Biodivers Conserv (2009) 18:1979–2000
DOI 10.1007/s10531-008-9568-0

ORIGINAL PAPER

Conservation planning on a budget: a "resource light" method for mapping priorities at a landscape scale?

**Karl A. Didier · David Wilkie · Iain Douglas-Hamilton ·
Laurence Frank · Nicholas Georgiadis · Max Graham ·
Festus Ihwagi · Anthony King · Alayne Cotterill · Dan Rubenstein ·
Rosie Woodroffe**

Received: 11 July 2007 / Accepted: 22 December 2008 /

Abstract Conservation projects may be reluctant to attempt Systematic Conservation Planning because existing methods are often prohibitive in the time, money, data, and expertise they require. We tried to develop a "resource light" method for Systematic Conservation Planning and applied it to the Ewaso Ngiro Landscape of central Kenya. Over a 6-month preparation period and 1-week participatory workshop, we used expert assessments to select focal biodiversity features, set quantitative targets for these, map their

---

K. A. Didier (✉)
Global Conservation Programs, Wildlife Conservation Society, 907 NW 14th Ave., Gainesville,
FL 32601, USA
e-mail: kdidier@wcs.org

D. Wilkie
Global Conservation Programs, Wildlife Conservation Society, 18 Clark Lane, Waltham, MA 02451,
USA

I. Douglas-Hamilton
Department of Zoology, University of Oxford, Oxford, UK

I. Douglas-Hamilton · F. Ihwagi
Save the Elephants, P.O. Box 54667, 00200 Nairobi, Kenya

L. Frank
Wildlife Conservation Society, 2300 Southern Blvd, Bronx, NY 10460, USA

L. Frank
Museum of Vertebrate Zoology, University of California, Berkeley, CA 94720, USA

N. Georgiadis · A. Cotterill
Mpala Research Center, P.O. Box 555, 10400 Nanyuki, Kenya

M. Graham
Department of Geography, University of Cambridge, Cambridge CB2 3EN, UK

A. King
Laikipia Wildlife Forum, P.O. Box 764, 10400 Nanyuki, Kenya

current distribution, vulnerability, potential for recovery, and conservation costs, and, finally, map cross-feature conservation priorities. Preparation for and facilitation of the workshop required time investment by one part-time workshop coordinator, eight workshop committee members, six ecosystem experts, and two GIS technicians. Total time investment was approximately 56.5 person-weeks spread over facilitators and 40 workshop participants. Monetary costs for the workshop were approximately $US 42,000, excluding investments made by researchers previous to this project. Costs for a similar workshop could vary substantially, depending on need to cover salaries, international travel, food and lodging, and the number of participants. To stay within our resource constraints, we completed the exercise for only four of nine focal biodiversity features and did not negotiate trade-offs between conservation and human land-uses or use planning software to identify "optimal networks" of conservation areas. These were not considered critical for conservationists to try Systematic Conservation Planning, introduce landscape-scale conservation concepts to stakeholders, and begin implementing landscape conservation strategies. Participants agreed that further work would be needed to complete and update the planning process. Due to the lack of comparative cost data from similar planning exercises, we cannot definitively conclude that our approach was "resource light", although we suspect it is within the constraints of most site-based conservation projects.

Keywords Cost:benefit · Expert opinion · Kenya · Laikipia · Systematic conservation planning · Participatory workshop · Samburu · Vulnerability

Introduction

Recently, scientific interest has grown in developing effective methods for mapping conservation priorities, a process we refer to as Systematic Conservation Planning (Margules and Pressey 2000). Some consensus seems to be emerging among researchers about the critical steps needed to complete SCP (Table 1; Margules and Pressey 2000; Groves 2003; Conservation Measures Partnership 2007), including selecting focal conservation features, setting quantitative targets for those features, and mapping their distribution. However, debate still continues on the most appropriate methods and parameters to include (e.g., Moffett and Sarkar 2006).

While existing methods have undoubtedly been valuable, we believe that spatial priority setting exercises have not been tried by a larger number of applied conservation projects for several reasons:

- The existing methods are burdensome to implement in terms of time, energy, and money.
- The existing methods are generally complex and the results difficult to interpret for those not directly involved in their creation (i.e., the "black box" effect). This creates distrust of the results and difficulty securing buy-in from stakeholders.

D. Rubenstein
Department of Ecology and Evolutionary Biology, Princeton University,
Princeton, NJ 08544, USA

R. Woodroffe
Department of Wildlife, Fish, and Conservation Biology, University of California at Davis,
Davis, CA 95616, USA

Table 1 One version of the steps of SCP exercise, adapted from Cowling and Pressey (2003) and Groves (2003)

SCP step	Brief description and considerations	Selected citations
1. Define the initial parameters	Developing a broad conservation vision, defining the initial boundary and time frame for the exercise, planning units size and shape, participant list, etc.	Margules and Pressey (2000); Cowling and Pressey (2003); Groves (2003)
2. Define a set of focal conservation features	Choosing the elements of biodiversity on which resources will be focused. Can include any level of biological organization from species, vegetation communities, ecosystems, habitats, to genes	Coppolillo et al. (2004); Bottrill et al. (2006)
3. Define quantitative desired targets for each feature	Statements regarding the quantity and quality of conservation features that practitioners would like to reach or maintain. Can come in varied forms including number of occurrences, total area in conservation, minimum viable populations	Svancara et al. (2005); Tear et al. (2005); Sanderson (2006)
4. Map the current distribution of features	Methods include various statistical mapping approaches (e.g., linear regression, GARP), expert knowledge, participatory mapping	Pearce et al. (2001); Gaston and Rodrigues (2003); Guisan et al. (2006); Tole (2005); Rondinini et al. (2006); Yang et al. (2006)
5. Map the vulnerability of features to future reductions	Preventing future reductions of biodiversity is a clear impact and goal of conservation. Resources can be focused where current abundances of features are high and future threats are high. Can include future scenarios or measures of site availability/degradation	Turner and Wilcove (2006); Wilson et al. (2005); Davis et al. (2006)
6. Map the recoverability of features	Recovering (or restoring) biodiversity that has already been lost or reduced is another possible impact of conservation. Resources can be focused where current populations are low and carrying capacity is high	Kerley et al. (2003); Schultz and Crone (2003)
7. Map the relative cost or feasibility of conservation activities	Because conservation resources are limited, conservation activities aim to be efficient (i.e., have high impact and low cost). Can be based on detailed economic valuations or expert opinion	Moore et al. (2004); Cabeza and Moilanen (2006)
8. Map confidence/certainty	Confidence information highlights where information is lacking and more research is needed. When using expert knowledge, it can encourage experts to provide their "best available" information	Johnson and Gillingham (2004); Hartley et al. (2006)

Table 1 continued

SCP step	Brief description and considerations	Selected citations
9. Assess the effectiveness of existing conservation activities/areas in reaching or maintaining targets	Will help determine where current levels of investment are sufficient, where increased investment should go, and the extent to which recovery is important relative to preventing reductions. Should be strictly treated as decision-support for identifying priorities	Groves (2003, Chap. 5); Jennings (2000); Dudley and Parrish (2006)
10. Summarize the benefits and costs of planning units for meeting or maintaining quantitative targets of conservation features	Creating summary maps and indices highlighting where investment may be wise. May include benefit:cost ratios, irreplaceability scores, or other results of reserve design algorithms (e.g., from Marxan, C-plan, etc.)	Ball and Possingham (2000); New South Wales NPWS (2001); Moffett and Sarkar (2006); Turner and Wilcove (2006)
11. Negotiate a map of conservation priorities	Physically scoring planning units in terms of conservation priority, considering all information in previous maps, possible mistakes, and relevant information not in the maps (e.g., political constraints, opportunities). May also include evaluating tradeoffs, both among conservation features, and between features and human development objectives. Decision-support software can help (Marxan, C-plan, Vista)	Same as in 10; NatureServe (2006)

The process we list here focuses more mapping procedures. Groves (2003) includes an in-depth discussion of many of these steps

- The impression that a great deal of data, especially rigorously collected field data, are necessary to complete the exercises, and sufficient data do not already exist.

Our goal was to develop a simple yet effective method for mapping conservation priorities that would be attractive to field practitioners, and to implement the method in the Ewaso Ngiro landscape of central Kenya. Our audience is primarily field practitioners who:

- Want to map conservation priorities for multiple conservation features (e.g., species, communities, ecosystems) across landscape scales (e.g., typically 10,000–100,000 km^2);
- Want to complete an initial exercise in 6–12 months and produce useful map products for guiding immediate conservation action;
- Want a participatory approach involving many stakeholders;
- Have access to sufficient accumulated knowledge (in the form of experts or existing maps) of the landscape, conservation features, and threats to map the distribution of features;
- Would like to incorporate into their planning process not only the current distribution of biodiversity, but vulnerability of biodiversity to future threats, potential for recovery, and conservation costs
- Because of data, budget, or time constraints, would prefer to make distribution maps for conservation features using expert scoring rather than statistical modeling procedures based on detailed observational data; and

- Do not want the budget for the planning exercise to exceed approximately $US 40,000 (although our method could be implemented for considerably less depending on local circumstances).

Our aim was not to complete an in-depth consideration of all the steps of SCP (Table 1), but to introduce local practitioners and stakeholders to SCP and train them so that they could carry the planning process forward, while producing critical products to help participants quickly apply action.

Study area

Our project was conducted within a 52,800 km^2 region located in north-central Kenya (36.1° N–0.3° S, 36.2° E–38.1° E), encompassing the districts of Laikipia, Samburu, a large part of Isiolo, and small portions of 10 others (Fig. 2). The region is drained primarily by the Ewaso Ngiro river, for which the landscape is named. The region is primarily acacia savanna, interspersed with a few dry montane forests and montane moorlands, especially around Mt. Kenya (Olson et al. 2001). In Laikipia district, where most of the land is tenured, land-uses include ranching, pastoralist grazing of livestock, cultivation of crops (e.g., flower farms), and tourism. In the primarily untenured lands of Isiolo and Samburu districts, pastoralist grazing occurs in the savanna, and some forest management within the montane forests. Several protected areas are scattered throughout the region, including Mt. Kenya National Park, Samburu, Buffalo Springs and Shaba National Reserves, and several privately owned conservancies.

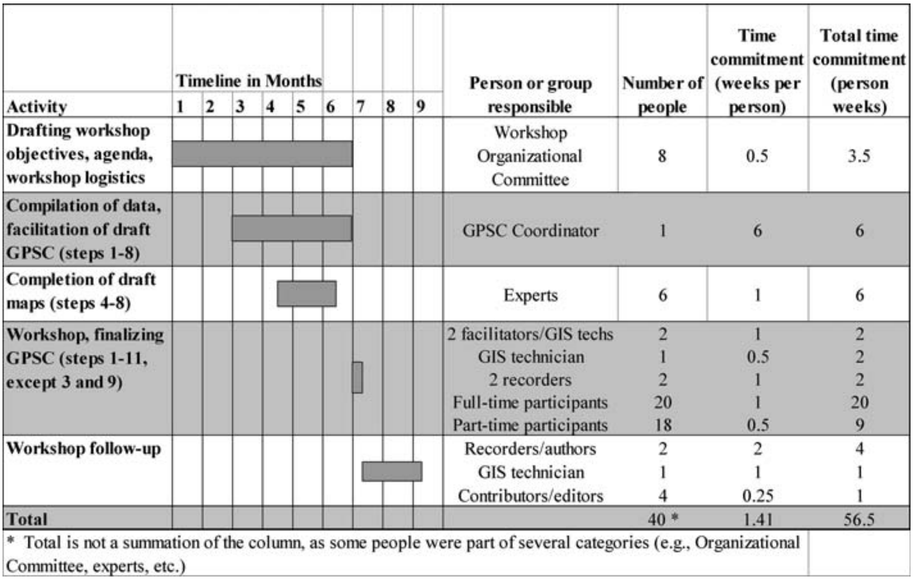
Methods

To produce maps of conservation priorities for The Ewaso Ngiro, we proceeded through the SCP steps in (Table 1), with the exception of assessing the effectiveness of existing conservation areas (step 9) (our steps are adapted from Cowling and Pressey (2003) and Groves (2003), but focus more on mapping steps). We proceeded through these steps in three stages: workshop preparation, a participatory workshop, and workshop follow-up (see Fig. 1).

Workshop preparation

For the 6 months prior to the workshop, an organizational committee developed the workshop agenda, organized workshop logistics (e.g., housing and food), and compiled relevant spatial data into a GIS. Also during this time, the organizational committee and a set of experts produced draft outputs for steps 1–8 of SCP. The committee agreed on a boundary for the planning region and divided it into 2,112, 5 × 5 km units. The committee selected four initial focal conservation features, considered to be likely selections by the stakeholders at the workshop, including African elephant (*Loxodonta africana*), lion (*Panthera leo*), wild dog (*Lycaon pictus*), and Grevy's zebra (*Equus grevyi*).

After selecting conservation features, we asked experts for the four features to score a series of five maps for the planning region, with the understanding that the maps would be revised at the workshop. Corresponding to steps 4–8 in SCP, these maps were:



Activity	Timeline in Months 1	2	3	4	5	6	7	8	9	Person or group responsible	Number of people	Time commitment (weeks per person)	Total time commitment (person weeks)
Drafting workshop objectives, agenda, workshop logistics	▨	▨	▨	▨	▨	▨				Workshop Organizational Committee	8	0.5	3.5
Compilation of data, facilitation of draft GPSC (steps 1-8)			▨	▨	▨	▨				GPSC Coordinator	1	6	6
Completion of draft maps (steps 4-8)				▨	▨	▨				Experts	6	1	6
Workshop, finalizing GPSC (steps 1-11, except 3 and 9)							▨			2 facilitators/GIS techs GIS technician 2 recorders Full-time participants Part-time participants	2 1 2 20 18	1 0.5 1 1 0.5	2 2 2 20 9
Workshop follow-up							▨	▨	▨	Recorders/authors GIS technician Contributors/editors	2 1 4	2 1 0.25	4 1 1
Total											40 *	1.41	56.5

* Total is not a summation of the column, as some people were part of several categories (e.g., Organizational Committee, experts, etc.)

Fig. 1 Approximate timeline and time commitments needed for SCP in Ewaso Ngiro. Total time commitment for all people involved in organization of the workshop and facilitation of the SCP was approximately 28 person-weeks. Including workshop participants, total time commitment was approximately 57 person-weeks

1. Current Importance of each planning unit
2. Potential for Future Loss/Reductions (in the absence of conservation; i.e. vulnerability)
3. Potential for Recovery
4. Conservation Cost
5. Confidence

The first four of these were scored on relative scales of 0–10 (with minor adaptations for specific maps), as this scale appeared to provide sufficient precision for experts (i.e., they did not further divide the scale) but did not create a false impression of rigor or accuracy of information provided. At least one expert for each feature completed the set of maps (three for Grevy's zebra, four for elephants, one for wild dog, and one for lions). We considered consistent interpretation of mapping directions to be critical to the comparability of maps across features and, therefore, provided detailed guidelines for completing and interpreting the maps. Some of these guidelines are provided in Table 2, with corresponding example maps in Figs. 2, 3. Further detail on mapping procedures is available on request from K.A.D.

We encouraged experts to use all information available to them to complete the maps (i.e., field surveys, models, personal experience, literature). They were encouraged to score all 2,112 planning units for each map even if scores were "wild guesses" but then to score their confidence. Experts were given the option to complete the maps on paper or directly within a geographic information system (GIS; ArcView 3.2 or ArcGIS 9.0). Expert maps were returned prior to the workshop, checked for errors and appropriate interpretation, and compiled within a GIS.

Table 2 Description of four maps and guidelines given to experts for completing the maps, during a conservation planning workshop in Laikipia, Kenya, January 2006. Examples of these maps are provided in Fig. 2. All maps were scored on a relative 0–10 scale, with a few additional categorical values in the Conservation Cost map. If maps completed by experts did not include 10 (highest relative value), the values were normalized (stretched) to 10. A fifth map reflecting the confidence of the experts in the data they provided was also completed, but is self-explanatory (see Fig. 3)

Map name	Short description	Meaning of critical values	Guidelines and important factors affecting the score
Current Importance	Relative contribution that a planning unit (PU) makes toward supporting the current population across the landscape	0 No importance either because the habitat in the PU does not support the species or because no animals currently exist there or use it 10 Highest importance	Score can reflect current abundance of the species in the unit *and* also if it contains a critical habitat feature (e.g., seasonal habitat, watering hole, corridor) Score can reflect non-local importance (e.g., the unit supports animals that are seasonal residents, but spend most of the year elsewhere) Habitat that *could* support the population (given conservation), but currently does not should receive 0
Potential for Future Loss/Reductions	Relative potential for future reductions in the landscape population over the next 10 years due to human activities in the unit	0 Human activities will not occur in the unit or will have no negative impact on the abundance of animals in the landscape 10 The highest potential loss, in number of animals lost from the landscape	Current Importance can affect the score—PUs that have higher importance can possibly lose more Units that receive a Current Importance of 0 should receive a 0 here Scores should reflect probability that human activities will occur and the size of their impact Assume that all current conservation actions are stopped and no future ones begin
Potential for Recovery	Relative contribution that the unit could make to recovering the population across the landscape	0 No potential for increasing the population in the land-scape by working in the unit 10 Highest potential	Consider both recovery and restoration (i.e., to places where animals are not present) Score should consider carrying capacity and the possible growth due to mitigating reversible human impacts (i.e., those that are not cost prohibitive) Assume a liberal budget
Conservation Cost	Qualitative, relative cost to prevent negative human impacts from occurring in the unit or mitigating their impacts	0.01 Minimal or no cost 1 Low cost 10 Highest relative cost 999 Cost prohibitive	1–9 Scored on a linear scale Interpret as (1) relative monetary amounts, (2) the probability of success, or (3) simply, “how hard is it to do conservation?” in the unit

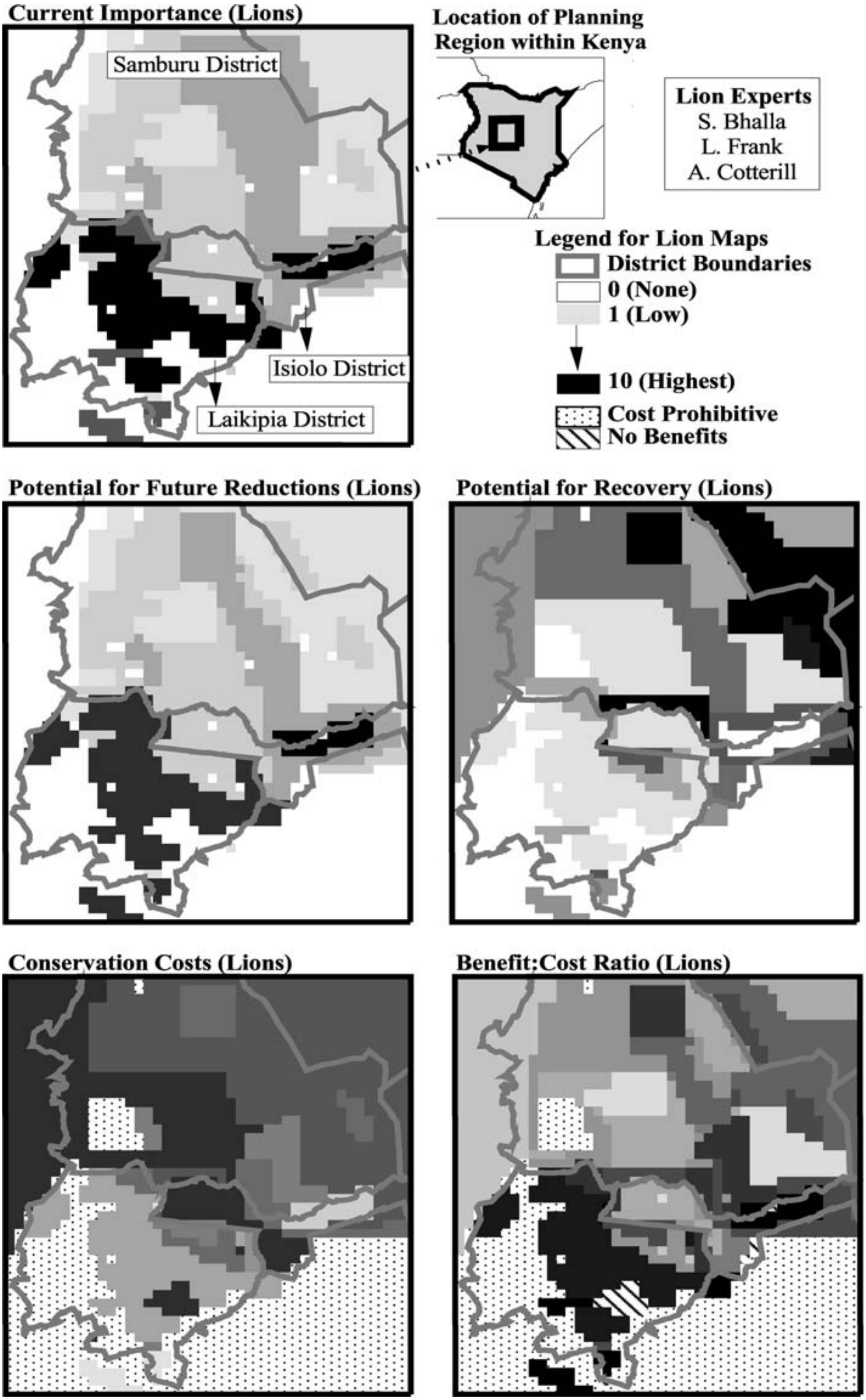
Fig. 2 Examples of the planning maps created for four conservation features for the Ewaso Ngiro ▶ landscape, in this case for lions. Maps are final, consensus versions by lion experts and workshop participants. Current Importance represents the relative contribution that each planning unit makes toward supporting the *current* population across the landscape. Potential for Future Reductions represents the relative potential for reductions in the landscape population over the next 10 years due to human activities in the unit, assuming that no new conservation activities will be undertaken and all current activities are stopped. Potential for Loss/Recovery represents the relative contribution that the unit could make to recovering the population across the landscape if conservation activities were performed, and assuming a liberal budget for those activities. In general, these first three maps reflect local abundances of the species (or reductions in abundance), although in certain circumstances the score for a unit reflects that it contains a critical habitat element (e.g., watering holes) or that the local abundance does not reflect the unit's contribution to the population across the landscape. For the Cost map, we relied on a qualitative estimate of cost and instructed experts to score costs to reflect (1) actual monetary amounts that would be required to successfully prevent reductions and recover animals in the planning unit, (2) the probability of successfully preventing reductions and recovering animals under a fixed, realistic conservation budget, or (3) simply, "how hard is it to do conservation?" in the unit. The benefit:cost ratio is calculated and is the weighted sum of the Potential for Future Reduction map and Potential for Loss/Recovery maps divided by the Cost map. The map represents the benefit:cost ratio for performing conservation activities, by either preventing future reductions or working to recover the species. These maps were used by workshop participants to assign planning units to priority classes (Fig. 4)

Participatory workshop

The participatory workshop was held from 25 to 29 January, 2006, at Mpala Research Station in the Laikipia District. Approximately 40 participants representing 15 different organizations, attended. About one day of the workshop was spent reviewing the basic parameters of conservation planning and revising conservation features (steps 1 and 2). Participants developed a consensus vision/goal statement, discussed an appropriate boundary for the landscape, revised the draft set of conservation features, set quantitative targets for these features, and identified the major threats to biodiversity. Revision of the mapping exercise took approximately 3 days (steps 3–8, 10–11), during which time we presented the five draft maps to the stakeholders, solicited review and refinement of the maps, produced final consensus versions, and created maps of conservation priorities. The final day was dedicated to mapping current activities of the various conservation stakeholders and discussing implications of the SCP exercise for action and follow-up. Workshop follow-up consisted of developing and distributing press releases, and compilation, editing, and distribution of the workshop proceedings.

After selecting a final set of conservation features (nine in total), participants agreed to complete the mapping exercises (steps 4–11) using only the four pre-selected features, although they recognized that that SCP would not be entirely complete until all features were included. Participants divided into breakout groups according to feature, and spent approximately 1 day revising the draft maps produced by experts. Draft maps were displayed from the GIS software using a projector, and revision was performed directly within the GIS. After revising maps for the first time, revised versions were presented to the entire workshop for additional revisions. During this time, groups also estimated the current abundance of each feature across the study area and set quantitative targets for conserving them. To set quantitative targets, each group completed the statement "To be successful in 10 years, we would like to have maintained or have a restored population of X individuals across the study area", although modifications to this statement were made by particular groups.

After completing revisions, a map of the benefit:cost ratio for performing conservation actions in planning units was calculated for each conservation feature as:


Current Importance (Lions)
Samburu District
Isiolo District
Laikipia District
Location of Planning Region within Kenya
Lion Experts
S. Bhalla
L. Frank
A. Cotterill
Legend for Lion Maps
District Boundaries
0 (None)
1 (Low)
10 (Highest)
Cost Prohibitive
No Benefits
Potential for Future Reductions (Lions)
Potential for Recovery (Lions)
Conservation Costs (Lions)
Benefit:Cost Ratio (Lions)

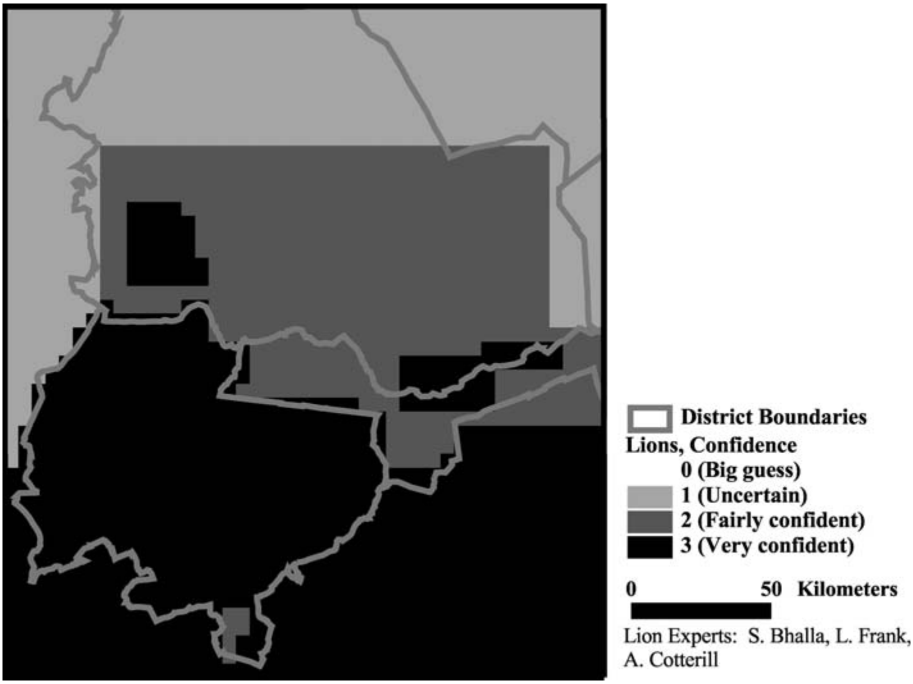


Fig. 3 An example of the Confidence maps created for the Ewaso Ngiro landscape, in this case for lions. The map is the final, consensus version created by lion experts and workshop participants, and is a subjective reflection of the expert's confidence in the information he or she provided in the first four maps. The map was also critical for encouraging experts to score all 2,112 planning units, using their best information, even if the quality of this information is not sufficient for estimation of statistical significance

$$\frac{L + (R * W)}{C}$$

where L is the Potential for Loss/Reductions map, R is the Potential for Recovery map, C is the Cost map, and W is a constant for weighting the Potential for Recovery relative to the Loss/Reductions map (given the weight for the Loss/Reductions map is 1). We asked each break-out group to provide this weight, given that the Reductions map would receive a weight of 1. Groups were asked to assign the weight based on the feasibility and cost of actions aimed at recovery relative to those aimed at preventing future reductions (i.e., if it was less feasible to recover the species' population than prevent its further decline, the weight should be <1). Actual weight values ranged from 0.2 to 1.5 depending on the species. For certain features (e.g., elephants) in certain locations, recovery options are difficult to implement or inappropriate because the species is currently abundant; while for others (e.g., lions) recovery is a viable option, as their current populations are far below potential levels.

After presenting benefit:cost maps, participants returned to species' breakout groups and were tasked with creating a final map of conservation priorities for their feature over the next 10 years by assigning each planning unit to one of six priority levels:

- *Conservation Not Possible or appropriate in the planning unit.* Either costs are prohibitive or there are no benefits for performing conservation here (e.g., non-habitat).

- *More Information Needed* to make a decision regarding priorities for conservation action in the planning unit. Confidence in the existing information is too low.
- *Increased Investment Needed, Low Priority*. Investment of resources beyond current levels is needed to prevent reductions and/or recover the species (or critical habitat elements) in the unit. The unit is a low priority for conservation investment/actions aimed at the species.
- *Increased Investment Needed, Medium Priority*. Increased investment of resources is necessary. The unit is only a medium priority for conservation investment/actions.
- *High Priority, No Increased Investment*. The unit is a high priority for conservation actions aimed at the species. However, investment of resources beyond current levels is not necessary.
- *Increased Investment Needed, High Priority*. Increased investment of resources is necessary. The unit is high priority for conservation investment/actions.

We instructed participants to use the benefit:cost ratio and other maps as priority-setting guides, but suggested that strict adherence to the benefit:cost ratio was unnecessary, as many additional factors (e.g., politics, opportunities, mistakes in the mapping) could affect their decisions. We asked participants to place planning units requiring increased investment into the three relevant categories (low, medium, high) in approximately equal proportions.

Finally, we created an integrated map of conservation priorities across all four conservation features, although participants recognized that most decisions were made on a feature by feature basis. We placed planning units into six mutually exclusive categories:

- Units where the conservation of all species is not possible or appropriate;
- Units receiving Low Priority or More Information Needed for at least one species, but not High or Medium Priority for any species;
- Units receiving at least Medium Priority for one species, but not High Priority for any;
- Units receiving High Priority for at least one species, but not High Priority, Increased Investment for any;
- Units receiving High Priority, Increased Investment for at least one species;
- Units receiving High Priority, Increased Investment for all species.

Many other logical combinations are possible, but the above categories were sufficient to facilitate discussions about where to direct collaborative conservation actions that could benefit all species.

Results

Activity timeline, participants, and time and monetary costs

General workshop preparation required about 6 months of lead time (Fig. 1), and involved approximately 15 people. The workshop itself lasted 5 days and was attended by approximately 40 people, about half of whom were able to devote an entire week of time. Post-workshop follow-up lasted about 2 months, mostly consisting of writing the workshop proceedings.

Approximately half the total time invested in the project was dedicated to workshop organization, facilitation, and follow-up (about 27.5 person-weeks). The remainder consisted of time dedicated by the 40 workshop participants during the workshop itself. Our workshop budget, including travel and salary-coverage for two facilitators, room and board

Table 3 Breakdown of monetary costs used in preparation for, follow-up, and facilitation of the SCP workshop in Laikipia, Kenya, January 2006

Budget category	Description	Cost ($US)	% of budget
International travel	For two people, US to Kenya	4,770	11.2
Technical support	Salary for two technical leaders and GIS tech	11,488	27.0
Logistical support, supplies and salary	Salary for support staff and supply costs	8,350	19.6
Workshop, direct costs	Food, lodging, and local travel for participants	7,499	17.6
Follow-up	Salary for two staff to write workshop proceeding and printing costs	10,500	24.6
Total		42,607	100.0

Costs for a similar workshop could vary substantially, depending on whether it was necessary to cover salary for technical leaders and support staff, international travel, food and lodging, and the number of participants

for five nights, and miscellaneous costs, was approximately $42,600 (Table 3). These cost estimates exclude the substantial investments of time and money previously made by researchers about the ecology and human use of Ewaso Ngiro.

Workshop outputs

Workshop participants developed a consensus conservation vision and name for the planning region: “To conserve the natural biodiversity and integrity of the Ewaso Ngiro landscape.” The “Ewaso Ngiro” is the drainage system encompassing most of the planning region.

Participants also agreed on a sub-set of the biodiversity within the Ewaso Ngiro landscape which would act as good surrogate for protecting the other native biodiversity. The suite of conservation features was comprised of nine biodiversity elements (Table 4), including all four features pre-selected by the organizational committee (elephant, Grevy’s zebra, lions, and wild dogs), two additional species, two vegetation communities, and an ecological system/service. Greater detail on the rational, methods for selecting these conservation features, and the human activities that threaten them can be found in the workshop proceedings (available upon request from K.A.D.).

Over the course of approximately 1 day during the workshop, participants successfully refined the draft maps produced by experts and created final, consensus maps. Examples of these for lions are in Figs. 2, 3. Maps for other species can be found in the workshop proceedings (available upon request from K.A.D.). During this time, they also agreed on total abundance estimates and draft quantitative targets (Table 4).

Finally, breakout groups successfully created maps of conservation priorities for the four focal species in approximately 3 h (Fig. 4). The compiled map of conservation priorities was created in approximately 2 h, and presented back to the workshop participants for discussion (Fig. 5).

Discussion

Many of the previous approaches for mapping conservation priorities are admirably complete and explicitly consider much of the complexity of making conservation decisions

Table 4 The suite of focal biodiversity features selected by participants at the Ewaso Ngiro Landscape Conservation Planning Workshop (January 2006), and quantitative conservation objectives for these features

Focal conservation feature	Estimate of current abundance (January 2006)	Range of estimated abundance	Quantitative conservation target[a]
African elephant (*Loxodonta africana*)	8,000 animals	7,000–9,000	10,000[b]
Grevy's zebra (*Equus grevyi*)	1,700 animals[c]	1,600–2,100	4,500[d]
Lion (*Panthera leo*)	450 animals	400–500	500
African wild dog (*Lycaon pictus*)	300 animals in 17–18 packs	250–350	20 packs[e]
Jackson's hartebeest (*Alcelaphus buselaphus*)	Information not compiled during this exercise		
Reticulated giraffe (*Giraffa camelopardalis reticulate*)			
Acacia-grassland mosaic			
Dry upland/montane forest			
Hydrological system			

Subsequent to selecting these features, participants concentrated on only the top four, although the other features should be considered in future exercises. The quantitative conservation objective represents the total population that participants would like to see across the landscape in 10 years in order to be considered successful

[a] The quantitative targets are to reach and maintain the amounts within 10 years

[b] Redistributed from their current distribution to: 2,000 in Laikipia district (decrease from current); 6,000 in Samburu (increase), and 2,000 in the Mt. Kenya region

[c] A recent drought may have reduced the population from the more long-term mean of approximately 1,900 animals

[d] Representing approximately a 10% increase/year

[e] Extrapolating from a range of 300 animals in 17–18 packs to 20 packs, gives a range for the objective of 333–353 animals

(Table 1). An example of a comprehensive SCP was completed for the Cape Floristic Region of South Africa and published as a set of 16 published articles (see among others Cowling and Pressey 2003; Younge and Fowkes 2003). This exercise involved in-depth assessment of the current spatial occurrence of 858 conservation features (Pressey et al. 2003), quantitative targets for all features, future threats to biodiversity including climate change (Midgley et al. 2003; Rouget et al. 2003), and costs (Frazee et al. 2003).

While projects such as the Cape Floristic exercise are more likely to pass rigorous scientific scrutiny, they may be beyond the budgetary or time constraints of many applied conservation projects. Practitioners on tight budgets (in terms of money, staff, or expertise), or those who wish to introduce the concepts of SCP to local stakeholders, may need to begin with a more modest approach. Our project was an attempt to develop and test such an approach in an applied setting. Below we discuss the advantages of our approach, and consider what we left out.

A resource light method?

While it is important for practitioners to understand the relative benefits of the various SCP approaches, to make wise decisions about which approach to take, we believe it is equally

Fig. 4 Conservation priorities by conservation feature for Ewaso Ngiro, produced by workshop participants. Participants were instructed to use the benefit:cost ratio and other previous maps (Fig. 2) as guides to making these maps, but were told that strict adherence to the benefit:cost ratio was unnecessary. Participants were asked to place planning units requiring increased investment into the three relevant categories (low, medium, or high) in approximately equal proportions. Species-specific conservation recommendations were these made from these maps. For example, for lions, high priority areas where conservation investment is currently sufficient are comprised primarily of commercial ranches of Laikipia and the National Reserves. Additional investment is critically needed (high priority) in the community areas of Laikipia and Isiolo Districts (particularly along luggas which lions favor as habitat) and a buffer zone around National Reserves in Isiolo (to allow for safe dispersal of lions out of the reserves), and the Matthew's Mountain Range in Samburu District (habitat that has low human population density and could support more animals). Areas where there are many people and high densities of livestock are considered either a low priority or conservation is not possible. The level of knowledge on lions in much of the north of the landscape was considered insufficient to make a decision on priorities. More research is needed in this area as there may be potential for recovering lions ▶

important for them to understand the costs of the approaches, in terms of money, time, and staff. Unfortunately, estimates of the resources needed to run SCP exercises have rarely if ever been provided in the scientific literature. Our study represents one of the first attempts to provide this information on a SCP exercise, and we challenge our colleagues to begin making this information available in the future in at least a basic form.

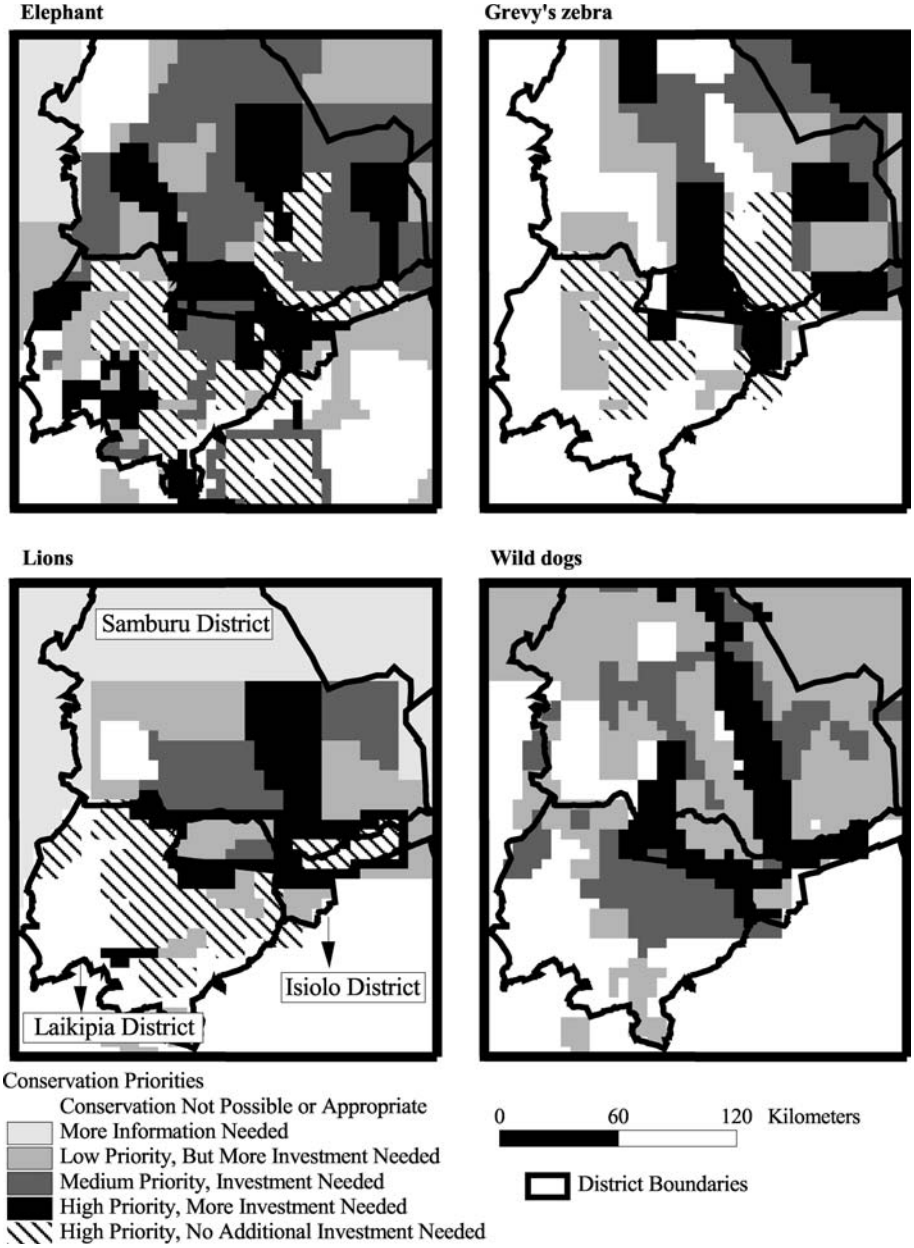
The lack of comparative data from other studies makes it impossible for us at this time to demonstrate whether our approach is truly "lighter" than others in terms of resources. Additionally, future comparisons will not be perfect because costs for similar workshops could vary substantially, depending on whether it was necessary to cover salary for technical leaders and support staff, international travel, food and lodging, and the number of participants. Also, as we note later, there is a great deal of follow-up work to do be done, and the costs of these would add to the total cost of landscape planning.

Given these qualifications, we believe that the time and monetary resources necessary to complete a SCP exercise similar to what we accomplished (i.e., <9 months, ~$20,000–50,000) are within the constraints of most long-term conservation projects operating at landscape scales (i.e., 10,000–100,000 km^2).

A simpler, more intuitive method

Most practitioners are familiar with the "black-box effect"—as more complexity is included in an exercise or model, it becomes less accessible to those people not intimately involved in its creation. By increasing the complexity of SCP, practitioners increase the expertise, time and money needed to complete the exercise. Furthermore, they risk making it too difficult for stakeholders to participate, interpret the results and, consequently, trust and support the conclusions. When multiple stakeholders are involved, it may be necessary to sacrifice some comprehensiveness in the interest of understandability.

The basis of our approach is a simple question: "Over the next few years, where can we have a big conservation impact for relatively low cost" and closely parallels Davis et al.'s (2006) "Utility Maximization Framework". Our method answers this question using expert and stakeholder information, similar to a Delphi approach (Dalkey 1969), and a simple benefit-cost analysis. The cost:benefit layers and the subsequent priority maps are based on five, basic elements: the current distribution of the conservation feature, two layers defining the impacts that conservation could have (preventing future loss/reductions and recovery), a cost layer, and a confidence layer.



While there are many complexities that affect the scoring of each of these five layers, we suggest that these five are widely applicable and, along with quantitative targets, represent the minimum set of knowledge necessary to make decisions about spatial priorities. For example, the Potential for Future Reductions layer is dependent on many factors, including the distribution of future threats (e.g., poaching, land-conversion), the potential impact of those threats on features, and the probability that threats will occur

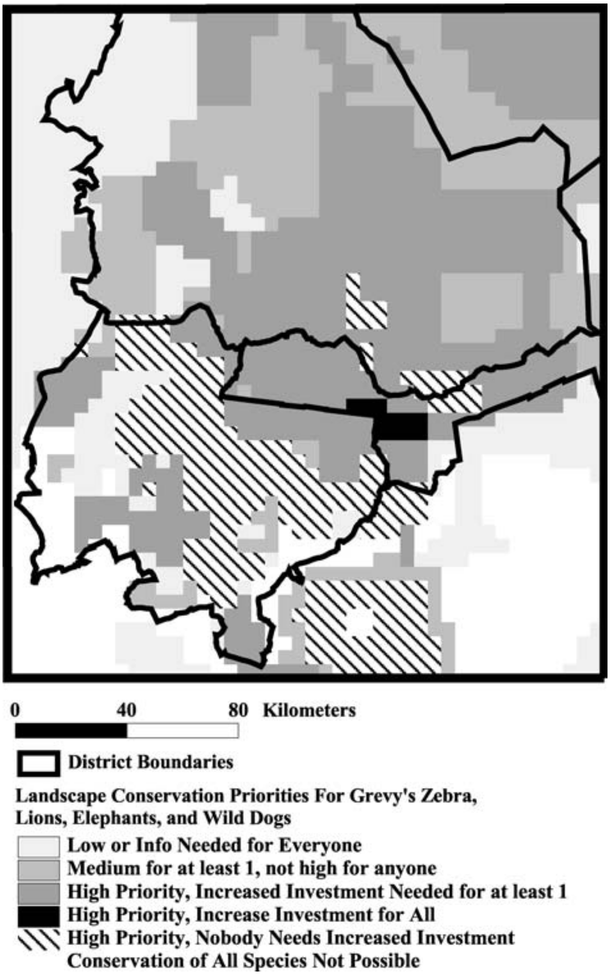


Fig. 5 Conservation Priorities for Ewaso Ngiro, across all four conservation features (elephants, Grevy's zebra, lion, and wild dog)

(Wilson et al. 2005). Our approach asks participants to consider all these complexities to produce one all-inclusive score for potential reductions that conservation could prevent. Our experience suggests that participants are typically willing and able to do so if the exercise is clearly explained.

We avoided using more complex decision support software (e.g., Marxan, C-plan) and selection algorithms, because in the context of Ewaso Ngiro, it was not necessary at this point in time to identify a *complete* network of conservation areas to meet quantitative targets (Ball and Possingham 2000; New South Wales NPWS 2001). Monetary resources needed to secure any complete networks would surely be large, and are clearly not available at this time. A few recent studies (Meir et al. 2004; Turner and Wilcove 2006) have demonstrated that when resources are unavailable to fully implement conservation networks at the time of their creation, these networks often quickly become irrelevant or inefficient for meeting goals, especially in regions where human use of the landscape and land tenure are dynamic (e.g., the Ewaso Ngiro). In such cases, it is probably best simply to secure places where target richness or irreplaceability are highest, and then to adapt to changed conditions when more resources become available. In our setting, it was sufficient to clearly identify, through consensus, those places that do not need additional conservation investment at this time, and those where additional investment is necessary and a high priority.

Incorporating vulnerability, potential recovery, and costs

Many SCP exercises are based solely on the current distribution of conservation features. However, a number of recent studies have emphasized the importance of incorporating the vulnerability of areas to future loss/reductions in conservation features (Noss et al. 2002; Rouget et al. 2003; Turner and Wilcove 2006; Wilson et al. 2005). In a framework which incorporates vulnerability, conservation priorities are judged on potential of conservation actions features (e.g., education, anti-poaching patrols, community-based management) to prevent reductions in the conservation features. Thus, sites with high abundances of conservation features and high vulnerability to future threats receive higher priority, given that all else is equal (e.g., costs).

The flip-side of vulnerability to future reductions is the potential for features to recover/recolonize relative to their current state (Didier et al. in press). For the most part, potential recovery has only been included in SCP projects when restoration or reintroduction is an explicit goal or necessity to reach quantitative targets (Kerley et al. 2003; Schultz and Crone 2003). In many places, recovery of biodiversity is a realistic or even the best option available to conservationists (e.g., Walker et al. 2004), and should be given its due consideration in priority setting exercises. In the Ewaso Ngiro, it is possible to increase populations of all four of our focal species, in particular parts of the landscape, and is in fact necessary for all the species to reach landscape-wide quantitative targets (Table 4). Grevy's zebra is most in need of recovery, as its current population is less than 50% of the target. Recovery can best be realized for this species by securing grassland habitat, safe water, and limiting the numbers of plains zebra (*Equus quagga*). For lions, wild dogs, and elephants, actions that could recover populations include reducing human-wildlife conflict and the resulting killing of animals (elephants and lions in particular) and reducing possibility of disease outbreaks (wild dogs).

Restoration per se (i.e., recovery from zero) to parts of the landscape is not a required action for any species to reach quantitative targets, as targets can potentially be met by growing populations where they already exist. However, restoration is an option, especially for lions and wild dogs in the north (these species could expand their current range by approximately 10% and 30% respectively). Restoration, however, is an expensive option (see cost map in Fig. 2), primarily because there is currently little conservation presence in the north and the region is plagued by security issues, including armed violence. For all four species it is generally more feasible to grow populations where they already exist but are below carrying capacity.

Our approach also explicitly asks stakeholders to incorporate conservation cost into mapping priorities. While practitioners rarely have quantitative measures of conservation cost, they usually have an intuitive sense of where implementation of conservation activities will be difficult or expensive. Though estimating cost by expert opinion may be uncomfortable territory for many scientists, we believe it would be unrealistic to ignore the concept or to oversimplify its estimation (e.g., assume that cost is related only to area or boundary lengths).

Sacrifices of our method

While we believe ours to be a simple method for assessing spatial priorities for conservation at landscape scales, that it is within the resource constraints of many site-based conservation projects, and that it has significantly advanced conservation in the region, our approach necessarily sacrificed in-depth consideration of several SCP components. In the interest of staying within a budget of approximately $40,000, and a time frame of 9 months, we cut corners in four important ways.

First, we based our maps on expert knowledge rather than direct observational data and empirical/statistical mapping methods (e.g., logistic regression). Following in the tradition of Delphi approaches (Dalkey 1969), we relied on experts and a group of participants to synthesize the existing information on the threats to and distribution of their features in an iterative process (from individual to small group to large group). We did not independently assess the quality of the results, although we did ask individual experts and groups to self-evaluate their confidence in the information they provided. It is well understood that models based on expert opinion can suffer from various sources of bias and be less accurate than empirical models (Pearce et al. 2001; Yang et al. 2006). However, empirical models are usually more expensive and time consuming to produce, especially considering the costs of collecting and compiling good observational data. For practitioners, the choice of whether to perform a SCP exercise similar to ours will partly depend on the costs of compiling quality observational data, performing empirical models, and confidence in expert opinions.

Second, our mapping exercise only considered four conservation features. While these coarse-grained features are clearly important for maintaining landscape structure and ecosystem function, workshop participants felt they were not sufficient for a complete conservation umbrella. They identified an additional five features that would need to be conserved to even approximate complete conservation of all the landscape's native biodiversity (Table 3). In addition to conserving all nine identified features, several fine-grained features (e.g., endemic or endangered species) may require very specialized attention (Poiani et al. 2000; Groves 2003).

Third, while we specified quantitative targets, the process of mapping spatial priorities did not incorporate these targets because targets and maps were expressed in different units. Most spatially-explicit priority setting exercises are basically benefit:cost analyses that are designed to identify a near-optimal network of conservation areas to reach a set of quantitative targets for the lowest cost (e.g., Ball and Possingham 2000; Davis et al. 2006). To do so, spatial layers measuring the conservation benefit must be expressed in the same units as the quantitative targets. In our exercise, while our quantitative targets were generally expressed in abundance units (e.g., number of zebras), maps were expressed in relative measures of the importance of a particular planning unit for contributing to a population across the landscape. For example, planning units containing corridors for elephants and watering holes for zebras were scored highly (for prevention) not because they contain many animals relative to other places, but because they are critical resources for animals that may concentrate elsewhere. This disjunct between local abundance in a planning unit and the importance of the unit for supporting a population at the landscape-scale complicates spatial priority setting, and is generally worse for highly mobile species.

The solution to the dilemma may lie in the inclusion of both critical habitat features such as watering holes (with benefit maps and targets expressed in area or occurrence units) and the species (with maps and targets expressed in abundance units) as focal conservation features. However, this will take more time and effort. Alternatively, it is possible, as we've done here, to proceed with initial spatial decisions without constraining the process with quantitative targets, although it will be difficult to judge when a network of conservation areas is sufficient to reach our quantitative targets. Although we did not use quantitative targets in making spatial decisions, they are still critical components of our planning as they provide baselines against which actions can be measured and adapted (Rodrigues and Gaston 2001; Conservation Measures Partnership 2007).

Finally, our method did not assess possible tradeoffs among our biodiversity features or between our features and human land uses. In many cases, biodiversity features compete with each other, and conservation efforts focused on one may negatively affect the other (e.g., Grevy's and plains zebra). The same is true for human development and biodiversity features (predators and livestock). A complete conservation portfolio would need to assess these trade-offs, answering the questions "Can both be met in Ewaso Ngiro?" and, if so "How can we spatially arrange our activities to do so?" Existing software packages such as Marxan (Ball and Possingham 2000), C-plan (New South Wales NPWS 2001), and NatureServe Vista (NatureServe 2006) are designed to help land-use planners incorporate multiple conservation features into planning and assess tradeoffs between competing land-uses in an interactive fashion. To be effective in the Ewaso Ngiro, however, such an effort would require a broader range of stakeholders than we had at our workshop, including more people representing development interests in the region (e.g., flower farmers, ranchers, community leaders). Additionally, it would probably require an equally rigorous and spatially explicit assessment of development goals and priorities (e.g., how many livestock are in various areas? How many do we want? What areas to we want to develop?). We do not feel that such an effort was within our budget and time constraints, although this is a clear next step for land-use planning in the Ewaso Ngiro.

Follow-up and progress since the workshop

While much was accomplished at the SCP workshop, participants unanimously agreed that more work was needed, especially in terms of (1) implementing actions in priority places, (2) improving communication and data sharing among partners in the landscape, and (3) completing work on SCP, including work on the four "sacrifices" mentioned above.

Implementation of conservation actions has progressed in two ways. First, the workshop has directly resulted in several actions to prevent the building of livestock holding grounds and a slaughter house in the "Isiolo corridor" (the area in Fig. 5 considered "high priority, increased investment needed" for all four features). The Northern Rangelands Trust has initiated a new project in the area and Save the Elephants has helped train rangers. Also, in mid-2006 and as a result of the workshop, participating partners formed the Ewaso Conservation Group (ECG) partly to coordinate landscape-scale priority actions. One of their first actions was to produce a position paper and policy brief on the holding grounds and present these to local politicians and community members. As of now, plans to develop the holding grounds and slaughter house are not moving forward.

Implementation has also occurred in a less direct fashion, as other independent processes and organizations have relied on workshop products. For example, since the workshop, the Kenyan Wildlife Service (KWS) has developed a management plan for Grevy's zebra that was informed by SCP exercise. KWS has also formed a technical committee to more closely examine the movements of Grevy's across the landscape, so that critical habitats and corridors can be more precisely defined. Although it is difficult to quantify the exact role that the SCP exercise had in these activities, both the mapping products and quantitative objectives compiled during the workshop were consulted. The synthetic activities of SCP exercise, which was attended by all the technical committee members, brought all members up to speed regarding the conservation status of zebra and other species, and helped create consensus on important steps for management and research.

In addition to encouraging implementation, the workshop has increased communication, data sharing, and collaboration among conservation partners. Since 2006, the ECG group has met several times, and plans to continue doing so on at least an annual basis. The group also hired a coordinator, whose job it is to organize meetings for partners to present their work and coordinate actions, to organize a shared database of spatial information for the landscape, and to create a web-site for data sharing. Also, Save the Elephants, the Grevy's zebra technical committee, and ECG partners now share experience and technology related to remote tracking (GPS) of animals, and have created a common database of this information.

Finally, while there has been some progress in terms of implementing actions and data sharing, little progress has been made in term of continuing and completing the formal planning steps of the SCP (e.g., working on additional focal biodiversity features). While there appears to be interest in continuing the SCP efforts, lack of dedicated funding and a dedicated facilitator (a person or organization) to lead the effort appear to be the greatest obstacles. Both the funding and facilitation of the 2006 workshop were provided through a conservation organization that does not have a long-term presence in the region, and has not yet been able to dedicate additional resources to the effort. The Ewaso Conservation Group and its coordinator are excellent candidates for leading additional planning efforts. However, additional and sustainable funding is certainly necessary to ensure that landscape planning continues, although we do not think that future investments will need to be as large as those dedicated to the original workshop.

Although incomplete, our exercise appears to have been "complete enough" that participants felt confident in implementing at least some actions. Lack of further implementation can probably best be attributed to lack of funding than lack of enthusiasm in the planning process or products, although that is only our opinion. Clearly, any actions based on an incomplete process risk being wrong, or at least sub-optimal. However, this is always the case with conservation planning, either because the process is incomplete or because information on which it is based is imperfect. We strongly suspect that actions aimed at stopping the livestock holding grounds would remain a high priority even with a more complete planning process, but we cannot be positive of this. As with nearly all other examples of SCP, our process should be seen as a continuing and adaptive one, that will improve as more time and resources are dedicated to it and better information becomes available.

Conclusion

A great deal of research over the last decade has been dedicated to articulating the critical steps of SCP and exploring its complexities. Researchers have succeeded in creating a versatile and complete tool, though it can be unwieldy in terms of resources and expertise needed to use it. We suggest that what is now needed for improved conservation on the ground are pared-down tools suitable for those practitioners on restricted budgets, who are novices and are exploring the utility of SCP for the first time, or who need to sell the approach to non-scientist stakeholders. These tools should produce products that advance conservation and SCP in short time frames and are intuitively understandable to scientists and non-scientists alike. Studies should document what steps of SCP have been emphasized and which have not; and, most importantly, report project costs so that practitioners can judge whether the methods are within their budgetary constraints.

Acknowledgments The authors thank E. McBean for her grateful financial support of this project. We also thank all those who contributed time and information to the workshop and its results, including Shivani Bhalla, Geoffrey Chege, Ian Craig, Richard Hatfield, Onesmas Kahindi, Fred Kihara, Dominic Kilonzo, Delphine King, Juliet King, Anthony Leaduma, Moses Lenairoshi, Philip Lenaiyasa, Fabian Lolosoli, Belinda Low, Jonathan Moss, Philip Muruthi, Josephat Musyima, James Munyugi, Wycliffe Mutero, Kierna Mwandia, Chris Odhiambo, Nick Oguge, David Parkinson, Leslie Scott, Chris Thouless, Fritz Vollrath, Stuart Williams, and Phillip Winter. Finally, for logistical support, we thank K. Outram and the staff from Mpala Research Station; J. Deutsch, M. Wrobel and the staff from the WCS Africa Program, and D. Kelly.

References

Ball I, Possingham H (2000) Marxan: marine reserve design using spatially explicit annealing, a manual. Available from http://www.ecology.uq.edu.au/index.html?page=27710. Accessed Sep 2006

Bottrill M, Didier K, Baumgartner J, Boyd C, Loucks C, Oglethorpe J, Wilkie D, Williams D (2006) Selecting conservation targets for landscape-scale priority setting: a comparative assessment of selection processes used by five conservation NGOs for a landscape in Samburu, Kenya. World Wildlife Fund and the US Agency of International Development, Washington

Cabeza M, Moilanen A (2006) Replacement cost: a practical measure of site value for cost-effective reserve planning. Biol Conserv 3:336–342. doi:10.1016/j.biocon.2006.04.025

Conservation Measures Partnership (2007) Open standards for the practice of conservation. Available from: http://conservationmeasures.org/CMP/Site_Docs/CMP_Open_Standards_Version_2.0.pdf. Accessed Oct 2008

Coppolillo P, Gomez H, Maisels F, Wallace R (2004) Selection criteria for suites of landscape species as a basis for site-based conservation. Biol Conserv 115:419–430. doi:10.1016/S0006-3207(03)00159-9

Cowling RM, Pressey RL (2003) Introduction to systematic conservation planning in the Cape Floristic Region. Biol Conserv 112:1–13. doi:10.1016/S0006-3207(02)00418-4

Dalkey NC (1969) The Delphi method: an experimental study of group opinion. Rand Corporation, Santa Monica

Davis FW, Costello C, Stoms D (2006) Efficient conservation in a utility-maximization framework. Ecol Soc 11:33. Available from http://www.ecologyandsociety.org/vol11/iss1/art33/. Accessed Oct 2006

Didier KA, Glennon MJ, Novaro A, Sanderson EW, Strindberg S, Walker S, DiMartino S The landscape species approach: spatially-explicit conservation planning applied in the Adirondack (USA) and San Guillermo-Laguna Brava (Argentina) Landscapes. Oryx (in press)

Dudley N, Parrish J (2006) Closing the gap: creating ecologically representative protected area systems. Secretariat of the convention on biological diversity, technical series 24. Montreal, Canada, 108 pp

Frazee SR, Cowling RM, Pressey RL, Turpie JK, Lindenberg N (2003) Estimating the costs of conserving a biodiversity hotspot: a case-study of the Cape Floristc Region, South Africa. Biol Conserv 112:275–290. doi:10.1016/S0006-3207(02)00400-7

Gaston KJ, Rodrigues ASL (2003) Reserve selection in regions with poor biological data. Conserv Biol 188–195. doi:10.1046/j.1523-1739.2003.01268.x

Groves CR (2003) Drafting a conservation blueprint: a practitioner's guide to planning for biodiversity. Island Press, Washington

Guisan A, Lehmann A, Ferrier S, Austin M, Overton JMC, Aspinall R, Hastie T (2006) Making better biogeographical prediction of species' distributions. J Appl Ecol 43:386–392. doi:10.1111/j.1365-2664.2006.01164.x

Hartley S, Harris R, Lester PJ (2006) Quantifying uncertainty in the potential distribution of an invasive species: climate and the Argentine ant. Ecol Lett 9:1068–1079. doi:10.1111/j.1461-0248.2006.00954.x

Jennings MD (2000) Gap analysis: concepts, methods, and recent results. Landsc Ecol 15:5–20. doi:10.1023/A:1008184408300

Johnson CJ, Gillingham MP (2004) Mapping uncertainty: sensitivity of wildlife habitat ratings to expert opinion. J Appl Ecol 41:1032–1041. doi:10.1111/j.0021-8901.2004.00975.x

Kerley GIH, Pressey RL, Cowling RM, Boshoff AF, Sims-Castely R (2003) Options for the conservation of large and medium-sized mammals in the Cape Floristic Region hotspot, South Africa. Biol Conserv 112:169–190. doi:10.1016/S0006-3207(02)00426-3

Margules CR, Pressey RL (2000) Systematic conservation planning. Nature 405:243–253. doi:10.1038/35012251

Meir E, Andelman S, Possingham HP (2004) Does conservation planning matter in a dynamic and uncertain world? Ecol Lett 7:615–622. doi:10.1111/j.1461-0248.2004.00624.x

Midgley G, Hannah L, Millar D, Thuiller W, Booth A (2003) Developing regional and species-level assessment of climate change impacts on biodiversity: the Cape Floristic Region. Biol Conserv 112:87–97. doi:10.1016/S0006-3207(02)00414-7

Moffett A, Sarkar S (2006) Incorporating multiple criteria into the design of conservation area networks: a minireview with recommendations. Divers Distrib 12:125–137. doi:10.1111/j.1366-9516.2005.00202.x

Moore J, Balmford A, Allnutt T, Burgess N (2004) Integrating costs in conservation planning across Africa. Biol Conserv 117:343–350. doi:10.1016/j.biocon.2003.12.013

NatureServe (2006) NatureServe Vista, online help documentation. NatureServe, Arlington

Noss RF, Carroll C, Vance-Borland K, Wuerthner G (2002) A multicriteria assessment of the irreplaceability and vulnerability of sites in the greater Yellowstone ecosystem. Conserv Biol 16:895–908. doi:10.1046/j.1523-1739.2002.01405.x

NPWS New South Wales (National Parks, Wildlife Service) (2001) C-Plan, conservation planning software, user's manual. NSW NPWS, Armidale

Olson DM, Dinerstein E, Wikramanayake ED, Burgess ND, Powell GVN, Underwood EC, D'amico JA, Itoua I, Strand HE, Morrison JC, Loucks CJ, Allnutt TF, Ricketts TH, Kura Y, Lamoreux JF, Wettengel WW, Hedao P, Kassem KR (2001) Terrestrial ecoregions of the world: a new map of life on earth. Bioscience 51:933–938. doi:10.1641/0006-3568(2001)051[0933:TEOTWA]2.0.CO;2

Pearce JL, Cherry K, Drielsma M, Ferrier S, Whish G (2001) Incorporating expert opinion and fine-scale vegetation mapping into statistical models of faunal distribution. J Appl Ecol 38:412–424. doi:10.1046/j.1365-2664.2001.00608.x

Poiani KA, Richter BD, Anderson MG, Richter HE (2000) Biodiversity conservation at multiple scales: functional sites, landscapes, and networks. Bioscience 50:133–156. doi:10.1641/0006-3568(2000)050[0133:BCAMSF]2.3.CO;2

Pressey RL, Cowling RM, Rouget M (2003) Formulating conservation targets for biodiversity pattern and process in the Cape Floristic Region, South Africa. Biol Conserv 112:99–127. doi:10.1016/S0006-3207(02)00424-X

Rodrigues ASL, Gaston KJ (2001) How large do reserve networks need to be? Ecol Lett 4:602–609. doi:10.1046/j.1461-0248.2001.00275.x

Rondinini C, Wilson KA, Boitani L, Grantham H, Possingham HP (2006) Tradeoffs of different types of species occurrence data for use in systematic conservation planning. Ecol Lett 9:1136–1145. doi:10.1111/j.1461-0248.2006.00970.x

Rouget M, Richardson DM, Cowling RM, Lloyd JW, Lombard AT (2003) Current patterns of habitat transformation and future threats to biodiversity in terrestrial ecosystems of the Cape Floristic Region, South Africa. Biol Conserv 112:63–85. doi:10.1016/S0006-3207(02)00395-6

Sanderson E (2006) How many animals do we want to save? The many ways of setting population target levels for conservation. Bioscience 56:911–922. doi:10.1641/0006-3568(2006)56[911:HMADWW]2.0.CO;2

Schultz CB, Crone EE (2003) Patch size and connectivity thresholds for butterfly habitat restoration. Conserv Biol 19:887–896. doi:10.1111/j.1523-1739.2005.00462.x

Svancara LK, Brannon R, Scott JM, Groves CR, Noss RF, Pressey RL (2005) Policy-driven versus evidence-based conservation: a review of political targets and biological needs. Bioscience 55:989–995. doi:10.1641/0006-3568(2005)055[0989:PVECAR]2.0.CO;2

Tear TH, Kareiva P, Angermeier PL, Comer P, Czech B, Kautz R, Landon L, Mehlman D, Murphy K, Ruckelshaus M, Scott JM, Wilhere G (2005) How much is enough? The recurrent problem of setting measurable objectives in conservation. Bioscience 55:835–849. doi:10.1641/0006-3568(2005)055[0835:HMIETR]2.0.CO;2

Tole L (2005) Choosing reserve sites probabilistically: a Columbian Amazon case study. Ecol Modell 194:344–356. doi:10.1016/j.ecolmodel.2005.10.027

Turner WR, Wilcove DS (2006) Adaptive decision rules for the acquisition of nature reserves. Conserv Biol 20:527–537. doi:10.1111/j.1523-1739.2006.00333.x

Walker S, Novaro A, Funes M, Baldi R, Chehébar C, Ramilo E, Ayesa J, Bran D, Vila A, Bonino N (2004) Rewilding Patagonia. Wild Earth, Fall-Winter 2004–2005:36–41

Wilson K, Pressey RL, Newton A, Burgman M, Possingham H, Weston C (2005) Measuring and incorporating vulnerability into conservation planning. Environ Manage 35:527–543. doi:10.1007/s00267-004-0095-9

Yang X, Skidmore AK, Melick DR, Zhou Z, Xu J (2006) Mapping non-wood forest product (matsutake mushrooms) using logistic regression and a GIS expert system. Ecol Modell 198:208–218

Younge A, Fowkes S (2003) The cape action plan for the environment: overview of an ecoregional planning process. Biol Conserv 112:15–28. doi:10.1016/S0006-3207(02)00393-2