Landscape-Scale Conservation Planning of the Ewaso Nyiro: A Model for Land Use Planning in Kenya?

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ABSTRACT. The unique wildlife of the Ewaso Nyiro and valuable services that the ecosystem provides for humans (e.g., clean water and productive grasslands) cannot be conserved by working solely on traditional conservation strongholds such as the national reserves and private ranches of central Laikipia. To reach objectives for conserving wildlife, stakeholders must work to preserve wildlife habitat and corridors in the surrounding human-dominated landscape—a daunting task considering the complexity of working at large spatial scales (e.g., many landowners, competing land uses) and limited conservation resources available. Systematic, landscape-scale conservation planning helps stakeholders set meaningful and transparent objectives, identify where to work to meet those objectives, and prioritize areas for immediate investment. We describe results and implications of an initial landscape-scale planning exercise for the Ewaso Nyiro that culminated in a workshop in January 2006. Forty participants selected nine focal features, set quantitative objectives for four of them (elephants, Grevy's zebra, lions, wild dogs), and set spatial conservation priorities for the entire landscape on the basis of complementary needs of critical species. The modest objectives for these species (e.g., maintaining a population of 300 wild dogs) cannot be met by conservation focused solely on traditional strongholds. The exercise indicated that nearly 84% of the landscape needs conservation investment, and it identified three near-term priorities: (1) maintain current investments in conservation strongholds, (2) increase investment to secure the narrow corridor between Samburu and Laikipia Districts, and (3) increase investment to secure portions of Samburu District, including the Matthews Range. The results we describe represent the initiation of a land use planning process that, if continued, can help meet both biodiversity and livelihood development objectives. We recommend this process be carried forward in the Ewaso Nyiro and then in similar ecosystems in Kenya and eastern Africa.

INTRODUCTION

From previous chapters in this book, it seems clear that in the Ewaso Nyiro ecosystem, conservation goals cannot be achieved by focusing solely on the few parcels of land that are currently under conservation-friendly land uses and management. To improve chances of conserving wildlife in the Ewaso ecosystem and more generally throughout much of Kenya, we believe that stakeholders need to adopt a systematic approach to prioritizing conservation investments at the landscape level.

A *landscape-scale* framework for planning conservation is needed for two main reasons. First, many valued species cannot be effectively conserved on the few increasingly isolated patches of lands on which biodiversity conservation is the primary land use objective (Gardner et al., 2007). This is particularly true for species that require extremely large areas and access to many different habitats to persist, i.e., many of the large herbivores and carnivores common in Kenya. Landscape-scale approaches to conservation aim to explicitly address the needs of these area-demanding species and to ensure their long-term persistence (Nicholson et al., 2006; Rouget et al., 2006; Salomon et al., 2006).

A second reason that a landscape-scale framework is needed is that many critical ecological processes (e.g., migration and gene flow) and ecosystem services (e.g., production of clean water) also cannot be effectively conserved by working solely with landowners whose property covers only a small percentage of the landscape (Poiani et al., 2000; Chan et al., 2006; Salomon et al., 2006; Rouget et al., 2006). These processes and services are often critical for both biodiversity elements (species and ecological communities) and people. Landscape-scale planning approaches help to determine the spatial scope of activities that are needed both to meet the needs of species and to maintain ecological processes and ecosystem services important for people.

A systematic approach to planning (Margules and Pressey, 2000; Groves et al., 2002), with clearly defined steps and procedures, is also useful because it instills transparency into the process. This is particularly valuable in places where governance is weak, contested, incomplete, or has been abdicated by the state. The systematic approach aims to define a clear and transparent process for arriving at conservation priorities—a process that allows for broad stakeholder participation. Systematic conservation planning also immerses people, often for the first time, in a process focused on biodiversity rather than economic development. It also allows a wide range of stakeholders to bring to bear their distinct and often underappreciated knowledge of the ecology of a landscape. Most importantly, the systematic approach tries to instill transparent, objective, and effective criteria into a process for prioritizing conservation actions and areas (Margules and Pressey, 2000). It is almost always the case in conservation that we cannot conserve, in the immediate sense, everything we need to, and prioritization is needed. Objective and rigorous criteria help ensure that our resources are directed most efficiently.

Systematic, landscape-scale conservation planning now has a history of nearly two decades. It began when conservationists first recognized that existing protected areas were necessary but not sufficient to preserve biodiversity effectively (Rodrigues and Gaston, 2001; Brooks et al., 2006). Many hundreds of projects at various spatial scales (e.g., Younge and Fowkes, 2003) around the world now use systematic procedures for conservation planning (Sarkar et al., 2006). More recently, several international conservation organizations have created planning approaches designed particularly for the landscape scale and firmly rooted in a systematic framework (Sanderson et al., 2002; Conservation International, 2004; Henson et al., 2009; Pressey and Bottrill, 2009).

We present here the results and implications of a systematic, landscape-scale conservation planning exercise for the Ewaso ecosystem. The exercise was conducted over a six-month period that ended in a five-day workshop in 2005–2006. The approach we initiated is novel in that it was designed to skirt some of the weaknesses of existing approaches, which often demand more time and resources than are available. The methods and its novelties are described in detail in Didier et al. (2009) and in the workshop proceedings (King and Malleret-King, 2006) and are presented here only briefly.

Our objectives are to first present the results of the exercise for a larger audience not present at the workshop, including local stakeholders from the Ewaso region and the wider conservation and development community in Kenya. Second, we discuss briefly the implications of the exercise for the particular species considered and for conservation in the Ewaso Nyiro in general. Third, we discuss what we could not achieve during our time- and resource-limited project and how we think the process should be carried forward in the future.

METHODS

The group proceeded through the basic steps of systematic conservation planning as outlined in Box 1 (full

description of methods can be found in King and Malleret-King, 2006, and Didier et al., 2009). Nine focal biodiversity features (in this case all "features" were species) were identified whose conservation requirements not only were considered to be complementary to each other but also, when added together, would, if met, cover the conservation needs of most other features in the landscape. We did not complete these planning steps exhaustively for all species, rather, for a subset of four species (elephant, Grevy's zebra, lion, and wild dog), aiming to produce useful products for making near-term decisions and to create a framework for proceeding with conservation priority setting in future. We proceeded in two phases. First, a six-month preparation phase by a small organizational committee and a group of ecologists who were each familiar with the landscape and particular biodiversity features produced draft plans for the four species. We completed all the planning steps for four of nine focal species, although conservation objectives (step 3; see Box 1) were considered preliminary and were not explicitly incorporated into the subsequent steps. The exercise was largely centered on the creation of five component maps for each species that were used to guide decisions about which areas were a priority for immediate conservation investment. For these maps, each 5 × 5 km grid square was classified as to (1) its current importance for supporting the population of the focal species, (2) the potential for recovering the population of the species, (3) the potential for future decreases in the population as a result of human activities, (4) the cost of conservation action, and (5) confidence in the information provided. The maps were then used as guides to make species-specific and cross-species maps of conservation priorities.

BOX 1. The steps of systematic, landscape-scale conservation planning.

The steps to systematic conservation planning at any scale (global, national, etc.) are fairly similar, are well accepted among organizations involved in conservation, and have been thoroughly described elsewhere. Our description is adapted from those of Margules and Pressey (2000), Groves et al. (2002), Groves (2003), and Sarkar et al. (2006). Further detail is also provided in the proceedings of our workshop (King and Malleret-King, 2006) and by Didier et al. (2009).

1. Define the context, compile critical information, and set overarching goals/vision. Basic information on the extent of the landscape, ecology, human influences/threats in the landscape, and stakeholders need to be summarized, and broad goals need to be set. Spatial information should be compiled on the current biodiversity value of areas throughout the planning region (i.e., presence or abundance of focal conservation targets), the vulnerability of biodiversity to future loss, the potential for recovery of biodiversity value (if locally relevant), and costs of conservation.

2. Define a set of focal biodiversity features. Because it nearly impossible to plan conservation around all the possible elements of biodiversity (species, habitats, and ecosystem functions and services), it is necessary to select a suite of focal features on which to plan conservation efforts. The number and type will depend on the context (e.g., availability of data, complexity of environment).

3. Set quantitative objectives for each focal conservation feature. It is important to set quantitative objectives for conservation feature (i.e., how much do you want?), so that the spatial extent of conservation actions necessary to meet these objectives can be considered and progress toward the objectives can be measured.

4. Assess the effectiveness of existing conservation activities/areas. This step should first involve assessing whether current activities and the extent of areas where activities are occurring are sufficient for meeting quantitative objectives for all focal features. If targets are currently at quantitative objectives across the landscape, are current activities and areas sufficient to maintain features at or above quantitative objectives (i.e., prevent future losses)? If features are currently below objectives, are current activities and areas sufficient to increase focal features to quantitative objectives?

5. Summarize the benefits and costs of continuing current activities/areas and starting new ones in order to meet or maintain quantitative objectives of conservation features. This step involves creating summary maps and indices highlighting where investment may be wise. It may include benefit:cost ratios, irreplaceability scores, or other results of reserve design algorithms (e.g., from Marxan, C-plan, etc.).

6. Negotiate a map of conservation priorities. Physically score planning units in terms of priority for investment, considering all information in previous maps, possible mistakes, and all relevant information not in the maps (e.g., political constraints, opportunities, etc.). May also include evaluating trade-offs, both among conservation features and between biodiversity features and human development objectives (e.g., increasing livestock numbers). Decision-support software can help (Marxan, C-plan, Vista).

RESULTS

Vision for Biodiversity Conservation

Workshop participants agreed on a simple, consensus vision statement for biodiversity conservation in the region: "To conserve the native biodiversity and integrity of the Ewaso Nyiro landscape."

Focal Biodiversity Features

Participants discussed and then selected a subset of the biodiversity within the Ewaso landscape that would help focus conservation planning efforts. The focal suite comprised nine biodiversity features (Table 1). Elephants, Grevy's zebra, lions, wild dogs, and reticulated giraffe (*Giraffa camelopardalis*) were selected because they represented major habitats or threats to biodiversity (see King and Malleret-King, 2006). Jackson's hartebeest (*Alcelaphus buselaphus*) was added because it was viewed by participants as being unique to the Ewaso Nyiro and participants felt its conservation could not be guaranteed by focusing attention on the other features. The suite also included what participants felt were the two most important vegetation communities: the acacia-grassland mosaic, which covers most of the landscape, and dry upland/montane forests (Matthews Range, Kirisia Hills, and Mukogodo Forest in particular). Finally, the suite of focal features included one ecological system/service, the hydrological system, because maintaining water flow and water quality in the landscape was seen as central to both conservation of biodiversity and livelihoods. As a whole, participants agreed that the suite of features would act as a good surrogate for protecting the other native biodiversity of the region and that if these features were successfully conserved, most if not all of the other native biodiversity in the landscape would also be conserved. It was agreed that the steps of conservation planning would include only four species because of available time and resources.

Quantitative Objectives for Biodiversity Features

Workshop participants produced preliminary estimates of (1) the current population size across the landscape for each of the four species, (2) a range around that estimate, and (3) a preliminary conservation objective (Table 1). Estimates represent "best information" and were based on consensus among a subset of participants working on each particular species. In some cases, estimates were based partially on empirical data collected from parts of the landscape and extrapolated to remaining areas for which empirical data did not exist. Quantitative objectives for all four species represented an increase from the current population estimate, although the objective for Grevy's zebra represented a nearly 165% increase, whereas for the three other species the objectives represented only 10%–25% increases. Although the objective for elephants represented an overall increase in the population, participants produced a more specific objective to

TABLE 1. The suite of focal biodiversity features selected by participants at the Ewaso Nyiro Landscape Conservation Planning Workshop (January 2006) and quantitative conservation objectives for these features. 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 to be considered successful. Information was not compiled during this exercise for the following features: Jackson's hartebeest (*Alcelaphus buselaphus*), reticulated giraffe (*Giraffa camelopardalis reticulate*), acacia-grassland mosaic, dry upland/montane forest, and hydrological system.

Focal biodiversity feature	Estimate of current abundance (January 2006)	Range of estimated abundance	Quantitative conservation objective [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]

[a] To reach and maintain the amounts below 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 Mount 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/yr.
[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.

reduce populations in Laikipia District while raising them in Samburu District.

Component Maps

Participants completed, by consensus, a set of five maps for each of the four focal species (Figures 1–3). The maps were then used as guides for setting conservation priorities. Some comparative summaries of these maps are provided in Table 2, and a description of the maps for each species is provided below.

Elephants

Of all the focal species selected, elephants are considered the most resilient to many of the threats facing biodiversity, primarily because of their relatively large population in the region, high level of protection, and ecological adaptability. Workshop participants estimated that there were approximately 7,000–9,000 elephants in the landscape, between 5,000 and 6,000 in Samburu and Laikipia and possibly 2,000 in Mount Kenya, although no firm information exists for Mount Kenya. The elephant population appears to be increasing. Elephants currently use approximately 88% of the landscape (based on the current importance map in Figure 1). They are particularly abundant in and around the commercial ranches of Laikipia, Mount Kenya, and parts of Samburu, particularly in the Matthews Range, Kirisia Forest, and the national reserves. Key corridors were highlighted as being particularly important habitat features for maintaining connectivity for the elephant population across the landscape (Figure 4).

If conservation investment is not continued and in some cases increased, there is a high potential for reductions in the elephant population, particularly in known poaching hot spots that currently support high abundances of elephants (e.g., Kirisia Forest, east of Matthews Ranges, Mukogodo Forest, and the Laikipia Nature Conservancy). Failure to continue conservation investment in these areas would likely lead to increased poaching. Potential reductions are also high in the national reserves and along the Ewaso Nyiro River. The potential for future reductions in the population is generally lower in the private ranches in Laikipia, where conservation is more established, and higher in Samburu, where conservation is more tenuous.

It is also possible to recover populations in much of the landscape through conservation investment, although there is little potential for range expansion (<1% of the planning units where recovery could occur are currently unused). Potential for recovery is particularly high in much of Samburu, especially in the north, if security is improved. Recovery potential is generally lower in the national reserves, southern Samburu along the Ewaso Nyiro River, and in much of Laikipia, where elephant numbers are currently near ecological, or at least social, carrying capacity. Recovery is not possible in approximately 25% of the elephants' current range. There is also no potential for recovery in the agricultural areas of southern Laikipia and Meru Districts.

Cost of elephant conservation is higher in the southern part of their range than in the north. This is primarily because elephant conservation in the south involves securing land that is more arable and therefore more valuable than land in the north. In addition, elephant conservation in southern Laikipia requires the mitigation of human-elephant conflict, particularly crop raiding, which could involve the construction of electrified elephant-proof fences. Cost for conservation in the Kirisia Forest is considered higher than elsewhere in Samburu since currently there is little conservation investment in this area and threats are high. Conservation for elephants in most of Samburu would involve improving security, which can be done for a relatively small investment in terms of cost per unit area, and would have an impact over a large area.

For elephants, participants were fairly or highly confident in the information they provided for nearly the entire landscape, except for in the Mount Kenya region and the northwestern and northeastern corners of the landscape (Figure 3).

Grevy's Zebra

Grevy's zebra currently use about 48% of the landscape (calculated at 5 × 5 km resolution) and number around 1,700 animals. Central Laikipia, the Laisamis area in the northeast of the landscape, Wamba to the west of the Matthews Ranges, Lewa, and the national reserves currently support relatively high abundances of Grevy's zebra. Besides maintaining high abundances, certain areas are important because they contain water holes or are grazing areas, nursery areas, or corridors. Laikipia is the southern edge of the species range; the species only recently moved into this area and Lewa (since the early 1970s), and these areas are now critical for the species. Much of the information on Grevy's zebra is based on radio-tracking data, data from community scouts, and aerial surveys.

There is a high potential for future reductions in the population of Grevy's zebra across much of their current range if investment in conservation is not continued.

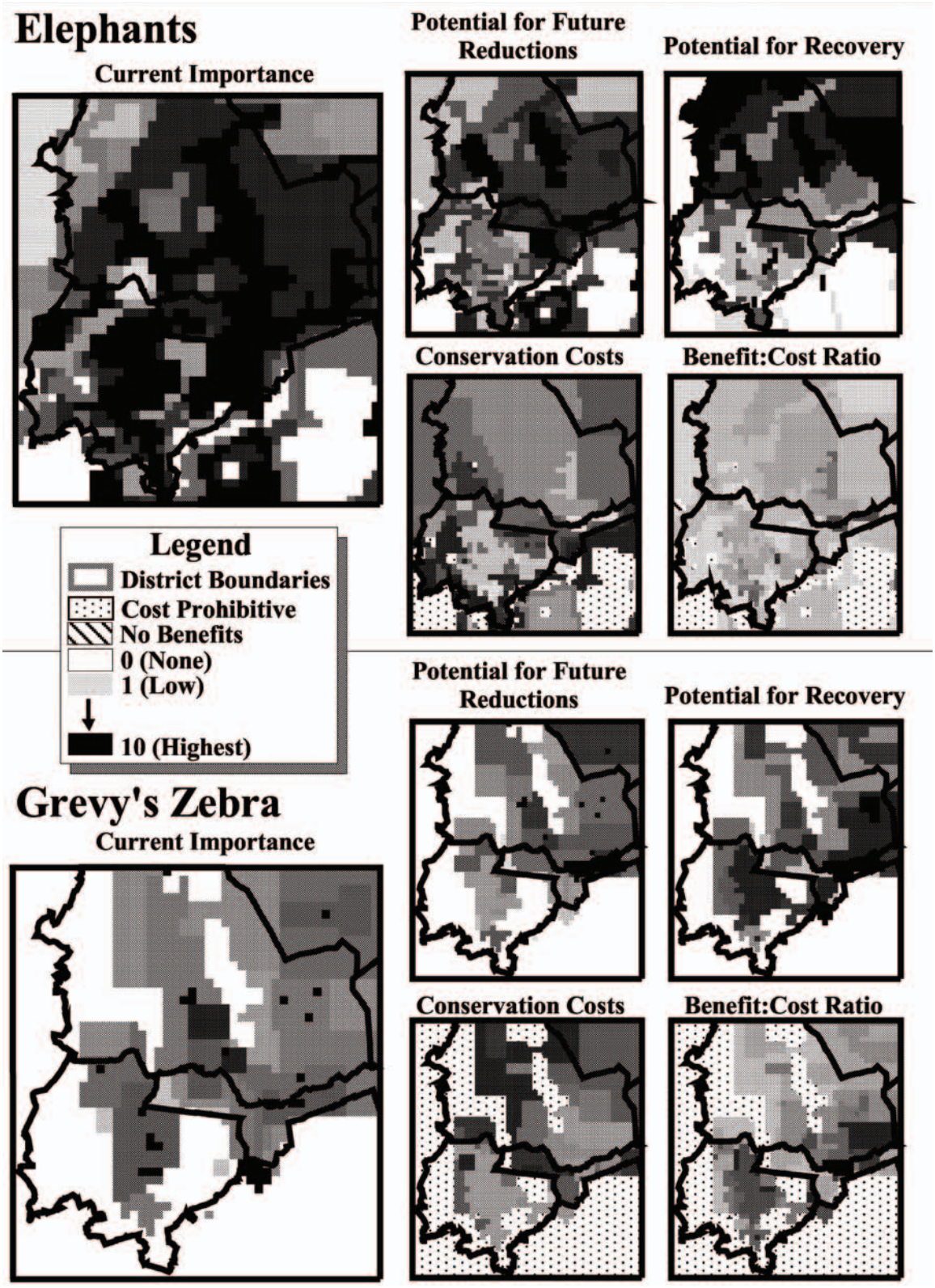

FIGURE 1. Component maps for elephants and Grevy's zebra. The maps were produced by participants at the Ewaso Landscape Planning Workshop (January 2006) and were used to help set conservation priorities.

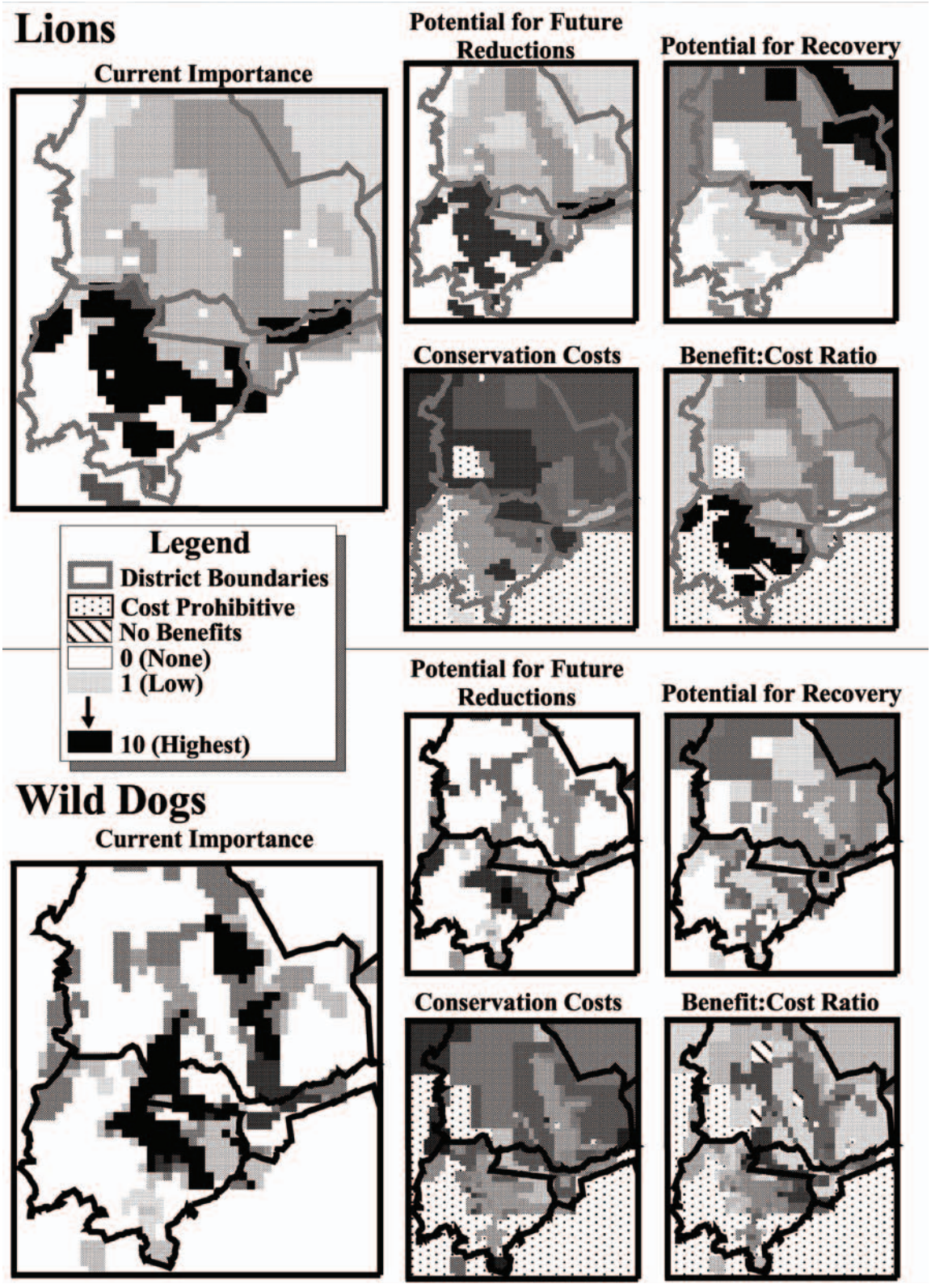

FIGURE 2. Component maps for lions and wild dogs. The maps were produced by participants at the Ewaso Landscape Planning Workshop (January 2006) and were used to help set conservation priorities.

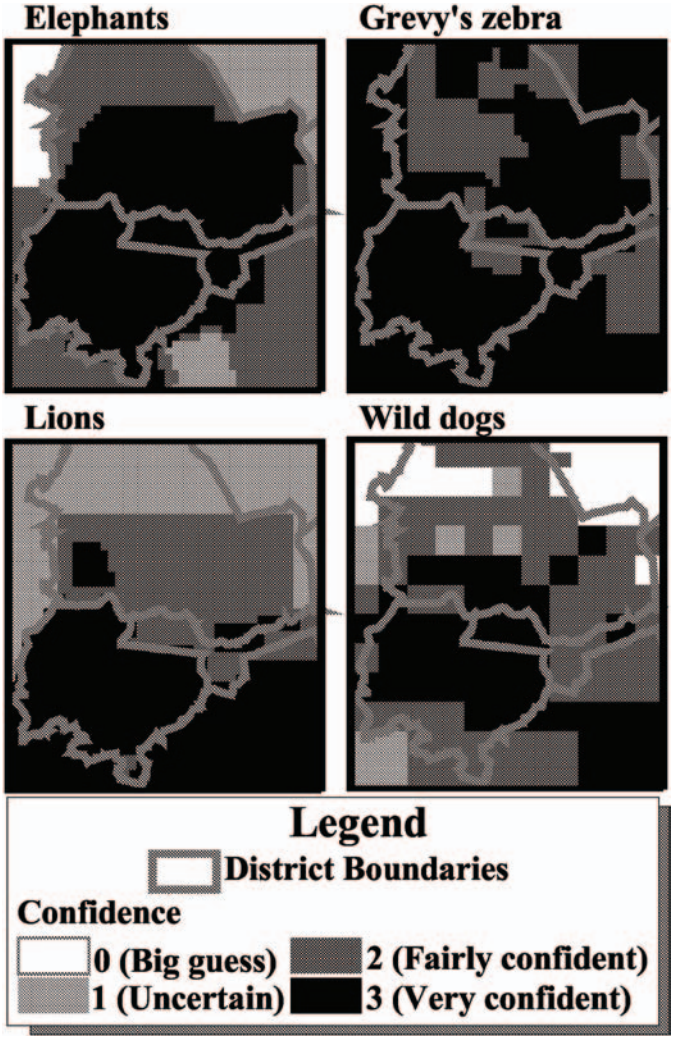

FIGURE 3. Confidence maps for the spatial data (component maps in Figures 1 and 2) for elephants, Grevy's zebra, lions, and wild dogs. The maps were produced by participants at the Ewaso Landscape Planning Workshop (January 2006).

TABLE 2. Summary of component maps for each of four biodiversity features (Figures 1 and 2). Maps were produced by participants in the Ewaso Nyiro Landscape Conservation Planning Workshop (January 2006) and were the basis for a conservation planning exercise.

	Planning units (%)		Current distribution (%)	
Focal biodiversity feature	Currently used	Potentially used[a]	Recovery not possible[b]	Future losses possible[c]
African elephant	87.6	87.8	19.6	97.7
Grevy's zebra	47.4	49.7	2.3	99.5
Lion	60.3	71.0	6.3	99.9
African wild dog	28.7	61.9	1.6	99.3

[a] If new conservation actions were taken or current ones continued.
[b] In some proportion of current range, recovery is not possible because the population is at carrying capacity.
[c] If current conservation actions were abandoned and no new ones begun.

Although the potential for reductions on the commercial ranches of Laikipia is low because landowners generally maintain wildlife-friendly land management practices, it is relatively high in community areas of Laikipia because of competition with livestock. There is high potential for loss in the national reserves, if they lose their integrity through lack of conservation investment, at key hot spots (e.g., water points), and in areas of Wamba, West Gate, and Laisamis.

It is possible to increase populations of Grevy's zebra across nearly all of its current range as all existing subpopulations are below carrying capacity. There is also some

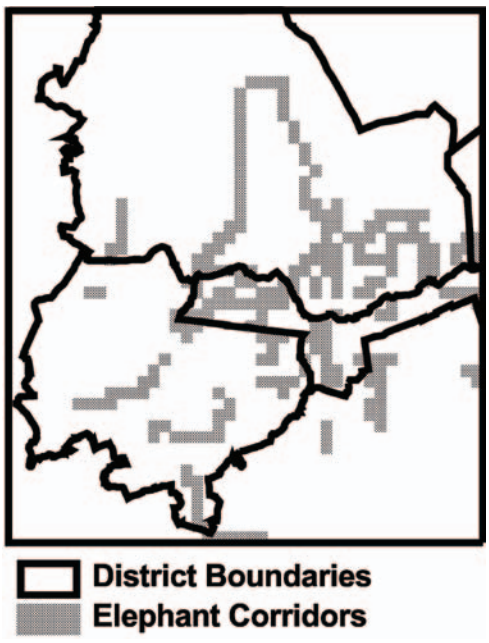

FIGURE 4. Elephant corridors. The map was produced by participants at the Ewaso Landscape Planning Workshop (January 2006) and was used to help set conservation priorities.

potential for expanding the current range to areas that are currently unused, but this is limited to ranches in Laikipia District (<3% of the landscape). Recovery is possible if conservationists can secure enough grassland habitat and safe water and limit the numbers of plains zebra and lions. The subpopulation in Laikipia is growing at only 1%–3% per year. Although the reason for the low increase is not known, it may relate to habitat quality or interspecific competition (i.e., with other herbivores) at the southern edge of their historical range. There is also a high potential for recovery in the community-managed areas of Samburu District.

In general, the cost of conservation activities aimed at Grevy's was scored lower in Laikipia and Lewa Conservancy, where there has already been substantial investment in direct conservation and conservation education with communities and where relationships have been built with local people. Cost is moderate in the national reserves and neighboring communities (West Gate, Kalama, and Wamba, where work is ongoing), and costs are highest farther north and in the Kipsing area of Isiolo.

Through most of the landscape, participants indicated high confidence in the information they provided, based on the large amount of research (radio tracking, surveys, and community monitoring) that has been performed.

Lions

Approximately 450 lions currently use around 60% of the landscape (calculated at 5 × 5 km resolution). Abundance is highest on commercial ranches of Laikipia and the national reserves of Samburu, Buffalo Springs, and Shaba. Agricultural areas cannot support lions. Other areas that support subpopulations include the Matthews Range and Kirisia Forest. The buffer areas around the national reserves are important dispersal areas for lions. There are lions throughout the pastoralist areas but in low numbers, therefore those areas are not as important for the landscape population.

In general, the areas with the highest potential reductions in the future are those where lions are currently most abundant. The highest potential for loss is on the commercial ranches in Laikipia and the national reserves and surrounding areas, where in the absence of conservation efforts, lions would likely be persecuted. In most of Samburu, threats are intense, although the current abundance of lions is low, and therefore, the potential future reductions are also low.

Potential for recovery is low in the commercial ranches of Laikipia, where lions are nearer carrying capacity, and in pastoralist areas. Potential for recovery is higher where there are few people and where habitat is suitable, including northeast Samburu and the northern Matthews Range, assuming that conservation and incentives can improve the attitudes of local people toward lions. Lions could potentially expand out from their current range to an additional 11% of the landscape, primarily in the northwestern extreme of the landscape, although participants indicated that they were uncertain about the current status of lions in this region and the possibility of recovery.

Cost for conserving lions is primarily influenced by attitudes toward conservation. Areas where communities have some conservation awareness were given lower cost than those with no exposure to or history of conservation. Costs were also low in areas where lion numbers are highest, even though lion populations in these areas will be artificially suppressed (e.g., Lewa, Solio, and Ol Pejeta).

Participants indicated that they had high confidence in their conclusion that lions would continue to persist in Laikipia and southern Samburu, and especially within the national reserves. Participants indicated that their confidence was based on the intensive research that has been performed in these places. Confidence was somewhat lower in the northern parts of the landscape, where information is based on local knowledge.

Wild Dogs

Wild dogs current use approximately 29% of the landscape and currently number around 300 animals in 17–18 packs. Core areas that support higher abundances and have resident animals are the commercial ranches in central Laikipia and the group ranches on the edge of the Laikipia escarpment. The area of Isiolo District between Laikipia and Buffalo Springs/Shaba, although it may not support resident animals, is important for maintaining connectivity between these two subpopulations. Dogs move through northern Laikipia in the Kirimun area to the east of the Kirisia Hills and the Seiya Lugga. Another very important area is the Matthews Range, where there are several wild dog packs. Local knowledge suggests there are some packs in central Samburu and a pack newly established in Shaba National Reserve.

Potential for reductions in the wild dog population is generally high where animals are resident and threats exist. Reductions could be high in the Suguta valley if more land on the Loroki Plateau is used for wheat, which would, in turn, force pastoralists to move more of their livestock into the Suguta valley. Areas where there is high

potential for loss also include areas where a high level of conflict exists between human populations and wild dogs and where wild prey risk being depleted.

The wild dog population across the landscape is in a recovery phase after becoming locally extinct, at least in Laikipia. With conservation action, dogs could potentially double the size of their range to nearly 60% of the landscape (based on 5 × 5 km resolution). Hilly areas have the highest potential for recovery as wild dogs tend to prefer that habitat. Potential recovery is lower where current abundances are high, as these are likely to be already at carrying capacity. Large areas of the landscape are not suitable for wild dogs and, therefore, have no potential for recovery.

There are no areas where the cost of conservation actions aimed at wild dogs is zero, primarily because there is a major disease risk to wild dogs (primarily from domestic dogs), which has the potential to wipe out the entire population. The cost of conservation is lowest in community areas of Laikipia, on the Laikipia escarpment, and in the Matthews Range, where there is little conflict, prey species are abundant (dik-dik), wild dogs are currently doing well, and the only cost is due to disease risk. Areas where costs are high are either insecure, from the standpoint of operating a conservation project, or have depleted prey. The cost was considered prohibitive in agricultural areas where conservation would require conversion of habitat. Participants indicated that they had high confidence about the information they provided in Laikipia, where animals are radio collared, but that confidence was lower in other areas.

Spatially Explicit Conservation Priorities

After completing the five component maps for each of the four focal species, a map reflecting the benefit to cost ratio for conservation action was calculated (Figures 1, 2). Conservation benefits were calculated by weighting then adding the maps of potential recovery and maps of potential reductions. In other words, benefits from conservation in any location include either helping to recover populations or preventing future reductions. For each species, participants assigned relative weights to these two maps (i.e., how important is prevention relative to recovery). For each species, the weights (prevention:recovery) were as follows: elephant, 1:1; Grevy's zebra, 2:3; lions, 2:1; and wild dogs, 5:1.

The benefit:cost maps, in combination with the five component maps, were then used by participants as guides for producing maps of conservation priorities for each species (Figure 5, Table 3). Finally, an integrated map of conservation priorities across all four conservation targets was created (Figure 6).

Species-Specific Priorities: Elephants

For elephants, the strong conservation investment currently being put into the ranches and conservancies of Laikipia, Buffalo Springs, Samburu and Shaba National Reserves, Mount Kenya National Park, and a few group ranches and conservancies (Namunyak) in Samburu should be maintained, as these are elephant strongholds. Additional investment over the next decade should be aimed at securing strong subpopulations that are vulnerable to decline, bolstering subpopulations in some places, and securing corridors. Areas where subpopulations are currently strong but increased investment is needed to maintain them include the following:

1. Laikipia Nature Conservancy requires improved community outreach and development of community-owned conservancies and associated tourism among the neighboring communities, particularly the Pokot, to the west and north of the property. Investment is also required to improve security and upgrade elephant-proof electrified fences.
2. Mount Kenya Forest Reserve requires the mitigation of human-elephant conflict on smallholder land surrounding the forest and the establishment of corridors to the Laikipia Plateau to maintain connectivity between subpopulations.
3. Rumuruti Forest is the highest conflict area in the landscape. Unless the Marmanet and Ol Arabel forests, located west of the Rumuruti Forest, can be secured and rehabilitated, there is no future for elephants in this area, and efforts should instead focus on removing them to the large-scale ranching matrix in central Laikipia.

High-priority areas where populations could be bolstered with increased investment include the following:

1. In north Laikipia and Samburu, investment aimed at the Kirisia Forest, Mukogodo Forest, the Matthews Range, and the Sera Conservancy should attempt to reduce poaching and increase security.
2. In Lekurruki and the Livestock Marketing Division in Isiolo, activities should aim to maintain an area of low livestock densities and reduce insecurity (i.e., poaching).

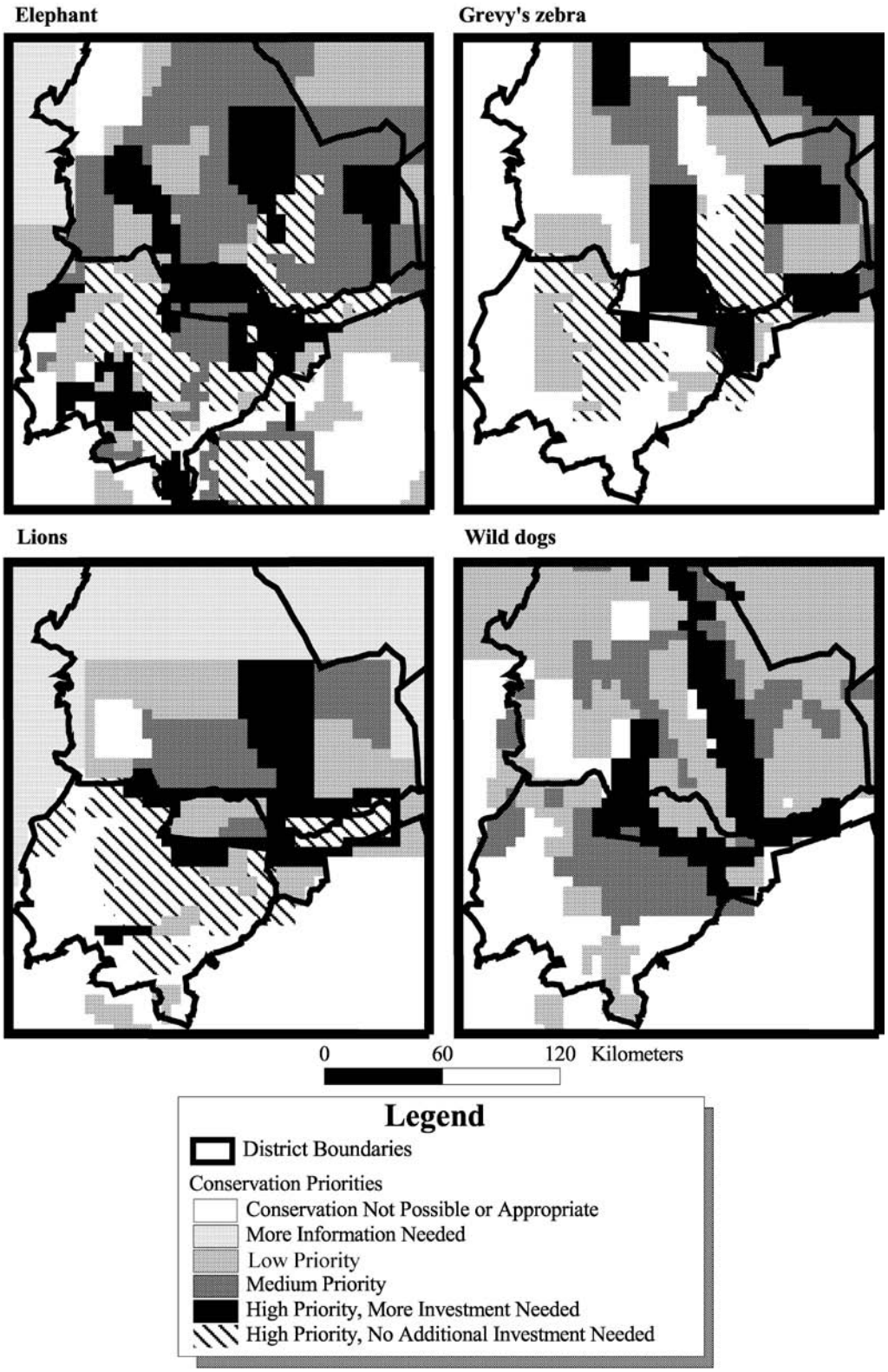

FIGURE 5. Conservation priorities for individual species as described by participants at the Ewaso Landscape Planning Workshop (January 2006).

TABLE 3. Summary of the feature-specific priority maps for each of four biodiversity features. Maps were produced by participants in the Ewaso Nyiro Landscape Conservation Planning Workshop (January 2006).

Focal biodiversity feature	Planning units needing conservation investment (%)	Range needing increased investment [a] (%)	High-priority units needing increased investment (%)
African elephant	80.1	83.4	54.8
Grevy's zebra	47.3	80.2	59.5
Lion	69.5	84.9	48.6
African wild dog	60.1	100	100

[a] Range here is defined as any of the 5 × 5 km planning units needing conservation of some kind (continued investment at current level or increased). This column reflects the percentage of those units that need increased investment (low, medium, or high priority or for more information).

Several critical corridors need to be maintained through increased investment, particularly those linking Mount Kenya to Laikipia and several through Isiolo, which link Laikipia and Samburu.

Species-Specific Priorities: Grevy's Zebra

For Grevy's zebra, current levels of conservation investment are sufficient in some areas, including the commercial ranches of Laikipia, Lewa, Il Ngwesi, Namunyak, West Gate, and Kalama and the reserves of Samburu and Buffalo Springs. These levels need to be maintained to ensure continued success.

High-priority areas needing additional investment include areas that are important for grazing, watering, and reproduction. Securing these areas is considered essential for both recovering the species and preventing any future declines. Specific areas that are a high priority for increased investment include Shaba National Reserve and the Livestock Marketing Division and Kipsing areas of Isiolo. These latter two areas are important for retaining the migration link between the Laikipia and the northern subpopulations of Grevy's zebra. They are also important for recovery or recolonization, as they were good habitat in the past. Additional high-priority areas around Laisamis, Serolivi, and the northernmost subpopulation near Baragoi are areas that were historically the core of the species range and where there is high potential for recovery.

Conservation is not possible in areas that are outside the historical range of the species, unsuitable habitat (e.g., mountains and forest), and agricultural land.

Species-Specific Priorities: Lions

For lions, current levels of conservation investment are sufficient in the commercial ranches of Laikipia and the national reserves and should continue in these areas. Additional investment is critically needed in the community areas of Laikipia (e.g., Naibunga), through the Kipsing and Livestock Marketing Division area of Isiolo (particularly along luggas, which lions favor as habitat), and in a buffer zone around the reserves (to allow for safe dispersal of lions out of the reserves). There also needs to be more investment in education and awareness in these community areas to maintain connectivity for lions in the landscape. The Matthews Range is also a high priority for increased investment, as this is potentially important habitat that could support more lions and has low human population density. Additional investment is also strongly needed in the area north of Ol Pejeta to create a link to the rest of Laikipia. Areas where there are many people and high densities of livestock are considered to be areas where either priority is low 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 that area as there may be potential for recovering lions.

In general, educational efforts aimed at community residents are needed to explain the rationale for and practice of predator conservation. People are receptive to the idea when presented in terms meaningful to their own lives, but it is not always easy to convince them that they can benefit from wildlife, especially predators on their livestock. Development of tourism in the communities, with

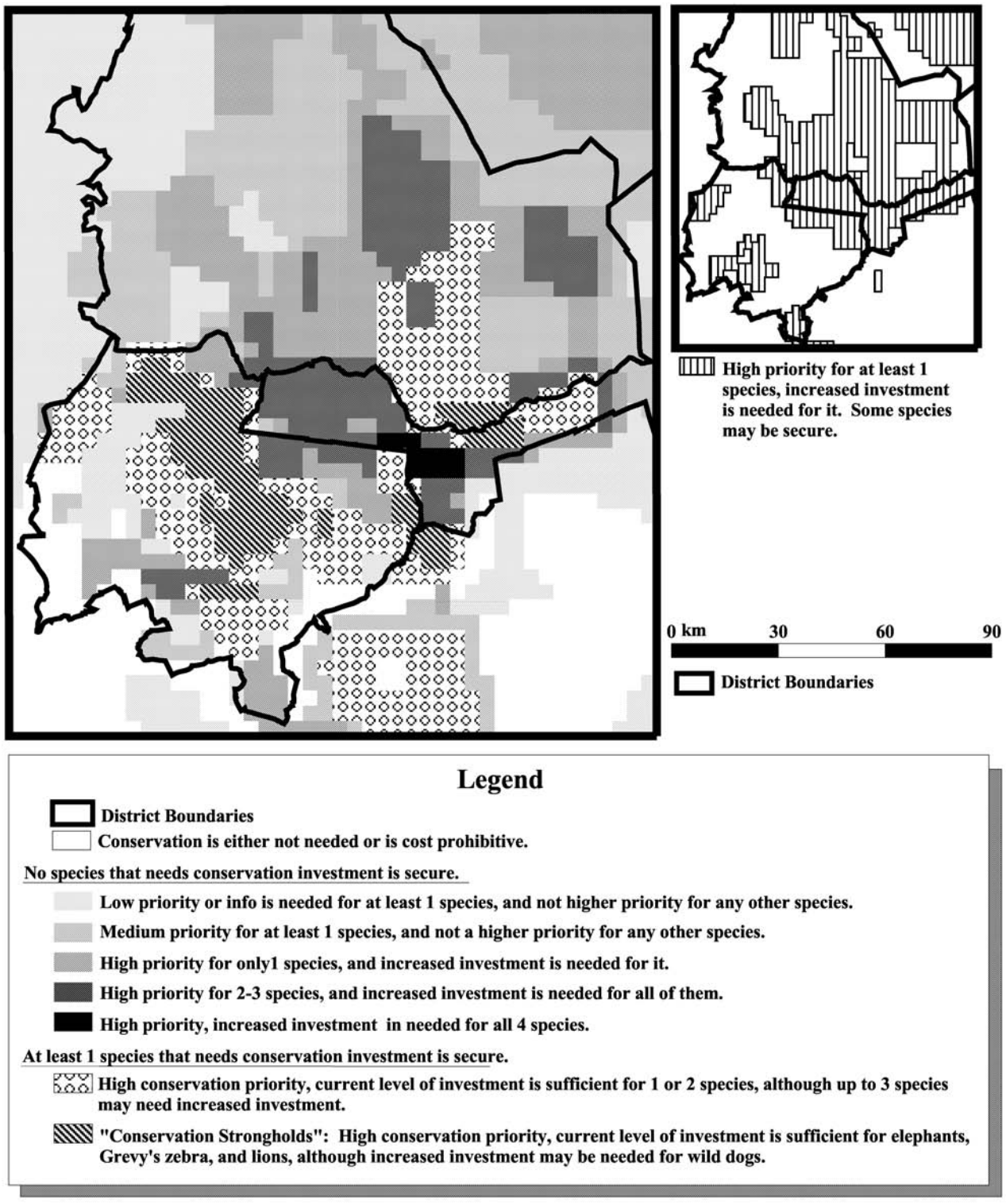

FIGURE 6. Conservation priorities across four species. The map was produced by combining priority maps for individual species and creating useful categories and is a product of the Ewaso Landscape Planning Workshop (January 2006).

transparent and equable distribution of profits, would provide some incentive for people to tolerate carnivores. Trophy hunting would have great potential in northern Laikipia, especially given the good numbers of leopard and great kudu.

Species-Specific Priorities: Wild Dogs

For wild dogs, investment in conservation is insufficient across the entire landscape. Risk of infectious diseases is a major threat to wild dogs, with highest risk in community areas. The priority for conservation is to secure the known populations of wild dogs. Community areas along the Laikipia escarpment (e.g., Naibunga Conservancy) and into Isiolo District (with linkages through Isiolo into Samburu) are important habitat for wild dogs and a high priority for conservation needing additional investment. The Seiya Lugga, Matthews Range, and Ndotos Range are also high conservation priorities needing additional investment. The commercial ranches of Laikipia are considered medium priority. Some additional areas are considered medium priority and are important for providing connectivity. Southern Laikipia and Meru Districts are not considered suitable habitat for wild dogs and are unlikely to ever become a part of the wild dog range. Therefore, conservation is not possible in those areas.

Cross-Species Priorities

Overall, participants indicated that if current levels of conservation investment are maintained, only about 3.6% of the landscape is secure (i.e., does not need additional investment) for all four species. Approximately 4.6% of the landscape is secure for three or four species but often needs additional investment for wild dogs (diagonally hatched areas shown in Figure 6). These areas are the most secure areas in the landscape and include the commercial ranches and conservancies of central Laikipia, Lewa Wildlife Conservancy, a small area in Samburu around West Gate and Wamba, and Samburu and Buffalo Springs National Reserves. For the remainder of the paper, we will refer to these areas as the "conservation strongholds."

An additional 13.4% of the planning units are "partially" secure, meaning that levels of investment are sufficient for one or two species that require it but up to three species may need increased investment (areas with small circles in Figure 6). An excellent example of this type of area is Shaba National Reserve, which is secure for elephants and lions but is a high priority for increased investment for Grevy's zebra and wild dogs.

The analysis concluded that fully 84% of the landscape needs continued or additional conservation investment at low to high priority. Almost half (45%) of the landscape was given high-priority status for continued or additional conservation investment for at least one species. About one-third of the landscape was given a high-priority status for at least one species and was identified as needing increased investment (Figure 6, small map). Specifically, this land includes all of the national reserves and land west; Solio; Laikipia ranches, Naibunga Conservancy, and parts of southwestern Laikipia; elephant corridors between Ngare Ndare Forest to Mount Kenya and Solio to Mount Kenya; much of Samburu, including the Kirisia Forest and the Matthews Range; Sera; and the northeastern part of the landscape in Marsabit District.

About 1% of the landscape is at high priority for additional investment for all four species, and about 4% is at high priority for at least three species. Increased investment in these high-priority locations would benefit not only all or most of these species but also, by association, much of the biodiversity of the region. The majority of planning units in this category are located in either the "peninsula" of Isiolo District between Laikipia and Samburu Districts or the Matthews Range in Samburu.

DISCUSSION

Implications for Conservation in the Ewaso Ecosystem

We suggest there are three important implications of this exercise for conservation practitioners working in the Ewaso ecosystem. These implications are likely to be similar for ecosystems throughout Kenya and eastern Africa.

1. *Conservation objectives in the Ewaso Nyiro cannot be achieved by focusing only on traditional strongholds of biodiversity conservation. Planning and investment strategies are needed across much of the landscape.*

The traditional strongholds of conservation in the Ewaso Nyiro include about 9,500 km^2 of land (~18% of the landscape), composed mostly of the commercial ranches and conservancies of central Laikipia, Lewa Conservancy, and two of the three national reserves (Buffalo Springs and Samburu; see the areas in Figure 6 with diagonal hatch-marks). The critical question is, can we meet our objectives for biodiversity conservation (see Table 1) by focusing conservation only on the traditional strongholds? The four species on which our exercise focused are excellent examples of why the answer is a resounding *no*.

Although it may seem possible to reach modest conservation objectives, such as reaching and maintaining a population of 10,000 elephants within 10 years, by simply trying to increase the number of animals within the traditional strongholds, this supposition is not true for two main reasons. First, for all four species, substantial portions of their populations currently reside outside of the conservation strongholds. For example, significant subpopulations of Grevy's zebra are resident in and around Laisamis in the northeast of the landscape and Wamba to the west of the Matthews Range, and lions, elephants, and wild dogs all have significant subpopulations in the Matthews Range (see the current importance maps in Figures 1 and 2). If conservation investment is not increased in those areas, these subpopulations could decrease dramatically in the next 10 years because of changing land use patterns, poaching, settlement, and disease (see the future reductions maps). These factors would make it difficult to maintain current numbers, let alone increase populations to the conservation objectives.

The second reason that it will be impossible to reach conservation goals by focusing only on strongholds is that even subpopulations within the strongholds rely on habitat in the surrounding landscape. This dependence is particularly evident for the 8,000 or so elephants currently living in the landscape. This population relies on an enormous proportion of the total area (nearly 88% of the planning units), far beyond the strongholds, including a large number of corridors connecting various subpopulations (Figure 4). A failure to increase investment in areas beyond the strongholds will likely lead to declines in the elephant population. Further, increasing the population to 10,000 animals will require that habitat outside of the strongholds is used more intensively (see the potential for recovery maps in Figures 1 and 2), especially considering that elephant subpopulations in most of the strongholds are currently at or near carrying capacity. The same is more or less true for the other species considered in our exercise: although their populations spend more time within the strongholds, they rely heavily on habitat and corridors outside of those strongholds (from 29% to 47% of the planning units in the landscape) and will need to spend more time in this habitat if populations are to increase.

In addition to the four species considered here, we suspect that conservation focused only on strongholds will be insufficient for protecting many of the other species, ecological processes (such as herbivore migrations), and ecosystem services of the Ewaso Nyiro. Gardner et al. (2007) recently demonstrated that strictly protected areas created for large mammals in Tanzania were ineffective at conserving other taxa (e.g., butterflies and birds). The same is likely true for the Ewaso Nyiro. Although we do not yet have conservation objectives or maps for the other focal biodiversity features chosen by workshop participants (Table 1), many certainly require conservation at landscape scales and beyond the current strongholds. For example, reticulated giraffe populations suffer from poaching, mostly for meat and mostly in areas outside of the conservation strongholds. Finally, the hydrological system, which provides a critical service to both the wildlife and humans living in the Ewaso Nyiro, obviously cannot be effectively conserved with activities focused within the traditional strongholds. In fact, one can make the case that although the Ewaso River itself is the most critical resource to wildlife residing in the strongholds, its flow and water quality can only be assured by effective water management and conservation upstream, in the agricultural areas and at its source in the forests of Mount Kenya, where logging inside and outside of the national park is a problem.

2. *Thus far, the systematic, landscape-scale process suggests three priorities for conservation investment, which are, in order of priority, continue conservation investments at current levels to preserve the strongholds, increase investments to prevent the loss of the Isiolo corridor, and increase investments to improve the status of biodiversity features in portions of Samburu District.*

Because there is so much land in the Ewaso Nyiro that requires some level of conservation investment (about 84% of the landscape) and it is certainly beyond current resources to work in all of that land, a process for prioritizing future investments is needed. Thus far, although the planning process has focused on only four of nine species, three clear priorities have emerged for how conservation practitioners should invest their resources in the future. Although other priorities exist on an individual species basis (e.g., Kirisia Forest is a high priority for increased investment for elephants), the priorities below represent ones where the combined energy of the conservation community can be marshaled to benefit a large range of biodiversity.

First, the planning process clearly demonstrates the importance of continuing the levels of investment currently being directed at conservation strongholds. With the possible exception of elephants, the majority of the populations of the four focal species reside within the conservation strongholds. Further, the potential for

future reductions maps (Figures 1, 2) indicate that in the absence of current levels of investment by conservation practitioners, large reductions in the subpopulations residing on the strongholds would likely occur. Although the land use practices on many of the privately owned ranches and conservancies in Laikipia would probably remain wildlife friendly in absence of active conservation and research (assuming ownership did not change), the national reserves would likely lose their integrity. Continuing investment in active conservation on strongholds will ensure that subpopulations persist and, often, increase. In some cases, additional investment in the strongholds is needed in order to preserve and recover wild dogs, although these investments are often a lower priority for dogs than those needed outside of the strongholds (Il Ngewsi, Loisaba Conservancy, and the national reserves are a high priority for increased investment for wild dogs). The resources currently being invested in the strongholds should in no way be redirected toward the other priorities below.

Second, in the near future, practitioners should raise and invest resources to secure, as continued wildlife habitat, the Isiolo corridor: the peninsula of Isiolo District separating Laikipia and Samburu Districts. Increased investment is needed in several critical locations. Most important is a stretch of land in the center of the Livestock Marketing Division, along the Ewaso Nyiro River, which separates northeastern Laikipia (Il Ngwesi, Lukurruki Ranch, Mukogodo Forest, etc.) from Buffalo Springs National Reserve (Figure 6). Increased investment in this area is a high priority for all four species considered in our exercise and would certainly benefit the species by both preventing future declines of subpopulations using the region and helping to increase subpopulations. Most importantly, however, investments could help secure the area as a corridor between the strongholds of central Laikipia and the national reserves (and by extension, much of northern Samburu, including the Matthews Range).

Increased investment should also be focused on other portions of Isiolo District, including Kipsing and Ol DoNgiro, especially the northern portions of these areas bordering Samburu, which are important for three species. Similarly, the group ranches along the Laikipia escarpment bordering Isiolo (e.g., Naibunga Ranch) and Lekurruki Ranch need increased investment.

Concerns about the future of the Isiolo corridor center around (1) increased interest of local communities and government in livestock marketing and the possibility of creating an abattoir with extensive livestock holding grounds and (2) the lack of interest or perceived value by local communities in wildlife. Any development that did not consider wildlife would certainly be injurious to conservation since this vital wildlife corridor could be permanently closed. Engagement particularly with the Isiolo County Council along with the councils in Samburu and Laikipia is critical for success in the corridor, as these councils hold trust over most of the land.

Finally, increased investment should be aimed at several portions of Samburu District. In particular, Matthews Range and surrounding areas represent an important forest and thicket habitat for elephants, wild dogs, and lions (but not for Grevy's zebra, which are restricted to more open habitats). Increased investment should be aimed at securing this area as a vital "island" that would create a "source" for recovering populations across the northern half of the landscape. Other important areas for increased attention in Samburu include the following. The habitat in and around Sera Conservancy in western Samburu could help increase subpopulations of both Grevy's zebra and elephants in addition to the two carnivores. Namunyak and Kalama conservancies, although they are secure for the herbivores, need increased investment for wild dogs and lions, and they form an important link between the national reserves and the Matthews Range. Finally, the group ranches south of Kirisia Forest are also important for both wild dogs and elephants as linkages from Laikipia to the Kirisia Forest and areas east.

3. *Some conservation objectives will conflict with human livelihood objectives. Part of a comprehensive landscape-scale planning process needs to be dedicated to negotiating these conflicts so that all objectives can be met to the greatest extent possible.*

Assessment of the landscape-scale priorities for our four focal species highlighted a challenge of conservation in Ewaso Nyiro: it may be difficult to meet all conservation objectives and human livelihood development objectives on the same areas of land. For example, it will be difficult to maintain or increase livestock grazing and marketing on lands also important for meeting conservation objectives for conserving predators and large herbivores. We believe that, ultimately, conservation planning in the Ewaso landscape needs to evolve into comprehensive land use planning that incorporates both conservation and development objectives and negotiates trade-offs. Sometimes, the objectives of both may be partially met on the same lands (e.g., wildlife tourism), but often, this may not be the case, and priority may need to be given to one objective at the expense of another.

Next Steps for Systematic, Landscape-Scale Planning in the Ewaso Nyiro

Although this exercise proved valuable for clarifying the scope of the conservation challenge in the Ewaso Nyiro, compiling useful information, and prioritizing some areas for conservation investment, it was only partially complete. We recommend that landscape-scale planning, as we have demonstrated here, continue and, in fact, become an integral part of conservation thinking in the Ewaso Nyiro. The process should be revisited and updated over time, possibly once every two to five years, depending on the changing conservation and development context. If substantial progress toward conserving biodiversity is made (e.g., the Isiolo corridor is secured), priorities should be reevaluated. The same should happen in the case of failure. We recommend that an inclusive and collaborative group of stakeholders concerned with landscape-scale conservation and development, such as the recently formed Ewaso Conservation Group, take a leadership role in carrying the process forward. Important next steps for the planning process include the following:

1. *Review the quantitative objectives for the elephants, Grevy's zebra, lions, and wild dogs (Table 1) and incorporate these more explicitly into the spatially explicit priority setting.*

The objectives shown in Table 1 represent preliminary and short-term (over the next 10 years) conservation objectives. A more formal and rigorous process for establishing quantitative objectives would be useful, such as those described in Groves (2003), Tear et al. (2005), and Sanderson (2006). Several possible quantitative objectives should be considered (e.g., minimum viable populations, ecologically functional populations, sustainable yield objectives, historical levels, several redundant populations), as this will help stakeholders set near- and long-term objectives and consider what is truly necessary for long-term conservation success (e.g., are 20 packs of wild dogs a sufficient long-term goal?). These objectives then need to be compared on a quantitative basis with the maps produced in this exercise to guide decisions about how much land is needed to reach the objectives (e.g., could areas marked as a high priority support sufficient number of animals to reach the objectives?) (Rodrigues and Gaston, 2001; Boshoff et al., 2002). If maps can be expressed in the same units as the quantitative targets (e.g., abundance), indices that are useful for prioritizing areas can be produced, including irreplaceability and marginal benefit:cost ratios (Cawardine et al., 2006), and "optimal" networks of conservation areas that meet objectives for all focal targets can also be produced.

2. *Complete the planning steps for the remaining focal conservation features.*

Thus far, the planning process has proceeded while considering only four of nine focal conservation features. Workshop participants agreed that planning based on all nine features was necessary to ensure that other forms of biodiversity, critical ecological functions (e.g., herbivore migration), and services (e.g., production of clean water) were well protected. Therefore, the planning process (especially steps 4–6; see Box 1) should include consideration of the remaining five features (i.e., reticulated giraffe, Jackson's Hartebeest, acacia-grassland mosaic, dry upland/montane forest, and the hydrological system) and possibly examine how well these surrogates represent a wider range of taxa (Gardner et al., 2007). The process of setting quantitative targets, producing the component maps (e.g., current importance), and prioritizing actions for each feature doubtlessly would be enlightening and may significantly shift near-term priorities.

3. *Complete the planning steps for livelihood development goals and objectives and negotiate land use solutions that meet both conservation and development objectives.*

As we noted above, we do not believe a landscape-scale plan can be successfully implemented if it has not also incorporated, to some degree, objectives for human livelihood development and attempted to negotiate a network of land uses that meet both conservation and development objectives (Faith and Walker, 1996; Stewart and Possingham, 2005). If both sets of objectives are not considered in a transparent and relatively objective process, conservation priorities run the danger of being largely irrelevant in future land use decisions. Local stakeholders interested in pursuing development objectives, such as county councils and development nongovernmental organizations, need to be given at least equal time, so that they buy into the process as a whole and do not simply disregard it as an attempt to usurp their rights to the land. Development objectives should not be treated as "opportunity costs" of conservation (as in Stewart and Possingham, 2005) but, rather, as true objectives on an equal level with conservation objectives. In this way true conflicts, where conservation and development objectives are incompatible, as well

as unique opportunities to meet both sets of objectives can be identified.

We recommend that first, conservation and development priorities be assessed separately, possibly in separate workshops, but using the same framework (such as the one in Box 1). The framework should ask participants to express their development objectives in quantitative and measurable terms and to consider the benefits and costs of various areas for meeting those objectives (e.g., what are the benefits and costs of increasing livestock grazing in particular areas). After independently setting priorities, development objectives and conservation objectives should be brought together, and solutions for meeting both negotiated. Producing future conservation and development scenarios (e.g., Baker et al., 2004; Hulse, 2004) may be a useful way for exploring options and their consequences. In general, land use planning processes that explicitly incorporate both conservation and development objectives are in their infancy, but the Ewaso Nyiro could easily lead in this arena.

CONCLUSIONS

In many places in eastern Africa and, indeed, the world it is becoming apparent that the traditional approach of conservation focusing on protected-area creation and management, though essential, will likely be insufficient to meet conservation goals. Many species, especially the area-demanding ones that are so common in eastern Africa, and ecosystem services simply cannot be effectively conserved on small patches of land. Conservation practitioners need to increase their effort beyond the traditional conservation strongholds to the surrounding landscape dominated by human land uses. Unfortunately, taking conservation to sufficiently large scales is often a daunting undertaking, as was demonstrated in our exercise (84% of the landscape needs conservation investment), and requires conservationists to work with a huge range of landowners and stakeholders who may not be primarily concerned with conservation. Systematic, landscape-scale conservation planning approaches help practitioners to set ecologically meaningful and transparent objectives, to define the scale at which they need to work to meet these objectives, and to define priorities that help ensure that they invest their limited resources to make the most efficient progress toward their daunting objectives. The planning approach we have demonstrated here is an important step for scaling up conservation in the Ewaso Nyiro and setting clear conservation priorities for immediate action. It has produced concrete, near-term priorities for investment (e.g., secure the Isiolo corridor) that conservation practitioners in the region can work together to meet. It has catalyzed the creation of the Ewaso Conservation Group, a partnership of organizations and local governments that is charged with carrying the planning and prioritizing process forward and implementing actions based on the process. We encourage all those interested in creating a landscape that meets the needs of people and wildlife to help the Ewaso Conservation Group carry the process forward in the Ewaso Nyiro and to other areas of Kenya, such as Tsavo or the Mara, which face similar challenges.

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