Kunene Regional Ecological Assessment

Volume one: Introduction and Methods

Prepared for the **Kunene People's Park Technical Committee** by Round River Conservation Studies

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Introduction and Methods: Volume 1 of 3

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Principal Investigators: Jeff Muntifering, Dr. Christopher Lockhart and Richard Tingey
Assisting Investigators: Julian Griggs, Dr. Kimberley Heinemeyer, Dr. Jennifer Lalley, and Dennis Sizemore

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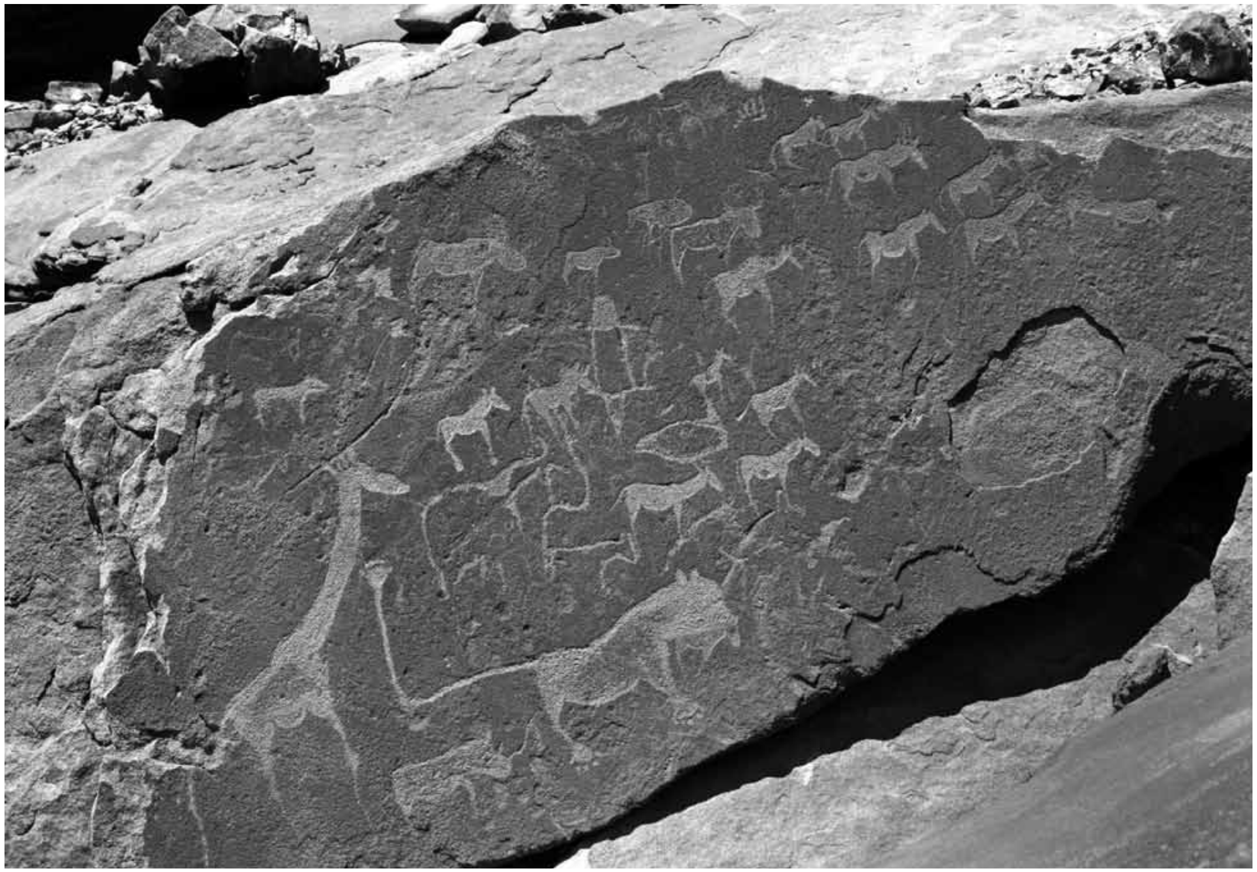

This assessment brings together and builds upon the work of many individuals and organizations conservation in the Kunene Region over the past half century. Many have contributed their valuable knowledge, data and time to this work.

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Executive Summary

The Namibian government, in collaboration with local communities, Traditional Authorities, NGOs and private sector stakeholders, has proposed a new contractual national park in the Kunene Region comprised of the four units of state concession lands, (totaling approximately 700,500 hectares). The purposes of the proposed park address both conservation as well as socio-economical goals. The conservation objectives of the proposed park are to conserve this vast wilderness and its wildlife, while also serving to link the Skeleton Coast and Etosha National Park, thereby facilitating wildlife migrations and creating one of the largest conservation area complexes in the world.

To provide an ecological basis to inform future planning, Round River Conservation Studies was requested to conduct a Regional Ecological Assessment situated within a conservation planning conceptual framework, that included stakeholder engagement and a collaboration strategy, to ensure the assessment results were linked to implementation activities. The goals of the Kunene Regional Ecological Assessment (KREA) are to: 1) Compile available data and identify key information gaps, 2) Foster collaboration through data and information sharing, 3) Conduct a regional ecological assessment, 4) Integrate KREA products into a Data Management System for shared decision-support, 5) Help guide the establishment of sound monitoring strategies and additional applied research projects to support adaptive management activities.

The data compilation and concurrent information sharing stages initiated in October 2006 have yielded spatial information for the 3 concessions under the People's Park proposal and the 10 surrounding conservancies. During these local mapping activities, project members visited 136 villages, interviewed over 1,000 local informants and inspected well over 500 water points while also introducing KREA objectives, and collecting relevant data. The resulting information merged with existing databases such as Namibia's Atlas, ConInfo, and additional data sets from Ministry of Lands and Resettlement Directorate of Survey and Mapping produced a set of spatial data for the region. This compiled set of information formed the basis for the assessment analysis.

The assessment analysis was comprised of a suite of individual analytical components aimed at specific conservation objective endorsed by the Kunene People's Park Technical Committee. A synthesis component merged the analytical components into an assessment framework allowing quantitative and qualitative goals to be set on representation of spatial values. This approach identified conservation priority areas across the region. The synthesis also integrated social values into the assessment to identify areas where conservation goals could be met with minimal conflict with existing competing traditional land use values, such as seasonal livestock grazing. This approach conducted through the use of a decision-support tool, enables users to assess trade-offs across the landscape to help reconcile ecological values with socio-political realities and implementation practicalities.

Although other regional assessments and plans have been developed for the Kunene, this is the first ecological assessment of its kind for the region that employs a systematic, scientific approach to identify priority areas for conservation actions. Utilizing the compiled database, each analytical component (focal species habitat, ecological land units, connectivity and livestock grazing) identifies each components' key driver variables and depicts their spatial values across the planning region. Thus, key areas were identified in a regional perspective across political boundaries.

To assess and identify and 'protect core wildlife habitat' as endorsed by the Kunene People's Park Technical Committee, we sought to model and map a suite of key focal species, black rhino, lion and elephant, habitats across the region. Driver variables and relative habitat suitability for each is presented in the results section with summary tables for spatial comparisons. The focal species coverage assessments illustrated interesting patterns with black rhino providing the best surrogacy for other data-deficient native wildlife (particularly mountain zebra), with elephant and lion providing less coverage but possibly capturing important movement routes that are used less frequently by other wide-ranging game of critical importance.

Where as, the proposed People's Park encapsulates the highest density of focal species habitat values, the surrounding conservancy lands support overall more area of suitable habitat. This emphasizes the importance of a regional perspective to inform future land planning as the areas within the proposed People's Park, albeit extensive, may not sustain viable populations of focal species on its own.

Mapping ecological land units (ELU) provides a further means to identify additional key conservation areas. This component specifically addresses the Kunene People's Park Technical Committee objective to 'maintain biodiversity and natural beauty' and 'conserve rare and endangered species'. For example, important areas for endemic plants are known to be the flat top etendekas, but were not identified as high quality habitat for any of the focal species. Important areas for such 'special elements' were identified by mapping the range of unique combinations of variables such as landforms (topography), geology, rainfall and moisture accumulation, there by, illustrating the diversity of the unique ecological systems present in the region. The mapping of each unique ELU identified areas containing the most density and diversity of ecosystems. These key areas (namely within Hobatere, #Khoadi //Hoas) are most likely to support the highest levels of overall biodiversity representation.

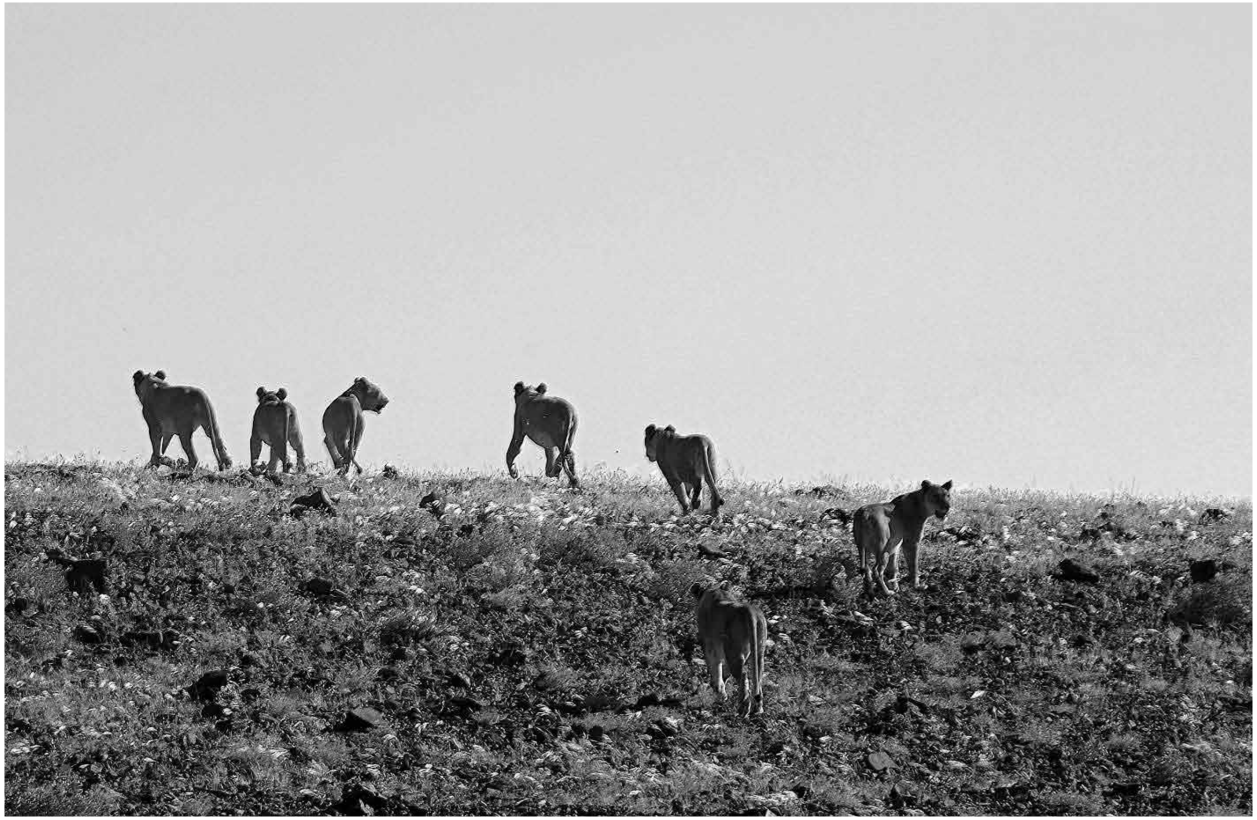
The final component in the assessment specifically addressed the importance of identifying key movement areas, particularly between Skeleton Coast and Etosha National Park. Water sources were used as the 'core resource base' for the connectivity modeling since permanent springs were a consistent driving factor in the habitat models and therefore highly spatially correlated with core wildlife areas. Key movement corridors were identified for both north-south as well as east-west directions between key core wildlife areas.

Seasonal livestock distribution was employed as a measure of traditional land use values across the landscape. A seasonal livestock distribution model was created from community mapping activities that was used to assess trade-offs (opportunity and conflict) between conservation and traditional land use values in the context of land use planning.

A suite of scenarios or conservation options maps were then produced under various sets of quantitative and qualitative goals. These included a range of representation goals for ecological values (focal species habitat, ecological land units and connectivity), reduced fragmentation of key conservation areas, and minimized overlap with competing traditional land use values (seasonal livestock grazing). Evaluating solutions for lower levels of representation identified the relatively more vital 'refugia' for conservation, while evaluating progressively higher levels of representation goals identified additional areas that would add the most conservation value by area. A series of these individual scenarios are presented in the results section. In the absence of more detailed information, we combined a range of representation scenarios into one cumulative solution (cumulative conservation values index) that illustrated where areas of relatively more conservation importance persist across a range of representation goals. These values may thresholded into appropriate categories designed to better match stakeholders' potential land use objectives to maximize benefits.

Since the focal species models predicted the relative likelihood of occupancy, identified areas of relatively high values for focal species they also help identify where premium tourism concessions may operate that maximizes both ecological (securing the best habitat) and economical (high priced tourism revenue through offering a better safari product) benefits. These areas may be situated within buffer areas that allow low levels of consumptive tourism (such as trophy hunting) and traditional land use (emergency or some dry seasonal grazing) to maintain the capacity for the key wildlife core areas to be spatially and temporally dynamic under potentially changing conditions. In a dualistic sense, other classes observed with relatively lower levels of cumulative conservation value may be interpreted as being more appropriate for human and traditional land uses such as settlements, higher frequency wet season livestock grazing, consumptive and problem animal hunting and higher impact tourism.

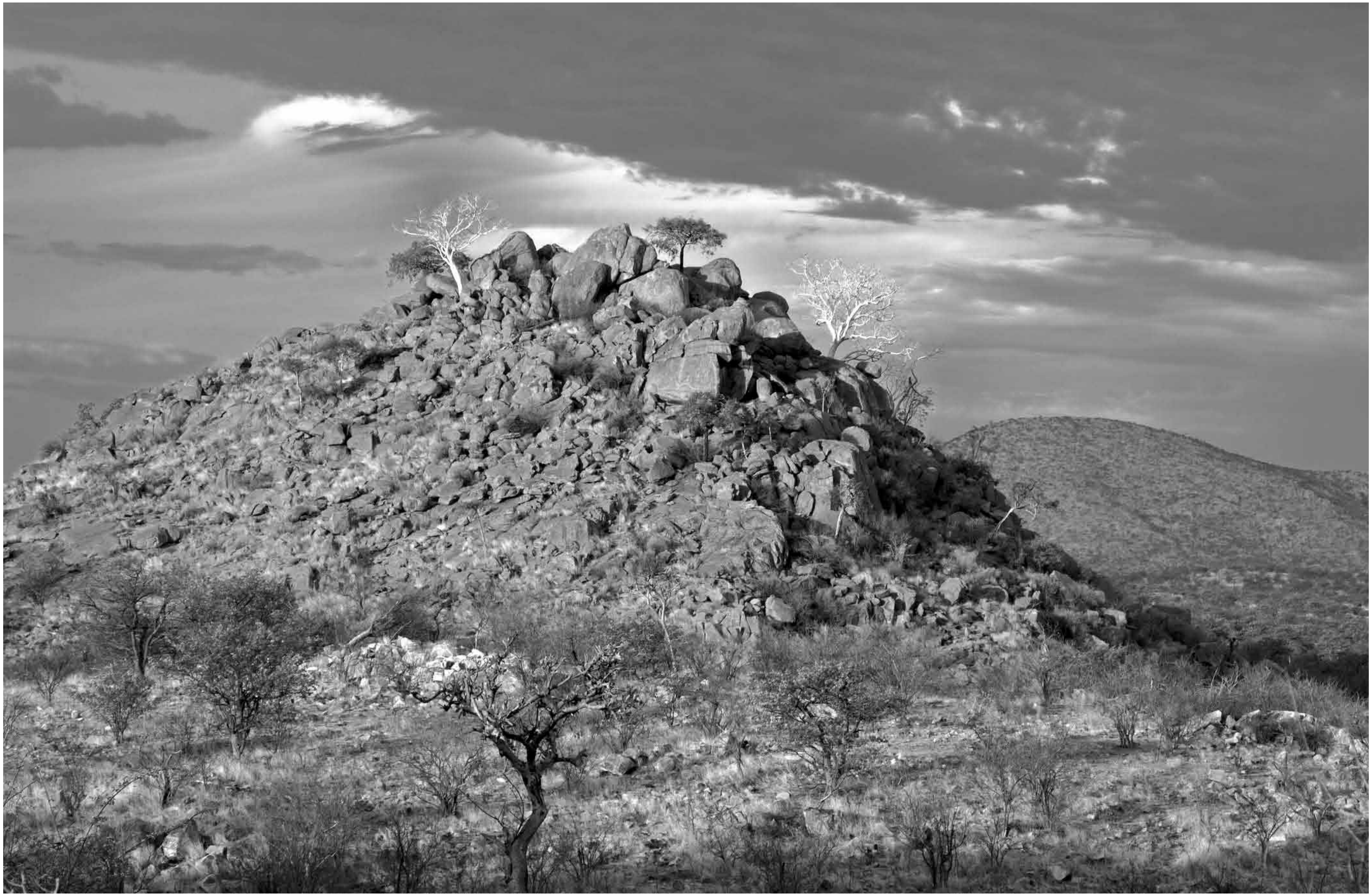
Conservation Core and Buffer Areas were thresholded by retaining all key connectivity paths, maintaining minimum representation goals of 30% and 50% respectively for focal species, and maintaining presence of each ELU across all core areas and minimum of 30% representation for the buffer zones. These two classes maintained these goals over 28% and 47% of the planning region respectively. The two classes characterizing areas relatively more suitable for higher level of resource utilization and human pressure sup-



ported well over 50% of the seasonal livestock grazing values with many of the conservancies maintaining over 70% of their areas with higher potential for livestock grazing. This approach, as well as additional conflict and trade-off issues are further discussed within the report.

The initial impetus for conducting this assessment was to provide a regional perspective on conservation values to identify and prioritize key area for biodiversity conservation. Thus, it was vital that the assessment was seen as being situated within a regional land use planning context from the very beginning. Thus, we have done our best to persistently engage and share information and map products within a wide range of regional governing and implementing bodies in hopes this may help promote and orchestrate a more effective planning and decision-making approach. At the regional scale, the cumulative conservation value index is one synthesis product that provides a regional perspective on key issues such as to help identify key areas within the park that would maximize its benefits by zoning for premium tourism, areas that could be utilized for emergency grazing with least impact on key conservation core areas, as well as where neighboring conservancies and the parklands would benefit most from aligning their respective land uses (i.e. premium tourism) with areas of relatively higher cumulative conservation value across the fenceless boundary. At a more local level, the KREA map products can be integrated within conservancy management plans and land use zonations, to add value and strength to support the various land management strategies employed. The KREA products also provide each conservancy with a regional perspective regarding how their land is situated in a broader context. This may help answer questions such as how much black rhino habitat does one conservancy have relative to other conservancies? Where do areas of key conservation areas extend across boundaries with our neighbors? Where should we establish exclusive non-consumptive tourism concessions to maximize our benefits that do not produce conflict with less compatible land uses that our neighbors may be planning (hunting or livestock area)? When decision-makers use the same information at the same scale, planning can be accomplished in a much more effective and sustainable manner such that everyone benefits. This is particularly critical in an open system such as the Kunene where everyone shares the resources to some extent, especially the wide-ranging wildlife.

The KREA is a dynamic tool, one that evolves over time as more data and knowledge becomes available as well as additional scientific refinements that will help contribute a continuous flow of demand-driven products for decision-makers. The KREA is not meant to replace previous work nor impose conservation action, but compliment and strengthen the existing regional community-based natural resource management programs. Thus, the next steps for KREA advancement and implementation will entail identifying the critical steps towards an operational framework along with periodical assessment refinements, and integrating the KREA into a monitoring system that can inform adaptive management.



Introduction

Project Context

The Namibian government, in collaboration with local communities, Traditional Authorities, NGOs and private sector stakeholders, has proposed a new contractual national park in the Kunene Region comprised of the four units of state concession lands, (totaling approximately 700,500 hectares). The stated purposes of the proposed park address both conservation as well as socio-economical goals. The conservation objectives of the proposed park are to conserve this vast wilderness and its wildlife, while also serving to link the Skeleton Coast and Etosha National Park, thereby facilitating wildlife migrations and creating one of the largest conservation area complexes in the world (approximately 5 million hectares). Similar park scenarios were proposed in the past, but did not come to fruition, in part because of a lack of local support from Traditional Authorities and local communities as they felt they were not being regarded as key players in the negotiation process (Owen-Smith, 2002). As a result, the latest proclamation proposal stipulates that communities be consulted from the beginning and agree on a specific set of conditions (such as equitable benefit sharing and local employment, emergency grazing, etc.). It is also recognized that the park is to be jointly managed by a representative board made up of government, community, NGO, and private stakeholders. The new park will not be fenced and it will be managed through "contractual conservation agreements" in order to accommodate the communities' needs within and surrounding the park.

In 2006, the Ministry Environment and Tourism (MET) initiated a series of discussions with regional stakeholders through the Kunene People's Park Technical Committee (TC). The purpose of these multi-stakeholder discussions was to complete a 'Contractual Agreement' to further the formal proclamation of the new park. It was also at this time that the MET under the Strengthening Protected Areas Network (SPAN) project invited Round River Conservation Studies, in partnership with Save the Rhino Trust, to conduct a Regional Ecological Assessment to contribute science-based products to inform discussions regarding park management and specifically to support the following endorsed TC objectives (Minutes of the 7th Kunene People's Park Technical Committee Meeting, 1-2 March 2008):

Conservation objectives

1. Maintain biodiversity and natural beauty
2. Conserve rare and endangered species
3. Provide a link between the Etosha National Park and Skeleton Coast Park and with neighbouring conservancies
4. Protection of core wildlife habitat
5. Research to inform park management
6. Monitoring of key wildlife species, and habitat condition

While the proposed park lands comprise a large area, they do not effectively connect the Skeleton Coast with Etosha. Surrounding communal conservancy and private lands must also support the protective area system if the park is to be ecologically viable and serve as a functionally effective corridor. Therefore, a multi-level, integrated conservation strategy is warranted to support the management actions of the various land components. Thus, in addition to compiling ecological data for the proposed park, communal land in the vicinity of the proposed park was also included in the assessment particularly to fill critical data gaps and document current traditional land use practices through community mapping engagements.

Therefore, the Regional Ecological Assessment's objectives (see below) provide the stakeholders with additional support for decision-making that aim to

specifically address the TC's Conservation Objectives. Additionally, it was stated and endorsed by the TC that (Minutes of the 7th Kunene People's Park Technical Committee Meeting, 1-2 March 2008): ….
'*In pursuing economic and social goals neither ecosystem health nor biodiversity within the park may be pushed over thresholds from which recovery is difficult.*'

Thus, a creative decision-making tool that is flexible and capable of producing scenarios, that dually aims to achieve the TC's Conservation Objectives while minimizing the 'cost' to the socio-economic goals is of high value.

Rationale for a Regional-scale Ecological Perspective

A regional ecological analysis provides a scientific basis to prioritize landscapes for the maintenance of functioning ecosystem processes and wildlife populations across appropriately large regions (Hawkins & Selman 2002; Howard et al. 2000; Jepson et al. 2002; Pfab 2002; Soulé & Terborgh 1999; Wisdom et al. 2002). Unfortunately, for the majority of existing protected areas their location, size and juxtaposition was determined primarily based on political factors rather than a comprehensive analyses of ecological requirements for sustainable conservation. For example, in Canada and the United States most protected areas are located in alpine or sub-alpine zones and are too small and isolated to maintain viable wildlife populations (Lewis & Westmacott 1996; Sanjayan & Soulé 1997). Further investigations in Indonesia (Jepson et al. 2002), Mexico (Galindo-Leal et al. 2000) and Africa (Brooks et al. 2001; Fairbanks et al. 2001; Heydenrych et al. 1999; Howard et al. 2000) have shown many ecological communities to be under-represented, under-protected and important connectivity considerations severely lacking to adequately protect existing biodiversity. Additionally, several studies on protected areas in North America and East Africa, have shown that single isolated protected areas are highly susceptible to becoming island-like when surrounded by landscapes inhabited by humans inhospitable to biodiversity and natural processes (Newmark 1995; Newmark 1996). These landscapes are losing key species, particularly wide-ranging mammalian species. Only those parks or park complexes that escaped the loss of mammal species over time were exceptionally large, over 1000 km2 and usually around 10,000 km2.

The need to carefully assess and analyze the regional context for balancing human and conservation needs becomes particularly critical when human use or populations increase, creating conflict between people and wildlife inside and outside of existing protected areas (Brashares 2003; Brashares et al. 2001; Newmark 1996; Parks & Harcourt 2002; Woodroffe & Ginsberg 1998). Increasing human use and population translate into an increasing need for careful selection of the location, size and juxtaposition of potential protected areas that can provide the cornerstones for ecological conservation. Parks & Hartcourt (2002) found that although size of protected areas is critical, loss of species is also tightly linked to human pressures in the surrounding matrix lands (e.g., agricultural conversion, urbanization). Additionally, human pressures (i.e., hunting) inside protected areas is important in determining the fate of native biodiversity (Brashares et al. 2001). Depending on long-term land uses, formal protected status may not be required across the entire region, if environmentally sensitive management is implemented across the wider landscapes. Within these mosaic landscapes, protected or conservation areas become our insurance that biodiversity and ecological processes remain viable across the region and activities outside of protected areas largely determine whether long-term conservation goals are met. Critically, a regional analyses allows the prioritization of land use designations across meaningfully large landscapes, to balance the level of conservation with existing and predicted human uses and needs for land and resources.

Planning for the maintenance of ecological functions and species across broad landscapes is particularly important in regions where ecosystem richness and productivity are maintained and/or influenced through large-scale disturbance regimes, weather events or ecological cycling (e.g., Bunnell 1995; Pringle 2001; Segerstrom 1997). Additionally, in systems with relatively low productivity (e.g., desert ecosystems), some species, particularly large mammal species, have evolved life-history strategies that require extensive landscapes to meet seasonal and annual life requisites for food and breeding. Maintaining ecologically effective populations of these species is key to the maintenance of community dynamics and complexity over the long term (Berger et al. 2001; Soulé et al. 2003).

Project Objectives

The SPAN and ICEMA initiatives recognize the importance of reliable and comprehensive data on which to base informed planning and management decisions, and to inform the design of conservation measures in areas such as the Kunene. For example, the SPAN program highlights the need for improved knowledge management, and ICEMA also notes the importance of information at both the regional and national level to support coordinated management in conservancies. Although efforts have been made to compile regional profiles in some parts of Namibia, there is a significant lack of data to support ecosystem management in the Kunene. Moreover, the SPAN initiative calls for 'systematic biodiversity monitoring mechanisms,' and a 'framework and plans to ensure coordinated and targeted monitoring of biodiversity conservation activities in PAs.' For these outcomes to be achieved, substantial baseline assessments are required.

Data is rarely ever fully complete and decision-makers often rely on estimates, risk-based management approaches, and tools such as adaptive management to cope with uncertainties. Nonetheless, considerable effort is often needed to develop adequate information sets on which to base planning and management decisions.

1. Data Compilation

Several independent single-species wildlife research initiatives are underway in the Kunene region, but these efforts have yet to be coordinated and results are not generally centrally available. As a result, no comprehensive analysis of ecological values is available. Furthermore, inventory is limited, and there have been few if any initiatives aimed at collecting local knowledge on conservation values.

The KREA aims to identify and compile existing research products and inventories, and develop and implement standardized data management systems so that information can be provided in a usable format for planning and management processes.

2. Fostering collaboration through information collection & sharing

International experience suggests that joint efforts to compile available information, solicit contributions from communities in the form of local knowledge, and cooperate on research initiatives to fill knowledge gaps can act as powerful tool in bringing together disparate interests. In the Kunene, the importance of a collaborative approach to the assessment of regional values is clear, particularly given the range of communities, diverse social cultures, private interests, conservancies and other community associations, NGOs, and other interests.

Collaborative approaches to information gathering and interpretation can also serve to engender commitment to joint planning initiatives, foster working relationships, and encourage the building of a shared vision for the future of the Kunene region. Moreover, in the absence of information, compliance with management measures is more likely if stakeholders have been involved in sharing information, collectively acknowledging data gaps, and have understood and jointly assumed the risks for management decision-making.

The KREA seeks to consult local, regional and national-level stakeholders and informants to refine and fill gaps in current databases while concurrently building trust and respect through joint efforts.

3. Complete a Regional Ecological Assessment

Advanced scientific tools and methods are now readily available that address and incorporate principles of conservation biology (which integrates ecological theory with sociological reality) while analyzing and synthesizing large datasets and models into useable products to inform decision-making. This process is aided tremendously by the improvements in Geographical Information Systems (GIS) data storage, analysis and mapping efficiency. It should also be noted that this type of analysis should remain a dynamic process, where new information or techniques would allow continued refinement.

The KREA assimilates base data including landscape, species, resource and human use variables into models that quantify and map ecological and social use values. These values form the foundation for a synthesis that identifies priority core and connectivity areas that meet specified representation goals for ecological values while minimizing the conflict with social values. A GIS-based decision-support tool allows decision-makers to assess a suite of different scenarios instead of computing 'one best option'. We hope that the KREA will be a dynamic tool that is regularly updated and sourced to help support decision-making at multiple scales across multiple sectors in the region.

4. Integrating the KREA into a Data Management System for Decision Support

Information collection is a necessary but not sufficient condition for sound planning and management. Data compiled to support regional conservation efforts must also be in a usable format, and made available in a timely fashion to support planning and management. Generally, a lack of coordination amongst both conservation and development efforts often stems from a lack of accessible data and the tools necessary to address questions of ecological processes and human activities at broad regional scales. This deficiency of easily accessible spatial data exacerbates the problem making strategic, data-driven conservation decisions difficult, time-consuming and expensive. Without such information a 'big picture' at a regional scale is missing to best inform cooperative, cross-jurisdictional actions. Recognizing this need, there is increasing worldwide interest amongst governments, conservation organizations and funding agencies to move towards technical methods to better manage complex ecosystems and human societies at the regional scale.

The KREA has the potential to be made available to multiple users in multiple forms such as:

- A set of static maps and tables that would be updated at regular intervals or when significant amounts of new data are made available
- A computer-based GIS software package called ArcReader that allows users to display various spatial data layers (maps) or tables compiled by the KREA. This would allow novice GIS users to still create maps combining various spatial data layers to help with certain decisions (see Appendix 4).
- The raw spatial data files that can be manipulated in a GIS for additional analysis and synthesis. Data can also be integrated, preferably, within an already existing and useable data management system such as the CONINFO database available on the internet.

The SPAN initiative calls for 'an open and free approach to information', where all non-confidential information will be placed in the public domain via the MET web site and by means of newsletters. In addition, it is proposed that MET reinstate its annual research meeting, where progress on monitoring and research are presented to all relevant stakeholders, with 'carefully designed interactive sessions to optimize debate and discussion.' Participation of communities and other stakeholders in various forms of knowledge management mechanisms is also be strongly emphasized.

5. Guide the establishment of monitoring strategies and applied research projects to support adaptive management

Monitoring is a fundamental activity for any conservation strategy particularly when various levels of 'use' are practiced in protected areas. It is an objective, transparent means to evaluate and adapt science-based management decision-making. Additionally, a regional ecological assessment process identify and prioritize potential data and knowledge gaps of key ecological components or drivers that require further research.

Many monitoring activities currently are onging in the region such as the annual game counts, and community game guard patrols that feed into an 'Event Book' system that documents a variety of observable metric in the field (NASCO 2007). As part of a dynamic process, the KREA recommends building off these ongoing monitoring strategies and research projects that continually refine and improve the overall utility and quality of science-based support products into the future. It is recognized that even this assessment, that brings together many years of data collection and assimilation, requires future refinement and adaptation to changing ecological and socio-political conditions.

Study Area Background

Boundary Extent

We chose to set the boundary extent for this analysis at the outer boundaries of the 6 adjacent conservancies to the proposed park boundary (concession areas) including Purros due to the critical utilized habitat by wildlife that migrate between the Hoanib and Hoarseb Rivers (see Results, Base Data). Although an 'ecological' assessment would typically use ecological boundaries, it seemed prudent to use political boundaries to 1) remain consistent with the current planning area for the proposed park while still setting the proposed park area in a regional context, 2) permit concurrent presentations to bordering conservancies that are engaged in conservancy-level management planning that set their conservancies in the a regional context (many of the adjacent conservancies fall only partially within major watersheds. It is also worth noting that the majority of the Project Area's extent falls within the 4 major watersheds (Hoanib, Uniab, Koigab, and Huab) except for an area in the upper Huab within the commercial (private) farmlands.

Ecological Context

Geological and Landform Diversity

The Kunene represents an incredible amount of geological diversity that supports diverse vegetation communities and landscapes, particularly the nutrient-rich lava (basalt) field covering a majority of the Uniab basin. Many geologic formations are also millions of years old where ancient rock art has been preserved for thousands of years. Major geological classes in the project area are described and mapped below.

Landforms also pay a critical role in the ecology of the region. Rocky slopes and outcrops (see left) provide key shelter for animals during the intense afternoon heat and help to hold temporary water. The basalt etendekas contribute to soil creation and nutrient flow (Burke, 2003) and provide refugia for endemic and rare plants (Barnard 1998, Burke, 2003). Low lying flats provide vital grazing and calving areas for the region's wide ranging game species such as springbok, oryx and the endemic mountain zebra and are especially important during drought periods. Landforms characteristic are crossed between relative measure of elevation and slope to yield 8 classes and are described and mapped below. These geological and landform classes fulfil a key component in the described ecological land unit model.

Water and Hydrological Resources

A key ecological element of any arid landscape is its water resources and their availability to different users. Although most wildlife species that inhabit the region have various adaptations to the harsh conditions, both wildlife and people are heavily reliant upon this limiting resource especially during periods of drought. The region's water resources can be classified as permanent or temporary, natural (springs, seeps, ghorras, or pools) or man-made (boreholes or wells).

The region's drainages, although dry on the surface, provide a steady flow of ephemeral (below-ground) water throughout the year. This provides the needed water nutrients to support the large woody tree species, such as the Ana Tree and Camelthorn that many of the native wildlife and people rely upon. The infrequent flash floods during the rainy season also create many temporary water pools that can remain for months in the rocky river beds. In addition, drainages of different size or stream order, depending upon their flow accumulation, sustain varying vegetation communities.

Large Mammals

The deserts of the Kunene Region in northwestern Namibia represent one of the last true wildernesses remaining in southern Africa. This distinctive and floristically rich desert ecoregion is home to the famed desert mega-herbivores (black rhino & elephants), a full complement of large carnivores (desert lion, cheetah, leopard and both spotted and brown hyena), and healthy populations of ungulates (endemic mountain zebra, giraffe, springbok, oryx and kudu). Namibia currently sustains over one third of the world's black rhino population, and the Kunene region is the stronghold for the desert-adapted subspecies. These free-ranging black rhino persist as the last substantial population of any species of rhino outside of a fenced protected area. In recent history, only two mammal species (African wild dog and hippo) are thought to have become regionally extinct.

Endemic and rare species

The escarpment zone of the Kunene, a narrow north/south band of rugged mountains, hills and Etendekas (flat-top mesas), has been categorized as a hotspot for endemic birds (Jarvis & Roberston, 1999), reptiles (Griffin, 1998), and plants (Burke, 2003) and promoted for its contribution to Namibia's overall biodiversity goals (Bernard, 1998). Many of these species are classified as threatened, endangered and/or endemic in Namibia's Red Data Books (see Appendix 2,3 for list of native rare and endemic wildlife and plants distributed in the project area).

Regional Ecological Processes

Due to its relatively wild and permeable nature (omitting the Veterinary Fence – although it is known to be quite porous), the region has also maintained many of its critical ecological processes. These include but are not limited to: nutrient flow, seed dispersal by wide-ranging wildlife (elephants and other ungulates), access to seasonal grazing flats, predation by a full suite of native large carnivores such as lion, cheetah, spotted hyena as well as meso-carnivores such as jackals, eagles, African wild cat. These top down processes maintain ungulates and small mammal densities below carrying capacity reducing the effects of overbrowsing of critical limiting vegetation. New developments such as fencing, roads, poorly placed settlement and/or tourism lodges, and unmitigated conflict with carnivores could potentially restrict these key processes.

Social Context

In 1970, the Odendaal Commission of the South African government proclaimed lands in the present day Kunene Region as homelands for the Himba, Herero and Damara people. At the time, this proclamation resulted in a de-proclamation of the Etosha Game Park. The Hoanib-Ombonde River became the boundary between the Himba/Herero's homeland to the north and Damara's homeland to the south (Owen-Smith, 2002). At Namibia's independence in 1991, these homeland boundaries were dissolved to some degree (although some Traditional Rights remain recognized under the Traditional Authorities Act) and the majority of the Himba (far northwest), Herero and Damara homelands were merged into what is now collectively known as the Kunene Region.

Land Jurisdictions and Management Practices

The land jurisdictions in the project area can be categorized as 1) State-Owned Protected Areas, 2) Communal Land comprised of 3 State-administered Concessions, and communal land largely covered by established Conservancies. The project area is bounded on the west by the Skeleton Coast Park and to the east by freehold farms and Etosha National Park. The central area is the proposed park lands, which remains currently the State-administered Concessions Areas (Palmwag, Etendeka, Hobatere) and a disputed area between Etendeka and Hobatere. North and south of the central project area are communal conservancy land specifically: Torra and #Khoadi \Hoas to the south, and Sesfontein, Anabeb, Omatendeka, Ehirivopuka to the north. Additionally, Purros, Okangundumba, Ozondundu, Orupupa, and Otjambangu were added to broaden the project area to fully include the majority of the 4 key watersheds: Huab, Koigab, Uniab and the Hoanib, roughly 4.5 million hectares.

Although the national parks are managed nearly exclusively by the Ministry of Environment and Tourism, except were private tourism concessions are leased out, such as Wilderness Safaris' Skeleton Coast concession, the three concession land holdings Palmwag, Hobatere, and Etendeka are managed by private tourism operators and administered by the Ministry of Environment and Tourism.

The communal conservancy land is managed mainly for different forms of tourism by the conservancy committee, encompassing locally-elected community representatives, with Traditional Authorities retaining the jurisdiction of allocating livestock grazing rights. Namibia's pioneering community-based natural resource management (CBNRM) legislation has enabled conservancies to acquire benefit rights to the resources within their boundary under a set of restrictions and adherences (NASCO, 2008).

Traditional Livestock Grazing

Both Herero and Damara people have a long historical culture tied to livestock; generally Herero with cattle, Damara with goats/sheep. To date, current grazing practices and trends have only been roughly documented for the project area. Generally, Herero cattle herders are mainly distributed north of the veterinary fence and are much more nomadic with their herds, especially during the dry season when forage is limited. Damara tend to farm smaller herds of mixed goats and sheep while remaining much closer to their permanent settlements, boreholes and kraals year round (although some longer distance travel is required during the dry season should forage become entirely consumed nearby). Detailed livestock grazing patterns for each conservancy is presented below which includes grazing distribution for both wet and dry season separated by the Veterinary fence.

Pastoralism and grazing numbers have likely increased in recent years as a result of a growing cash economy (cash is typically used to purchase more livestock) and a series of above-average rainy seasons (from 2000-2005). Since then, however, the region has experienced a pronounced drought, which has forced some pastoralists to seek grazing for their stock into wildlife areas as they search for adequate and/or emergency grazing areas.

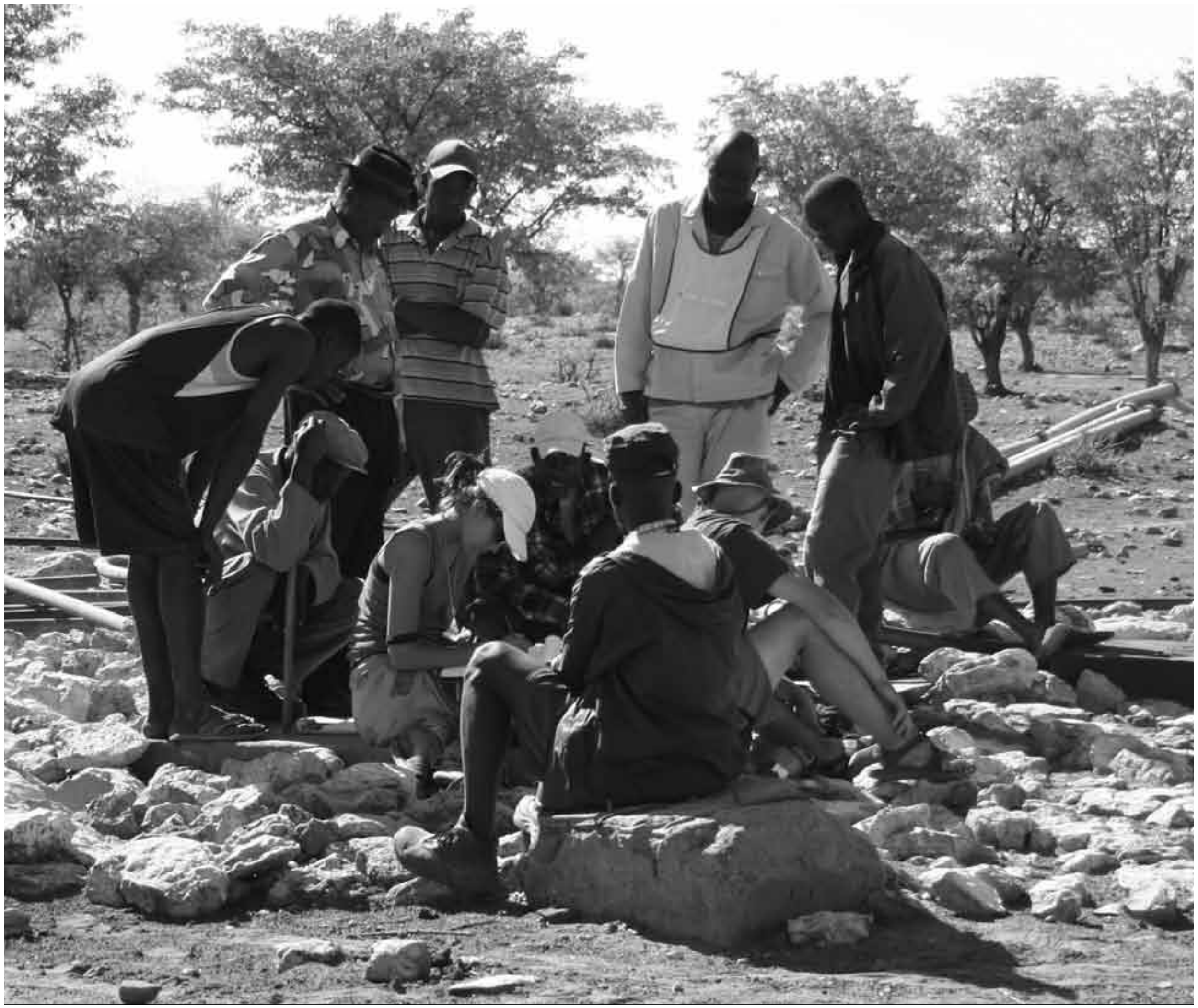
Tourism

The tourism industry has embraced the Kunene's natural resources wealth illustrated by an annual 20% increase in tourism activities for the past 5 years. In the region, state-owned concessions are managed by a private tourism operator. In adjacent communal conservancies, contractual agreements exist between the conservancy and private tourism companies. In 2006 and 2007 over 50% of revenues for almost all the of conservancies came from joint venture tourism (NASCO, 2007 & 2008). Tourism must be conducted responsibly in order to maintain the very resources promoted. In particular, one increasing pressure is the number of tourists taking advantage of the Kunene's 'open system', which permits unregulated non-commercial driving on all communal lands, particularly in critical wildlife areas such as the main river channels of the Huab and Hoanib Rivers. Furthermore, private sector tourism has invested in dozens of new lodges and campsites. Local communities are also planning their own tourism infrastructure as was anticipated under the new conservancy arrangements. Rapid expansion of tourism will almost certainly lead to extensive infrastructural development (i.e., roads, communications, gas stations, etc.).

In addition, nearly every communal conservancy bordering the proposed park engage in some form of consumptive tourism such as trophy hunting, shoot and sell, or cropping. These forms of tourism also contribute to their revenue generated for the conservancy to distribute, on average about 35% of revenues in 2006 and 2007 (NASCO, 2007 & 2008).

As the proposed park's management plan evolves, it will be crucial that it is informed by both socio-economical (livestock, non-consumptive and consumptive tourism) as well as ecological goals and appropriate and acceptable trade-offs are sufficiently explored.

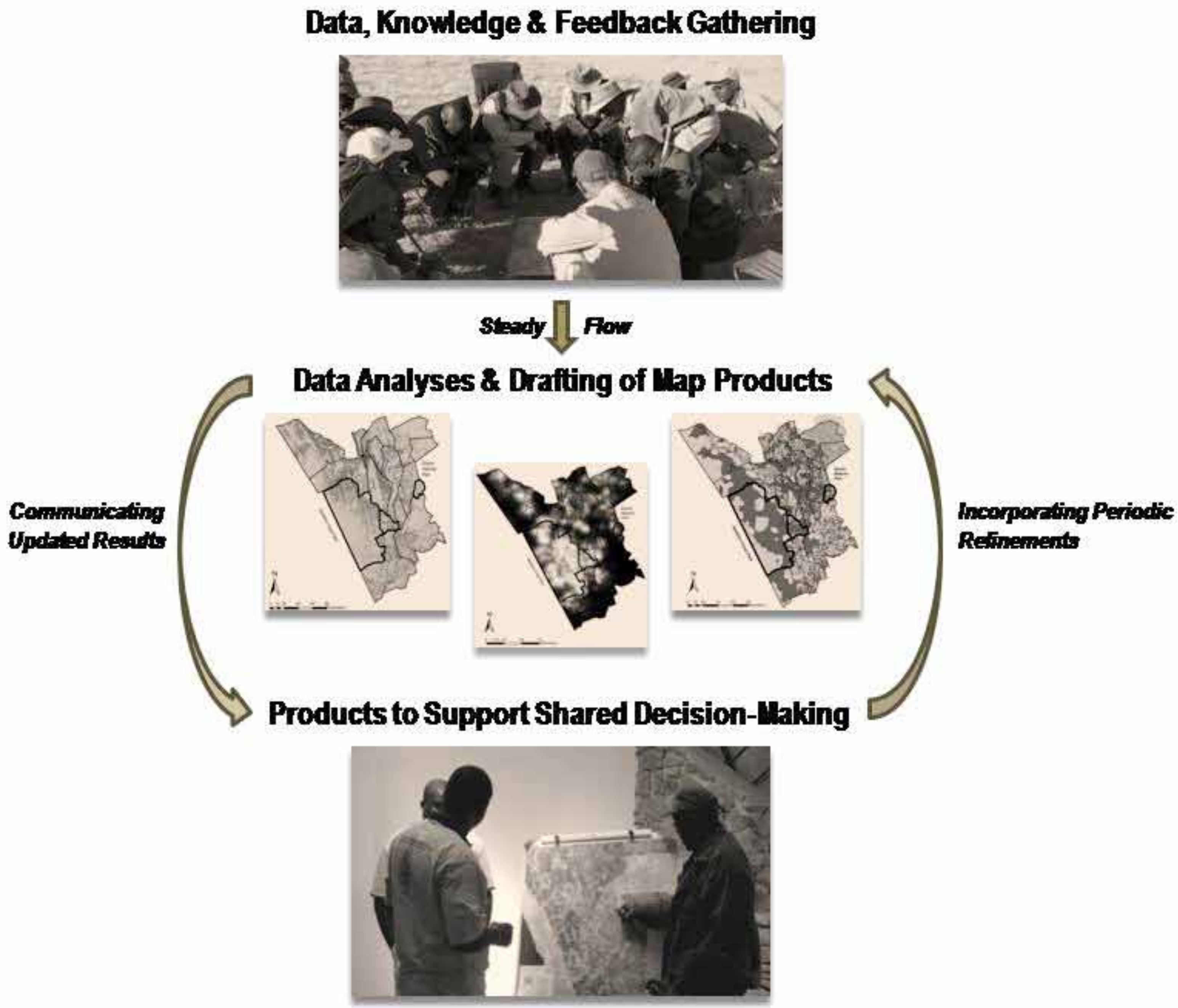
Methods Overview



Ecological patterns and processes are inherently complex systems comprised of countless parts and pieces that are integral to its functionality. In an ideal situation, information on each element's biology and ecology would be available. However, in reality, the information that is generally made available usually falls well short of a comprehensive knowledge base. Yet, in the face of increasing development pressures, particularly where development incentives are directly linked with natural resources, there is significant merit in searching for creative solutions to best utilize the available knowledge and information to provide an ecological foundation to support informed decision making. A regional ecological assessment attempts to uncover potential solutions systematically and scientifically through:

- Individual and Combined Base Data Layers: a comprehensive knowledge and information base, including both scientific documentation as well as expert opinion, on available ecological and sociological elements,
- Ecological and Social Values Maps: models and maps from our knowledge database that illustrate our best interpretation of key social and ecological values that represent the region's diversity
- Synthesis and Decision-Support Products: a set of easy-to-use, easy-to-understand tools and products that stakeholders can access to support management strategies that effectively balance the costs and benefits (trade-offs) for both ecological and social values.

As development is necessary to enrich livelihoods, planning a sustainable development strategy around an ecological foundation ensures that critical ecosystems and their processes will be maintained. In addition, since nature-based tourism is the major economic sector and development driver in the region, fostering an ecologically-informed development strategy helps sustain the very resource that current livelihoods and future prosperity depend upon.



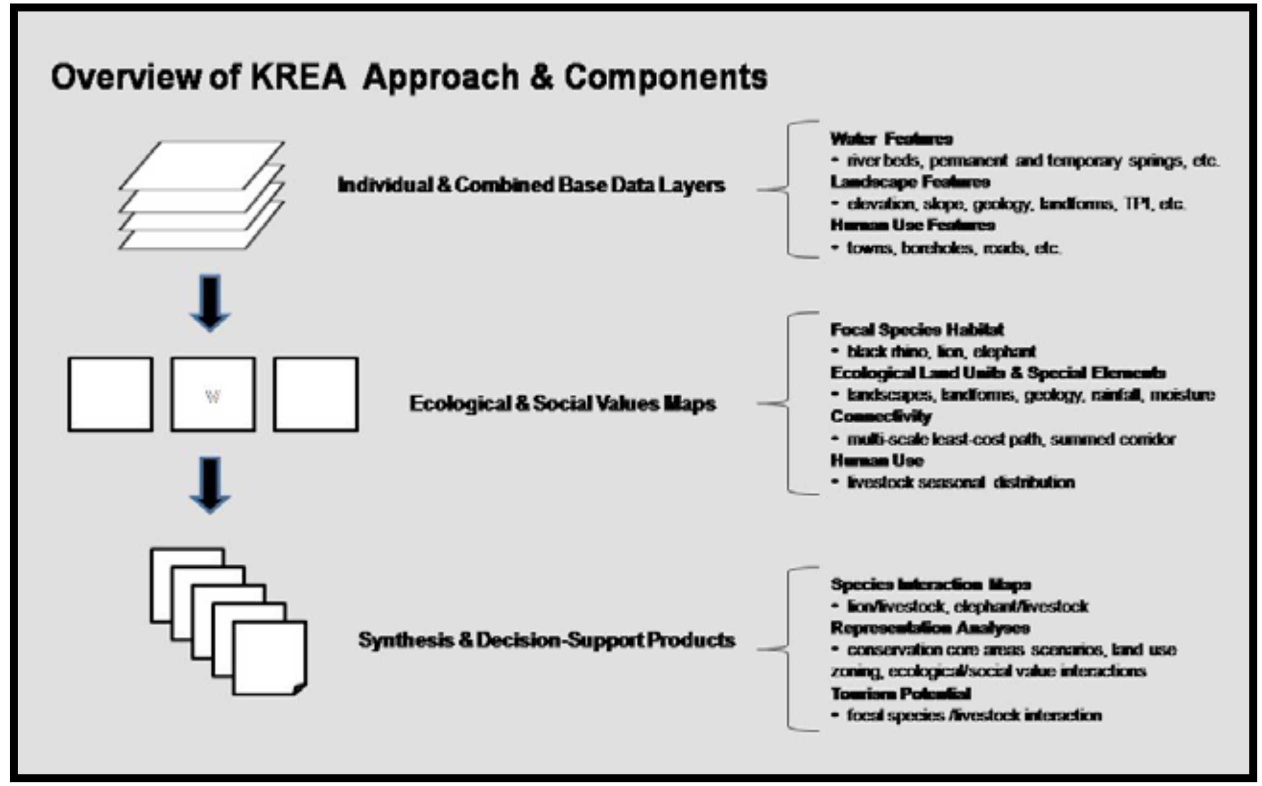
Data, Knowledge & Feedback Gathering
Steady Flow
Data Analyses & Drafting of Map Products
Communicating
Updated Results
Incorporating Periodic
Refinements
Products to Support Shared Decision-Making

Uncertainty and the Precautionary Principle

The designation of protected areas or regional mosaics of land use designations should incorporate the uncertainty inherent in relying upon limited data about uncertain and dynamically changing human and natural systems. The "precautionary principle" forwards that the uncertainty in managing natural systems should be explicitly acknowledged and managers should make every effort to err on the side of caution (Raffensperger and deFur 1999; deFur and Kaszuba 2002; Van Den Belt and Gremmen 2002). The Preamble to the international Convention on Biological Diversity (of which Namibia is a signatory country) provides a definition of the "biodiversity precautionary principle" as:

"…Where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat."

Given the finality of extinction, regional analyses should incorporate wide margins of safety against the potential loss of organisms, populations or ecological processes. In particular, biodiversity conservation plans must carefully consider the consequences of further human impact and loss of natural habitat, even when no obvious role or effect on the ecosystem has been empirically described. The absence of ecological data does not equate with the absence of ecological importance. Sophisticated tools are increasing becoming available to allow robust use of limited data and to allow the incorporation of uncertainty into regional analyses. This approach is particularly important in an arid, unpredictable open system such as the Kunene.



Base Data Components

Knowledge and Information Gathering

Decision-makers in conservation biology and wildlife management are generally restricted by the availability of data and knowledge. In addition, poorly coordinated data management often results in research duplication wasting valuable effort and conservation funds. Therefore, it is a prudent approach in any engagement to expend effort a priori to thoroughly assess the availability of existing data and what data-deficient gaps need to be filled to achieve conservation objectives. This was a major investment of time and energy during the start-up phase of the project.

Existing data layers

There are many scientists, field biologists and wildlife managers collecting and storing excellent field data in Namibia. Unfortunately, some of this data is not made readily available. The MET offices have good records of permitted in-country field projects and served as a starting point for identifying past and present research in the Kunene including principle investigators (contact information), reports, publications and raw data. Namibia also has national, regional and local-scale electronic data in GIS format made available from the Namibian Atlas Project, the MET-driven ConInfo data system, as well as the Ministry of Resettlement's Directorate of Surveys and Mapping, and the Ministry of Agriculture's Directorate of Water Affairs. The past

4 years of conducting field work in the Kunene has also provided opportunity for overlap and collaboration with many of the other field biologists conducting research in the region. This resulted in expanding our working relationships and knowledge of present research.

Local informant input and field studies

Local informant input in conjunction with targeted field studies is generally an effective approach to ecological assessments. The process facilitates the assimilation of individual research providing a more integrated ecological perspective required for an optimal regional assessment. Through multiple consultations with government, other national and regional conservation groups and our own experience, individuals with varying levels and areas of expertise and knowledge were identified and interviewed (see acknowledgements). These local informants were contacted initially to introduce the project's approach and goals, while ascertaining their interest in collaboration and scope of expertise. A standardized questionnaire and a series of regional maps were used to validate current available data, while also fill information gaps in key resource and ecosystem elements particularly the locations and attributes of critical water sources, areas deemed critical refugia and movement areas for wildlife, and important ecological land classes. Confidence in expert information will also guide the extent of field validation efforts.

Traditional Knowledge

Traditional knowledge, ecological and cultural, is often underestimated and underutilized in ecological assessments. Local indigenous people tend to have intimate relationships with the land and thus retain a great deal of knowledge regarding wildlife movements, critical landscape features, traditional resource uses and extent, and cultural significance. The process of collecting traditional knowledge also cultivates local buy-in and ownership over the assessment outcomes resulting in a more efficient and viable implementation strategy. Round River Conservation Studies has experience integrating these two types of traditional knowledge into regional ecological assessments: traditional ecological knowledge (TEK) and traditional land and resource use (TLRU).

Three indigenous groups currently occupy the project area: Herero, Himba, and Damara people. Various levels of TEK exist and a suite of TLRU is practiced. Many of these traditional use activities are coordinated and managed through the novel conservancy system implemented throughout the project area (NASCO, 2008). Since land use and water feature mapping is an important component of the KREA, community engagement and data collection focused on the collection of spatial and descriptive data related to villages, water features, and grazing at the conservancy level. It is also the primary means by which community engagement is initiated and conservancy leaders and Traditional Authorities are informed of and participate in the overall project.

Given the understood deficiencies in critical, base-line water and land use data, it was concluded that any analytical tools provided by the KREA with the explicit purpose of supporting land management planning and decision-making processes would be fundamentally flawed if based on existing data sets. Subsequently, it was decided to collect this data directly in order to strengthen the KREA's effectiveness and, in the process, to update the ConInfo database.

Data collected for the land use and water feature mapping component of the KREA include the following:

• Water: type (natural spring, borehole, well/ghorra, pool/wetland), locally recognized name, GPS coordinates, status (permanent or temporary), currently active (yes or no), size, users (wildlife, livestock, and/or people), current users (villages), and any additional information deemed pertinent. Each water feature is also photographed.

• Village characteristics: GPS coordinates, locally recognized name, estimated number of households, estimated number of people, water features used by the village, and estimated number of livestock (including cattle, goats, sheep, donkeys, and horses). In addition, individuals were asked various questions related to historical changes in wildlife numbers, wildlife conflicts (type and frequency), and general community issues in the area.

• Grazing: grazing patterns in the wet and dry season during a typical year (data collected here are based on community mapping exercises where individuals work together to draw on a map the estimated wet and dry season grazing patterns for their village using widely recognized spatial cues and landscape features).

Data collection methods are based on a series of steps related to each conservancy in the project area. These steps include the following:

1. Meet with all local leaders (including both Conservancy Management Committee Members and Traditional Authorities) in order to explain the project, gather feedback, obtain permission to collect data in the conservancy, and hire 1-4 local guides (typically a mix of community game guards and local leaders).

2. Divide into 1-4 teams (depending on availability of cars and personnel). Each team is assigned to a pre-defined area in each conservancy, where they will visit all water features and villages (both temporary and permanent) in the conservancy. At least one land use interview is conducted in each village. Typically, the interviews are a group exercise with an average of 7-10 local participants. Every effort is made to include local Headmen/Traditional Authorities, women, and individuals who are locally recognized as particularly knowledgeable of the area. In addition to land use interviews, every water feature is visited and additional spatial and descriptive data collected.

3. Data are entered into a GIS software program and draft conservancy maps are created. During this step, redundancies in data are identified and eliminated (i.e., between new data and existing data from ConInfo).

4. Draft conservancy map products are presented to each conservancy leader for review and refinement.

5. Final database and conservancy map edits are updated based on the feedback provided by local leaders.

6. Final versions of conservancy map products are brought back to local leaders in each conservancy for approval. At this point, more in-depth discussions may be initiated regarding how the information is being integrated into the KREA decision support tool, and the use and application of these products for conservancy (individual conservancies) and regional-level (Kunene Park Technical Committee and/or Kunene Regional Conservancy Association (KRCA)) land management planning processes.

Analytical Components (Ecological and Social Values)

Livestock Grazing Distribution

The most widely distributed human land use in the project area generally involves smallstock (goats and sheep) and cattle grazing. Mapping the spatial and temporal extent of livestock grazing through the TLRU process produced livestock grazing polygons that were needed in order to evaluate livestock presence as an attraction/avoidance variable in habitat models, while also indicate areas and intensities of high social (traditional land use) values.

We chose to enhance the information by calculating a livestock distribution probability surface across the project area that was stratified by season (wet and dry) and a generalized grazing practice (free-ranging cattle vs sedentary small stock), based upon local informant knowledge. This approach combined 4 models (below) into a dry and wet season livestock distribution map.

- Northern Herero cattle distribution probability during an average dry season
- Northern Herero cattle distribution probability during an average wet season
- Southern Damara small stock distribution probability during an average dry season
- Southern Damara small stock distribution probability during an average wet season

These models were then validated using 2 independent data sets of cattle, sheep and goat locations collected during aerial surveys conducted by the MET in 2005 and 2007.

Focal Species Habitat Modeling

Determining ecological needs for all aspects of biodiversity is impossible and possibly counterproductive. Therefore, planning for a selected suite of 'representatives' for biodiversity is a prudent, accepted approach. In theory, establishing protection measures for these representatives, or focal species, concurrently will protect co-existing biodiversity through their 'interaction importance' or 'umbrella effect'. The Kunene region is endowed with full assemblages of native wildlife, of which the lion, elephant, black rhino may fulfill these criteria. Integrated habitat models for focal species can identify spatially-explicit common critical areas that, if protected, would increase their persistence probability while also indirectly protecting additional co-existing biodiversity. This component also explicitly addresses one of the Technical Committee's key conservation objectives to 'protect core wildlife habitat'.

There are a handful of different techniques and approaches to describe and map species distribution and habitat selection. The choice of which approach is most appropriate is usually driven by the type of available data sets, the ecology of the species and the output objectives (Johnson and Gillingham, 2005). In many situations, very little if any information is available for species known to be key focal species. The best option for habitat modeling in these cases is to create Habitat Suitability Indices. Information is compiled either from published literature or from expert knowledge that can then be used to rank different habitat units (United States Fish and Wildlife Service, 1981; Larson et. al., 2003). Typically this is an additive or multiplicative equation with suitability rankings for various environmental factors (i.e. slope, elevation, distance t o resources, vegetation type, etc.) derived from expert opinion or published literature. Another approach that has recently been embraced by conservation scientists is Resource Selection Function (RSF) modeling (Manly et. al., 2002). This technique is more quantitative and data-driven as it normally relies upon actual movement data for the species under study. It has many advantages and strengths:

- data-driven and benefits from expert review
- systematic and transparent
- easier to assess levels of precision and statistical inference (i.e. the probability of a variable significantly contributing to the model's power)
- can handle categorical (i.e. vegetation classes) or continuous (i.e. distance from springs) data
- can be easily and efficiently interfaced with a GIS (sampling, multi-scale, predictive mapping production, inclusion into assessment framework)
- RSF values within a finite area can be related to population dynamics (carrying capacity and reproductive parameters) and linked with a population viability assessment (PVA)
- has been used successfully in conservation and management of other endangered species (tigers, brown bears, wolves, spotted owls)

RSF modeling also includes an objective/transparent procedure of variable selection, computation of their respective importance or weights in driving selection, and produces a relative suitability score that can easily be mapped (Manly et. al., 2002; Johnson and Gillingham, 2005) . Like other habitat modeling approaches, RSF models make the assumption that higher RSF scores, even though relative, directly correlate with habitat quality or importance. Further, since RSF produce relative probabilities proportional to use, it is possible to relate species population parameters to their habitats (Boyce and McDonald, 1999) as well as incorporate and set quantifiable targets within a conservation planning framework (Johnson et. al., 2004).

Since years of hard work and money have been expended on recording fairly detailed and long-term movement patterns of various elephants (Leggett, 2006), lions (Stander, 2007) and black rhinos (SRT, pers. com.) in the project area, it was decided that RSF models would best utilize this hard-won data. Moreover, the resulting habitat models could be readily refined and updated as new information becomes available and can be directly incorporated into synthesis products to help support important decisions made regarding the proposed park's management and the surrounding conservancy lands.

We validated our focal species models for accuracy using a mix of independent location data collected from multiple aerial surveys, ground tracking, and withheld telemetry data from the 'model training set'. In additional to validating each focal species model, we also were able to assess their plausible coverage or 'representativeness' of other native, data deficient wildlife species. The MET aerial surveys from 2005 and 2007 provided independent location data for many species across the project area including: springbok, oryx, mountain zebra, elephant, black rhino, ostrich and livestock such as cattle, goats and sheep. These location points were overlaid on each focal species RSF model and the count of locations in each focal species habitat class was calculated.

Ecosystem & Special Elements Representation

Limiting regional representation goals on individual or a suite of species' (focal species) protection requirements has been highly criticized due to the poor assumption that these species alone provide adequate coverage for full biodiversity representation. An additional technique that compliments focal species' potentially incomplete umbrella effect is to classify and map unique ecosystems. This approach makes the assumption that generally, unique species compositions will be linked closely to specific ecological communities or land units (ELUs) (Noss et. al. 1999). Another benefit of incorporating an ecosystem approach is the relative ease and accuracy (compared with acquiring useful information on data deficient species) of describing and mapping these ELU features due to the recent advances in remote sensing and availability of high resolution satellite imagery. Establishing representation goals that account for each unique ELU thus acts as a 'course filter' in the assessment process, capturing additional critical features that may have been missed by focal species representation alone.

Additionally, characterizing and mapping ELUs allow easy adjustments in goals for specific classes that may be vital for rare and/or endemic species (special elements). For example, the flat top Etendeka mesas are known to be critical refugia for a diverse array of rare and endemic plants. Thus we can identify these areas by combining specific landscapes (Etendeka Lavas) and landforms (areas that are relatively high and flat) while also adjusting the representation goals for this extra important ELU class. This component of the ecological assessment thus addresses the conservation goals endorsed by the Technical Committee, 'Maintain biodiversity and natural beauty, and Conserve rare and endangered species'.

Based upon local informant recommendations and literature review, we created an ELU classification that included unique combinations of:

- Namibia's Landscapes (Atlas): Central Western Plains, Etendeka Plateau, Kalahari Sandveld, Kamanjab Plateau, Karstveld, Kunene Hills
- Geology (Atlas): Granite, Lavas and sandstone, Limestones and dolomites, rhyolites and sandstones, sands and calcrete, sandstones and shales, schists and dolomites
- Landforms (RRCS): Relatively low and flat, Relatively low and gentle slope, Relatively low and moderate slope, Relatively low and steep slope, Relatively high and flat, Relatively high and gentle slope, Relatively high and moderate slope, Relatively high and steep slope,
- Rainfall (Atlas) (mm): 50 – 350 in six 50 mm interval classes
- Flow Accumulation (RRCS): 1 – 5 classes with 5 being the highest (main river channels – Hoanib)

Additionally, we utilized the Namibia's National Biodiversity Atlas and expert opinion (M. Griffin, personal communication) to extract rare and endemic birds, mammals, amphibians and reptiles that are believed to occur in the project area (see Appendix 1). The database also contained information regarding broad critical habitat classes that could be identified within the ELU classes. We also included 'mesa specialist' plants surveyed by Burke (2003) in the project area (see Appendix 2). The ability to identify these 'extra important' ELU classes permitted weighted goals to be set for representation scenarios.

Connectivity

Maintaining regional connectivity is critical to ensure movement of key wildlife species and major ecosystem processes are unrestricted to increase long-term viability prospects. These routes not only provide for needed gene flow but also allow uninhibited movement to water source refugia during times of localized and regional droughts. Connectivity is explicitly addressed in the vision statement endorsed by the Kunene People's Park Technical Committee (TC):

'allow for free movement of wildlife and to provide a link between the Etosha National Park and the Skeleton Coast Park .'

Moreover, it was mentioned in the 7th Kunene People's Park TC meeting that 'The vision is where the parties would like to achieve in future, and not necessarily what there is currently.' This statement emphasizes the TC's desire to work towards improving social as well as ecological conditions where they remain unsatisfactory. For wildlife connectivity, this means ensuring that critical corridors are maintained and even possibly enhanced.

To address this critical objective, priority connectivity zones and corridors were identified and mapped on a GIS through integrating least-cost path attributes (topography and path distance) and wide-ranging focal species' habitat models (habitat attraction/avoidance surface) to calculate corridors between key water resources. This is a 3 step process described below:

1. Least-cost Path Modeling outputs the 'most efficient' movement route between 2 defined points that depends upon the combination of variables believed to influence an animal's movement decisions such as topography (slope), minimizing distance traveled, while avoiding/selecting routes based upon its habitat characteristics. We chose to estimate least-cost paths between a subsample of 'key' water features across the project area, identified by multiple local informants as critical (see Appendix 3), using the Global Cost Function in ArcInfo.

2. We then 'locked in' these paths as root paths.

3. Lastly, we calculated a corridor zone off these root paths that quantified the summed solutions of additional likely pathways (of equal or lesser effort than the least cost path between source points) that overlapped at any given site.

Identifying these priority connectivity zones help to ensure appropriate areas are targeted for protection to maintain or enhance connectivity between Etosha and the Skeleton Coast National Park.

Synthesis Approach

Although each analytical component can be useful on its own, the true power of a regional ecological assessment is a synthesis procedure that draws them all together integrating their complimentary strengths to best represent the full range of biological diversity within a region. The output is a suite of 'conservation options' across the planning area that reflects desired goals (Driver et. al., 2003). This is also the stage where the usability and applicability of a decision-support tool becomes critical. Good science alone will remain 'alone' if it cannot be applied in an appropriate, demand-driven context and presented in a user-friendly manner. A synthesis procedure typically involves choosing decision supporting tool (DST) that best handles your data and provides appropriate outputs to help support key decisions by stakeholders. Thus, we chose to assess and present synthesis products using a relatively novel DST called Marxan that is suitable to best address the objectives set forth by the Kunene People's Park TC, which includes attaining a suite of both conservation and socio-economical objectives (listed above) in addition to explicitly acknowledging the importance of assessing appropriate and acceptable trade-offs between social and ecological resilience:

'In pursuing economic and social goals neither ecosystem health nor biodiversity within the park may be pushed over thresholds from which recovery is difficult'..

Why Marxan?

Marxan has many of the general desirable components that make it favorable as a DSS for supporting decision-making such as the ability to handle large amounts of data, set quantified goals, and link to a GIS. However, Marxan also has unique qualities that are especially useful and applicable to the Kunene People's Park situation. Two broad goals that have clearly emerged from the Technical Committee meetings during the Kunene People's Park stakeholder process are 1) the co-management and shared decision-making power between all stakeholders and 2) reconciling both social and conservation objectives. Marxan is well suited to address both of these goals through its ability to create a suite of 'near-optimal' solutions that meet user-defined conservation targets while minimizing 'cost' with social values. This approach that explicitly integrates social and conservation goals helps decision-makers explore and evaluate trade-offs both within and between various scenarios (Ardron et. al., 2008). Generally, Marxan requires users to:

1. Assemble All your input data that will allow users to assess their goals

2. Select the type and size of assessment units: such as hexagons, squares, or ecological watersheds that are appropriate in shape and size for management planning,

3. Package your conservation and social values in the assessment units: such as your conservation and social value models,

4. Establish representation goals for your conservation and/or social values: such as capture the best 50% of focal species habitat,

5. Set your fine-tuning parameters and 'cost' inputs: such as to minimize fragmented solutions (boundary length modifier), any weight factors in your conservation values that would give more or less importance

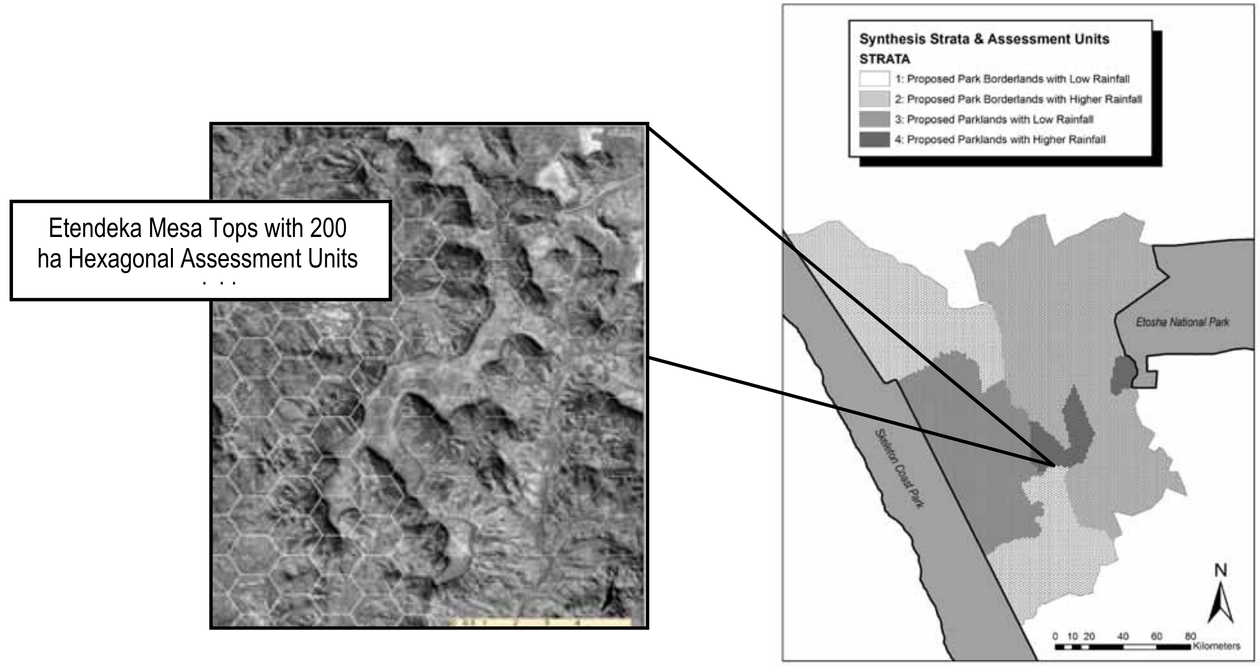
for finding solutions that explicitly meet goals for more important features, or to minimize the spatial conflict (overlap) with social/economical values that may be less compatible with conservation goals.

6. Select the number of times to run Marxan on a given set of scenarios (different goals and costs) to produce a suite of 'very good, and near optimal' solutions and an overall site selection frequency map for further analyses.

7. Investigate the pros and cons of the various Conservation Options with stakeholders to identify which options meet ecological, economical and political objectives.

Following the data and input procedures, Marxan explores million of different possible combinations of assessment units to finally select the most efficient solutions (groupings of sites or assessment units) that meet or closely meet your representation goals while minimizing any 'costs'. One of the largest benefits of Marxan is that users can explore multiple different 'near optimal' scenarios under various representation goals and cost surfaces. These sets of 'conservation options' allow users to explore trade-offs between conservation objectives and other land uses.

This process also situates decision-making power entirely in the stakeholders' hands while the science-based scenarios, that integrate both conservation and socio-economical values, remain in a decision-supporting role. Yet precaution in goal setting and conservation option selection should be granted to less negotiable values and features, which are usually key ecological patterns and processes.



Project Area Stratification & Assessment Units

- Since the project area is vast, with a steep rainfall gradient and multiple management strategies and scales, we divided the assessment area into 4 sections (strata) that account for these variables while still maintaining a regional context. This will allow goals to be stratified across the project area, for example, setting higher representation goals in areas that are more sensitive (more arid) and have less conflict with high levels of impact (such as within the concessions).
- Hexagons address area bias concerns (watersheds) by providing units that are universal in size and would not, by nature, divide key features. We thus created a surface of 200 ha hexagons across the project area (15,006 in total). All analytical components for synthesis were then packaged individually into these hexagonal assessment units.

Representation Analysis & Core Conservation Areas

One goal of the synthesis procedure is to identify sites across the landscape that has relatively higher representation of ecological values. Another goal is to effectively minimize the 'costs' of conservation by avoiding areas that also have high representation of social values – which may or may not be directly compatible with conservation, identifying sites that provide an 'efficient' solution. Efficiency, or the ability to achieve conservation goals while minimizing the costs to social values, is a key strength of Marxan. Moreover, since Marxan does not product a single, optimal solution, a variety of efficient solution scenarios across multiple representation goals (i.e. 30%, 50% and 70% representation of ecological values) under multiple social goals (i.e. retaining key livestock grazing areas or high impact tourism areas) can be explored. This allows decision-makers to evaluate the ecological and social trade-off between multiple 'near optimal' scenarios. Our preliminary site selection procedure involved:

• Summarizing the focal species, ELU, connectivity and livestock activity values by hexagonal boundaries, enabling comparisons of these values across space.

• Locking in the cumulative connectivity values across the planning area. Marxan solves for the minimum set of sites that represent our established conservation goals and costs would build off these key movement zones.

• Marxan software was used to create indices of the relative importance of sites based on their contribution to the (spatially efficient) representation of ecological values while incurring the least conflict with social values.

• Marxan allows for the specification of a "cost" value, which is an "avoidance" factor in the representation analysis. In other words, as Marxan selects solutions for ecological representation goals, it will prefer to select sites that do not conflict with social values. For this analysis we used the livestock maps as "cost", in order to force a spatially efficient solution to the representation problem.

• For each representation goal (20, 30, 40, 50, 60, 70, and 80% overall ecological value representation), Marxan creates 100 unique spatial solutions that achieve these goals and minimize conflict with livestock distribution.

• Marxan will then provide a 'very good' solution that represents the most efficient solution with a set of solution options. Although each scenario will produce the most efficient solution based on the set goals, there may be other solutions that still achieve stated objectives and are more acceptable and practical for stakeholders to agree on and implement.

• Marxan also identifies how many times each site was selected as a member of an "efficient" solution set. Sites that were selected in a large proportion of the total number of selection runs (number of times selected out of 100), can be thought of as being highly irreplaceable conservation 'hotspots' or very critical for representation of these ecological values. These areas may be considered as 'core conservation areas'. Sites selected fewer times in the selection solutions are more flexible or less critical.

The summed solutions for each scenario and respective representation goals are one approach to help identify 'core' conservation values as areas of high selection frequency indicate high levels of 'irreplaceability'. Further, these 'core' areas can be thresholded for each scenario in each summed solution by assessing the relationship between percentage of goal represented and proportion of area required as a measure of efficiency.

A suite of preliminary Marxan scenarios, which include each scenario's 'very good' solution as well as each scenario's summed solutions (site selection frequency), are presented. Core conservation area thresholds were further explored in the scenario site selection frequency solutions and also presented.

ROUND RIVER
Conservation Studies

284 West 400 North; suite 105
Salt Lake City, Utah 84108 USA
slcoffice@roundriver.org
www.roundriver.org