Avoiding conflict and balancing trade-offs: Biodiversity Conservation in the context of Competing Land Uses

Authors: D. B. Segan, J.E.M. Watson, G. Nangendo, S.Ayebare and A.J.Plumptre

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Acronyms

ABCG	Africa Biodiversity Collaborative Group
MARXAN	Marine Reserve Design using Spatially Explicit Annealing
NGO	Non-governmental organization
NGO	Non-governmental organization
REDD+	Reducing Emissions from Deforestation and Forest Degradation with climate change mitigation solutions
UNDP-GEF	United Nations Development Program's Global Environment Facility
WCS	Wildlife Conservation Society

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Executive summary

Conservation planning methods have been developing rapidly over the past 20 years to address the realities of a world with ever competing land uses. These methods allow us to carefully plan resource allocation, explore trade-offs between different interest groups (stakeholders), and promote thoughtful and informed land-use decisions. They also provide a framework to ensure our conservation objectives are achieved, while minimizing the cost to other stakeholders.

In the Murchison-Semliki Landscape, one of six key landscapes identified for conservation in the Albertine Rift region of Africa, several competing land uses are present including biodiversity conservation, tourism in parks and forest reserves, small scale agriculture, large scale agriculture, carbon sequestration, timber extraction and oil mining. How can we maximize biodiversity conservation in this landscape while at the same time minimizing the potential conflict with other land uses and people's livelihoods? This is a question that is often faced by conservation planners but until recently has been difficult to answer.

This report summarizes how a conservation planning decision support tool such as Marxan, can be used to examine trade-offs in land use in the Murchison-Semliki Landscape aiming to minimize conflicts as well as identifying options for offsets for residual industrial impacts. It results from a workshop held in Kampala in late August 2012 that demonstrated the Marxan tool, and solicited input from attendees on conservation objectives for the landscape, and relative importance of minimizing the opportunity cost to other stakeholders/land-uses in the region. We used this information to develop six scenarios to demonstrate how the Marxan could be used to identify priority areas for conservation in the landscape. These help identify which areas of the landscape are non-negotiable and which areas are potentially up for discussion and could potentially be switched with another area if it minimizes conflict between the land use options.

This preliminary analysis does not include all the data or input from all the stakeholders that would be needed for a complete landscape-scale analysis. However, the preliminary results indicate that areas where exploration for oil is currently taking place are critical for the achievement for conservation objectives. The overlap between areas of high conservation importance, and oil exploration, highlights the need for careful planning of extractive activities to ensure the long term conservation of species important for the tourism industry such as Rothschild giraffe (an endangered species) and the lion (vulnerable species).

The framework presented here provides an objective and transparent way of analyzing and documenting how decisions are made. It also outlines how an inclusive decision making process can incorporate of the interests of multiple stakeholders, and provide feedback on how preferences for one stakeholder group will impact the interests of others. This transparent planning process minimizes subjectivity, and the use of a spatial optimization tool avoids inefficient outcomes. We aim for this report to provide an example of how systematic conservation planning can be used to address difficult decisions, and would encourage the Strategic Environment Assessment for Oil to seriously consider using similar methods to balance the demand for extractive resources with conservation in this landscape.

Maximizing conservation benefits in the face of competing land uses

Biodiversity conservation does not occur in a vacuum, and we have to recognize it as one of many competing land uses. Conservation interests often compete with industry and human livelihoods and as a result it can be pushed to the lands less desirable for other uses. A number of studies on the placement of protected areas have shown that their placement is biased towards areas with steep slopes, and lower soil fertility, presumably because these are the lands where there is least competition (Pressey, 1994; Joppa and Pfaff, 2009). This bias in the protected area network means that many species are not represented within the existing network, and potentially increases the long term costs of conservation because of inefficient resource allocation (Tognelli et al. 2008; Watson et al. 2011).

The science of conservation planning developed over the past twenty years to provide a more strategic framework for making conservation decisions, and overcome the bias and inefficiency outlined above (Wilson et al. 2009). The information processing requirements of conservation planning can be overwhelming, but the recent advances in computing power has meant that analyses that were previously impossible can now be performed on a standard desktop computer. These advances in computing power have been accompanied by a corresponding influx of conservation software packages (commonly referred to as decision support tools) that can be applied to identify efficient solutions to complex conservation problems. Marxan is one such tool, developed and maintained by the University of Queensland, it has been used to solve a variety of complex conservation problems, and is freely available on their website (http://www.uq.edu.au/marxan/).

This report uses an analysis of the Murchison-Semliki Landscape in Western Uganda (figure 1) as a case study to demonstrate how Marxan can be used to explore trade-offs in how conservation objectives are achieved. The analysis considers a number of competing land-uses and examines the impacts on each under different land-use scenarios.

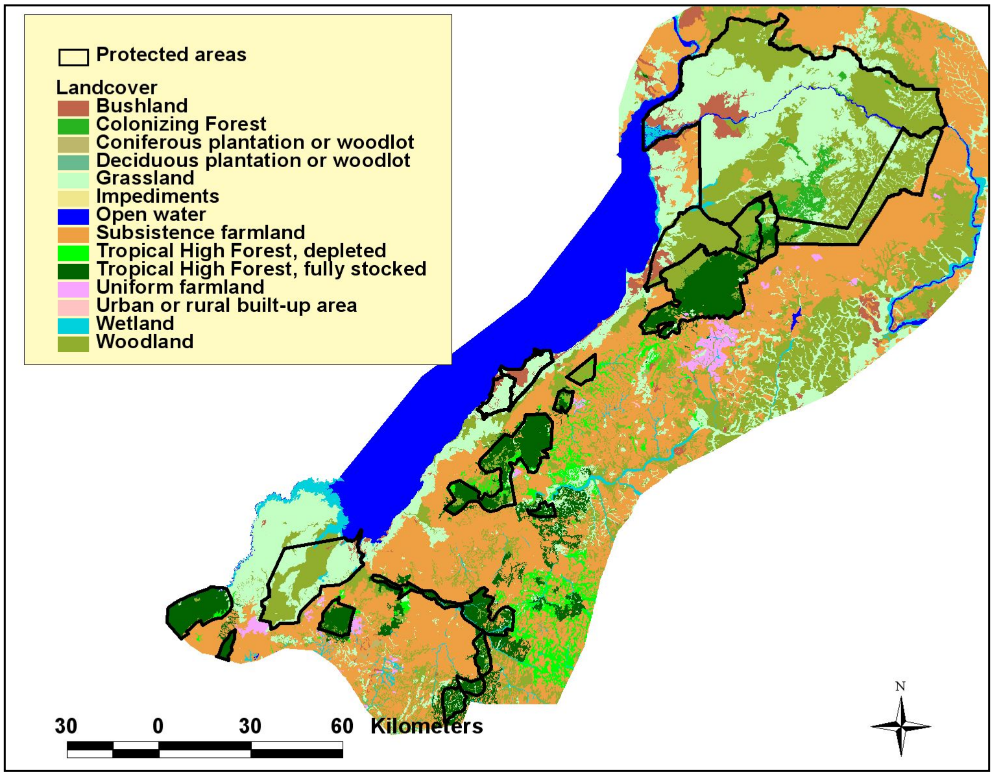

Figure 1. Map of the Murchison-Semliki Landscape showing general land cover types and location of protected areas.

THE MURCHISON-SEMLIKI LANDSCAPE

The Murchison-Semliki Landscape is one of six key landscapes in the Albertine Rift region of Africa. The Albertine Rift is one of the most biodiverse parts of the African continent and contains more threatened and endemic vertebrates than anywhere else on the continent (Plumptre *et al.* 2007). Although the Murchison-Semliki landscape does not contain so many of the endemic species as the other landscapes it is still a rich region with 37 species endemic to the Albertine Rift and, 48 threatened species and 2,583 vertebrate and plant species known from the region (Table 1). Recent taxonomic changes in ungulate species indicates that several species known from the landscape will likely be classified as threatened in the near future as their populations are confined to much smaller areas (Groves and Grubb, 2012). These include Rothschild giraffe (*Giraffa camelopardalis*) which has been elevated to a species of which the largest population in the world occurs in Murchison Falls National Park; and Uganda Kob (*Kobus thomasi*) which occurs in Uganda, Virunga Park in eastern Democratic Republic of Congo (DRC) and a small area in western Kenya and as a result a large proportion of the species occurs in the Murchison-Semliki Landscape.

Table 1. Endemic and threatened species known from the Murchison-Semliki Landscape for five taxa.

Landscape	Mammals	Birds	Reptiles	Amphibians	Plants
Endemic species	3	0	1	2	31
Threatened species	8	4	1	0	35
Species numbers	200	684	78	41	1,580

Competing land uses with the conservation of this biodiversity include:

1. 1. The recent discoveries of oil in several of the protected areas as well as outside them in the landscape
2. 2. Timber extraction from the forest reserves to meet some of Uganda's timber needs
3. 3. Small scale agriculture for subsistence farming by people living in the landscape
4. 4. Large scale agriculture such as tea, coffee and sugar plantations
5. 5. Wildlife tourism
6. 6. Conserving carbon sequestration through REDD+ financing options in the future

Some of these are more compatible than others with biodiversity conservation and yet each of them does have an impact on biodiversity and as a result competes in some way as a land use. In addition each of these land uses is likely to expand in the future and will be looking for additional land in order to do this. How can we ensure that enough of the biodiversity in the landscape survives in the face of these other options, to remain viable in the long term? How important are some of these other land use options for the conservation of some of the endemic and threatened species in the landscape? Some of the species such as lions, hyaenas, chimpanzees and Rothschild giraffes all require large areas of continuous habitat in order to maintain viable populations and are likely to have to reside in areas where other land use options are taking place, such as oil extraction, tourism, carbon sequestration and timber harvesting.

A recent UNDP/GEF project in the Ministry of Water and Environment, and managed by WWF, developed a landscape conservation action plan for the Murchison-Semliki Landscape (MWE, 2012) with the input of a wide variety of stakeholders including the Districts, the Bunyoro Kingdom, International and National NGOs and private forest owners. The Wildlife Conservation Society (WCS) was subcontracted to undertake an analysis of the conservation needs of the landscape and the viability of 'landscape species', those species that require large areas to maintain viable populations (Didier *et al.* 2009). This analysis identified several corridors in the landscape (figure 2) that if conserved and restored would enhance the viability of some of these larger species such as chimpanzees, forest raptors, understorey migratory birds such as green-breasted pitta, and medium size carnivores such as jackals and golden cats.

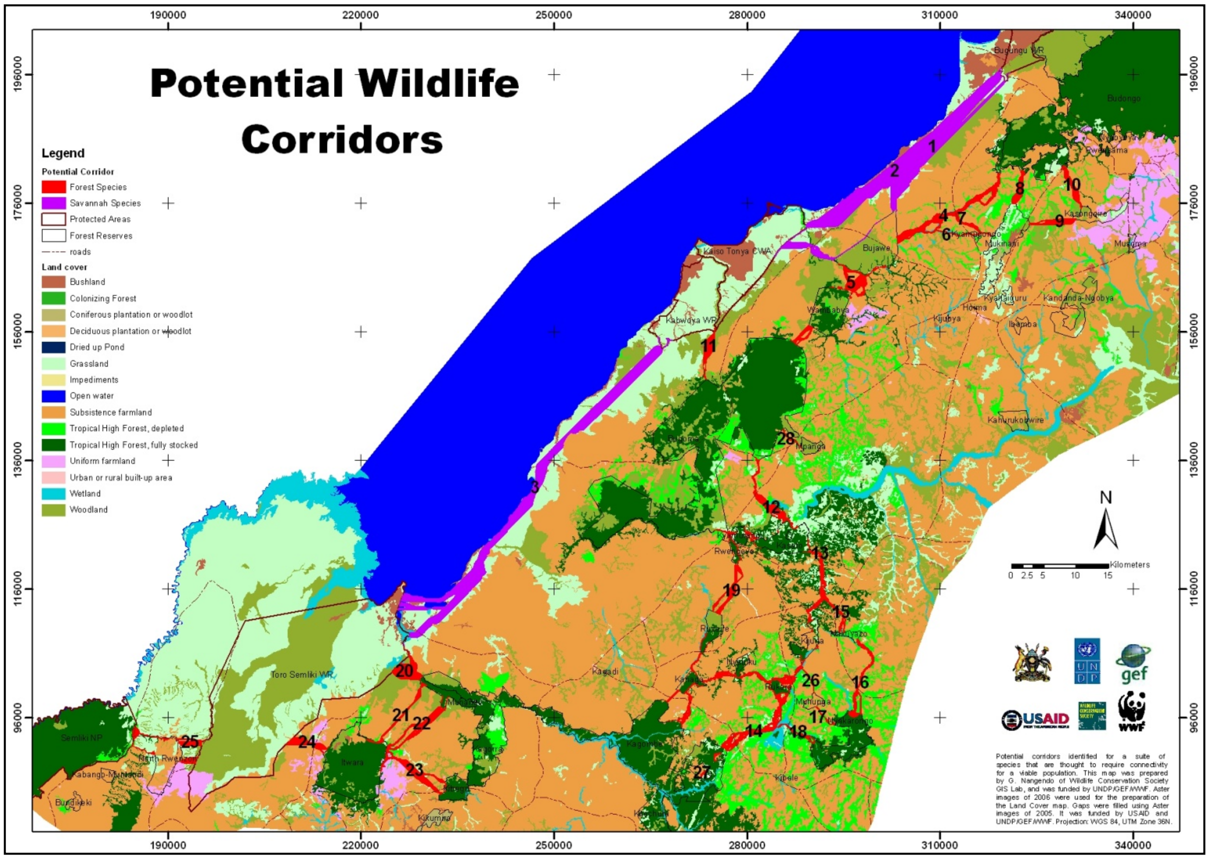

Figure 2. Areas (red and purple lines) where corridors would best be conserved or restored to maintain connectivity between forest blocks and improve the viability of landscape species.

The action plan also analyzed the feasibility of obtaining carbon financing through the REDD+ mechanism to provide an incentive to farmers in the landscape to conserve natural forest on their lands. Dr Miguel Leal of WCS analyzed the potential income to farmers from the conservation of forest and showed that while REDD+ funding could not offset the opportunity costs of clearing forest for cash crops within the first 3-5 years of cultivation, over a twenty year period the funding could be attractive because the fertility of the soil declines over time and the amount of crops that can be grown (without inputs) is likely to decline (Leal *et al.* 2011). Carbon financing, if successful, could provide an alternative revenue stream for land owners in the region that would compliment biodiversity conservation.

Loss or degradation of Natural Habitat in the Murchison-Semliki Landscape

The Murchison-Semliki Landscape is under a lot of pressure and natural habitat has been converted to small scale agriculture at a rapid pace in the last ten years. Much of this transformation has taken place at the expense of natural forest on private land or within local forest reserves, but some has taken place within central forest reserves also and totals more than 8,000 hectares each year (figure 3).

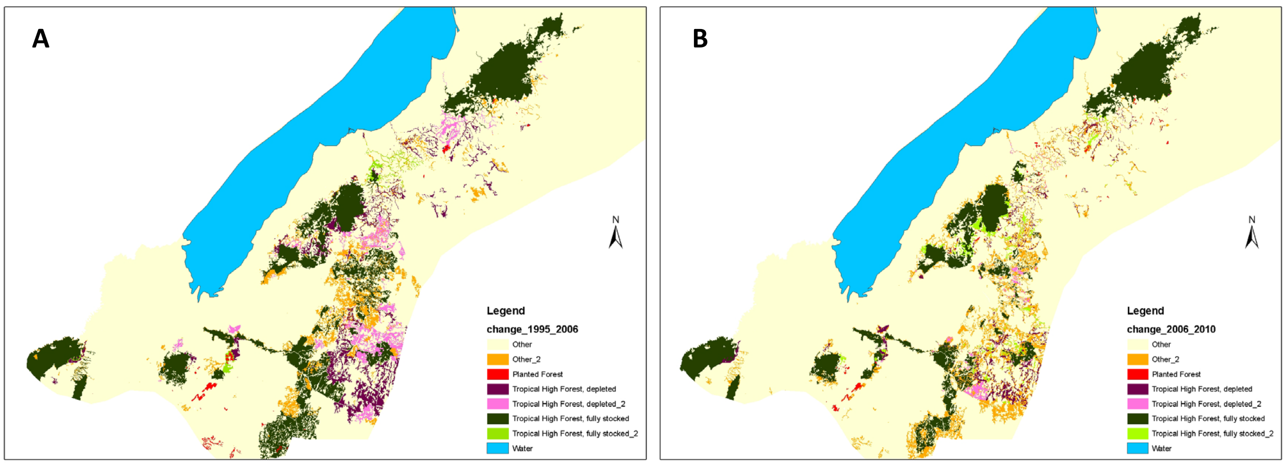

Figure 3. Forest loss in the Murchison-Semliki Landscape between 1995-2005 (A) and 2006-2010 (B). Orange = Conversion to non-forest; Pink=Conversion to degraded forest

Work by Dr. Grace Nangendo at WCS looked at some of the drivers that were leading to this forest loss which included demand for land for small scale agriculture, conversion to land for tobacco or sugar cane farming and conversion for tea plantations. She developed a model that could accurately predict the changes in forest from 2005 to 2010 and used that to develop a probability of conversion of the remaining forest in the future (figure 4). This showed that the smaller forests, particularly outside protected areas were most at risk of being lost. Similar changes are occurring in the remaining savanna woodlands and grasslands in the landscape where conversion to agricultural land and increased livestock grazing is leading to the degradation of these habitats.

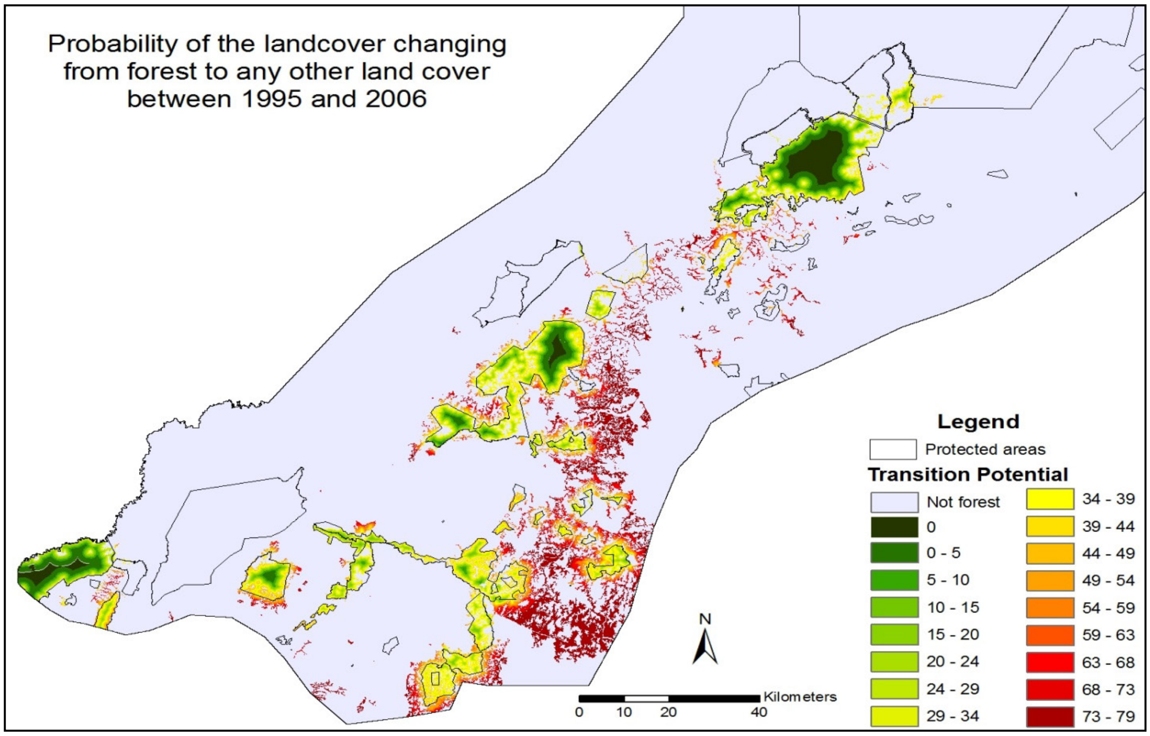

Figure 4. The probability of land cover change in forests of the Murchison-Semliki Landscape based on a prediction model developed using observed changes between 1995-2005 and 2005-2010.

The development of oil in the region will also impact these ecosystems as oil pads are prepared, wells drilled, access roads created, pipelines established, people move into the area to find work and a refinery established. While oil is only projected to last 20-30 years before the wells are exhausted it is likely to have a significant impact on the landscape and there is a need to ensure that its impacts are minimized wherever it occurs and at the same time any residual environmental impacts are offset in a meaningful manner. Oil exploration has been taking place within protected areas in the landscape and it has been shown that animals avoid areas where oil activities are taking place (Prinsloo *et al.* 2012). This means that the contribution of protected areas to the preservation of species must be re-evaluated in areas where oil exploration is ongoing.

Similarly timber harvesting in the central forest reserves has modified these reserves considerably (Plumptre, 1996). While some of the changes have benefited some species such as the primates (Plumptre and Reynolds, 1994), many species have experienced declines in number (Owiunji and Plumptre, 1998). Over the past 20 years increased illegal activity, particularly illegal pit sawing, has led to greater degradation of the forests and the loss of the planned sustainability of the timber harvesting. Forest degradation and clearing has already led to the isolation of chimpanzee populations in forest reserves and will likely require the establishment of corridors of riverine forest between the various reserves to ensure viable populations in the long term.

Tourism in the landscape is increasing and Murchison Falls National park now receives more tourists than any other park in Uganda (UWA tourism records 2011). As a result there is increased traffic in the park leading to disturbance to the animals, increased littering and pollution and increasing incidences of off-track driving leading to habitat degradation. While it is recognized that tourism brings in the funding needed to manage this park and other reserves it also has to be acknowledged that it also increases the threats to the conservation of biodiversity in the park. Species such as lions, leopards and hyenas, are currently at very low numbers in the landscape, with an estimated 130 lions and only about 40-60 hyenas. These species cited by tourists as those they most want to see in Murchison Falls National Park, and 50% indicated they would be less likely to visit the park or would want the entry fees to be reduced if the species were not encountered on park visits (WCS 2012). The main area where species of tourism interest occur (e.g. lions, giraffes, elephants and leopards) also coincides with the primary area of oil exploration in the Murchison Falls National Park. As such this is an area of potential conflict between the tour operators who derive a living from tourism and those interested in exploiting the oil.

Minimizing conflicts over land use in the Murchison-Semliki Landscape

It is clear that the competing demands for sometimes incompatible land-uses pose the potential for conflict in the Murchison-Semliki Landscape. The growth of the human population in the region (augmented by an inflow of migrants looking for work in the oil fields), will place additional demands on the landscape for resources. To ensure the long-term persistence of biodiversity in the region, and continued growth in eco-tourism that is reliant upon it, careful planning of future development will be required. How can we balance the sometimes competing demands of development and conservation to minimize the potential for conflict, ensure functioning ecological systems and maximize value for users?

Several spatial planning tools have been developed that have been designed to help answer this type of question (Wilson et al. 2009). Marxan is one such tool that specifically incorporates the **costs** of conservation action and aims to minimize the costs as well as find solutions which maximize the benefits to competing options (Ball, Possingham and Watts, 2009; Game and Grantham, 2008). Cost in Marxan does not have to be quantified in economic terms, it can also be the total area or a measure of landscape utility for other uses. We used Marxan because it has been used for identifying proposed conservation areas that minimizes trade-offs throughout the world (e.g. Carwardine et al. 2008; Smith et al. 2008; Klein et al. 2009). Marxan uses a simulated annealing algorithm to select multiple alternative sets of areas that meet pre-specified species or ecosystem targets whilst trying to minimize overall cost (Ball et al. 2009).

This report provides a preliminary analysis which shows how Marxan could be used in the Murchison-Semliki Landscape to look at trade-offs between different land uses, aiming to maximize the benefits to individual stakeholders, while ensuring that biodiversity is conserved effectively in the landscape.

Using Marxan to analyse trade offs in land use

DATA REQUIREMENTS FOR MARXAN

Using Marxan to explore trading-offs in land-use planning requires spatially explicit information on features of conservation interest (e.g. species, ecosystems) and the suitability of the landscape for non-conservation land-uses (e.g. farming, oil extraction). Spatial information on location and abundance of conservation features in the region informs the relative value of an area for achieving conservation objectives. Information on the relative suitability for uses other than conservation, provides information on the opportunity cost of setting aside an area for conservation. Because the Marxan optimization routine is spatially explicit, it is essential that all conservation features of interest and value for alternative land uses be defined spatially. We cannot measure the benefit of, or account for the costs of, anything that is not delineated spatially.

Ideally the planning effort would be supported by perfect information on distribution of, and processes that support each species and ecosystem in the planning region. However, even in the best studied regions, such information is never available. This means that planning efforts typically rely on detailed information on a suite of key species, and utilize "surrogates" to represent other species. Within the parlance of conservation planning, a surrogate is a feature that acts as a placeholder or representative for a suite of species within the planning process. For example, the map of grasslands within a region could be used as a surrogate in the planning process for grassland dependent species. The use of surrogates relies on the assumption that by conserving a portion of the surrogate (eg. x% of grasslands), that grassland dependent species will also be conserved.

The ABCG project team began to collect the required information to examine trade-offs in the Murchison–Semliki landscape early in 2012. The preliminary analysis uses species distribution models developed specifically for key threatened and endemic species in the Albertine rift (Figure 5), and uses habitat types and land cover surrogates which represent the species not directly modeled.

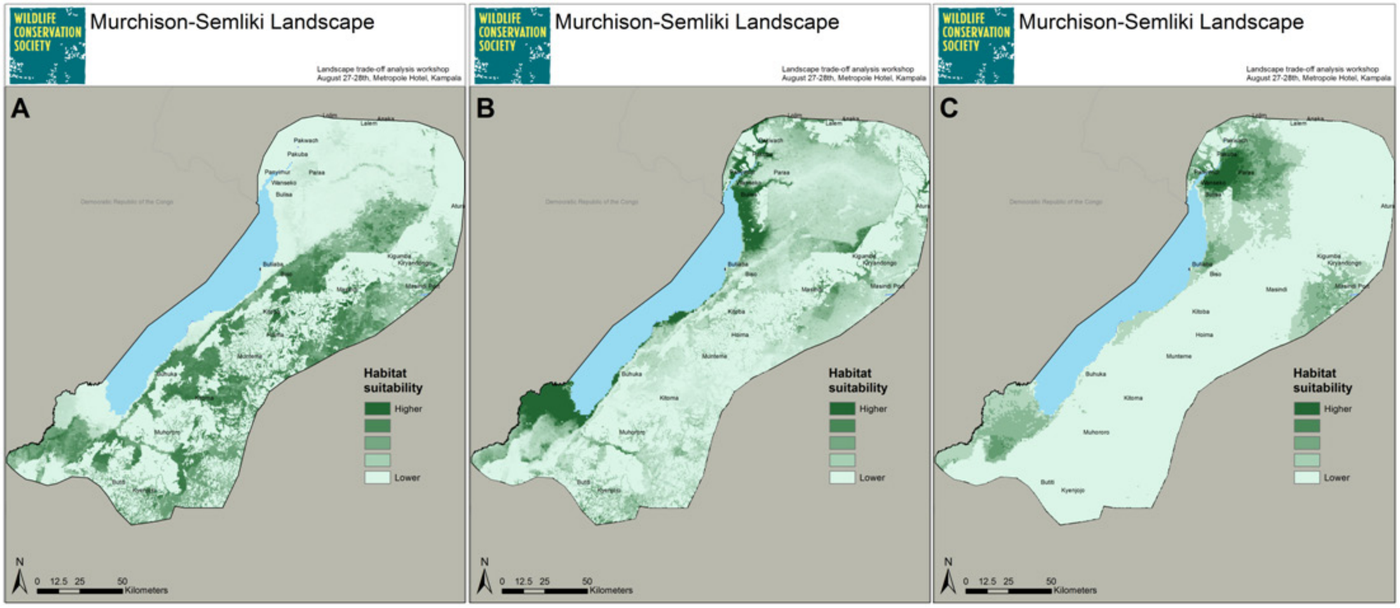

Figure 5. Examples of species distribution models for key species in the Murchison-Semliki landscape. A) Chimpanzee (Pan troglodytes), B) Grey Crowned Crane (Balearica regulorum), and C) Lion (Panthera leo).

Examining trade-offs between alternative land-uses also requires information on the relative suitability of each portion of the landscape for those uses. This information provides the context in which conservation decisions are to be made. This analysis uses preliminary information on three prospective land uses within the region (Figure 6). We used these layers for illustration purposes only, and their inclusion should not be interpreted as an endorsement that these are the only land uses that should be considered in the planning process.

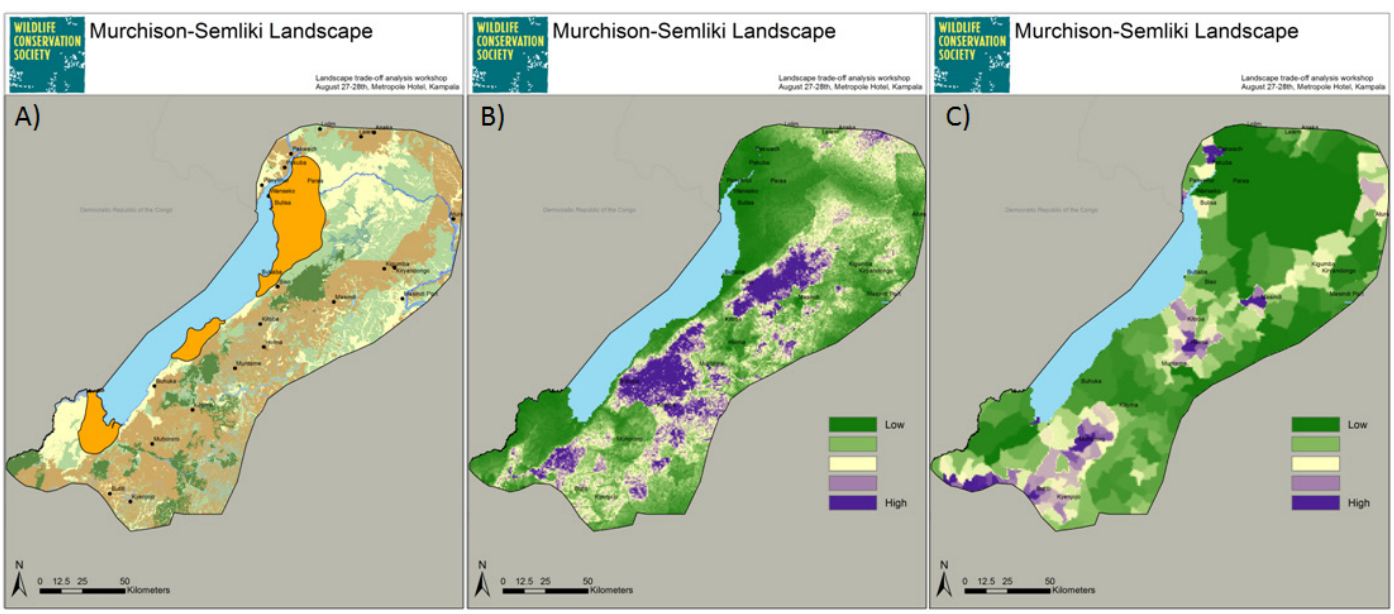

Figure 6. Costs surfaces used in the analysis. A) Areas of potential value for petroleum, B) Relative concentration of high value timber species, C) Population density, as surrogate for agricultural demand.

In addition to the underlying data requirements, a Marxan analysis requires decision makers to articulate quantifiable conservation objectives. An example would be to conserve 80% of lion habitat within the region. Conservation objectives for the preliminary analysis were established by stakeholders during a planning meeting in August 2012 in Kampala. At the meeting, participants defined a range of conservation objectives to be explored in different scenarios. For the purpose of this analysis we have focused on a single set of conservation objectives (Table 2). The objectives are at the lower end of what the group felt were appropriate for the landscape. All areas of the landscape that are already modified (e.g. urbanized, agricultural areas) were excluded from the analysis, because our focus is achieving conservation objectives within intact landscapes.

SCENARIO PLANNING IN MARXAN

Scenario planning within Marxan requires defining a set of conservation objectives to be achieved, and specification of the cost of achieving those objectives in each portion of the landscape. In each scenario the Marxan optimization algorithm attempts to minimize the cost of achieving the conservation objectives. The cost against which objective achievement is measured, can be as simple as the total area required, or a complex mix of the opportunity cost to a variety of alternative land-uses in the region. In this preliminary analysis, we utilized a single set of conservation objectives, and six different cost scenarios: 1) Minimize total area required to achieve the objectives, 2) Minimize the total area required, with existing managed areas always included in the selected set, 3) Minimize inclusion of areas with potential for petroleum production, 4) Minimize inclusion of areas with potential for petroleum production with protected areas locked in, 5) Minimize inclusion of areas with the greatest potential for Timber production, 6) Minimize the weighted impact of the various land uses to multiple stakeholders as specified by attendees at the ABCG meeting in Kampala.

Table 2. Base target, range of analysis established by workshop participants, and the target used in the preliminary analysis.

Ecosystems	Base Target	Range	Target used
Woodland	70%	± 20%	50%
Grassland	80%	± 5%	75%
Wetland	100%	± 10%	90%
Bushland	45%	± 10%	35%
Colonizing Forest	80%	± 20%	60%
Tropical High Forest Fully Stocked	80%	± 20%	60%
Tropical High Forest Depleted	80%	± 20%	60%
Species			
Threatened species at low density (<1/km2)	80%	± 10%	70%
Threatened species at medium density (1-20/km2)	70%	± 20%	50%
Threatened species at high density (>20/km2)	50%	± 10%	40%
Albertine Rift endemic species at low density (<1/km2)	90%	± 10%	80%
Albertine Rift endemic species at medium density (1-20/km2)	80%	± 20%	60%
Albertine Rift endemic species at high density (>20/km2)	80%	± 20%	60%
Tourism value species (Chimpanzee, lion, elephant, leopard, giraffe, hyena, hippo)	80%	± 15%	65%
Species where >10% of World population occurs in region	90%	± 10%	80%

Note: Targets at the lower end of the identified range were selected for the preliminary analysis to afford greater spatial flexibility in where conservation objectives could be achieved.

The scenarios examined in the preliminary analysis explore options for achieving a single set of conservation objectives, with alternative constructions of the underlying cost surface. The use of a single set of conservation objectives facilitates comparison across scenarios, by ensuring that the achievement of conservation objectives serves as a common denominator and focuses attention on the areas identified for achieving the objectives, and the resulting impact on other potential land-uses.

Conservation objectives are rarely fixed in stone apriori to the analysis process, and scenario planning can also be useful in exploring what achievement for different sets of conservation objectives would actually look like. Through such an iterative analysis stakeholders, decision makers and planners can collectively explore the cost of achieving conservation on stakeholders.

Results of scenario planning to examine trade-offs in land use

Marxan provides two outputs that can inform land-use planning decisions. The first is complete sets of areas that achieve the conservation objectives (Figure 7). The second is a measure of an area's "irreplaceability" within an efficient conservation network. Irreplaceability is an objective specific measure of conservation value that provides feedback on how likely it is that an area will be included in an efficient solution (Segan et al. 2010). Areas that are highly irreplaceable have fewer substitutes if conservation objectives are to achieved efficiently. Areas with lower irreplaceablity can be more easily substituted out of conservation areas.

The analysis revealed that there is flexibility in where the preliminary conservation targets can be achieved in the Murchison-Semliki landscape. This spatial flexibility was apparent for both the areas identified as priorities for conservation, and in the differing opportunity cost and distribution between alternative land-uses.

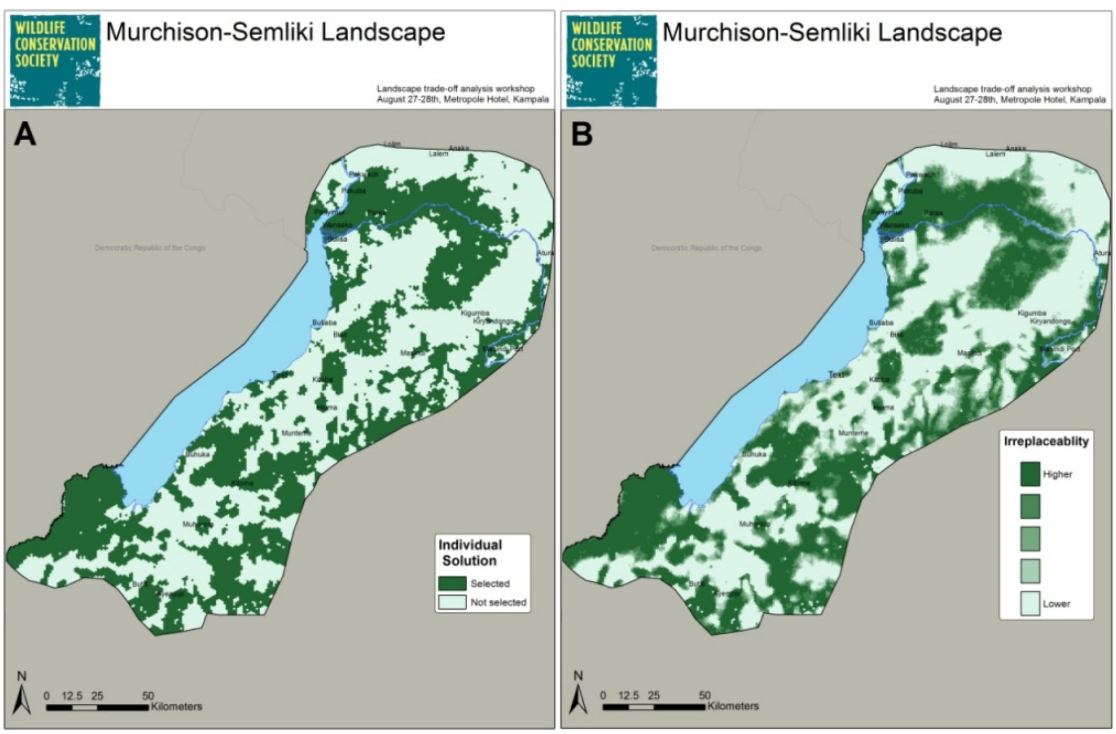

Figure 7. Example output from a Marxan analysis. (A) shows a single Marxan solution (areas selected for conservation in dark green) that achieves the specified conservation objectives. (B) displays the relative importance of areas to achieve conservation objectives efficiently (darker areas are more importance) by combining multiple runs of the software.

The areas identified for inclusion in conservation zones had different impacts on potential other uses in the Murchison-Semliki landscape (Figure 8). In the six scenarios, the area required to achieve the objectives ranged from 62%-71% of the unmodified area in the landscape. The cost associated with achieving the conservation objectives ranged from a high of 74% of the area identified as suitable for petroleum to less than 25% of the oil exploration areas. While impact on oil had the highest range, wide ranges were also observed for other features, impact to timber varied from less than 50% to greater than 70%.

The diversity in range reflects the spatially flexibility in where the conservation objectives can be achieved in the landscape. The differences are non-trivial and reflect the need for thoughtful planning to avoid imposing unnecessary costs stakeholders.

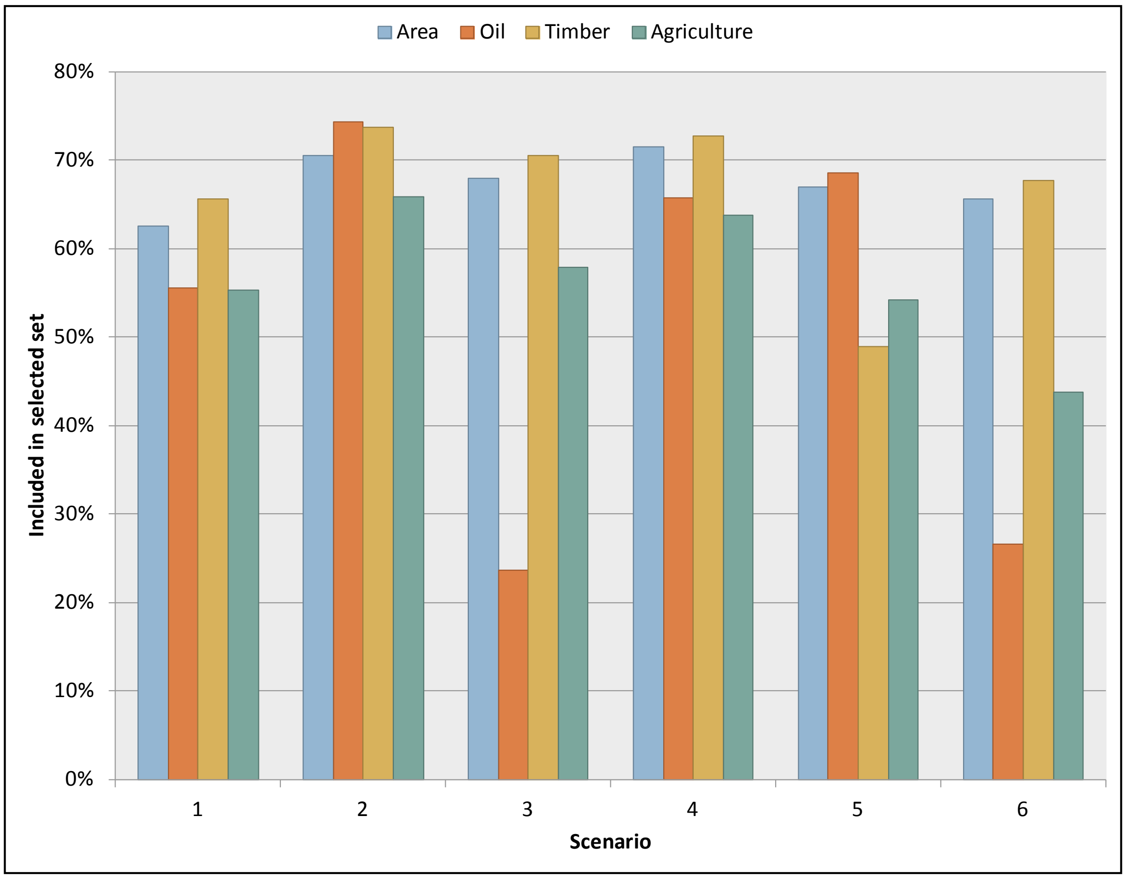

Figure 8. Percentage of the total mapped value of four alternative land-uses that was included in the selected set of conservation areas in each of the six scenarios.

Two of the scenarios considered what would happen if the full extent of all areas currently managed for conservation (National Parks, Central Forest Reserves, Community Wildlife Areas, Local Forest Reserves, Wildlife Reserves and Wildlife Sanctuaries) are included at the start of the analyses (scenarios 2 and 4), while four other scenario considered how conservation objectives could be met with a blank slate.

Conservation areas also represent a potential source of revenue for communities and local and national government. Here we looked at two potential benefits from setting aside areas for conservation. The first is potential revenue from tourism in the region. Tourism value as calculated as the abundance of charismatic species in the selected areas. We also considered potential for REDD+ payments and quantified the amount of above ground carbon included in the selected areas (Figure 9). Relative to cost objectives, representation of features with revenue generating potential was more stable in conservation areas (range 72-82% of available value). The narrower range for these two land-uses reflects their closer spatial correlation with underlying biodiversity features. We did not attempt to place an economic value on either activity. Like the opportunity costs, values are expressed as a percentage of the total in the landscape.

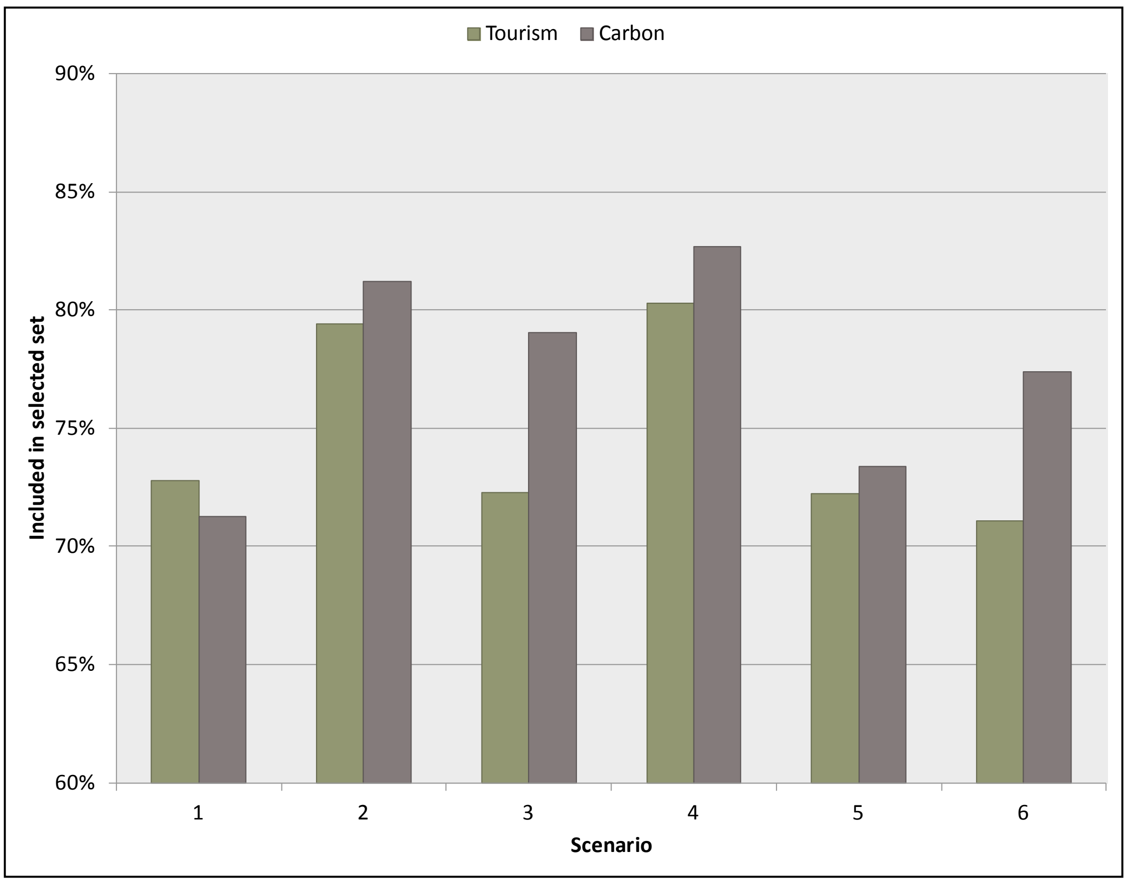

Figure 9. Potential contribution of the areas selected for conservation to protection of species of high value to tourism, and protected of standing carbon stocks.

Examination of individual scenarios in isolation can also be useful to identify areas of difference between the scenarios, while combining assessments of conservation value from scenarios with different underlying objectives, can be useful in identifying areas that are robust to subtle differences in underlying objectives. In the current analysis, in which all scenarios share a common set of conservation objectives, that aggregation of results from the scenarios, provides a good indication of which areas are required to achieve conservation objectives even when placing varying importance on avoiding areas for each of the alternative land uses (Figure 10).

Overlaying areas selected for conservation in a single analysis on top of irreplaceability maps for another stakeholder, provides that stakeholder with a understanding of where compromises can be made in the landscape (Figure 10). The darker green areas in figure 10B are areas for which there are few substitutes, while areas that appear much lighter, were included in the current solution set, but which can easily be exchanged for other areas in the region.

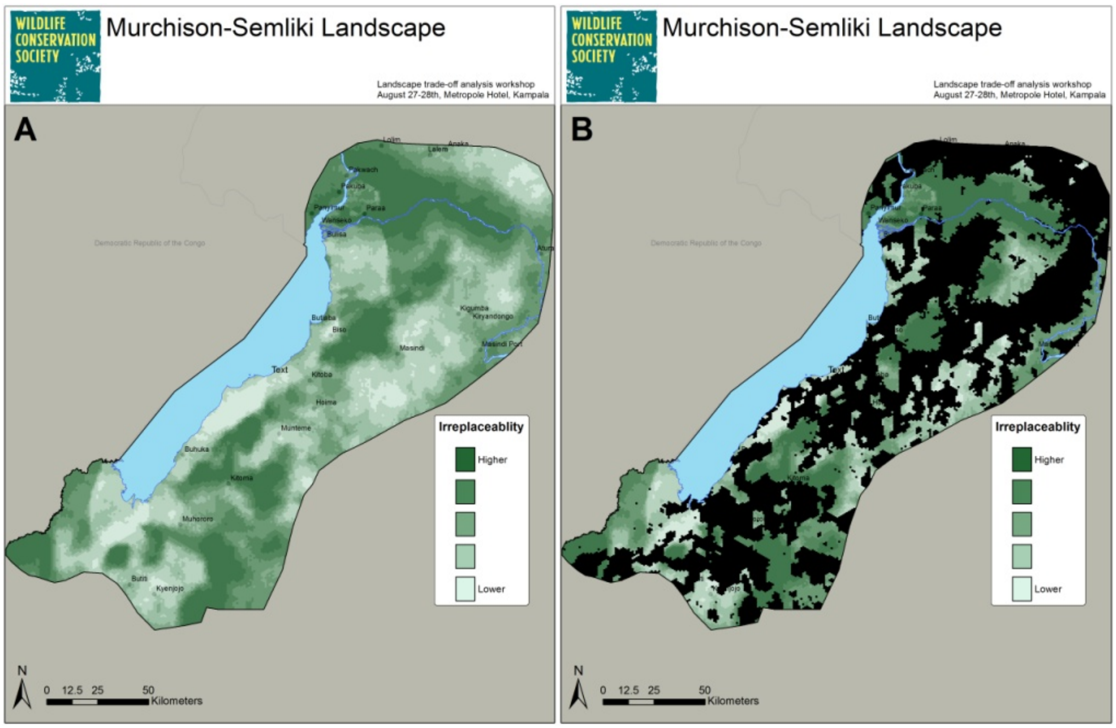

Figure 10. Example output from the Marxan analysis. (A) Displays the irreplaceability summed across the six scenarios in the analysis (darker areas have higher irreplaceability across the range of scenarios). (B) Solution from scenario 1 (minimize total area) overlaid on the aggregate irreplaceability map. The areas selected to minimize the total area required for conservation are transparent, and areas not selected are in black.

Scenarios that focus primarily on the interests of an individual stakeholder (eg. scenarios 3 and 5), establish baselines for overlap between the conservation objectives and the interests of that stakeholder group. These baseline scenarios inform the interpretation of other scenarios that consider a complex mix of stakeholder interests, by providing insight into the expected impact in the absence of competing landscape interests. For example, in scenario five which attempts to minimize inclusion of high value timber areas, the opportunity cost to timber is just under 50% of the total landscape value. In all other scenarios, the opportunity cost incurred by timber is higher than 50% (Figure 8). The higher opportunity cost reflects how accommodating the interests of multiple stakeholders can place an additional burden on an individual stakeholder group.

Other planning exercises have recognized that economic efficiency is often not the sole measure by which proposed plans are measured, and many stakeholders often look at the equitability of outcomes

(Klein et al. 2008). We also looked at the distribution of lost opportunity to potential users. We found that by adjusting the relative importance of avoiding areas of high importance to individual users there was a wide variety in how the costs of planning were distributed between users. Relative load placed on areas of prospective interest to the petroleum industry ranged from 19-45%, and the relative load on timber ranged from 32-58% (Figure 11). These differences are not inconsequential and thoughtful planning is required to ensure that the landscape of the future meets the needs of stakeholders of the region.

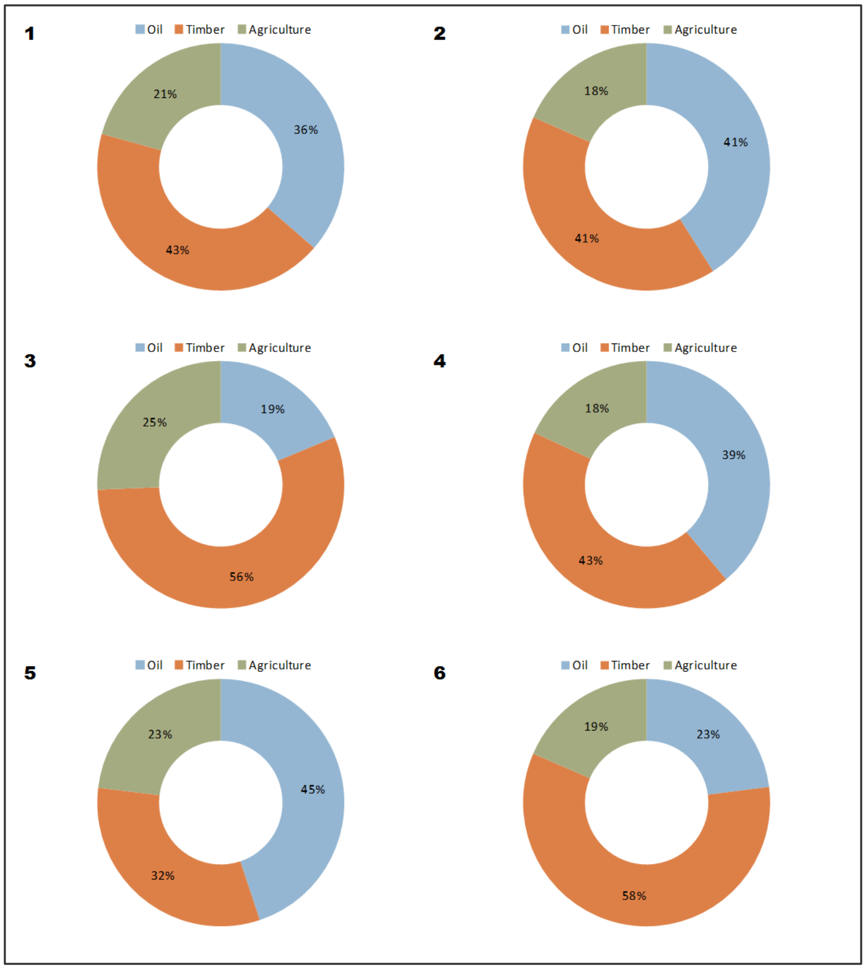

Figure 11. The opportunity cost of individual land uses relative to the cumulative opportunity cost of the proposed conservation areas in six scenarios. Total opportunity cost is calculated by placing equal weight on each activity and then summing the percentage of area suitable for that activity that was displaced by the planning process or included in the areas selected to achieve conservation objectives.

Planning to avoid or minimize conflict over land use

This report demonstrates how the spatial optimization tool, Marxan, could be used to identify efficient conservation areas, while balancing the opportunity costs to multiple stakeholders. It also provides a method to identify areas critical for achievement of conservation objectives and where greater efforts need to be made to ensure that two or more land uses are compatible.

The data and targets utilized in this analysis are preliminary, and the analysis of overlap and impact should be treated as preliminary as well. The process involved only a subset of the data and stakeholders who need to be included in the larger decision making process. For the landscape to conserve the biodiversity it currently holds, and maximize potential benefit from other land-uses will require careful planning. One such effort is being undertaken by the Strategic Environmental Assessment (SEA) for oil in the Albertine rift in Uganda which is aiming to plan for the long term impacts of the oil industry in this region. However, the current SEA process is focused primarily on oil and biodiversity, where a holistic view of the landscape that incorporates land uses such as carbon, timber harvesting, agriculture and tourism, is required to ensure that all objectives are achieved.

It is clear that if the biodiversity of the Murchison-Semliki Landscape is to be conserved in the long term careful planning will be required to minimize the impact of other activities. This particularly applies to timber extraction, the oil industry and small/large scale agriculture, which are seen as drivers of primary threats to species persistence in the landscape (MWE 2012).

Using a simple example, we have demonstrated how planning for the future use of this landscape can balance the interests of multiple users and provide economic benefits at the landscape scale. Marxan has been used for similar trade-off analyses between competing land uses elsewhere and need not be used solely for planning around conservation. While the example presented here considered only the identification of conservation areas, it is also possible to consider the placement of mixed use zones or the optimal location for multiple management actions within the landscape (Watts et al. 2009). The Wildlife Conservation Society is interested in building the capacity for such analyses to be made in Uganda and elsewhere to help minimize potential conflicts over land use but also to ensure the long term conservation of the rich biodiversity of this country and ensure the long term viability of its tourism industry.

References

Ball, I.R., Possingham, H.P., and Watts, M. (2009). Marxan and relatives: Software for spatial conservation prioritisation. Chapter 14: Pages 185-195 in *Spatial conservation prioritisation: Quantitative methods and computational tools.* Eds Moilanen, A., K.A. Wilson, and H.P. Possingham. Oxford University Press, Oxford, UK.

Carwardine J, Wilson KA, Watts M, Etter A, Klein CJ, et al. (2008) Avoiding Costly Conservation Mistakes: The Importance of Defining Actions and Costs in Spatial Priority Setting. PLoS ONE 3: e2586.

Didier, K. A., Glennon, M.J., Novaro, A., Sanderson, E.W., Strindberg, S., Walker, S. and Di Martino, S. (2009). The Landscape Species Approach: spatially-explicit conservation planning applied in the Adirondacks, USA, and San Guillermo-Laguna Brava, Argentina, Landscapes. *Oryx*, 43, 476-487,

Game, E.T. and Grantham, H.S., (2008). *Marxan User Manual: for Marxan version 1.8.10*. University of Queensland, St Lucia, Queensland, Australia and Pacific Marine Analysis and Research Association, Vancouver, British Columbia, Canada.

Groves, C. and Grubb, P. (2012). *Ungulate Taxonomy*.

Klein C, Steinback C, Scholz A, Possingham H (2008) Effectiveness of marine reserve networks in representing biodiversity and minimizing impact to fishermen: a comparison of two approaches used in California. *Conservation Letters,* 1: 44-51.

Ingram, J.C., Redford, K. H. And Watson, J.E.M. (2012, in press). Implementing the Ecosystem Services Approach for Biodiversity Conservation: Benefits and Challenges. S.A.P.I.E.NS.

Joppa, L. and Pfaff, A. (2009). High and far: Biases in the location of protected areas. PLoS ONE 4(12): e8273. doi:8210.1371/journal.pone.0008273.

Leal, M., Akwetaireho, S., Nangendo, G. and Plumptre, A.J. (2011). *Murchison-Semliki Landscape: Feasibility study for REDD.* Unpublished report to UNDP/GEF project UG0031.01., JGI and CSWCT.

MWE (2012). *Strategic Plan for the Northern Albertine Riftof Uganda 2011-2020.* Ministry of Water and Environment, Government of Uganda.

Owiunji, I. & Plumptre, A.J. (1998). Bird communities in logged and unlogged compartments of Budongo Forest, Uganda. *Forest Ecology and Management,* 108, 115-126

Plumptre, A.J. (1996). Changes following 60 years of selective timber harvesting in the Budongo Forest Reserve, Uganda. *Forest Ecology and Management,* 89, 101-113

Plumptre, A.J. & Reynolds, V. (1994). The impact of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology,* 31, 631-641

Plumptre, A.J., Davenport, T.R.B., Behangana, M., Kityo, R., Eilu, G., Ssegawa, P., Ewango, C., Meirte, D., Kahindo, C., Herremans, M., Kerbis Peterhans, J., Pilgrim, J., Wilson, M., Languy, M. and Moyer, D. (2007). The Biodiversity of the Albertine Rift. *Biological Conservation*, 134: 178-194

Pressey, R.L. (1994). Ad hoc reservations: forward or backward steps in developing representative reserve systems? *Conservation Biology* 8: 662-668

Prinsloo, S., Mulondo, P., Mugiru, G. and Plumptre, A.J. (2012). *Measuring responses of wildlife to oil exploration operations in Murchison Falls National Park*. Report of USAID WILD Program.

Segan, D. B., J. Carwardine, C. Klein, H. Grantham, and R. L. Pressey. 2010. "Can We Determine Conservation Priorities Without Clear Objectives?" Biological Conservation 143 (1): 2–4.

Smith R.J., Easton, J., Nhancale, B.A., Armstrong, A.J., Culverwell J., et al. (2008) Designing a transfrontier conservation landscape for the Maputaland centre of endemism using biodiversity, economic and threat data. Biological Conservation 141: 2127-2138.

Tognelli, M. F., P. I. Ramirez de Arellano, and Marquet, P. A. (2008). How well do the existing and proposed reserve networks represent vertebrate species in Chile? *Diversity and Distributions* 14:148–158.

Watson, J.E.M., Evans, M.C., Carwardine, J., Fuller, R.A, Joseph, L.N., Segan, D.B., Taylor, M.F., Fensham, R.J. and Possingham H.P. (2011). The capacity of Australia's protected-area system to represent threatened species. *Conservation Biology* 25:324-332.

Watts, M. E., I. R. Ball, R. S. Stewart, C. J. Klein, K. Wilson, C. Steinback, R. Lourival, L. Kircher, and H. P. Possingham. "Marxan with Zones: Software for Optimal Conservation Based Land- and Sea-use Zoning." *Environmental Modelling & Software* 24, no. 12 (2009): 1513–1521.

Wilson K.A., Carwardine J. and Possingham H.P. (2009) Setting Conservation Priorities. Annals of the New York Academy of Sciences: The Year in Ecology and Conservation Biology: 1162: 237–264.

WCS (2012). *Attractions of Murchison Falls National Park: Perceptions about the Development of a Golf Course*. Unpublished report to Uganda Wildlife Authority.