Towards a systematic conservation plan for the Arabian Peninsula

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Abstract. Geographical Information Systems (GIS) based systematic conservation planning can form the basis for prioritizing conservation actions in a strategic and efficient manner. However, to date in the Arabian Peninsula conservation plans have generally taken an *ad hoc* approach to prioritizing actions spatially. Previous Sharjah Conservation Workshops highlighted this gap in our understanding of the spatial patterns of biodiversity across the Arabian Peninsula, and in particular identified the need to specify areas where conservation priorities that cross-national boundaries exist, and which may be best addressed using a Transboundary Conservation Area (TBCA) approach. Therefore a GIS and systematic conservation planning workshop was held as part of the 2010 Conference on Biodiversity Conservation in the Arabian Peninsula in order to test the potential for conducting a rapid systematic conservation assessment for the Peninsula. This paper outlines the concept and benefits of systematic conservation planning, reports on the process, data analyses and initial outputs of the GIS and systematic conservation planning workshop, and charts the way forward for developing a more robust assessment for the Arabian Peninsula.

Key words. Systematic conservation planning, reserve expansion, threatened species, Geographical Information Systems, GIS.

Introduction

Geographical Information Systems (GIS) based systematic conservation planning can be used to prioritize conservation implementation strategically and efficiently. This planning process has been successfully applied and refined in areas and habitats as diverse as the Cape Floral Kingdom, grasslands, forests and succulent deserts of Southern Africa; the rainforest of the Amazon and Papua New Guinea; marine areas of California, South Africa and Australia; and freshwater systems in South Africa and the USA (Margules & Pressey 2000, Pressey & Taffs 2001, Desmet et al. 2002, Cowling et al. 2003, Nel et al. 2007, Klein et al. 2008). However, systematic conservation planning processes have not been applied at regional scales in the Arabian Peninsula. As robust and tested methodologies now exist and best practice guidelines have been developed (Bottrill & Pressey in prep.; with sections currently available in Pressey & Bottrill 2009), the opportunity exists to utilize established methodologies within the framework of international best practice to quickly and efficiently undertake a systematic conservation assessment for the Arabian Peninsula.

Conservation within the Arabian Peninsula has focused to date on protecting iconic species such as the Arabian Oryx *Oryx leucoryx* and Arabian Leopard *Panthera pardus nimr*.

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Although there have been significant successes in these conservation efforts, this has generally been based on an *ad hoc* approach to prioritizing conservation actions spatially. Furthermore, little effort has been put into understanding the conservation context across national boundaries. Previous Conservation Workshops held in Sharjah, identified the need to develop an understanding of spatial conservation priorities within the Arabian Peninsula (Knight 2008, Seddon et al. 2009). In particular, the previous meetings had identified the requirement to understand where (and if) conservation priorities exist that cross national boundaries and which may be best addressed in a Transboundary Conservation Areas (TBCAs) approach. Therefore a GIS and systematic conservation planning workshop was held as part of the Conference on Biodiversity Conservation in the Arabian Peninsula (Seddon & Budd 2010).

The workshop aimed to explore whether it would be possible to conduct a rapid systematic conservation assessment for the Arabian Peninsula. In order to do this, the workshop aimed to collate and review the available biodiversity GIS data for the Peninsula; to evaluate this data and to chart the way forward for a rapid systematic conservation assessment, and thereby to develop an illustrative conservation assessment for the Arabian Peninsula that would demonstrate the potential application of the planning process. Importantly, there were also a number of less technical aims of the workshop, which sought to expose the participants to the logic and application of systematic conservation planning, and more broadly, to illustrate the potential benefits of sharing spatial data on biodiversity across the region.

This paper outlines the concept and benefits of systematic conservation planning, reports on the aims, process, data, analyses and initial outputs of the GIS and systematic conservation planning workshop, and charts the way forward for developing a more robust assessment for the Arabian Peninsula.

What is systematic conservation planning?

Systematic conservation planning aims to identify the most important areas for promoting the long term survival of all natural features including biodiversity pattern and ecological processes, and the ecosystem services delivered by these processes (Margules & Pressey 2000, Pressey & Bottrill 2009). Systematic conservation planning involves a structured, replicable, transparent and defensible process of decision making. Although the process often identifies protected area expansion priorities, it can additionally or alternatively be aimed at prioritizing areas for a range of other measures such as stewardship by landowners and managers, resource protection measures such as controls on fishery methods or hunting intensity, or land-use controls such as zoning. The process strategically identifies an efficient and effective system of conservation areas rather than relying on conservation areas being identified through isolated and *ad hoc* decisions, or alternatively being defined by the left-over areas that are not suitable for any other activity.

Two key concepts distinguish systematic conservation planning from other approaches (Bottrill & Pressey, in prep.). The first is the use of quantitative targets. This forces conservation planners to be explicit about what they intend to achieve, and provides a benchmark for monitoring implementation. The second is the principle of complementarity (Margules & Pressey 2000). Complementary areas are ones which collectively achieve biodiversity objectives, and hence areas are selected which contain the range of species or habitat types that are required to meet targets. A consequence of this selection method is that systematic conservation planning tends towards the identification of an efficient set of conservation areas that protect the required biodiversity features in as small an area as possible or in a configuration that is least conflicting with other activities and land-uses.

Systematic conservation planning processes can vary widely in scope, scale, purpose, approach and methods used. The best practice guidelines on conservation planning, under development by IUCN initiative convened by the Species Survival Commission (SSC) and World Commission on Protected Areas (WCPA), identifies 11 major stages within a systematic conservation planning process (PRESSEY & BOTTRILL 2009, BOTTRILL & PRESSEY in prep.). Table 1 provides an overview of the process. Although it is summarised as a linear sequence, in reality these steps are overlapping, iterative, and interlinked, and should be embedded within an adaptive management framework that allows for continued improvement.

What are the potential benefits of systematic conservation planning?

The rapidly maturing science of systematic conservation planning bridges the interface between biodiversity science and the implementation of conservation actions (BOTTRILL & PRESSEY, in prep.). The process is designed to inform decisions about where, when and how to allocate conservation resources to minimize the loss of both biodiversity (which includes biodiversity pattern and the ecological processes on which it depends) and the ecosystem services which are dependent on this biodiversity. Importantly, the process directly addresses two fundamental issues. Firstly, the planning process integrates human and development requirements with the needs of the environment. The process is not simply aimed at biodiversity, but rather at optimally integrating biodiversity and developmental requirements, and recognizes the need to address social issues in planning and designing for biodiversity requirements (KNIGHT et al. 2006). Secondly, the process is not just aimed at identifying the particular locations where important biodiversity exists, but also heavily emphasizes identifying and protecting the areas that are important for the long term ecological persistence of the biodiversity and the ecosystem services that it delivers (EGOH et al. 2007). These areas can include the areas required for climate change adaptation such as corriodrs and linkages, and areas delivering important ecosystem services such as groundwater recharge.

Systematic conservation planning systems have the potential to deliver a range of benefits:

- They provide efficient spatial solutions to resource allocation problems. This can be seen in terms of spatial efficiency (i.e. the ability to meet conservation or protection targets in the smallest possible area), cost efficiency (i.e. meeting the targets in a least-cost design) and efficiency in minimizing spatial conflict with other land-use activities.
- The process is powerful in identifying real as opposed to perceived priority areas and features. In areas with limited resources available for conservation activity, or strong competing development sectors, it is important that the priorities are correctly and transparently identified.
- Systematic conservation plans provide an integrated view of spatial priorities; across sectors, agencies and non-governmental organizations. Having a map of identified priorities can serve a strong focus for strategic planning and interventions. These plans are particularly useful in focusing interventions into areas where conservation objectives for a variety of different species can be met (e.g. areas may exist where shorebirds, Dugongs *Dugong dugon* and terrestrial priority species may be conserved in a single contiguous reserve covering a variety of habitats).
- A systematic conservation plan can play a powerful role in integrating conservation effort by different specialists. The process requires integration of information from

the full range of specialists (across all biodiversity groups). This cooperation is useful in forming the basis for other cooperative/integrative activities.
- Planning is heavily focused on ecological processes. This makes it possible to deliberately accommodate climate change in the planning process.
- The process makes best use of available data. There is no point in having large datasets (e.g. point data for specific species) collected at great expense if these data are not integrated and assessed. Although this is not the only method for integrating different spatial biodiversity datasets, it is a robust method to do this.
- The spatial biodiversity datasets collated for a systematic conservation plan can serve as a basis for other biodiversity planning and assessment processes.
- A target-driven systematic planning process forms a solid conceptual and operational basis for reporting on the state of the environment at any scale. Both the specific tools, such as Marxan (BALL & POSSINGHAM 2000, POSSINGHAM et al. 2000), and the underlying concept (quantitative review against set targets) form a natural basis for the monitoring and evaluation portions required for the adaptive management of biodiversity.

Methods

The workshop was attended by 29 invited GIS users and others with knowledge of spatial patterns of biodiversity across the Arabian Peninsula. There were representatives from all countries of the peninsula, except for Kuwait. Workshop participants were requested to bring spatial data on protected areas, habitat or vegetation maps, the distribution of special species (e.g. threatened or culturally significant species), land transformation and degradation, and identified priority areas for conservation (e.g. Important Bird Areas (IBAs) or areas identified for reserve expansion). The data were supplemented by species and protected area data collated by the Breeding Centre for Endangered Arabian Wildlife, Sharjah, as part of the annual Conservation Workshops meetings held in preceding years (AL MIDFA et al. 2011).

Datasets

The following datasets were used in the conservation planning process:

Base habitat map. An integrated base habitat map represents the framework around which a systematic conservation plan is built. The workshop identified that a habitat map of sufficient quality for fine-scale assessments does not currently exist for the Arabian Peninsula. Marine habitat data were especially lacking (with the exception of Abu Dhabi Emirate), and a decision was made to concentrate on terrestrial habitats and species for this demonstration assessment. Although it is at a very broad scale, the WWF Ecoregions map (OLSON et al. 2001) is the best currently available terrestrial habitat available for the whole region, and was used in the assessment. More detailed habitat maps were available for Jordan, and these were included as additional features in the assessment. Possibilities exist for the creation of an integrated habitat map through the extension of the soon to be available “ecotype” map for Saudi Arabia, as well as potential collaboration with the Important Plant Areas (IPA) Program (for inputs from Yemen and Oman) (O.A. Llewellyn 2010, pers. comm.). The assessment set targets for 12 WWF Ecoregions and 13 distinct habitat units from Jordan.

Species data. Species data compiled at the annual Sharjah Conservation Workshops and other processes have given us good information on fishes, larger mammals and reptiles. The data included distributions for 36 snake species, 14 mammal predators (e.g. Arabian Leopard and Sand Cat *Felis margarita*, six endemic fish, and two charismatic and endemic Arabian Peninsula herbivores (Arabian Oryx and Arabian Tahr *Arabitragus [Hemitragus] jayakari*). It is recognized both that these datasets are incomplete in terms of the number of species included, and that the accuracy of the distribution data is variable. This dataset needs to be refined and extended, and systematic criteria need to be utilized to identify which species are included in the analysis (e.g. only internationally Red Listed Species of Vulnerable, Endangered or Critically Endangered status).

Ecological process data. No data on ecological processes (e.g. wadi systems, ecotones, climate change corridors) were included in the workshop assessment. This is a major gap which would need to be addressed in order to identify a set of priority areas that are likely to be persistent in the long-term.

Other priority areas. Data on IBAs in the Arabian Peninsula and more detailed data from Jordan were included in the analysis. The Conservation International Horn of Africa and Eastern Afromontane hotspots were also included. Areas identified as being important for protected area expansion were included from Jordan and Saudi Arabia. In Jordan these areas were focused on climate change connectivity between existing reserves, while the Saudi Arabian dataset was focused on sites identified to improve the representivity of the existing reserve network.

Protected Areas (PAs). The existing database available for the area (the IUCN World Database on Protected Areas, see www.wdpa.org) was found to be both inaccurate and incomplete. More importantly, large areas that do not necessarily have protected area status (e.g. the Rub al Khali or Empty Quarter of Saudi Arabia which only has a hunting ban) have been included in the World Database as formal protected areas. The workshop was used to compile a significantly improved integrated layer of protected areas for the Arabian Peninsula, which is now available from the Abu Dhabi Global Environmental Data Initiative (AGEDI) Geoportal (see www.geoportal.ae/Portal).

Transformation data. Good quality transformation data for the Arabian Peninsula were not generally available for the assessment, although it is know that such data exist for many of the countries involved, but use of such information would involve engagement of authorities beyond those present at the workshop. The 1 km^2 resolution Global Landcover dataset sourced from the Global Land Cover Facility was used for the workshop assessment (HANSEN et al. 2000, see www.landcover.org). Because of its age, its broad scale and known inaccuracy, it was not used to determine where habitat and other biodiversity features remain intact, but rather as a cost surface to push selected areas away from those with conflicting land uses. This is an area where the trial assessment would need to be significantly improved.

Analyses

The data were compiled in ArcView 3.2 and ARCGIS 9.3.1. Marxan (BALL & POSSINGHAM 2000, POSSINGHAM et al. 2000) was used for the conservation planning analysis. The CLUZ front end program for MARXAN written by Bob SMITH (www.kent.ac.uk/dice/cluz) was used to facilitate the data inputting process. This analysis was primarily done to explore the data and demonstrate the usefulness of the systematic planning process, rather than to identify a definitive set of priority areas, due to the incompleteness and relative accuracy of the underlying datasets. Hence, the details of the analysis are not important, but nevertheless, the basic detail of technical aspects of the process is outlined here.

Targets of 30% of original area were used for most vegetation types. Targets for vegetation types with limited extents (e.g. Juniper Forest) were determined on the following basis. If the extent of the vegetation type was under 25,000 ha, then the full extent was set as the target. Where 30% of the vegetation type area was under 25,000 ha, and the original extent of the vegetation type was over 25,000 ha, then a target of 25,000 ha was used. Identified priority areas such as IBAs were forced into the design by setting an 80% target for these areas. Species targets were determined on the basis of the extent of the distribution of that feature, with lower percentage area targets being set for species with wide distributions and higher percentages used for species with limited distributions.

The targets were calculated with the formula 50% - (30 x total distribution of a species (ha)/total distribution of the most widespread species (ha)). This gives an effective target of 20% for the most widespread species and approaching 50% for species with limited distributions. Similar to the process used for vegetation types, where the identified target was under 25,000 ha the target was increased to the highest possible of 25,000ha or the extent of the distribution of that feature.

A cost-surface was prepared to where possible push selected areas away from areas which have been heavily impacted by human activities and where strong competing land-uses exist. The basic cost was set at the area of each planning unit in hectares. Costs for transformed areas were increased by 100 times this base value. Costs in a 5 km buffer around transformed areas were increased 10 times, within a 10 km buffer they were increased 5 times, and within 20 km they were doubled. The total cost for a planning unit was determined by an area-weighted mean of these values. The 'spf' values were set very high at 10,000,000 to force selection of areas required to meet targets for all features. Boundaries of planning units were determined in meters. The boundary length modifier was set at '1' following an iterative process to explore values which led to an appropriate level of clumping of selected features in the landscape.

Results

The initial outputs from the conservation planning workshop are shown in Fig. 1. Note that the outputs of this assessment should be used with extreme caution as the underlying datasets are known to be incomplete, and the purpose of the exercise was to illustrate that the process was possible for the Arabian Peninsula, rather than to identify a definitive set of spatial priorities. To avoid data with known errors being taken up in the literature, detailed data on ecosystem status and protection levels of different habitats are not presented here. Nevertheless, the model does highlight some priority areas which are likely to be robust to the addition of more complete species data and better transformation data. Identified priorities are mostly in the escarpment or coastal areas with a chain of high priority areas along the western escarpment of Jordan, Saudi Arabia and Yemen; a chain of priorities along the south-eastern coastal areas of Yemen and Oman; and a crescent of high priority mountainous habitat mostly in northern Oman focused on Arabian Tahr habitat as well as some endemic fishes. A limited set of inland priorities exist in Oman and Saudi Arabia around the Arabian Oryx Reserve and the Rub al Khali respectively.

The preliminary analysis also illustrates that the reserve network on the Arabian Peninsula does not represent the range of biodiversity present. Little or no formal protection (under 10% of the target met) exists for 70 of the 86 biodiversity features present in the planning domain. Key unprotected habitats include Al Hajar Montane Woodlands, Mesopotamian Shrub Desert, Persian Gulf Desert and Semi-Desert, and Southwestern Arabian Montane Woodlands. 72% (26) of the 36 snake species included, and all of the endemic fish, are unprotected. The only reasonably well protected features are the Saline Vegetation, IBAs, the snake *Echis khosatzkii*, Sand Dune Vegetation and Socotra Island Xeric Shrublands. The last two features listed are the only ones where the targets have been met. Although the targets were rapidly developed, and may be too ambitious, they are nevertheless useful in illustrating that the current protected area network does not protect the range of biodiversity found in the Arabian Peninsula.

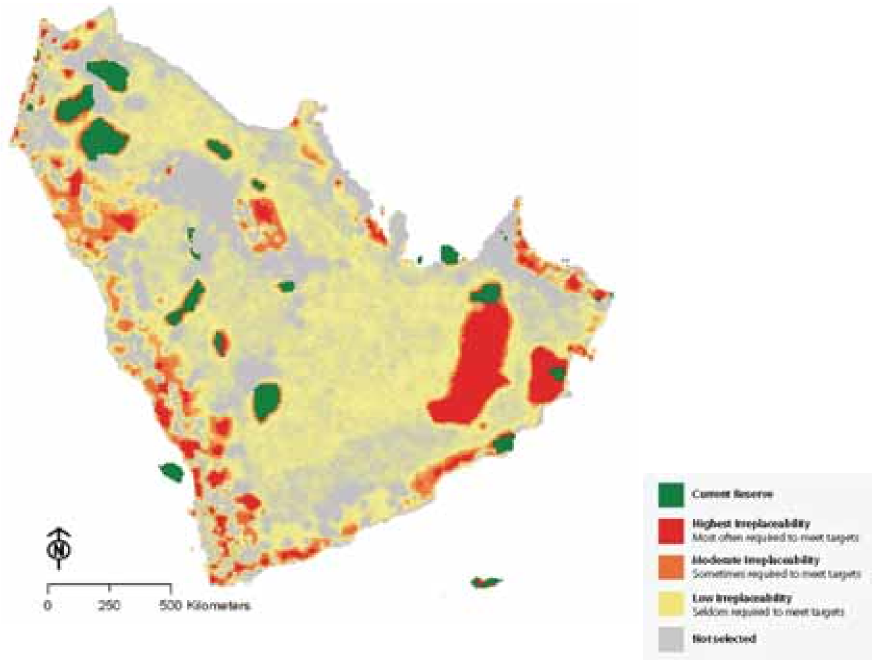

Fig. 1. Initial outputs from the rapid conservation assessment for the Arabian Peninsula. Grey areas are never selected by the model to meet targets, while the dark red areas are always required. Note that output is illustrative and should be used with extreme caution as it is known that the underlying data are incomplete.

Discussion

Strong potential exists to rapidly and successfully produce a systematic conservation plan for the Arabian Peninsula. Benefits can readily be gained in the Arabian Peninsula, where biodiversity spatial data exist but have not been previously spatially collated or integrated. A systematic conservation planning process would provide a strong spatial biodiversity focus to complement and derive additional benefit from the ongoing species focus of the Sharjah Conservation Workshops. The systematic conservation planning process is very powerful in identifying real as opposed to perceived priority areas and features. In areas with limited resources available for conservation activity, or strong completing sectors, it is particularly important that the priorities are correctly and transparently identified. The plans provide an integrated view of spatial priorities; across sectors, agencies and non-governmental organizations. Clear identification of national and international conservation priorities can help to consolidate conservation action both within government and NGO structures, and can guide broad scale conservation interventions, required policy changes and interventions, and clearly identify areas that require more detailed assessment. The identification of spatial priorities

Table 1. Description of the stages in systematic conservation planning developed by the IUCN initiative on Conservation Planning. Table adapted from Pressey & Bottrill (2009). For summary purposes it is shown as a linear sequence; but in reality these steps are overlapping, interlinked and iterative, and should be embedded within an adaptive management framework and designed in a way that allows for continued improvement.

Stage No.	**Stage**	**Description**
1	Scoping and costing the planning process	Decisions are necessary on the boundaries of the planning region, the neccessary planning team, the available budget and methods.
2	Identifying and involving stakeholders	Stakeholders include organizations, groups and individuals who will influence the planning process, be responsible for implementation or will be affected by conservation actions.
3	Describing the context for conservation areas	The planning team outlines the social, economic and political setting for conservation planning, identifying the threats to natural features that can be mitigated by spatial planning and the broad constraints and opportunities for conservation actions.
4	Identifying conservation goals	This begins with a broad vision statement for the region that is then refined into qualitative goals about biodiversity, ecosystem services, livelihoods and other concerns. Goals help to identify the specific spatial data required.
5	Collecting data on socio-economic variables and threats	Data will include spatially explicit information on variables such as tenure, extractive uses, costs of conservation, and constraints and opportunities to which planners can respond.

6	Collecting data on biodiversity and other natural features	The planning team will collect spatially explicit data on biodiversity and other natural features and processes that may include representation units (e.g. vegetation types), focal species, ecological processes and ecosystem services (e.g. maintenance of water flows, carbon sequestration).
7	Setting conservation objectives	Involves interpreting goals to define quantitative conservation objectives for each spatial feature (e.g. number of individuals of a species conserved) and, where necessary, qualitative objectives related to configuration (e.g. linkages between two conservation areas), restoration or other isues.
8	Reviewing current achievement of objectives	The extent to which objectives have already been achieved in areas considered to be adequately managed for conservation is evaluated.
9	Selecting additional conservation areas	This stage requires decisions about the location and configuration of additional conservation areas that complement the existing ones in achieving objectives. Factors influencing decisions will include stakeholder issues, costs, constraintsand opportunities for conservation. This stage is likely to include prioritization where resources are limited.
10	Applying conservation actions to selected areas	The most appropriate and feasible conservation actions are implemented.
11	Maintaining and monitoring conservation areas	The areas where conservation actions are implemeted need to be monitored to ensure that they continue to maintain the features or processes that they were designed to protect. Appropriate monitoring and evaluation processes need to implmeted, preferably in the context of a robust adpative management system.

for conservation action could potentially inform a range of site based and policy interventions, and ensure that these actions are undertaken efficiently and are focused on real as opposed to perceived priorities. An international assessment would be particularly useful in identifying where conservation priorities exist that cross national boundaries which could best be addressed in a Transboundary Conservation Areas approach (KNIGHT et al. 2011). These assessments are also very helpful in identifying priority areas for more detailed national and local scale assessments, and would provide a regional context for any national or local conservation planning initiatives.

A systematic biodiversity assessment process and program would not only provide useful spatial prioritization products to inform a range of conservation programs and initiatives, but would also provide the basis for developing sustainable and mutually beneficial relationships with a range of key biodiversity organizations. Layers developed within a conservation planning process (such as better habitat maps, distribution maps for threatened species and accurate protected area data) would significantly improve the state of biodiversity data and its availability in the region. An inclusive and integrated planning process and the associated data exchange and dissemination could potentially form the basis for long-term regional cooperation on biodiversity information, and facilitate better access to, and use of, quality spatial biodiversity information in robust, science-based integrated planning processes which contribute to regional environmental sustainability.

The workshop demonstrated the potential usefulness of a systematic conservation planning process and the need for these products for the Arabian Peninsula. Feedback from both the workshop participants and from the main conference strongly supports the development of an assessment both at an Arabian Peninsula and at a national scale (SEDDON & BUDD 2010). The workshop demonstrated that from a technical and data point of view, a rapid but robust assessment of spatial biodiversity priorities across the Arabian Peninsula is possible in the short-term. However, one must recognize that the main issues are not technical, but rather around political buy-in, institutional support, and a mandate. This is particularly important if there is to be a strong link to implementation and the policy which supports it. There is also the need to raise awareness and develop in-house level capacity in agencies. The key requirement for a successful conservation plan is the ability and willingness for individuals and countries to share spatial data in an organized way and to facilitate access to this data. The international AGEDI program housed within the Environment Agency Abu Dhabi (see www.agedi.ae) provides a potential forum for the collation and regional dissemination of this spatial data. Once spatial biodiversity data is being shared, systematic conservation planning processes are well placed to add significant value to the underlying data.

A way forward that is being explored by AGEDI is based on the development of pilot rapid assessments at multiple scales for Abu Dhabi, the United Arab Emirates and the Arabian Peninsula. Although AGEDI would be facilitating this process, it is anticipated that the project would be undertaken in partnership with all interested stakeholders and experts within and outside the region. In particular, potential synergy exists with ongoing biodiversity data compilation processes, notably the IUCN Red List projects, the IPA Program and the ongoing CAMP workshops. A systematic conservation planning process would provide a regional context for any national or local conservation planning initiatives, would provide a strong spatial biodiversity focus to parallel the species focus of the CAMP processes undertaken to date, and would support transboundary conservation initiatives.

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