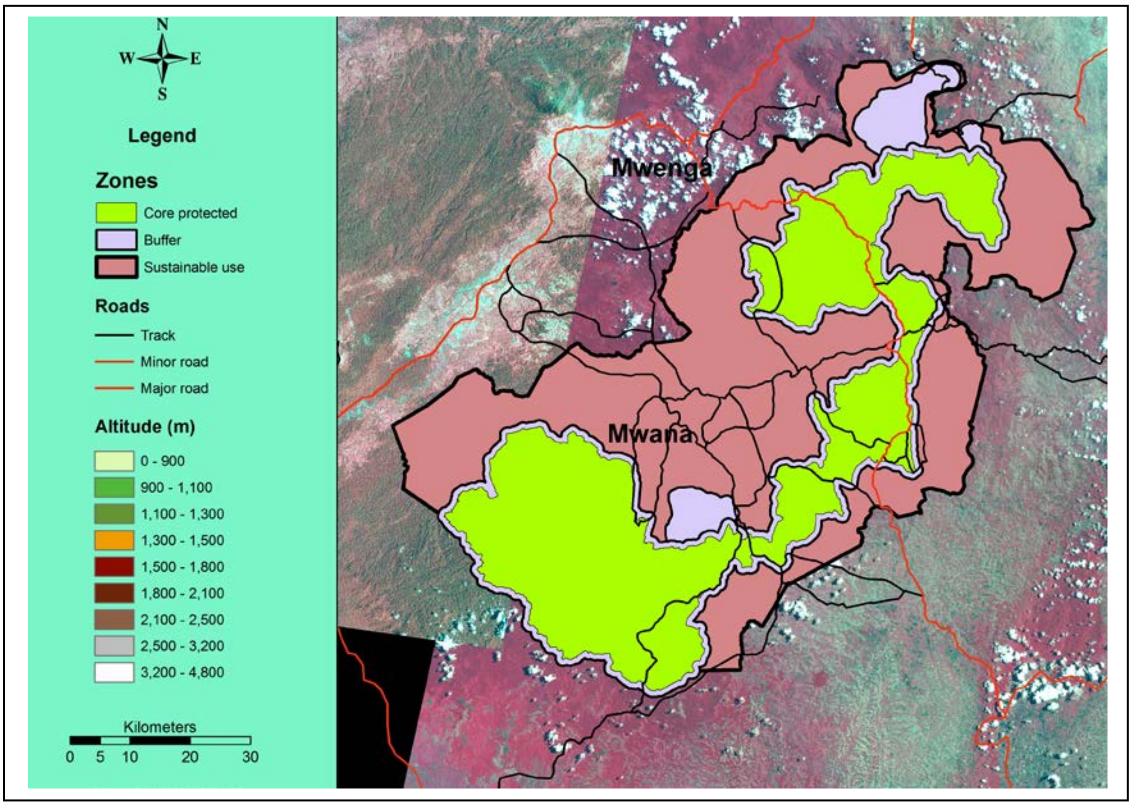


Figure 4. Draft Zoning plan produced based on known distribution of large mammals and areas that are uninhabited by people to identify areas where core protection and co-management will be necessary.

Species distribution modeling

WCS has been compiling all of its survey data throughout the Albertine Rift, together with compiling additional species distribution records from experts in various taxa to assemble the most comprehensive database of distribution records of endemic and threatened vertebrates and plants in the Albertine Rift. We have used these data to model species distributions within the Albertine Rift and have had the resulting maps checked by experts in each taxonomic field.

Here we describe how species distribution models were used to estimate the current spatial distribution of environments that are suitable for endemic birds (n=33), threatened birds (n=7), endemic plants (n=23), threatened plants (n=7), endemic large mammals (n=3), threatened large mammals (n=4), endemic small mammals (n= 22), threatened small mammals (n=7), endemic amphibians (n= 18) and threatened amphibians (n=10) found in Itombwe. We used species from these four taxonomic groups because they represent a diverse set of characteristics: sessile plants which often determine invertebrate diversity; wide ranging motile species such as some mammals and birds; taxa that are diverse and include many species (plants, amphibians and birds) and also tending to have many threatened species (mammals, amphibians and birds). Threatened species were defined using the IUCN Redlist web site (IUCN 2012). In the case of plants we modeled timber species as surrogates for the threatened species given limited time as well as the endemic plants.

Species distribution models estimate the actual or potential geographic distribution of a species through quantifying the relationship of known species occurrence records and the environmental conditions at those sites (Elith *et al.* 2006;2011; Pearson*,*2007). Quantifying species-environmental relationship requires the visualization of species occurrence records in both geographical and environmental space. Geographical space represents the species' distribution as plotted on a map (defined as a species 'occupied niche') while environmental space is a conceptual space defined by environmental variables to which species responds (Pearson*,* 2007). A species distribution model identifies the species' niche in environmental space as described by species occurrence records in geographical space. When the model is projected back from environmental space to geographical space, the model fits parts of the actual and potential distribution (Pearson*,* 2007). Species distribution models have been used to support a variety of conservation ends including: conservation planning and reserve selection (Watson *et al.* 2010), projecting impacts of climate change on species (Willis *et al*. 2009), guiding field surveys to find new species (Pearson*,* 2007), predicting invasive species (Thuiller *et al.,* 2005a), and testing bio-geographical, ecological and evolutionary hypotheses (Guisan and Thuiller, 2005).

Species occurrence data

Species occurrence data was obtained from various sources including Wildlife Conservation Society, Tanzania mammal data atlas and Global Biodiversity Information Facility (GBIF 2012: http://www.gbif.org/). A total of 70,000 occurrence records for birds, plants and mammals were used to fit distribution models using the Maxent algorithm. The number of presence records used for training the model varied from 15 to 3000 per species. The receiver operating characteristic (ROC) plots, were used for evaluating the predictive performance of our models (Freeman and Moisen, 2008; Manel *et al.* 2001). ROC plots provide a threshold independent measure of model accuracy of presence-absence models. The ROC plots area under curve (AUC) provides an effective indicator of model performance and AUC values ≥ 0.8 were selected for the final analysis (Manel *et al.* 2001). The list of species modeled is provided in Appendix 1.

Predictor variables

Predictor variables that are ecologically important for the distribution of birds, mammals and plants in the Albertine Rift were selected (Table 3). For current conditions, climate layers were obtained from the WorldClim database (http:\\www.worldclim.org) with a spatial resolution of ~1 km^2. Additional predictor variables that were included in the model are: cloud mean, cloud max, lithology, digital elevation model, distance to rivers, slope, eastness, northness, drainage basin, aspect. Cloud mean and cloud max were derived from MOD09GA Surface Reflectance data which is provided in Hierarchical Data Format (HDF) at daily temporal resolution and was calculated by G. Picton-Phillipps.

Rivers and roads data layers were obtained from the African data sampler dataset (WRI 2010). Prior to inclusion in the model the euclidean distance was calculated from in each point in the Albertine Rift to the nearest road or river. The distance to roads and rivers was used as a surrogate for human access to an area. Lithology reflects key geological parent materials which are determinants in the distribution of vegetation (Source; U.S. Geological Survey/ The Nature Conservancy). Slope, aspect, eastness and northness were computed from the 90 metre digital elevation model (Source: http://srtm.usgs.gov/). Drainage basins were obtained from USGS Global data set of 2003. All predictor variables were clipped to the extent of the Albertine Rift and resampled to a 1km^2 resolution using Arcgis 9.3.To remove multi-collinearity we ran a pairwise Pearson correlation using ENMTOOLs (Warren *et al.* 2010; a toolbox for comparative studies of environmental niche model; http://purl.oclc.org/enmtools) and only variables with less than (+/-0.75) correlation were retained.

Table 3. Predictor variables used for modeling the distribution of endemic and threatened species in the Albertine Rift.

Name of Variable	Description of Variable
Bio2	Mean daily temperature range
Bio7	Temperature annual range
Bio6	Minimum temperature of coldest month
Bio5	Maximum temperature of warmest month
Bio12	Annual precipitation
Bio17	Precipitation of driest quarter
Bio16	Precipitation of wettest quarter
Cloud mean	Annual normal percent cloud cover
Cloud max	Maximum cloud cover for each pixel
Roads	Distance to nearest road
Lithology	Geologic parent material
DEM	Digital elevation model
Rivers	Distance to nearest river
Slope	Rate of maximum change in elevation
Easteness	Orientation East - West
Northness	Orientation North- South
Drainage basins	Topographically delineated area drained by a stream system
Aspect	Direction a slope is facing

Species distribution models were developed using a Maximum Entropy approach (hereafter 'Maxent', Maxent version 3.3.3e; Phillips & Dudík, 2008). Maxent is a program for modeling species distributions from presence-only occurrence records (Philips *et al.* 2004, Phillips *et al.* 2006).The Maxent algorithm computes predictions or makes inferences from incomplete information (Phillips *et al.* 2006). We selected Maxent because it has been shown to consistently outperform other presence only methods (e.g. Bioclim, Domain) as well as presence-absence methods (e.g. GAM, GLM, GARP), (Elith *et al.* 2006). Maxent estimates the probability distribution with the maximum entropy (ie. that is most spread out, or closest to uniform), subject to constraints imposed by the information regarding presence records and the background information across the study area (Phillips *et al.* 2006; Elith *et al.* 2011). Default model parameters in Maxent were used for all species (Auto features, convergence threshold of 0.00001, maximum number of background points =10,000, regularization multiplier=1). We also ran Maxent just using Hinge features and compared the outputs with known distributions of the species. Hinge features are functions for piecewise linear splines and fit models closely related to GAMs (Elith *et al*. 2011). For about a third of the species modeled the 'Hinge features' model provided a more realistic result and these were selected for these species. A logistic format which provides an estimate between 0 and 1 of probability of presence of the species was the output.

The "maximum training sensitivity plus specificity" threshold rule was used to convert the continuous logistic output format from Maxent into binary (presence/absence) prediction of the distribution for each species (Freeman and Moisen, 2008; Manel *et al.* 2001). This threshold rule minimizes the mean error rate for positive observations and the error rate for negative observations (Freeman and Moisen, 2008). All areas with where the predicted probability of species presence was above the threshold were classified as "present" and areas with a predicted probability below the threshold were reclassified as "absent". A sampling bias layer was included in the Maxent runs for some some taxa to account for the intensity of sampling. A bias layer was created in Arc Gis 9.3 by using a three by three smoothing window for the sampled areas. The predictions were extrapolated from the bias layer to outside the sampled areas to predict species presences throughout the Albertine Rift. Bootstrapping was used as a form of replication (10 runs), with the random test percentage set to 25. The training data are selected by sampling with replacement from the species occurrence points and the number of points in each run is equivalent to the total number of points available for training.

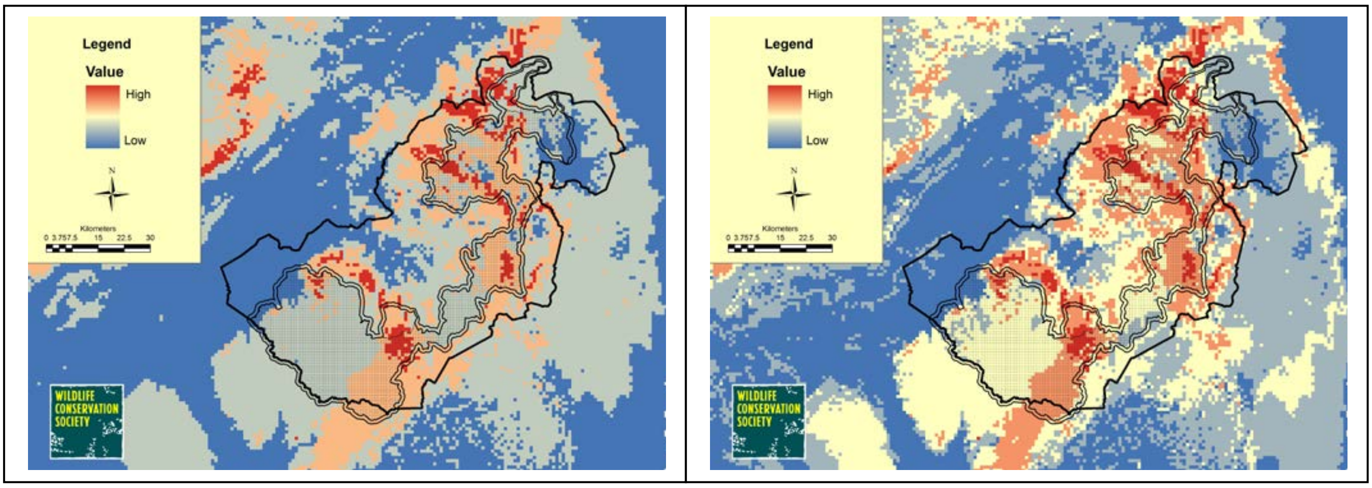
Where point locations were fewer than 10 and a species was known to be very restricted in range, we used the known location of a species and its maximum and minimum altitude recorded to model its likely presence in that location as a presence-absence layer. We constrained the distribution within the altitude range to be within the area of the IUCN range maps for the species. Where we had additional location points outside this range we would expand the IUCN range to include all additional points we were fairly confident had been identified correctly.

Assessment of species distributions in Itombwe

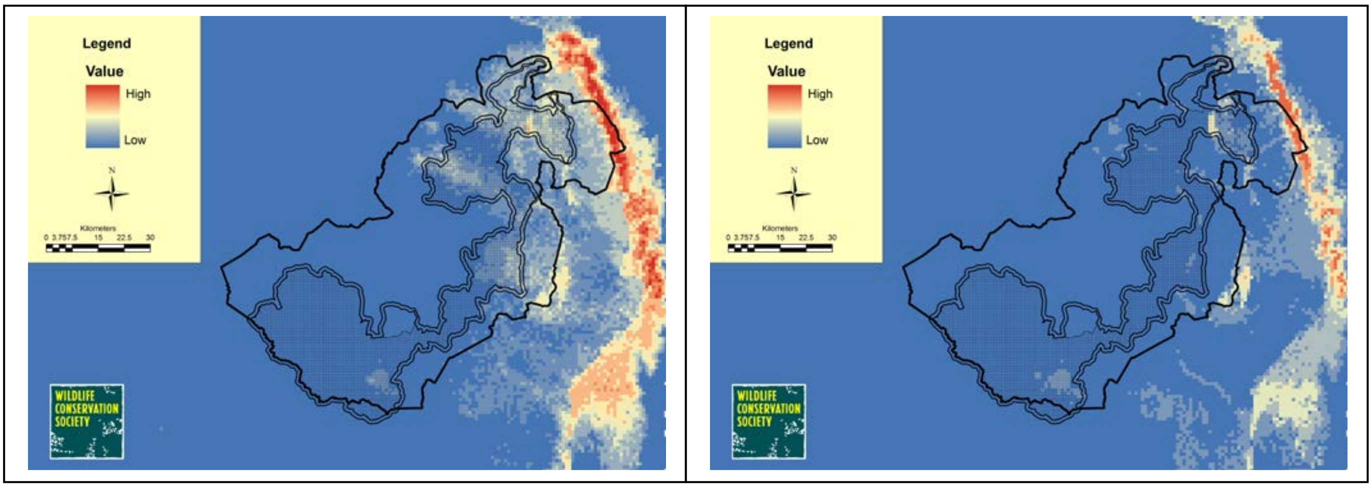
The results of the species modeling are presented here for all the endemic and threatened species found in Itombwe massif from the three vertebrate taxa and plants. We modeled all species for which we could find enough data using the methods described above. For a few species that have only been seen once or a very few times ad there is no record of its altitude range we could not model the distribution and instead we provide location points (figure 3). We were unable to model all 352 endemic plant species for the Albertine Rift as location data are very sparse and so only present results for those with sufficient data to model with the variable layers we used for other taxa above.

The results were combined for each taxonomic group (large mammals, small mammals, birds, amphibians and plants) into maps showing the number of endemic or threatened species in each 1x1 km cell across the proposed Itombwe Reserve (Figure 5). The maps provide a rapid way of visualizing where species are more abundant but care must be taken when interpreting them. Simply choosing the ‘richest areas’ in the maps won’t guarantee conserving all species in the proposed reserve and for this the individual species maps must also be reviewed.

Large mammals

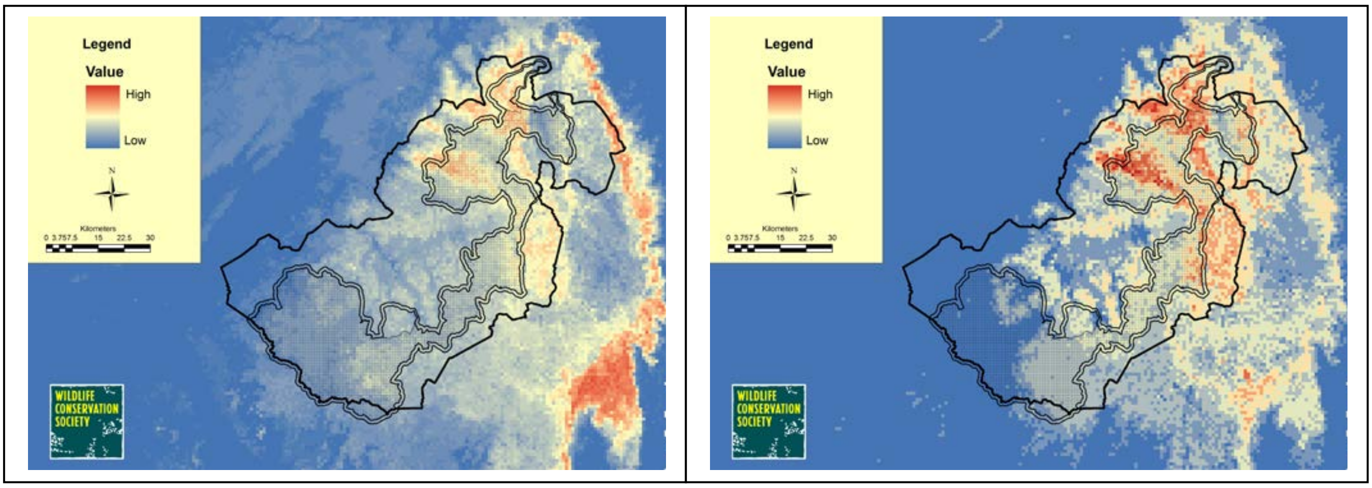


Small Mammals

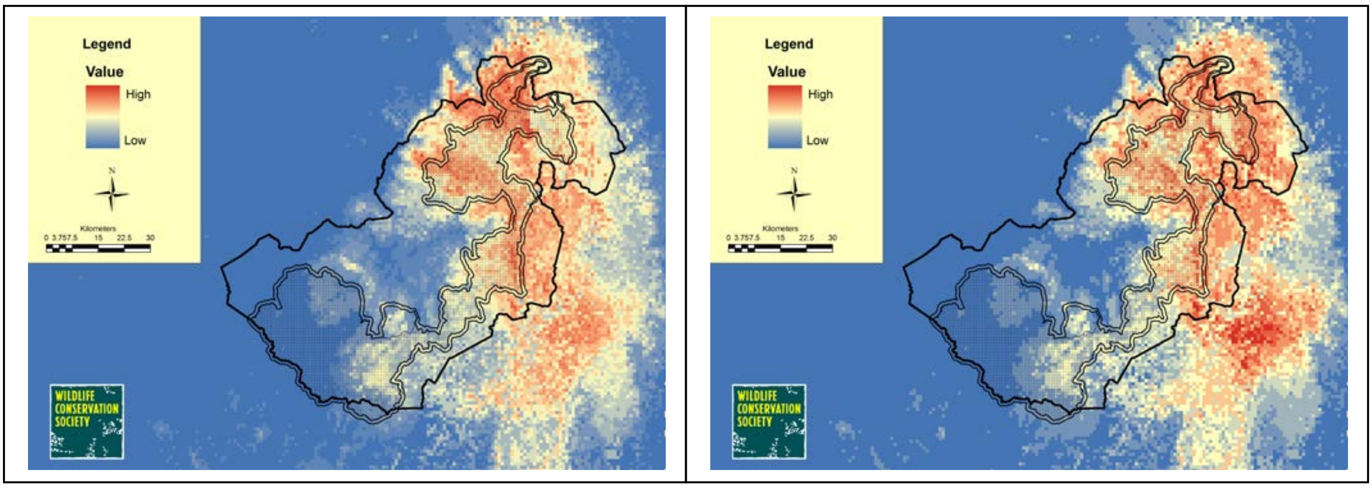


Endemic Threatened

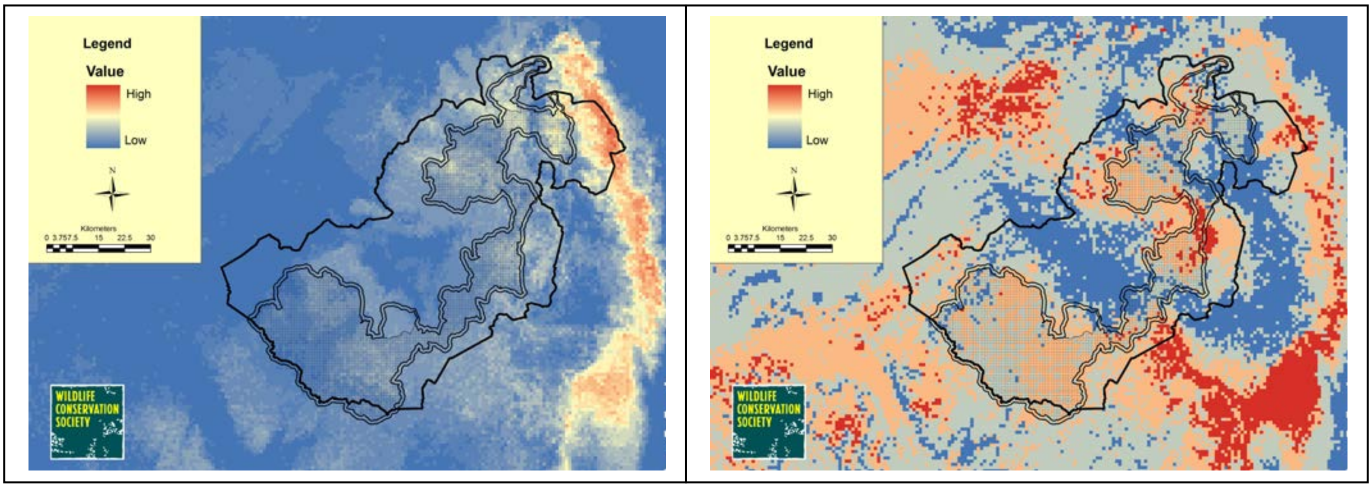
Birds



Amphibians



Plants



Endemic Threatened

Figure 5. Maps of the relative abundance of endemic species (left) and threatened species (right) for each taxonomic group. The boundary together with the Core Protected Area (stippled) and buffer zone currently proposed are overlaid on each map. The redder areas contain more species while the blue areas contain few.

Looking at these results it is clear that for some taxonomic groups, such as the large mammals, the current Core Protected Area will likely capture most of these species. Given that it was designed primarily for this group of species this is encouraging. However there are certain groups, particularly threatened and endemic small mammals, which mostly occur outside the Core Protected Area. These maps show the relative number of species in each 1km^2 cell across the reserve as well as outside but do not show which species do not occur within the core protected area. Table 4 lists the species that are not predicted within the Core Protected Area.

Table 4. Species that are not predicted within the Core Protected Area as currently mapped.

Species	Area predicted in Itombwe Reserve (km^2)	Location
Birds		
Dusky Crimsonwing	54	North East in high altitude grassland/forest
Red-collared Mountain Babbler	32	North East in high altitude grassland/forest
Rwenzori Double-collared	26	North East in high altitude grassland/forest
Strange Weaver	17	North East in high altitude grassland/forest
Small Mammals		
Crocidura lanosa	85	North East in high altitude grassland/forest
Delanymys brooksi	195	North East in high altitude grassland/forest
Hylomyscus denniae	64	North East in high altitude grassland/forest
Hylomyscus vulcanorum	160	North East in high altitude grassland/forest
Otomys denti	59	North East in high altitude grassland/forest
Praomys degraafi	100	North East in high altitude grassland/forest
Ruwenzorisorex suncoides	103	North East in high altitude grassland/forest
Scutisorex somereni	117	North East in high altitude grassland/forest
Sylvisorex lunaris	33	North East in high altitude grassland/forest
Thamnomys venustus	94	North East in high altitude grassland/forest
Plants		
Harungana montana	19	North East in high altitude forest
Impatiens purpureo-violacea	106	North East in high altitude forest
Isoglossa vulcanicola	339	North East in high altitude forest
Rubus runssorensis	211	North East in high altitude forest
Rytigynia kigeziensis	16	North East in high altitude forest
Amphibians		
Chrysobatrachus cupreonitens	638	North East in high altitude grassland/forest

If we map the distribution of these twenty species that are of conservation importance but also that mostly occur outside the existing proposed core area we can see how important the high altitude ridge in the north east of the reserve is for conservation (figure 6). This ridge runs from north of the reserve, through the north eastern part of the reserve and down to the south continuing to above Fizi town. While we do not propose slowing down the process of finally creating the reserve boundaries we believe that the option should be there to work with the local community in this area to negotiate expanding the reserve along this ridge to maximize the chance of conserving these species.

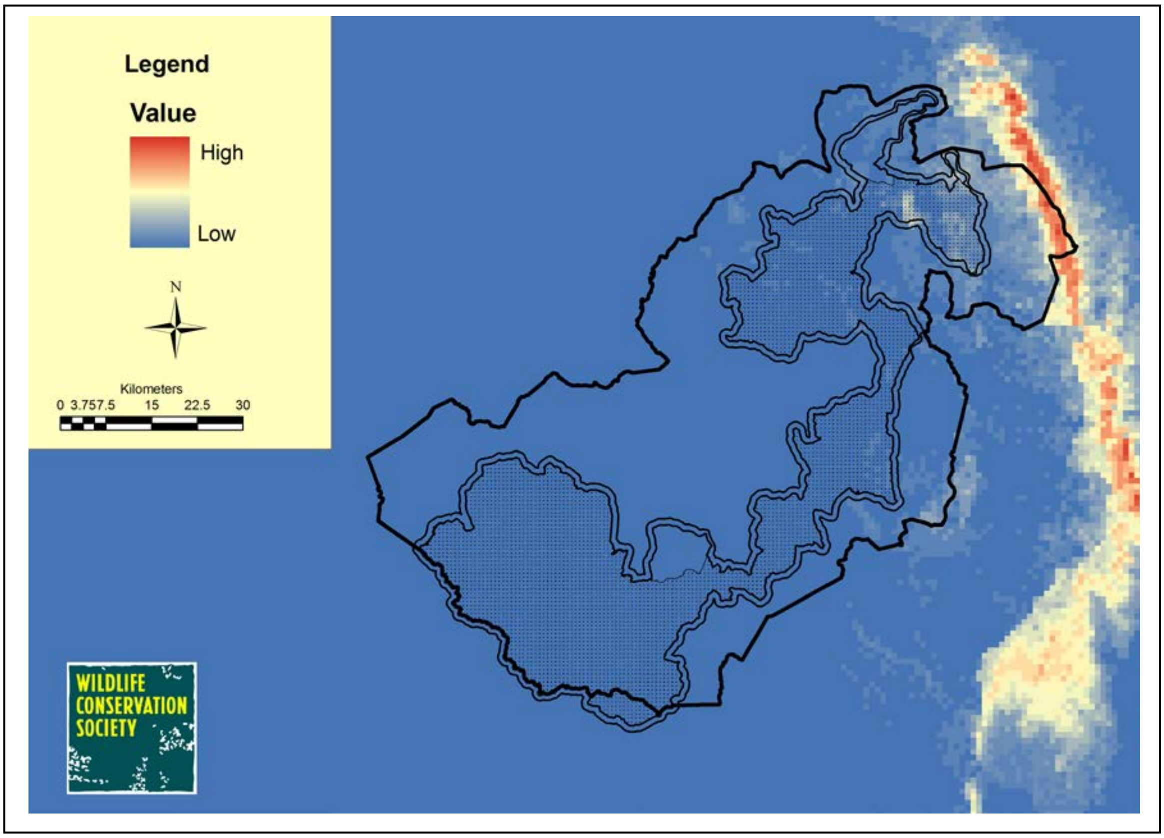


Figure 6. The combined distribution map of the 20 endemic and threatened species that mostly occur outside the existing Core Protected Area.

A more detailed assessment of some of the key large mammals though which maps actual sightings of the species rather than predicted distributions indicates that while the Core Protected Area does capture some gorilla, chimpanzee and buffalo locations it does not capture areas where elephants, bongo and several other concentrations of gorillas and chimpanzees occur (figure 7). It appears that there are particular areas in the Mwana area in particular but also east of Mwenga where large mammal species will need conservation actions but which also occur in areas where people are present. WCS is working with communities in the Mwana area to set management principles and agree on regulations.

Proposed changes to Itombwe Zoning

It is clear that the current three zone approach will not be sufficient to conserve some of the key species to be found in the Itombwe Reserve. Particular areas that need focus include:

1. the highland areas in the north east that are predicted to contain many endemic and threatened smaller species (small mammals, birds, amphibians and plants). It might be desirable to increase the area under protection in this region if possible but this will need extensive negotiations with people who live here and it may need to be linked patches of habitat.
2. The Mwana Region where elephants, chimpanzees and gorillas have been observed
3. The region east of Mwenga where there is a particular concentration of Grauers gorilla sign.

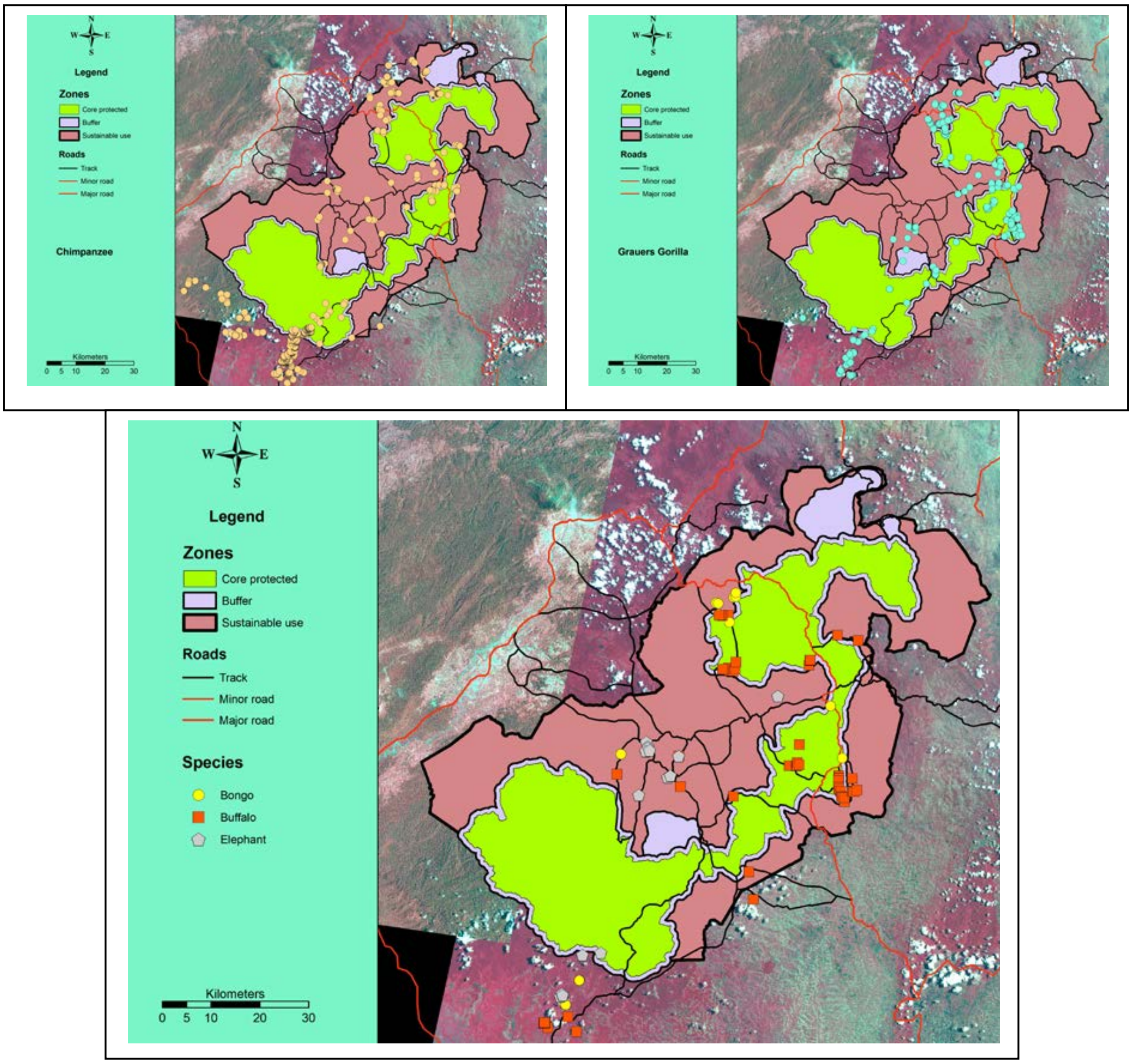


Figure 7. Locations of sightings of chimpanzee nests (top left), gorilla sign (nests/dung/sightings) (top right) and Bongo, Buffalo and Elephant (bottom) from WCS surveys in the proposed Reserve.

There are clearly several options that could be explored to revise the proposed zoning which can be summarized as follows:

a) to revise the core protected area to include some of these areas of importance

b) to revise the buffer zone which at the moment is very narrow and is unlikely to contribute much to the conservation of the Reserve and will be costly to demarcate

c) to zone the Sustainable use zone so that there are some land uses which are more compatible with conservation.

Any of these decisions will need to be made in consultation with the communities living in these areas but it will help to go to them with a proposed plan based on the information we have presented here and then discuss the details about whether the plan can work and if not how it might be adapted.

Revising the Core Protected Area

Given the clear importance of the highland grassland-forest mosaic area in the north east of the reserve we would propose that discussions are made with the local community to create a separate core protected area region here. Ideally it would extend beyond the current proposed boundaries of the reserve and would need further negotiations and modification of the reserve boundary. Given the need to establish the reserve soon though we would suggest that the current limits are maintained in the arêté and that once negotiations with the community are completed that any proposed changes be then made to the arête.

Revising the Proposed Buffer Zone

The buffer zone as proposed simply provides a narrow buffer to the Core Protected Area. It will be very costly to demarcate as separate from the Core Protected Area as it has a long edge and it is unclear what it will add to the conservation of the area. It is also unclear what activities will take place in the Buffer Zone compared with the Core Protected Area and the Sustainable Use Area (see below). We would suggest that the Buffer Zone is re-designed and incorporated as a land use zone within the Sustainable use Zone and that the existing narrow buffer area is incorporated in the Core Protected Area.

Planning in the Sustainable Use Zone

If the sustainable use zone is not planned then it is likely to develop over time into agriculture and settlement with some isolated patches of natural habitat. This process has occurred many times in East Africa where natural areas have been allowed to develop in an umplanned way and have occurred within 20-40 years in most places. There must be a process of zoning or ‘Land Use Planning’ in the Sustainable Use Zone to avoid this and this must be done with the local communities to ensure that boundaries are accepted. There needs to be an agreed set of options for the Land Use Zones and it must be very clear what activities are allowed and what is not in these zones.

We propose here a set of Land Use Zones that could be adopted in Itombwe Reserve with a summary of the activities that could take place in them.

1. *Settlement Zone*: This would be an agreed area of land where larger villages can develop and expand. Currently many people live in Itombwe in small hamlets and households and it is very difficult to provide development projects and improve people’s livelihoods here as a result as it would be impossible to provide this infrastructure for each hamlet. Ideally there would be an identification of key settlement areas where schools, clinics and other infrastructure to support the communities would be allowed to develop. This would hopefully attract people from the smaller hamlets to come and settle here, thereby freeing up areas of the reserve

that are currently settled by people. This type of development would not force people to move but provide an incentive to do so for their families.

Zones of settlement are likely to remove most of the natural vegetation and will not have any conservation value as a result.

2. *Agriculture Zone*: Each Settlement would need an agreed agriculture zone where farming could take place and potentially expand to. Studies in the Okapi Faunal Reserve identified that each household tended to farm 1 hectare of land each year (Brown 2009). This zoning study also estimated how to calculate the area of land needed to sustain the number of households in a village if they used a system of shifting cultivation as follows:

   The area required for sustainable agriculture given prevailing fallow farming practices for a given year (time t) with H farming households, is calculated by:

   $$(Sn + Sn \times F) \times H + (H \times 0.05)$$

   Where: S = average field size per household per year, n = number of fields planted per household per year, F = fallow period (years) and H = number of agricultural households (Brown, 2009).

   They admit that this is a rough estimate but that it provides a useful starting point to assess the potential land needs of a village. It applied to shifting agriculture practices only though and in the highlands of Itombwe it may be possible to improve agriculture production on smaller plots of land and to reduce the need to clear as much forest as a result.

   While fields that are recovering from cultivation will have natural vegetation it is unlikely that these areas will have any great conservation value.

3. *Pastoral grazing zones*: These zones will be areas agreed with the local community where cattle and other livestock can be grazed. Ideally this will take place in existing grassland areas where possible to avoid clearing forest to create new areas. Pastoral grazing zones will be near to villages in the same region as the agricultural zones.

   While not greatly important for conservation these areas may conserve habitat for grassland birds, plants and some amphibian. Wetland areas within the grasslands should be designated as sites of conservation interest (see below) to better protect these threatened amphibians.

4. *Timber and Non-timber Forest Product harvest zones*: These areas will be areas where the community agrees to harvest timber and other woody products sustainably. Other products could include fuel wood, building poles, medicinal plants, honey, rattan etc. They will also be areas where bushmeat hunting (of non-

threatened species) is allowed. Such areas are likely to be within the vicinity of villages and outside the agriculture zone.

Such areas will provide some conservation value but will be unlikely to conserve the threatened and endemic species described in this report.

5. *Mining areas:* Artisanal mining is practiced in the Itombwe massif and will continue for some time until the minerals can no longer be found easily. The people living in Itombwe want to be able to continue mining in the Reserve and it would be difficult to stop them. However, better regulations could be developed that aim to minimize the environmental and human health impacts while at the same time helping conserve the biodiversity in the vicinity of mining areas. If there could be agreements reached that only sustainable hunting of certain mammals is allowed in these areas it could act as a corridor region for others.

6. *Sustainable hunting zone*: These areas would only allow hunting of specific species (mainly duikers and bushpig) and not allow any other harvesting of natural products. They will tend to be larger areas and further from the villages. While hunting of bushmeat will be allowed in the Timber and NTFP Harvest Zones also the Sustainable Hunting Zone will be limited to hunting of certain species only and will aim to hunt them sustainably.

   These areas will be regions where species that are not hunted can be potentially conserved effectively and they can work as corridors linking parts of the Core Protected Area. They will be particularly important for species such as gorillas, chimpanzees, elephants and bongo.

7. *Sites of Conservation Interest*: We envisage specific areas of conservation value being designated as Sites of Conservation Interest (SCI's). These are likely to be wetland areas or rare habitats that are not found widely within the reserve and are likely to contain species of conservation value. They will be designated as such following discussion with the local community and also following an assessment of the potential biological importance of the site.

8. *Cultural Use Sites*: These areas will be similar to the SCI's but be areas where the people have particular cultural attachments to the site. They may be areas where ancestors are buried or where particular worship practices are carried out. They will be sites identified by the local community during the Land Use Planning.These areas may have some limited conservation value depending on what habitat they are in and how pristine it is.

The management of each of these zones will vary. In some it may be desirable to have a close co-management between ICCN and the community and in others the community can probably manage the zone by itself. So as well as discussing what activities can be allowed in each zone there is a need to agree on how management could happen there.

It is not possible to map all of these zones without any discussion with the local communities in the Itombwe Massif. However it is possible using the data we have presented above to identify where we want to improve the protection of habitat that is identified as being important for conservation. Three key areas identified above (p 20) can be mapped and land use planning could work to try to ensure their conservation where possible (figure 8). The corridor area through Mwana for instance could be developed with communities all agreeing to link their Sustainable Hunting Zone/mining zones in this region so that species such as the apes and elephants could use the corridor. Other areas may also be linked by thinking strategically how different village land use mapping processes can link to adjacent villages to create larger blocks of forest or corridor areas.

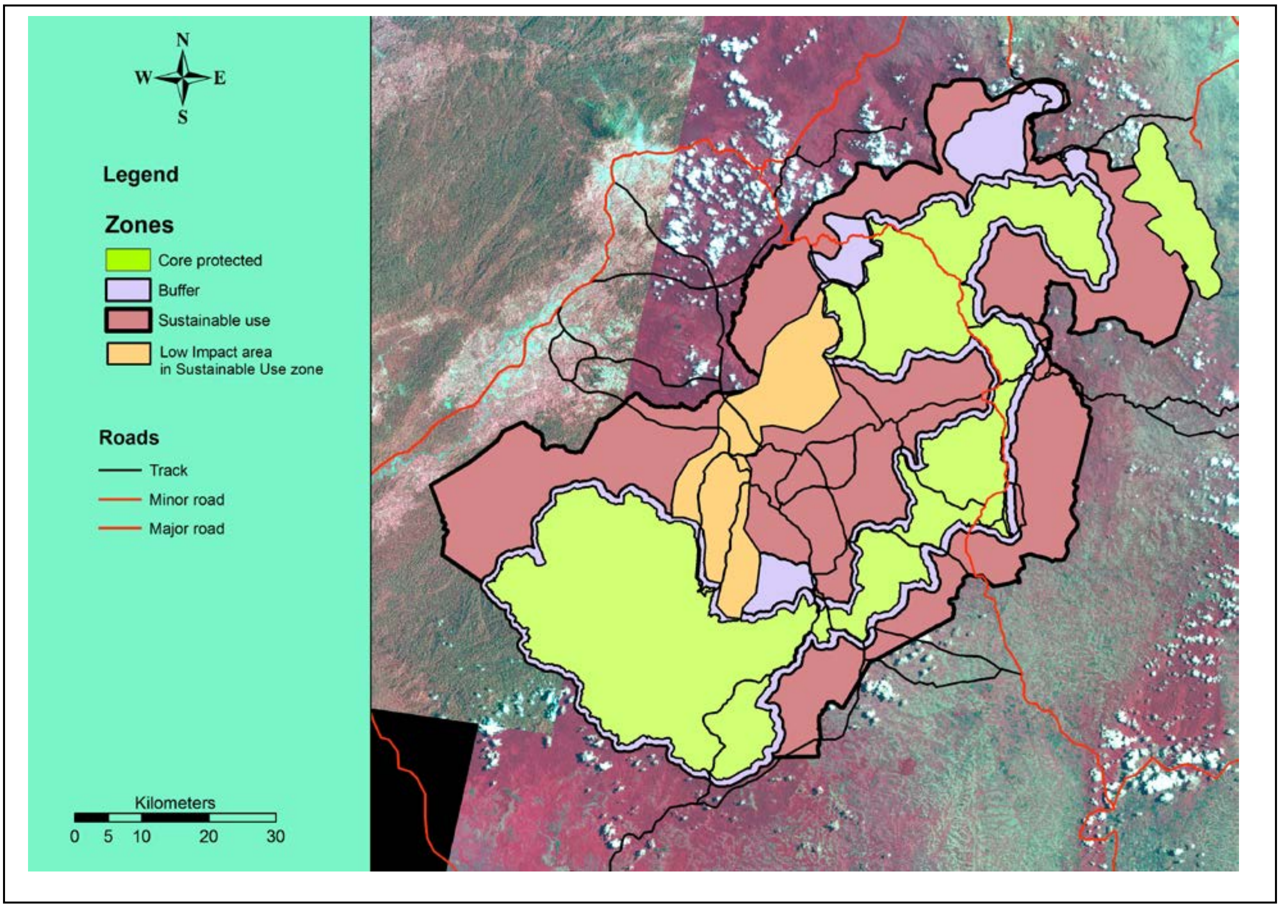


Figure 8. Revised zoning that highlights additional areas that need to be planned for, particularly the additional core area in the north east and the corridor of low-impact human use such as Sustainable Hunting Zones.

Proposed next steps to zone the Itombwe Reserve

Several things need to be done before teams start to discuss zoning with the communities in the Reserve.

First there needs to be agreement amongst the conservation partners on the different zones that could be proposed. Once a draft list of zones is developed it would probably be sensible to send teams to villages to test the various zones by discussing the various activities that would be allowed in each zone type and to refine them after these consultations. In particular there is a need to agree:

1. Whether the buffer zone is needed or not –what activities will be allowed here and how does it differ from Land Use Zones being proposed for the Sustainable Use Zone in the Reserve?
2. What Land Use Zones will be proposed for the Sustainable Use Area and clear definitions made for each zone that identify what activities would be allowed in each zone and what activities would be prevented.

Once this is agreed then and the zones discussed with some representative communities and refined then the conservation partners will need to work together to develop land use plans for each village and hamlet that incorporate these agreed zones. This zoning with the local communities needs to be done in a coordinated manner so that Land Use Plans for adjacent villages tend to put similar land use zones adjacent to each other and as much as possible these join up to form larger conservation units within the reserve. In order to achieve this there will need to be close coordination between partners and regular sharing of maps and plans so that an integrated zoning of the reserve is developed.

It is important that the partners continue to work together closely in order to achieve this so that the final product is the best we can achieve for conservation in this region. If poorly planned it could lead to the loss of the conservation value of most of the sustainable use zone but if done well it will provide a case study of how to properly zone a protected area.

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