A WORKBOOK FOR CONDUCTING BIOLOGICAL ASSESSMENTS AND DEVELOPING BIODIVERSITY VISIONS FOR ECOREGION-BASED CONSERVATION

Part I: Terrestrial Ecoregions

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SUMMARY

Many conservation organizations, governments, and donor agencies have intensified efforts to save life on Earth. The introduction of new tools like the Global 200 provides a valuable means for identifying terrestrial, freshwater, and marine ecoregions that deserve greater emphasis because of their outstanding biodiversity value (Olson and Dinerstein 1998). The Global 200 analysis identifies the most prominent biological features of each priority ecoregion, laying the groundwork for finer-scale analyses to conserve these features. To accomplish this urgent task, conservation groups are relying on landscape level conservation approaches. WWF (and The Nature Conservancy) refer to this as ecoregion-based conservation (ERBC), a rigorous approach at a spatial and temporal scale that allows allocation of efforts for safeguarding biodiversity over the long term. ERBC is consistent with WWF's main mission—biodiversity conservation. To meet this goal, we must preserve the ecological interactions and evolutionary mechanisms that generate and maintain species—and that require us to think, plan, and act at the scales at which nature operates.

A major commitment to the clear and comprehensive ERBC approach exists across the WWF network, and in many other arenas of the world. A current bottleneck, however, is the absence of guidelines for undertaking this new approach. In particular, the absence of a methodology to initiate the biological components of ERBC has been noted. The purpose of this workbook is to fill that gap by outlining the major steps involved in conducting a biological assessment and creating a biodiversity vision. A combined guide, teaching tool, checklist, and literature review, the workbook attempts to answer many of the questions that have been raised by conservation professionals, partners, and specialists as they have become engaged with ERBC.

The first installment of the workbook covers terrestrial ecoregions. Two supplements will treat freshwater and marine ecoregions respectively. These workbooks will serve as placeholders until biological assessments and biodiversity visions are published for a sufficient number of Global 200 ecoregions across all of the major habitat types. It is our hope that by the end of the year 2000, a sufficient number of prototype ecoregion analyses have been conducted so that a library of biological assessments will be available to guide practitioners of ERBC.

SCOPE OF THE WORKBOOK: A MESSAGE TO USERS

In January 1998, WWF staff from around the network gathered in Washington, D.C., to discuss ecoregion-based conservation (ERBC). Other organizations such as The Nature Conservancy also had begun to discuss and develop their approach to ERBC. The enthusiasm for adopting this new approach was tempered by the reality that little formal guidance in how to undertake ERBC was available. Conscious of the need to get started, the Conservation Science Program of WWF-US worked in collaboration with regional program staff to conduct biological assessments and to derive biodiversity visions for several Global 200 ecoregions. Two examples, the Chihuahuan Desert and Springs and the Eastern Himalayas (the latter as part of a larger assessment of the Himalayan range), are now published and available for distribution to teams undertaking ERBC elsewhere. Many of the examples we use here to illustrate basic concepts are drawn from these analyses, from material generated from a workshop in Kathmandu, Nepal, in the fall of 1999, and from several workshops in the Americas.

We feel strongly that the ideas, principles, and techniques developed in these two assessments are widely applicable to a number of terrestrial and freshwater ecoregions. However, there is still a clear need for a comprehensive workbook that, in simple language, will spell out the steps required to conduct rigorous biological assessments of ecoregions, which set the priorities for ERBC's foundation. In designing these guidelines, we are painfully aware that there is no textbook on the subject to pull from the shelf and consult when we run into a problem.

This approach is a pioneer undertaking, and we are inventing the science of ERBC as we go. Fortunately, WWF is not alone in this effort. Scores of conservation biologists are now addressing the science behind conserving biological diversity at larger spatial scales. The Nature Conservancy (as mentioned), the Conservation Biology Institute, and the Wildlands Project are three other groups that are now developing the science for conservation planning at the scale of ecoregions. Governments and donors are also recognizing the need for planning and working at larger spatial scales. In Madagascar, for example, the most recent phase of the National Environmental Action Plan is based on a landscape design. This is fully supported at a policy cross-sectoral level and by the major funders such as the U.S. Agency for International Development and the World Bank. This workbook draws on this growing body of knowledge. Future drafts will incorporate new knowledge, new examples from other ERBC specific efforts, and from landscape initiatives that have been undertaken by other relevant organizations. We welcome your critiques and suggestions.

Objectives

The purpose of this workbook is to

1. Introduce new staff to the biological basis of ERBC
2. Respond to requests for a workbook-style document to serve as a guide for developing rigorous biological assessments
3. Explain the key steps for creating a biodiversity vision
4. Illustrate approaches to ERBC with examples from biological assessments that are under way within and outside the WWF network
5. Provide more advanced analyses to guide biologists on the design of conservation landscapes in high-priority areas selected by the biological assessment

What is the Global 200

The Global 200 is derived from a comprehensive analysis of global biodiversity data leading to a selection of the most outstanding examples of each of the world's diverse terrestrial, freshwater and marine ecoregions. The central concept of the Global 200 is simple: if we can conserve a comprehensive representation of the world's habitats, we can conserve the broadest range of the world's species and most endangered wildlife, as well as the ecological and evolutionary processes that maintain the web of life.

Ecoregional analyses opened the way to this new method of setting international conservation priorities by selecting representative ecoregions across each biogeographical realm and ocean basin. This approach is at the heart of the Global 200 analysis. As well as the more familiar terrestrial habitats, the Global 200 highlights outstanding examples of freshwater and marine ecosystems. This is critically important because threats to aquatic biodiversity are even greater than the threats to plants and animals on land.

Representation of all the Earth's habitats is important. Although an estimated 50 percent of all species occur within a single major habitat type (tropical rainforests), the other half of all species is found elsewhere in the world's land, freshwater, and marine habitats. To conserve those species, and less biologically diverse but ecologically important areas (e.g., tundra and mangroves), the Global 200 proposes a full representation of the world's diverse ecosystems.

Structure of the workbook and intended audience

The workbook contains 13 chapters that cover the major topics involved in the biological component of ERBC. These are applicable to any ecoregion. Most of the chapters are divided into three sections: the first, **Concepts**, covers theory and background. The second, **Application**, guides ERBC practitioners through a step-by-step process of the tasks and analyses required to conduct a particular aspect of the assessment. The third, **Case Studies**, shows how these techniques have been applied to specific ecoregions.

In Part I (chaps. 1–2), we present basic concepts and strategies. We introduce the concept of ecoregions, the importance of scale in conservation efforts, and the explanation for why ERBC provides a valuable tool for conserving biological diversity and setting conservation priorities (chap.1). A unique element of the WWF approach to ERBC is a biodiversity vision; we discuss the data, decisions, and approaches required to construct a draft biodiversity vision (chap. 2). We also suggest a design for an orientation meeting to get started on a vision for the ecoregion.

Part II of the workbook (chaps. 3–8) explains how to conduct a biological assessment and refine the biodiversity vision for a terrestrial ecoregion. We outline basic preparatory steps, including forming the assessment team and designing the expert workshop. As part of this exercise, we review basic data requirements and discuss issues related to data quality and quantity (chap. 3). We then offer a step-by-step approach for conducting the workshop and the assessment, beginning with a chapter on understanding and mapping patterns of biodiversity at an ecoregion scale (chap. 4). We offer techniques to assess landscape integrity within the ecoregion and to assess the long-term persistence of biodiversity (chap. 5). Integrating data on biological distinctiveness and landscape integrity helps to identify where to act first, given staff and funding constraints. We offer guidelines for determining a plan of action for conserving critical areas, landscapes, and ecological processes, and we show how to conduct a gap analysis (chap. 6).

The biologists who assemble at workshops bring vast experience and an understanding not only of the biota but also of the threats to both ecoregion integrity and the persistence of critical habitats, processes, and species assemblages. To capture this valuable information, we offer an approach for assessing threats to biodiversity at the ecoregion and site scale (chap. 7). Next, we cover the steps required in the final write-up and refinement of the vision (chap. 8). We also offer a protocol to ensure a thorough peer review of the assessment and vision, thereby creating greater acceptance from local and regional biologists and managers.

Part III covers advanced topics. We begin by anticipating a future need: the design of landscape-scale conservation programs for high-priority areas that are identified by the biological assessment. We provide an example of how to accurately define the spatial extent of priority areas through the application of fundamental biological principles. These principles include the design of conservation landscapes both for assisting habitat specialists (chap. 9) and for addressing dispersal and connectivity requirements for wide-ranging and area-limited species such as large carnivores and megaherbivores (chap. 10). These species require special attention from conservation planners.

Some ecoregions are data rich, with abundant information on distributions of a variety of taxa. For this small subset, we review new algorithms that are designed to achieve representation and complementarity among the constellation of sites where one could invest in conservation (chap. 11). We discuss what to do when working in a biologically rich but data-poor ecoregion, an issue of great relevance for those WWF staff who are working in some tropical moist forest ecoregions. The main chapters of this workbook are based on experiences in large continental ecoregions. We tailor the ERBC approach to species and habitats that are found on isolated, small tropical islands (chap. 12), using the biodiversity vision for the Galápagos Islands (Powell, G., et al., in preparation). The spread of invasive species poses a significant threat to the integrity of island habitats and continental ecoregions where the remaining natural habitat has been reduced to small fragments. We provide a synopsis of an analysis now under way in the Galápagos Islands to demonstrate a way to quantify the effects of exotics and mitigate these threats. The last chapter covers the application of Geographic Information Systems (GIS) and identifies hardware and software requirements to conduct the biological assessments involved in ERBC (chap. 13).

The intended audience of this workbook is biologists who are working on ERBC, ecoregion coordinators, other WWF technical staff, and consultants who are hired to carry out various aspects of the analysis. For all these groups, we include government and nongovernment professionals. Throughout the workbook, we have tried to strike a balance between incorporating sound conservation biology principles and suggesting simpler guidelines that are operationally useful to undertaking ERBC. We have also tried to keep scientific jargon to a minimum. The process of undertaking biological assessments and other parts of ERBC, although difficult to show in a workbook-style document, should be tailored to the specificities of the individual ecoregion (without compromising the rigor of the assessment). Thus, in some ecoregions, this customizing may be a very locally based and locally owned process, whereas in other ecoregions, it may start in academic centers and work its way out. An ERBC workshop, from a WWF perspective, differs from other assessment exercises in its desire to contribute to the creation of a biodiversity vision, which is in itself a novel contribution to biodiversity conservation. The workshops also try to be predictive while emphasizing the importance of what an ecoregion was like prior to heavy alteration by humans. The many other strengths of ERBC workshops will become more evident as you make your way through this workbook.

We also provide additional tools: (1) a glossary of biological terms used in the workbook, (2) a bibliography of key literature, and (3) a Microsoft® PowerPoint® slide show that covers the basic biological steps of ERBC as outlined in these chapters (provided on a diskette that accompanies the workbook, filename: erbc_show.ppt).

From biodiversity vision to conservation action

The biodiversity vision is the foundation on which stakeholders can build a conservation strategy for the ecoregion. It focuses the conservation planning effort on the species, ecological processes, and geographic areas that are most important for sustaining and restoring biodiversity, and it suggests priorities for action. The biodiversity vision will shape and, in turn, will be influenced by an analysis of land-use and socioeconomic forces at work in the ecoregion. It is a significant step, but far from the final step in the ERBC process. The ultimate goal is a peer-reviewed conservation strategy with specific action plans that are widely embraced and implemented by a diversity of stakeholders.

To accomplish this goal, the biodiversity vision must be supplemented by rigorous, targeted socioeconomic analyses. Such analyses are under way in the two Global 200 ecoregions that are used as case studies in this workbook: the Chihuahuan Desert and Springs and the Eastern Himalayas. The techniques for conducting socioeconomic analyses will likely be covered in other documents and workbooks. The biological assessment and vision should precede detailed socioeconomic work. To conserve the full expression of biodiversity in an ecoregion in perpetuity—the basis of the vision—we first need to know what we are trying to conserve. One lesson learned from the Chihuahuan ERBC effort is that without access to at least a draft biodiversity vision, social scientists involved in ERBC were not focused on the key areas and ecological processes that formed the major goals of the proposed conservation effort**.** They did, however, endorse and concentrate on key threats identified through the biological assessment process. Other ERBC efforts will undoubtedly experiment with variations in the timing and depth of socioeconomic analyses at an ecoregional scale.

Although the biological assessment and biodiversity vision are best developed first, the ERBC team should begin an analysis of the most obvious overarching threats to biodiversity in the ecoregion (see the Chihuahuan example in chap. 2). Such analyses will certainly be needed, whatever the details of the biodiversity vision. However, unless a detailed threat analysis to specific areas is informed by the biodiversity vision, we run the risk of investing in areas that may have low persistence value, are biologically redundant, or do not adequately conserve ecological processes.

The most commonly asked question about ERBC is, Does conservation action have to wait until the entire ERBC process is completed? The answer is an emphatic no. Orientation meetings early in the process should identify a few critical activities and areas for immediate conservation action that are based on the consensus of the participants (e.g., forest policy in Valdivia). Further opportunities to advance conservation in these areas or to enhance the selected activities should not be ignored but should be agreed upon by a wider group of experts. Developing full portfolio of priority areas and activities, however, will require completing the ERBC process.

PART I: CONSERVING BIODIVERSITY AT THE SCALE OF ECOREGIONS

THE BIOLOGICAL BASIS OF ECOREGION-BASED CONSERVATION *1*

Introduction

WWF tries constantly to improve its effectiveness in conserving biological diversity. Increasingly, we find ourselves working at multiple scales: from saving an endangered species that is confined to a single forest fragment to ameliorating the effects of global climate change. Most of our field efforts to date have been with country or subregional programs, consisting typically of projects that are restricted to relatively small areas (e.g., a community-based project, buffer zone program, or protected area) for relatively short periods of time (1-3 years). These projects are the building blocks of conservation. However, to halt the global extinction crisis that we now face, we must conduct conservation planning over larger spatial scales and longer time frames than ever before. This task requires analysis and planning at the level of landscape or larger scales, with most actions implemented locally.

This chapter reviews the biological basis of ERBC and describes goals and targets. We cover what makes ERBC unique relative to other large-scale conservation approaches, and we offer several text boxes containing primers on various aspects of ERBC.

Concepts

The issue of scale and conservation effect

Landscape level planning and action, exemplified by ecoregion-based conservation, is rapidly emerging as a necessary strategy for achieving massive conservation results and for linking human development opportunities to that which sustains life on Earth—biological diversity. Conservation strategies that are formulated at an ecoregion scale effectively address the fundamental goals of biodiversity conservation:

1. Represent all distinct natural communities within conservation landscapes and protected areas networks
2. Maintain ecological and evolutionary processes that create and sustain biodiversity
3. Maintain viable populations of species
4. Conserve blocks of natural habitat that are large enough to be resilient to large-scale stochastic and deterministic disturbances as well as to long-term changes
5. Prevent the introduction of invasive species and eradicate or control established invasive species (modified from Noss 1992)

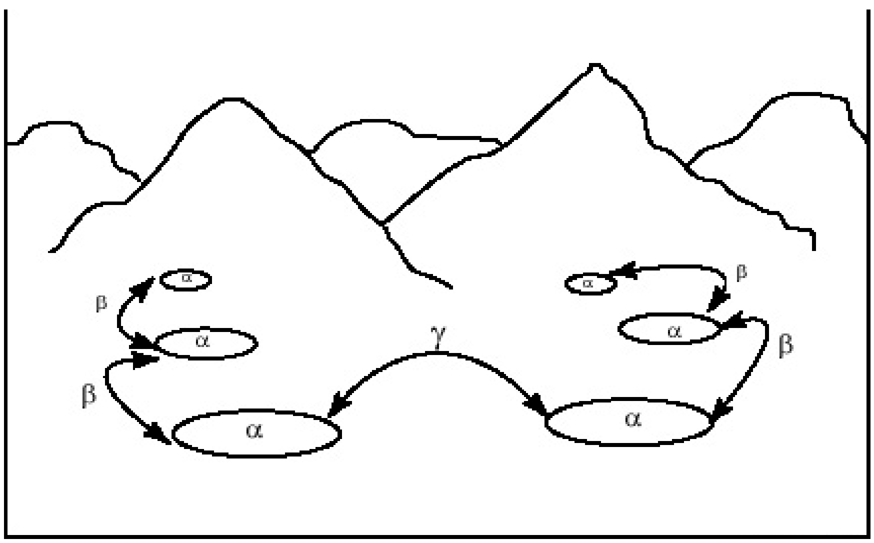
These goals have become widely adopted as the foundation of the science of conservation biology. Note that goals 2, 3 and 4 address conservation of processes as well as of species. These goals focus on such biological features as gene flow maintenance; local and hemispheric-scale animal migrations; predator-prey interactions; large herbivore and plant interactions, animal dispersal, and natural areas of sufficient size to accommodate natural disturbance regimes such as fires, floods, and hurricanes. The scales at which these processes operate require conservation planning and efforts at a landscape and ecoregion scale (see table 1.1).

The importance of scale for analyses

The traditional divisions of scale that are recognized in community and landscape ecology are relevant when thinking about ERBC methodology and approach. The following levels of scale are traditionally recognized by ecologists (see figure 1.1): global, continental, regional (epsilon); landscape (gamma); along a gradient (beta); and within a community (alpha) (see Whittaker 1977; Stoms and Estes 1993;) (refer also to chap. 4 discussion on beta-diversity). Alpha and beta level analyses provide data which allow distinctions to be made within an ecoregion.

The ERBC approach can be regarded as a global-continental scale analysis when ecoregions are being compared against each other and as landscape level analysis when analytical work is being conducted within ecoregions. Analyses of priorities within a single reserve or along an altitudinal gradient on a single mountain are typically at a smaller scale than ERBC. However, there are exceptions in some particular places (e.g., the Mount Cameroon ecoregion in Africa and some small isolated marine islands). Some of the problems of using different scales on the results of species-richness analyses have been presented elsewhere (Stoms 1992; Levin 1992).

We believe that the scale of ERBC is a compromise between large- and small-scale analyses. There are existing analyses at very large scales but the units of analyses cannot be easily applied for conservation planning (e.g., Gaston and Williams 1993; Williams and Gaston 1994). Moreover, although advocated as the ideal, the gathering of point locality data for all species at a very small scale (e.g., proposed by Frietag and Van Jaarsveld 1995) is impractical in many parts of the world and would take vast resources to complete.



α the species richness measured within a single habitat within a single geographic region (ecoregion)

β the turnover of species between habitats within the same geographic region (ecoregion)

γ the turnover of species between geographic regions (ecoregions)

Figure 1.1. The levels of scale traditionally recognized by ecologists. Gamma level analyses would help establish global priorities such as the Global 200. (Adapted and modified from Bond, W. J., 1991. The dynamic nature of biotic diversity. Pages 2-18 in B. Huntley, ed. Biotic Diversity in Southern Africa: concepts and conservation. Oxford University Press, Capetown.)

The ecoregion concept

What is an ecoregion? An ecoregion is a relatively large unit of land or water that contains a distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions. A terrestrial ecoregion is characterized by a dominant vegetation type, which is widely distributed—although not universally present—in the region and gives a unifying character to it. Because the dominant plant species provide most of the physical structure of terrestrial ecosystems, communities of animals also tend to have a unity or characteristic expression throughout the region.

Ecoregions are more suitable units for conservation planning because they

- correspond to the major driving ecological and evolutionary processes that create and maintain biodiversity;
- address the maintenance of populations of the species that need the largest areas, an element of biodiversity that cannot be accommodated at the site scale;
- encompass a logical set of biogeographically related communities for representation analyses; and
- enable us to determine the best places to invest conservation efforts and to better understand the role that specific projects can and should play in the conservation of biodiversity over the long term.

Finally, analyses and planning at these large scales provide the best basis for establishing conservation priorities. "Act locally, but think globally" is a useful motto because, although we invariably have to act locally, without thinking more broadly at global or regional scales, we lack a context (biological, social, and economic) for specific local actions that will produce long-term conservation benefits.

The easiest way to define a terrestrial ecoregion is to use an example. Here we select an ecoregion from the Global 200—the Terai-Duar Savannas and Grasslands of Nepal, India, and Bhutan (used also in table 1.1). The Terai-Duar Savannas and Grasslands are distributed along the flood plains of the major river systems at the base of the Himalayas. This area can be defined by distinct vegetation associations: These are the world's tallest grasslands, dominated by dense stands of elephant grasses (e.g., grasses in the genus *Saccharum*, *Erianthus* spp., *Narenga* spp., *Themeda* spp., and *Arundo* spp.). These habitats support a characteristic large vertebrate fauna (greater one-horned rhinoceros, hog deer, swamp deer, wild water buffalo, Asian elephant, pygmy hog, hispid hare). The highest densities of ungulates and tigers in Asia are also found in these grasslands. The entire ecoregion is under the strong influence of a southwest summer monsoon but there is a prevailing gradient with longer wetter monsoons in the east and shorter monsoons that are followed by more pronounced dry periods in the western part of the ecoregion. The alluvial soils are another characteristic feature. Ecological processes also help define the extent of the ecoregion: (a) predictable, annual, severe monsoon floods that are followed by periods of inundation maintain the structure of the grasslands by burying woody vegetation, recharging the grasslands by depositing large amounts of nutrient-rich silt from the Himalayas, and maintaining the high ungulate densities by providing lush forage year-round; (b) fires help maintain the structure of the grasslands by destroying tree seedlings not inundated by floods; and (c) browsing, trampling, and seed dispersal by dense populations of mega-herbivores shape the landscape. The adjacent ecoregions (Himalayan subtropical moist deciduous forests and Himalayan pine forests) consist of upland areas that are less affected by floods, underlain by stony soils, and are largely forested habitats. These ecoregions support much reduced numbers of large ungulates and predators.

Table 1.1. The relationship between scale of conservation effort and ability to address the five goals of biodiversity conservation

Scale of conservation effort	Typical area affected	Example	Is investment at this scale alone adequate to achieving five goals?
Community-based	1-2 villages; 10-20 km^2	Fuelwood plantations	No
Site-based	20-100 km^2	Buffer zone of Protected Area: forest fragment	No
Protected area	at 100-800 km^2	Royal Chitwan National Park, Nepal (932 km^2)	No
Landscape-scale	800-20,000 km^2 and larger	Chitwan-Parsa-Valmiki tiger Conservation Unit, Nepal and India	Yes, at upper end of range
Ecoregion-based	20,000-600,000 km^2	Terai-Duar savannas and grasslands, Nepal and India	Yes
Bioregion-scale	1,100,000 km^2	The remaining habitat of the Indian subcontinent	Yes
Continental	3,200,000 km^2	The remaining habitat of the Indo-Pacific region	Yes
Global	Planet Earth	Global 200	Yes

ERBC as a new paradigm for conservation

How does ecoregion-based conservation improve on current efforts to conserve biodiversity? First, the cornerstone of ERBC is a biodiversity vision that goes far beyond the current configuration of protected sites and management practices. To conserve the full range of biodiversity in most terrestrial ecoregions over the long run, conservation areas will need to be much larger and more numerous than what currently exists on the map today (see chap. 2, table 2.3). In addition to putting more natural habitat under protection, other related conservation activities—more sustainable use of natural resources, protection of watersheds, establishment of strong non-governmental organizations (NGOs), supportive legislation, and environmental education—need to be greatly expanded in scope and effort. Thus, in every ecoregion, we ask from a conservation perspective, What should the ecoregion look like 10, 20, and 50 years hence? This creation of a *biodiversity vision* highlights our commitment to the restoration of biologically valuable but degraded landscapes, strong legislation and enforcement programs that protect native biodiversity, and the nurturing of an ecoregion-wide conservation movement.

All of these actions take time to develop. Thus, the biodiversity vision requires us to plan conservation activities over larger spatial and longer temporal scales than in the past. To create a vision, conservationists are challenged to define what success looks like in the context of conserving an ecoregion's biodiversity in order to create a vision. This picture of success depends greatly on the biological assessment as it gets refined. Too often, we confine our efforts to protecting isolated sites rather than to developing a more far-reaching strategy for successful conservation at an ecoregion scale. Without the biodiversity vision, ERBC is only an incremental improvement over existing approaches. The creation of a vision and the implementation of an ecoregion conservation strategy depends on the active involvement of many: host governments, experts of many disciplines, local conservation groups, development organizations, and citizens of countries within an ecoregion. WWF's role will vary in each ecoregion and throughout the life of an ecoregion-based conservation initiative. In this workbook, we emphasize the contribution that the scientific community can play in developing rigorous biological assessments and creating ambitious biodiversity visions.

Second, ERBC highlights the conservation of ecological processes, important evolutionary phenomena, higher-order diversity (generic and familial), and rare habitat types as well as the more traditional taxonomic indicators of priority setting—species richness and endemism.

Third, in ERBC biological analyses, we highlight intact or near-intact large vertebrate assemblages as vital conservation targets because of their increasing rarity worldwide. Target areas and landscapes that support or, with moderate restoration efforts, could support assemblages of megafauna such as top predators, megaherbivores, and keystone species are identified. Top predators, such as jaguars, mountain lions, wolves, lions, tigers, and snow leopards, help to control native herbivore populations. Mega-herbivores, such as elephants, giraffes, hippos, and rhinoceroses, influence habitat structure through their trampling, browsing, and grazing. Keystone species sea otters, fig trees, or keystone herbivores such as beavers, bison, deer, and prairie dogs—are species whose removal or decline in an ecoregion would have a disproportionate negative effect on the persistence of other species. We also highlight the critical importance of less conspicuous invertebrates and diminutive vascular plants—the most abundant taxa in any terrestrial ecoregion.

Finally, a smaller goal of ERBC is to reduce overarching threats to biodiversity that operate over multiple areas within the ecoregion (and sometimes outside of an ecoregion) rather than to reduce these threats on a site-by-site basis.

Minimum conservation targets to achieve the goals of ecoregion-based conservation

The term biodiversity describes the full expression of life on the planet from genes to species to ecological interactions to whole ecosystems. The ERBC approach is designed to address the conservation requirements of the full experience of biodiversity; thus the fundamental goals of biodiversity conservation help shape the overarching vision for an ecoregion. Throughout this workbook, an emphasis is placed on representation, an idea with which you will become more familiar as we go through the chapters. Conservation professionals, unfortunately, cannot consider every element of biodiversity at the scale of an ecoregion; ERBC is likely to achieve only an estimated 70 percent representation, although it aims higher. In Chapter 11, we will present the concept of complementarity, which provides an added rigor to our selection of conservation targets. We mention it here to emphasize that the following conservation activities are the minimum targets we should aim for under ERBC. To be rigorous and effective in ERBC, we should focus conservation activities on five specific biodiversity targets:

1. ***Distinct communities, habitats, and species assemblages (distinct units of biodiversity).*** A primary conservation target is the representation of distinct biogeographic subregions, habitats, communities, and assemblages of species. Representation of specific assemblages may also be appropriate (see box 1.1 and 1.2). The particular combination of units to be represented in each ecoregion strategy will vary depending on (a) the distinguishing features of each ecoregion and (b) the availability and quality of information on patterns of biodiversity. We should strive to represent and conserve not only habitats but also the full diversity of species in each ecoregion.

2. ***Large expanses of intact habitats and intact biotas.***
Empirical studies demonstrate that large areas of intact natural habitat are best for conserving the full range of species, habitats, and natural processes. However, intact natural ecosystems and biotas are increasingly rare around the world. In particular, top predators and larger vertebrates are

disappearing rapidly in most ecoregions as human activities convert and fragment natural habitats and exterminate populations of vulnerable species through overexploitation.

3. ***Keystone ecosystems, habitats, species, or phenomena.***
At ecoregional scales, certain kinds of habitats may exert a powerful influence on biodiversity in surrounding habitats and across whole ecosystems. Their persistence and intact ecological functioning may be critical for many species and ecological processes in neighboring areas. For example, mangroves have strong ecological links to surrounding terrestrial, marine, and freshwater communities. Other keystone habitats include coral reefs, gallery forests in savannas, freshwater springs in deserts, and cloud forests that capture and regulate water for downstream ecosystems. Phenomena such as natural fires may also have a keystone role in maintaining species and communities. Some species, such as beavers and elephants, may also be viewed as keystone because of their strong influence on the structure and integrity of natural communities across whole ecoregions.

4. ***Large-scale ecological phenomena.***
The conservation of distinctive large-scale ecological processes, such as hemispheric-scale animal migrations, requires a combination of site-specific, regional, and policy-level efforts to be applied over vast continental areas or widely disjunct regions. Habitats or sites that may not be particularly distinctive (e.g., characterized by high richness or endemism) or intact may still act as critical habitats for migratory species. Conservation of such phenomena must be linked with ecoregion-level activities and coordinated among different ecoregions.

5. ***Species of special concern.***
Some species that are heavily hunted, depleted in numbers, or highly specialized in their habitat requirements run the risk of falling through the cracks of ERBC, a process which gives greater weight to representation than to single-species conservation efforts. However, in many ecoregions, targeted efforts to restore populations of sensitive species and their habitats are central to ERBC because these species serve as focal species for planning (see chap. 2).

We offer examples of applying the five conservation targets to two Global 200 ecoregions: The Chihuahuan Desert and Springs (box 1.1) and the Eastern Himalayas (box 1.2).

Box 1.1: Conservation targets for the Chihuahuan Desert and Springs

1. **Distinct communities, habitats, and assemblages**
   Representative examples of all distinct habitat types and species assemblages—ideally, over their full natural ranges of variation—are important conservation targets. Distinctive units include areas of extraordinary richness, endemism, higher taxonomic uniqueness, or unusual ecological or evolutionary phenomena. Some examples found in the Chihuahuan Desert are gypsum dune communities containing many local endemics, assemblages of endemic fish and invertebrates in desert springs, and distinct habitat types such as semidesert grasslands or montane chaparral.

2. **Large expanses of intact habitats and intact biotas**
   Chihuahuan examples of this target include areas of semidesert grasslands that still harbor prairie dog communities, pronghorn antelope, and intact floral communities. Other examples are intact pine-oak and chaparral habitats of some desert ranges and spring systems with their full complement of native species.

3. **Keystone ecosystems, habitats, species, or phenomena**
   At regional and local scales, certain habitats may exert a powerful influence on biodiversity in surrounding habitats and ecosystems. For example, riparian habitats or springs in the Chihuahuan Desert are vitally important for maintaining vertebrate populations in surrounding habitats. Riparian forests are also essential as feeding, shelter, and resting habitats for migratory songbirds and other species. Keystone species, such as larger mammalian predators (puma) and black-tailed prairie dogs, also have a strong influence on the structure and integrity of natural communities.

4. **Distinct large-scale ecological phenomena**
   The conservation of distinct large-scale ecological phenomena—long-distance migration of songbirds or the seasonal, transecoregion migrations of bats—are important targets that extend beyond the ecoregion. For example, conservation of flowering cacti across the ecoregion may be important for migratory bats. Habitats or sites that may not be particularly distinctive (e.g., high richness or endemism) or intact habitats may still act as critical habitat (steppingstones) for migratory species.

5. **Species of special concern**
   Depletion of populations of top predators is of serious concern in the Chihuahuan Desert. Mammalian predators along with aplomado falcons would be obvious targets for restoration efforts as part of ERBC. Hunters have depleted mammalian predators, and falconers have sought too many raptors. Highly specialized fish fauna that are threatened by invasions of alien species are another target for restoration (to be addressed in more detail in the freshwater workbook). Removal of cacti for the plant trade is a conservation concern that the ERBC team must address when designing the conservation plan.

Box 1.2 Conservation Targets for the Eastern Himalayas

1. Distinct communities, habitats, and assemblages

Distinct types of habitat that are important as targets include alluvial grasslands in the Terai-Duar savannas and grasslands; important wetland sites such as 20,000 Lakes (Nepal); mountain lakes such as Lake Rara or Tilicho Lake (Nepal); rhododendron forests in Bhutan, northeast India, and China; or larch forests in the Nepal Himalayas. Plant communities exhibiting high levels of endemism, such as isolated alpine valleys, are also good candidates. Thus, a target for ERBC would be to ensure that all natural habitats, assemblages, and communities are represented in a comprehensive conservation portfolio.

2. Large examples of intact habitats and intact biotas (e.g., intact vertebrate faunas)

The outer foothills of the Himalayas contain the highest densities of tigers and rhinoceroses on Earth, and the wild ungulate biomass in the alluvial grasslands rivals the large mammal assemblages native to the savannas of East Africa. The alpine and trans-Himalayan units of the Eastern Himalayas contain another rich and distinct large mammal community of montane ungulates that are preyed upon by snow leopards and wolves. One conservation target should be to establish large protected areas that can support and maintain viable populations of wide-ranging species and to link the core areas via corridors of natural habitats to create large protected area networks.

3. Keystone ecosystems, habitats, species, or phenomena

Many forested habitats in the middle hills of the Himalayan ecoregions protect watersheds that serve millions of people. The loss of forest cover in these habitats has dramatic downstream effects. At lower elevations, riparian habitats may be vitally important for maintaining vertebrate populations in surrounding habitats and acting as a natural source of flood control. Linkage habitats and migration corridors might also qualify as critical habitats for maintaining ecological processes. Seasonal bird migrations up and down the Himalayan massif are also highly distinctive. Degradation of the winter, summer, or the intervening staging areas of altitudinal migrants will threaten their survival. A conservation target would be to ensure that these critical ecosystems, habitats, and ecological phenomena are captured and included in a regional conservation strategy.

4. Distinct large-scale ecological phenomena

The conservation of distinctive large-scale ecological phenomena, such as long-distance migration of shorebirds, wading birds, waterfowl, or songbirds, spans whole ecoregions. Habitats or sites that may not be particularly distinctive (e.g., having high richness or endemism) or intact may still act as critical habitats for migratory species, for example, some breeding and wintering areas used by black-necked cranes. Maintaining these ecological phenomena should be included in ERBC plans.

5. Species of special concern

Even with conservation and restoration of their habitats, populations of tigers, bears, rhinoceroses, musk deer, and hornbills are in jeopardy because of poaching for the Chinese medicinal trade. Conservation plans must take into account strict protection of these populations. Similarly, populations of many medicinal plants may require more careful regulation to ensure sustainable extraction.

How does ERBC differ from Ecosystem Management?

ERBC is part of a worldwide effort to develop strategies on the spatial and temporal scales that account for ecological processes, which, in turn, determine the properties of ecosystems. The first approach that recognized the importance of planning at large spatial scales was termed Ecosystem Management (EM). EM was initiated as an effort to expand thinking beyond single species of concern and to focus also on their habitats and interactions among other species. ERBC builds upon the successes of EM by developing some key concepts more explicitly and incorporating them into long-term visions of conservation goals for an ecoregion.

The need for a biodiversity vision is the first and foremost key concept of ERBC. This vision requires that we analyze what the ecoregion must look like in 50 years to conserve its biodiversity and ecological processes. If anything separates EM from ERBC or ERBC from other approaches, it is our central goal of a vision to conserve the full expression of biodiversity of an ecoregion. To establish this ambitious vision, we strongly recommend using historical information to create a blueprint of the past prior to heavy disturbances by humans. EM also does not address looking clearly and logically at historical trends to conserve the full expression of biodiversity. EM focused on sustainable management of existing resources for human societies.

Second, ERBC is based explicitly on the five fundamental goals of biodiversity conservation, which have been widely accepted as the basis for conservation biology. EM does not use these goals as fundamental.

Third, ERBC sees core protected areas as the critical conservation targets whereas EM does not explicitly identify these areas as vitally important.

Fourth, ERBC addresses the overriding importance to represent all habitats and ecosystems in a network of protected areas. This fundamental goal of biodiversity conservation is perhaps the most important aspect of ERBC as practiced by WWF and The Nature Conservancy. Several of our ERBC workbook chapters focus on the central issue of representation. EM does not explicitly address this goal.

Finally, ERBC addresses the setting of minimum area requirements to maintain viable populations of wide-ranging or area-limited species or to maintain critical processes. This concept is fundamental in ERBC, but not in EM.

We need diverse tools to approach large-scale conservation. Each NGO and agency will want to develop an effective strategy by building on its own experience and those of others. We recommend that conducting large-scale conservation that is based on the principles of ERBC makes good biological sense. We can incorporate the best of the ecosystem approach into ERBC where rationalizing resource use with conservation takes priority, such as in buffer zones and multiple-use areas.

Steps to adjust thinking to the ecoregional level

To prepare yourself and your colleagues for ERBC, we suggest that you go through the following exercise.

1. List and review the outstanding biological features of your ecoregion and the overarching threats. This can be done at the orientation meeting (see chap. 2).
2. Ask the ERBC team biologists to organize the outstanding biological features under the five conservation targets listed in this chapter. We will revisit this list in chapter 4.
3. Review the current portfolio of field projects (of WWF and other NGOs or donors) in the ecoregion, if applicable. How do they relate to the five fundamental goals of ERBC and the five conservation targets?
4. In the context of ERBC, review the activities that you are currently pursuing to conserve biodiversity your area by answering the following questions:

    - What is the scale at which you plan your activities? Did you take into account boundaries that are ambitious enough to encapsulate fundamental large-scale ecological processes? If so, what are these boundaries?

- Were your field activities derived from a clearly articulated vision of what is required for the long-term conservation of biodiversity and ecological processes? Did you think and go beyond what is on the map today? State the vision briefly.
- Did your conservation plan explicitly address the four fundamental goals of ERBC (representation of all distinct natural communities, maintenance of viable populations of species, maintenance of ecological and evolutionary processes, and maintenance of resilience in the face of large-scale periodic disturbances)? If so, state how.
- Did you plan your activities on relatively large scales (greater than 1,000 km^2) and for more than isolated units such as national parks and buffer zones?
- Did you establish minimum levels of representation of species assemblages, habitats, and communities as a critical component of your conservation plan? List these levels of representation and identify gaps.
- Did you consider minimum habitat requirements for maintaining area-sensitive species, processes, and phenomena? What species, processes, and phenomena did you consider? Are there others that you have missed?
- Did you address connectivity between protected areas and other types of managed lands?
- Did you identify the need for restoration within your ecoregion? Do any projects involve restoration?
- Have you developed effective partnerships, particularly with biodiversity specialists and other NGOs, to help design landscape-scale projects and provide scientific peer review to your program?
- Did you identify the human activities that need alteration or termination because they are root causes of biodiversity loss (e.g., causing greater than 50 percent of habitat loss)?

If your answer to many of these questions is no, then likely, much of your planning efforts and fieldwork are at a finer geographic scale than that of the ecoregion. The goal of this workbook is to help you scale-up conservation efforts to the level that you can answer yes to all of these questions by the end of the ERBC planning process.

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THE BIODIVERSITY VISION: WHAT IS IT? WHY IS IT IMPORTANT? HOW DO WE GET STARTED? *2*

If you don't know where you are going, any road will take you there….

Introduction

The goal of ERBC is to conserve the full range of species, natural communities, habitats, and ecological processes that are characteristic of an ecoregion. The purpose of this chapter is to explain (a) the value of the biodiversity vision, (b) the process for creating a draft vision, and (c) key elements of the vision. This chapter may be the most important in the entire workbook. Please read it carefully and go through the visioning exercise at the end.

What is a biodiversity vision?

The key feature of ERBC is the clear articulation of a biodiversity vision that incorporates the full range of biological features, how they are currently distributed, how they may need to be restored, and how to safeguard them over the long term. A biodiversity vision is essential because it helps us to move beyond a business-as-usual approach to conservation. It serves as a touchstone to ensure that the biologically and ecologically important features remain the core conservation targets throughout the ERBC process. Even when we respond to local emergencies in the course of developing an ERBC program, a biodiversity vision provides a useful framework for interpreting threats to the integrity of the entire ecoregion rather than to individual sites. Without a vision, we lose sight of the overarching conservation targets, we have difficulty establishing priorities, and we waste scarce resources.

To be successful at ERBC, we need a vision of what we want the ecoregion to look like 50 years in the future. If ERBC in general forces us to consider larger spatial scales than before, it is the biodiversity vision in particular that requires us to consider much longer temporal scales than in the past. Getting the biodiversity vision right is a critical step in the process and makes the considerable investment in ERBC worthwhile. Securing active support for the vision setting is critical to the next steps in the ERBC process. Getting this support will be challenging and it will be ecoregion specific. When relevant government scientist or other influential experts are involved from the early stages of the process (as we will hear about later in this chapter), endorsement or ownership of the vision may be more likely.

Setting our sights high: The value of a biodiversity vision

To illustrate the visioning process, we first categorize approaches to conserving biodiversity under four main headings (fig. 2.1):

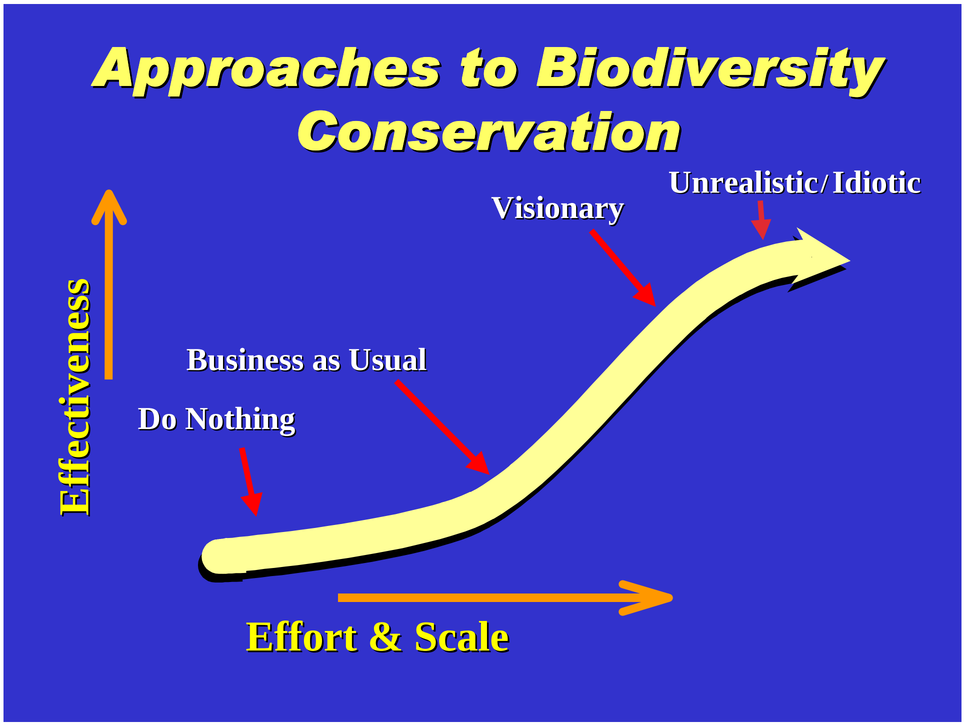


Figure 2.1. Approaches to biodiversity conservation

The first approach is to do nothing. If we do nothing in the face of threats to species, habitats, communities, and ecosystems, we know the result: extirpation of populations, extinction of species, loss of habitats and natural processes. In short, doing nothing will, with rare exceptions, allow current trends to lead to extensive loss of biodiversity. For a conservationist, that option is clearly untenable.

The second approach, business as usual, describes conservation interventions that rarely stray beyond treating isolated symptoms, even if these interventions do little to stem the overall decline of populations, species, and habitats. For example, consider the conservation effort on behalf of Amur or Siberian tigers in the mixed forests of the Russian Far East (RFE), a Global 200 ecoregion. The rapid decline in tigers in the RFE, a result of poaching for the medicinal trade, prompted the creation of antipoaching teams. The creation of these teams was an emergency response by the WWF network and its partners; it was an important and effective action to keep the number of tigers from dropping even further. In years past, however, our investment would have stopped at this point. But to restore the characteristic species (tigers and their prey) and processes (predator-prey interactions involving large carnivores) to this ecoregion, we had to take a more visionary approach. The elements of this approach included

- enforcing wildlife laws across the range to protect tigers and enforcing science-based hunting regulations to ensure an adequate prey base for the tiger
- reducing the demand for tiger products in consumer nations to reduce poaching pressure

- expanding existing reserves and creating new reserves to protect tigers and their habitat
- securing corridors and linkage areas to promote dispersal and connectivity among tiger habitats
- controlling logging of Korean pine and Mongolian oak, two tree species that produce seed crops that support the tiger's prey and many other vertebrates, and that may be the keystone species of the ecoregion
- integrating habitat requirements of tigers into landscape and ecoregion-scale conservation strategies
- determining the role of tigers as umbrellas for rare species and habitats given their now-truncated distribution in the Russian Far East

Dealing with these issues requires far greater effort than establishing a few antipoaching teams to maintain the short-term viability of the Amur tiger population.

Strategies or actions that are truly visionary change the course of conservation with a bold move that often requires strong political will and courage as well as a willingness to take some risks. These strategies also require thinking on larger spatial and temporal scales than communities, sites, or next year's work plan. Establishing a representative network of large protected areas in the Russian Far East—perhaps under the aegis of the WWF and World Bank Forest Alliance—is another example of a visionary step that would benefit many species and habitats within the ecoregion.

At the far end of the continuum, includes actions that are often viewed today as idealistic or idiocy—ideas or recommendations that are so far removed from the current reality they seem too foolish to be taken seriously. Return to our example in the Russian Far East (RFE). Establishing a network of interconnected tiger reserves covering large areas of Khabarovsk and Primorsky states in Russia may have seemed like idealism, or even idiocy in 1994 when it was first proposed (Krever et al. 1994). This recommendation came in the wake of political upheaval following the collapse of the Soviet Union and the bankruptcy of the strict nature reserve system. But the design of such a plan by Russian biologists and conservationists is now part of the ERBC vision in the RFE temperate forests and stands a good chance of being implemented (A. Kulikov, personal communication). Another example of visionary thinking in protecting biodiversity is the evolution of the national park system in Costa Rica (box 2.1). We recognize that, in addition to protected areas, many other tools to achieve biodiversity conservation exist. However, we believe protected areas are the cornerstone of biodiversity conservation.

We offer the paradigm in figure 2.1 and the two examples from Costa Rica and Russia to highlight three points. First, if we continue with business as usual in our approach to conserve biological diversity—planning mostly at isolated sites or communities—we will win battles here and there but are likely to lose the war (as is the case now). Second, ERBC offers an approach to biodiversity conservation that allows us to be truly visionary in the creation of conservation plans with a view to long-term biodiversity conservation. We are forced to think of the big picture and not accept what is on the current map as the limit to what can happen in an ecoregion.

Third, as we undertake ERBC, let us remember that ideas or initiatives that were once considered visionary but unachievable, or even idealistic, can soon become business as usual. Thus, conservationists should never be satisfied with the status quo—because we think that is all we can do—but should, instead, hope for and work towards goals on a grander horizon. What may seem hopeless now may become possible in a few year's time. We must always be prepared for the unexpected opportunity to occur. In the world of conservation, as in the world of politics, Berlin Walls do come down. Some other examples of visions once thought to be unachievable include

Box 2.1. Being visionary at the country scale: The example of Costa Rica

Figure 2.2. National Parks Coverage in 1970

Figure 2.3. National parks Coverage Today

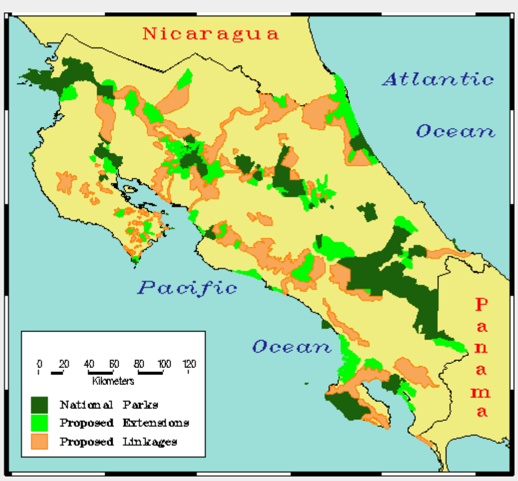


Figure 2.4. Proposed National Parks System

Costa Rica, currently considered one of the world's role models for biodiversity conservation, is also a superb example of the importance of being **visionary** even when the odds seem impossible. In 1970, Costa Rica was considered a hopeless case for biodiversity by all but a few visionary people. In fact, anyone who proposed a national park system comprising 10 percent of the country would have been considered **idealistic or idiotic**. The country had a growth rate of three percent, one of the highest in Latin America. It also had one of the highest deforestation rates in the world. There was only one recently established national park at that time (Fig. 2.2), an historic site that was overrun with cattle, belonging to people powerful enough to leave them in the park. Nearly everyone agreed that one national park of a few thousand hectares was as much as a small country like Costa Rica could be expected to achieve. However, visionaries were not deterred, and thanks to the leadership of a few, what was once considered idiotic is not **business as usual.**

Twelve percent of Costa Rica is protected in national parks and reserves (Figure 2.3). But, according to a recent gap analysis, the country's rich flora and fauna is still far from safe, and the need to be visionary is as strong as ever. That need has been recognized by many, including some in government, who today have helped to generate a National Biodiversity Conservation Plan that is truly visionary (Figure 2.4). That plan is probably considered just as idiotic (for the majority) as was the goal of protecting 10 percent of the country was in 1970. The lesson learned from the Costa Rica experience: Being visionary will always be a difficult but critical necessary activity for conservation planning.

- The President of Brazil's declaration to conserve 10 percent of the Brazilian Amazon in a network of protected areas that are representative of the basin's forest ecoregions
- The commitment to conserve 20 percent of the land area of Mongolia under formal protection by the year 2000, covering parts of three Global 200 ecoregions
- The ratification and implementation of legislation in Nepal to recycle 50 percent of all park revenues into local development activities in officially gazetted buffer zones rather than to return all funds to the Ministry of Finance, thereby linking economic development and biodiversity conservation in key reserves of the Eastern Himalayas ecoregion

Toward a draft biodiversity vision: Getting started

To initiate the ERBC process, you should first create a *Draft Biodiversity Vision.* (This can be a product of an initial phase, which brings together information, knowledge, and expertise.) To create this vision will require strong support for the ERBC process within the community of scientists who have expertise in the distribution of biodiversity in the ecoregion. Their knowledge of the area for which the biodiversity vision will be created and their support and promotion of the product are needed to achieve acceptance from the conservation community and governmental organizations that are ultimately responsible for implementation of the plan. You will want to engage these people in the planning process as early as possible.

Thus, if you are already knowledgeable about the ecoregion and its principle biological experts, it will be relatively easy for you to begin contacting those people and discussing with them the goals of ERBC and its methodology. If you are not already familiar with the ecoregion and do not know who the experts are, you will need to identify them and, again, initiate the process of contacting them and cultivating their interest in ERBC. Once they are in agreement, the assembled experts can help identify the activities that will be necessary to prepare for a full-scale experts workshop (chap. 4) and to secure their cooperation in the process.

Convening for an ERBC orientation meeting

To initiate the process of developing a draft biodiversity vision, you will need to convene an orientation planning meeting. The purpose of the meeting is to

- provide you with a quick analysis of the level of biogeographic knowledge of the ecoregion, relying on the experts identified earlier
- identify the outstanding and distinctive biodiversity features for the ecoregion that will be primary targets for conservation action
- produce or arrange for a set of preliminary analyses and products that will be used to assist the biological assessment and to accelerate the ERBC process
- determine the most appropriate type of biological assessment for the quality and quantity of biological data available for your ecoregion
- serve as a mechanism for educating the participants about the concepts and procedures of ERBC, and assemble a draft biodiversity vision to share with a larger group of stakeholders

Box 2.2 Hypothetical Conservation Actions and Targets for the High Plains Ecoregion

Quick Victories

- Develop a robust biodiversity vision that all stakeholders contribute and agree to as the approach for restoring the High Plains ecosystem
- Purchase ranches in Big Open landscape that address four goals:
  - a) enhance restoration of free-ranging bison
  - b) provide habitat for prairie dogs, mountain plover restoration, and for endangered black-footed ferret reintroduction
  - c) enhance connectivity between Charles M. Russell NWR and Fort Belknap Reservation
  - d) begin the process of restoration of mixed-grass prairie plant and animal communities under natural conditions
- Help finance restoration of free-ranging bison on Native American lands in the ecoregion
- Creation of a coalition of NGOs interested in restoration similar to Greater Yellowstone Coalition
- Assist current efforts by Native American tribes in the ecoregion to obtain congressional appropriation for wildlife conservation efforts on tribal lands.
- Help secure designation of and develop management policies for a national monument in the Missouri Breaks Bureau of Land Management land near Fort Belknap Reservation.
- Partner with American Rivers in the "Voyage of Recovery" for the Missouri River

1-10 Year Targets

- Through combination of public and tribal lands cooperation and private land purchases and easements, have at least one single block (or connected blocks) of 500,000 hectares (1.2 million acres) managed exclusively for High Plains biodiversity
- Five to six populations of free-ranging bison established in ecoregion
- Several populations of black-footed ferrets increasing
- Increased protection for black-tailed prairie dog populations
- Increased populations of breeding birds dependent on short-grass prairie
- Empowerment of Native American groups in restoration efforts through direct collaboration, training through Education for Nature (EFN), and ecotourism programs
- Organize Pennies-for-Planet Program to help recreate the American Serengeti where school children and classes become major stakeholders
- Encourage more natural management of bison
- End grazing subsidies for livestock
- Work with sympathetic ranchers on conservation easements**,** Public Lands Trusts, etc. to support their continued presence on the land as land-use shifts to supporting bison and away from cattle
- Make ecotourism the number-one currency earner in major portions of the ecoregion
- Capitalize on historical, (Lewis and Clark), emotional interest in ecoregion by enlisting writers and other artists to promote conservation of High Plains and to develop a national constituency
- Begin efforts to reintroduce large predators (at least wolves and perhaps grizzlies) in part of ecoregion
- Work with American Rivers and other groups to create more natural flows in the Missouri River and tributaries to restore native fish populations, fish-eating predators, and flood plain habitats

Long-Term Goals

- At least one free-ranging bison herd of 10,000-50,000 animals
- Removal of one or more dams on the Missouri River
- Viable High Plains grizzly bear population established (i.e., minimum number of 500 bears, with corridor to montane populations)
- Change local attitudes in part of ecoregion regarding reintroduction of large predators
- Change local attitudes in significant part of ecoregion in regards to black-tailed prairie dog colonies
- Shift view of High Plains as a place of exploitation to a place of restoration and spiritual and ecological healing
- Enlist large methane gas producers, coal mining companies, big agriculture to finance restoration
- Create a national park along Canadian border where bison and other wildlife can cross national boundaries as an example of a large mammal peace park.

Participants in the meeting should also strive to

- identify any overarching threats or pressures that need to be addressed immediately to create an entry point for targeted socioeconomic and political responses, and
- identify a few important conservation targets (areas or activities) where there is consensus on the need for immediate action

Particularly in ecoregions where WWF has been active for a while, the orientation meeting can be part of (or substitute for) what was formerly called the Reconnaissance Phase of ERBC. The last two meeting objectives above address two fundamental concerns about the ERBC process. By identifying overarching threats or pressures at the orientation meeting, the linkages between the biological and socioeconomic analyses begin to be elucidated. If socioeconomic information and perspectives are introduced into the process at the outset, social scientists can set to work collecting relevant data and conducting analyses based on identified biodiversity targets. If, by consensus, the meeting participants identify a few obvious conservation targets, then they can answer the often asked question, Does conservation action have to wait until the ERBC planning process is completed? by creating a small portfolio of activities to pursue immediately.

We suggest that the group consists of (a) 5 to 15 biologists (depending on the size and complexity of the ecoregion) who together offer a broad if not encyclopedic knowledge of the biodiversity of the ecoregion, and (b) a few key sociologists, economists, and political scientists who are knowledgeable about the ecoregion. We also strongly recommend that, in developing the draft vision, you include, when relevant, the views of indigenous peoples. For example, during an informal visioning exercise for the Bering Sea, a Global 200 ecoregion, a Native American spoke of a time 40 years ago. "My grandparents took me to the fall duck hunting grounds as a child. When we arrived, clouds of eider ducks erupted from the marshes, darkening the sky." Is an important element of the vision, or even part of the benchmark for the Bering Sea ecoregion to return waterfowl populations to the sizes observed four decades ago? In the case of the Bering Sea, indigenous peoples were important archivists of what the ecoregion was like when wildlife populations and processes fluctuated within their natural range of variation. In considering which indigenous participants to involve in your process, try to identify those with the level of knowledge, influence or importance that can contribute to the orientation meeting.

Whose vision is it?

Another important aspect of including a diverse group of knowledgeable and sympathetic stakeholders at the orientation meeting is to answer the question, Whose vision is it? Biodiversity visions should never be seen as the WWF vision but, rather, as a biodiversity vision that is endorsed by the ecoregion's conservation community with the backing of the most respected scientists working in the region. The consensus approach lends legitimacy to the vision. But WWF staff who are facilitating the workshop should keep in mind two key points. First, the orientation meeting must not devolve into a management plan meeting and must stay focused on the future of biodiversity conservation. Second, we must remember that despite the diverse group of stakeholders invited, they represent only one species—Homo sapiens. WWF staff must also represent the needs of the many millions of species who reside in that ecoregion but have no voice for their own future. As a conservation organization, we must ensure that the consensus vision focuses on their long-term survival.

Meeting products

During the orientation meeting, you should compile a list of activities, such as database and map preparations, that must be completed in preparation for the experts workshop to follow. The meeting should also be used as a forum to evaluate any previous biological assessments that have been completed in the ecoregion. You will want to determine to what degree the biodiversity vision can be constructed from existing reports and how much additional material will need to be generated through the synthesis of existing sources and field analyses. One component of this task is to review, where appropriate, Biodiversity Action Plans, National Conservation Strategies, and other NGO-generated strategies to determine how visionary these documents truly are. If they are not visionary, you will need to think about how to garner support for the draft vision without diminishing the importance of work that has gone before. Another component of the evaluation will be to evaluate previous priority-setting exercises for the country or countries included in the ecoregion. (See the end of this chapter for more details on assessing previous priority-setting efforts.) Finally, the meeting should be used to help define success in terms of protected (restored) biodiversity and its distribution in the ecoregion.

The preliminary meeting should be organized to produce the following products:

- a preliminary resolution of boundary issues (ecoregion and biogeographic subregions)
- a consensus on what are the outstanding processes and characteristics of the ecoregion that will need to be considered to establish the conservation goals and achieve success
- a list of focal species and ecological processes that can be used to decide minimum area requirements for conserving biodiversity
- a short list of specific threats or pressures and areas that should be top conservation priorities in the ecoregion
- a list of tasks that must be completed in preparation for the biological assessment (e.g., compilation of biodiversity data, analysis of focal species data, preparation of maps, etc.)
- an outline of a draft biodiversity vision to be completed and circulated for peer review soon after the meeting
- Identification of priority stakeholder groups who should be engaged in dialogue and information sharing leading up to the workshop

What type of biological assessment is appropriate for my ecoregion to refine the draft biodiversity vision?

Another major purpose of the orientation meeting is to assess the status of information in the ecoregion to determine which methodology should be used for the biological assessment. In the process of applying ERBC to priority ecoregions identified by WWF, we have recognized that three basic tracks are available for the assessment process (fig. 2.5). Perhaps the best way to decide which option is the best for you is to contact several biogeographers, taxonomists, and ecologists who have extensive knowledge of

Where data are not available in publications but are partially available in unpublished formats that are housed with taxonomic experts, you should be able to take the second approach of using the experts to identify conservation priorities. This methodology of convening a workshop of experts and having them identify areas of high species richness and endemism was used for the Chihuahuan Desert ecoregion and is fully documented in this workbook (chap. 3 and 4).

While these two tracks should cover the majority of ecoregions, there remains a final group of terrestrial ecoregions where biodiversity information is insufficient (even among scientists who are experts in the ecoregion) to identify specific conservation priorities. Examples include the Southwest Amazon moist forests and the Congo Basin moist forests. For these ecoregions, we are developing a method that involves focused sampling, and then predictive modeling of biodiversity within the ecoregion. We have found that, even in these data poor ecoregions, sufficient expertise exists to delineate biogeographic subregions that can then be used as the first cut for representation of biodiversity. Again, further delineation of conservation priorities within each of the subregions will depend on systematic selective sampling that can be used to predict patterns of biodiversity.

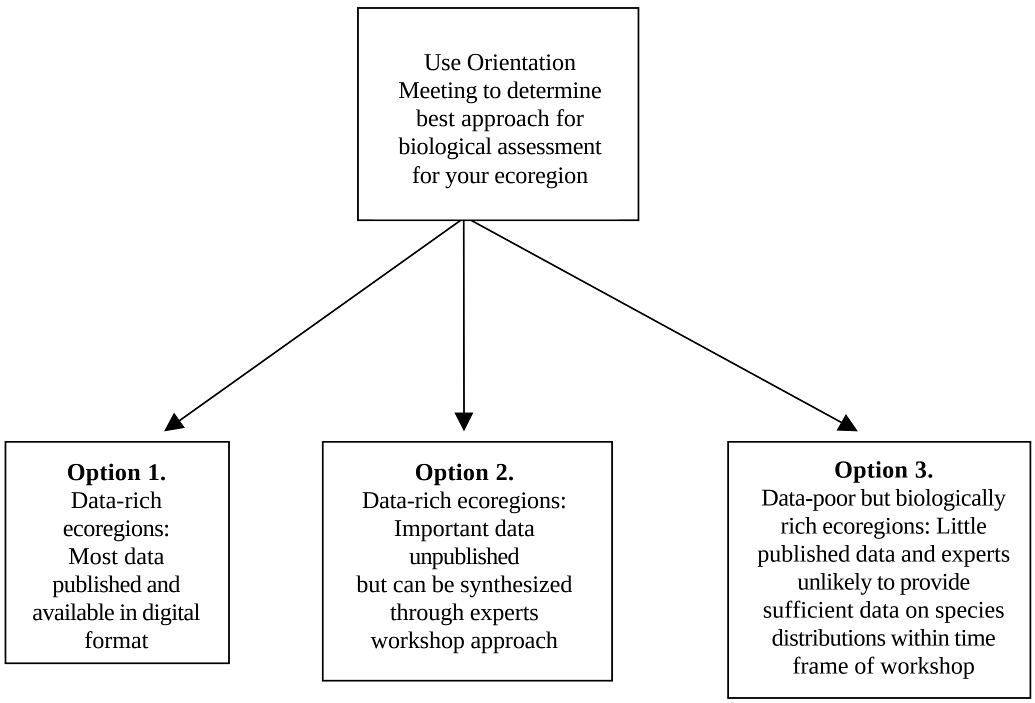


Fig. 2.5. Possible approaches to conducting a biological assessment *[1]

For ecoregions that are rich in published data, the best approach is to follow the model developed by the Conservation Biology Institute (with support from WWF) for the Klamath-Siskiyou ecoregion. This approach draws heavily on computer synthesis of digitized data and requires detailed information on species distributions. Other examples might be models for the Galapagos Islands terrestrial ecoregion, the Valdivian forest of the Chilean temperate zone, the New Caledonia dry forests, and the Fynbos of South Africa, where published digital data are sufficient to use a computer-based approach. If you decide to take this track, the Conservation Science Program of WWF can help you identify literature and experts to guide you through the process.

*[1] There are likely to be other tracks/options such as data poor, high political discord (war) as in some Africa nations. This does not allow access to in-country expertise. These are not treated here.

Doing your biological homework

Developing a draft biodiversity vision requires knowledge of several basic biological features:

- A general understanding of the outstanding biological features of the ecoregion—distribution, relative abundance, or area of influence (for processes), all developed into a conservation targets chart
- The original distribution of the native plant communities of the ecoregion
- The dynamics that influence habitat composition, the prominent disturbance regimes, and processes that sustain biodiversity
- Distributional patterns of species that, although limited today, may have been more extensive
- The demography (the size of populations and their trajectory) of important species (focal species) found within the ecoregion
- The presence of any important phenomena that formerly occurred (see checklist in next section) such as animal migrations or concentrations of breeding individuals
- Concentrations of species with localized ranges

As you begin to gather the data and necessary scientific expertise, you need to establish a baseline against which to judge options and define success. There is no simple way to determine the most appropriate baseline against which to develop a biological vision for an ecoregion and to judge what success would look like. Nevertheless, posing the following questions will help focus your attention on the key factors that should influence your decision.

- What did the ecoregion look like prior to anthropogenic influences that led to widespread land-use change?
- At what point in time did wildlife populations and ecological processes operate more or less naturally?
- How well can you determine when, how, and to what extent humans have heavily modified the ecoregion?

For example, in North America, the state of the ecoregion when Europeans first arrived is likely to be a useful baseline even though Amerindians did alter ecosystems substantially. Because the extinctions of the megafauna that the original hunting cultures caused are irreversible, it is impossible to recreate the ecosystems that existed in North America 10,000 years ago. Moreover, at that time, the climate was dramatically different from that of today. Thus, estimating what North America looked like when Europeans arrived and supplementing that with the knowledge of the role of human-caused fires on the vegetation is probably the best baseline to use.

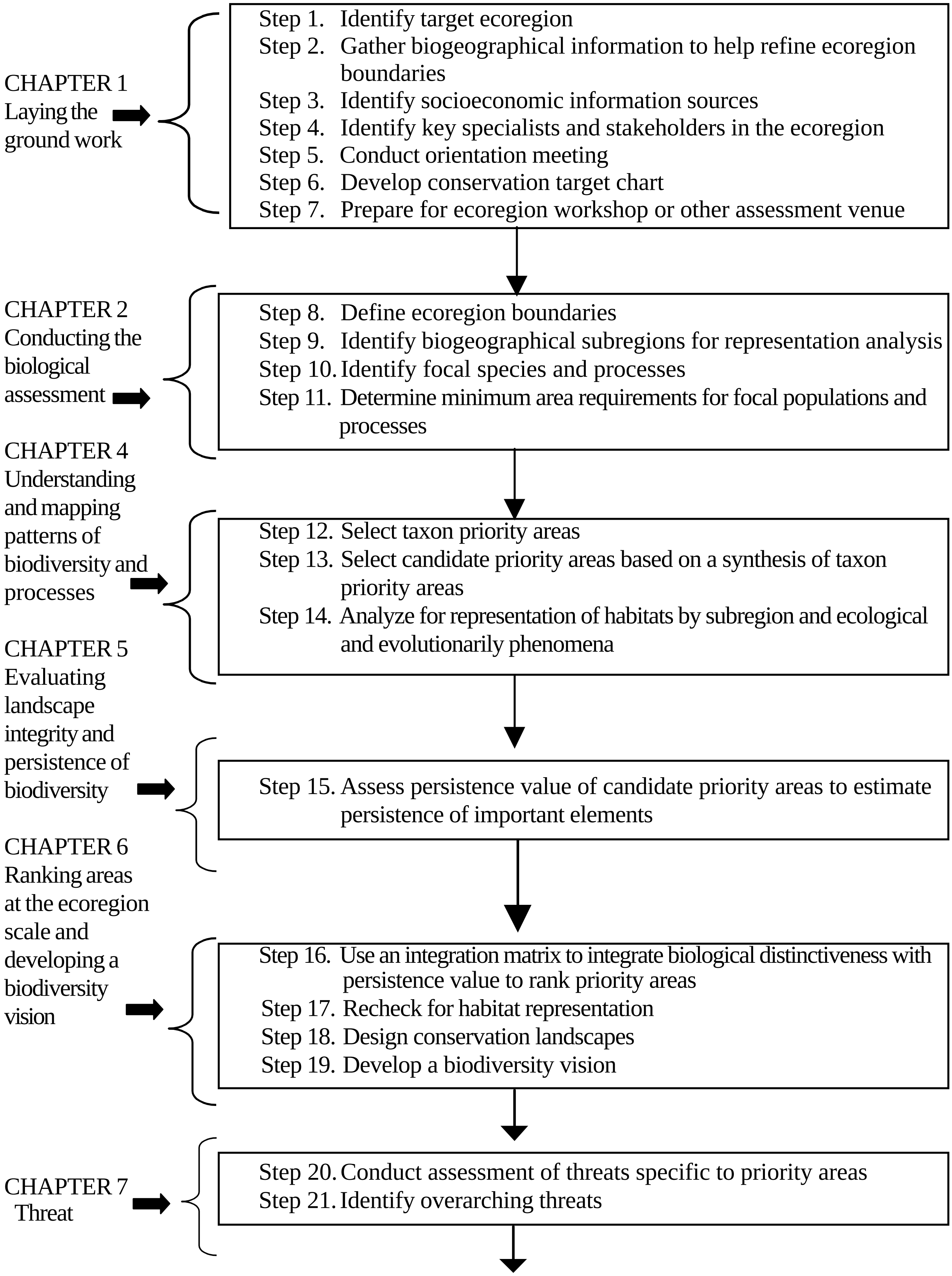
In contrast, the baseline for the Galapagos Islands' terrestrial and marine ecoregions was set (during the experts workshop in June 1999) at the year 1535 when the islands were first discovered by explorers and, presumably, when the first introductions of invasive species by humans occurred. In other areas of the world, especially in places where humans have modified landscapes for much longer time periods, potential baselines will be more difficult to determine.

In general, the rule of thumb is to aim for long-term persistence of all extant species, communities, ecological phenomena with distributions and abundances within their natural ranges of variation. Where possible, restoration of extirpated or diminished species may also be a long-term goal.

An overview of the vision process to share with participants at the orientation meeting

The vision process can be broken down and visualized as a set of sequential steps that are described in detail in the corresponding chapters of this workbook (see fig. 2.6).

Figure 2.6. Flow chart identifying steps in developing a biodiversity vision



CHAPTER 8
Final write-up and peer review ➡

Step 22.	Develop outline for assessment document, products (reports, CDs, maps, website), peer review and outreach strategy
Step 23.	Develop format for describing priority areas
Step 24.	Develop an adaptive implementation strategy

Steps to be completed during or soon after the orientation meeting

In the remainder of this chapter, we cover the first five steps of the vision process. These must be completed prior to a biological assessment workshop, and they will be needed to produce the draft biodiversity vision.

Step 1. Define the ecoregion boundaries.

The first task on the agenda will be to attain agreement on the boundaries of the ecoregion. The group should discuss what fundamental characteristics or processes set the ecoregion apart from neighboring ecoregions, identify the geographic limits of those characteristics, and use those limits to set the boundaries. For example, a savanna ecoregion would use the limits of the grass-dominated community to set the ecoregional boundary. However, most ecoregions rarely include sharp boundaries to delineate them, so decisions will depend on a consensus of the assembled experts.

Besides purely ecological considerations, you will need to consider the capacity of your organization or partners to develop the conservation strategy and implement actions. This consideration is especially important if you are dealing with a Global 200 ecoregion that is an agglomeration of several regional ecoregions (see box 2.2 and a list of combined ecoregions in annex 1). For an agglomerated unit, you should decide on the scale of your programmatic interests and capacity. Can your program handle the tasks that come with planning across several ecoregions that merge for good biological resources, or should you choose some of the more important component ecoregions? The recommendation is to consider the agglomeration, if possible, because the agglomeration was created for its conservation importance and ecological links.

The regional-scale ecoregion assessment maps, which provide the basis for the ecoregion boundaries, were undertaken at coarse scales of resolution. During the orientation meeting, these boundaries should be reviewed and, where necessary, refined. You can use the actual biological assessment workshop to obtain a larger buy-in for the delineation of the ecoregion. However, we learned from experience during the Chihuahuan Desert Ecoregion workshop that you may lose precious time engaging in detailed discussion on ecoregion boundaries. These are often difficult to resolve in a workshop setting, it may be that a large fraction of the participants may find this level of detail tedious and distracting. We therefore urge you to resolve boundary issues as best as is possible beforehand. Major revisions can be addressed at workshops, but we typically try to document minor revisions for later work. Areas outside of the ecoregion that harbor characteristic biodiversity of the ecoregion are often recommended in workshops to be included in the analysis.

It is important to have the ecoregion team, conservation partners, and collaborating experts understand and agree on the terms used for different scale units (Fig. 2.7). The scale of subregions, areas, and sites will vary somewhat among ecoregions with different patterns of biodiversity and degrees of intactness.

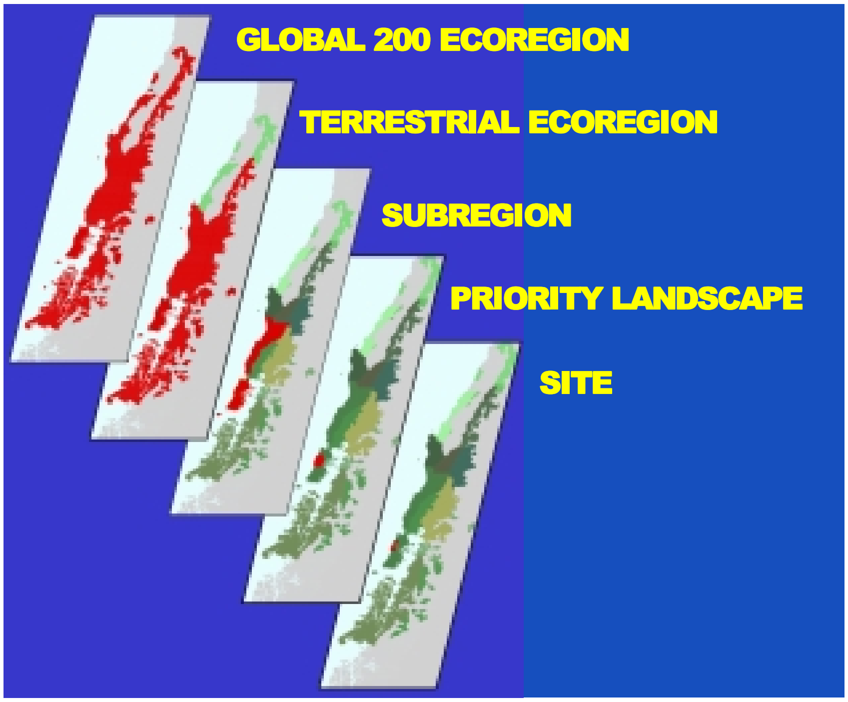


Figure 2.7. Variation in biogeographic scales from Global 200 units to sites in the Valdivian temperate rainforest ecoregion of central Chile

Step 2. Identify biogeographic subregions.

Once you have reached agreement on the ecoregion boundaries, you may want to consider dividing the ecoregion into biogeographic subregions (box 2.2). Most ecoregions are sufficiently large and biologically complex to justify dividing them further. Subregional classifications ease conducting a representation analysis in two important ways (chap. 4). First, they can serve as proxies for achieving full representation of biodiversity in ecoregions where there is insufficient biogeographical data does not allow you to accurately map distinct assemblages of species. Second, by ensuring that you have representation of all habitats in each subregion, they serve as a proxy for a beta-diversity analysis (beta-diversity, turnover of species along environmental gradients or with distance, is covered in chapter 4).

The group of experts at the orientation meeting, on the basis of their cumulative experiences in the area, will likely have a feel for how subregions should be delineated . They may identify subregions on the basis of key taxonomic groups such as primates, which are relatively well known, or on the basis of soil or distinct topographical characteristics, which are typically associated with high beta-diversity. During the orientation meeting, the experts should be provided with large format maps, annotated with as much vegetation data as is available, that will allow them to mark their proposed subregions. Typically, subregions are on the order of 100,000-200,000 km^2, or about 15-25 percent of the size of the individual ecoregions. Ecoregions are typically divided into about three to seven subregions.

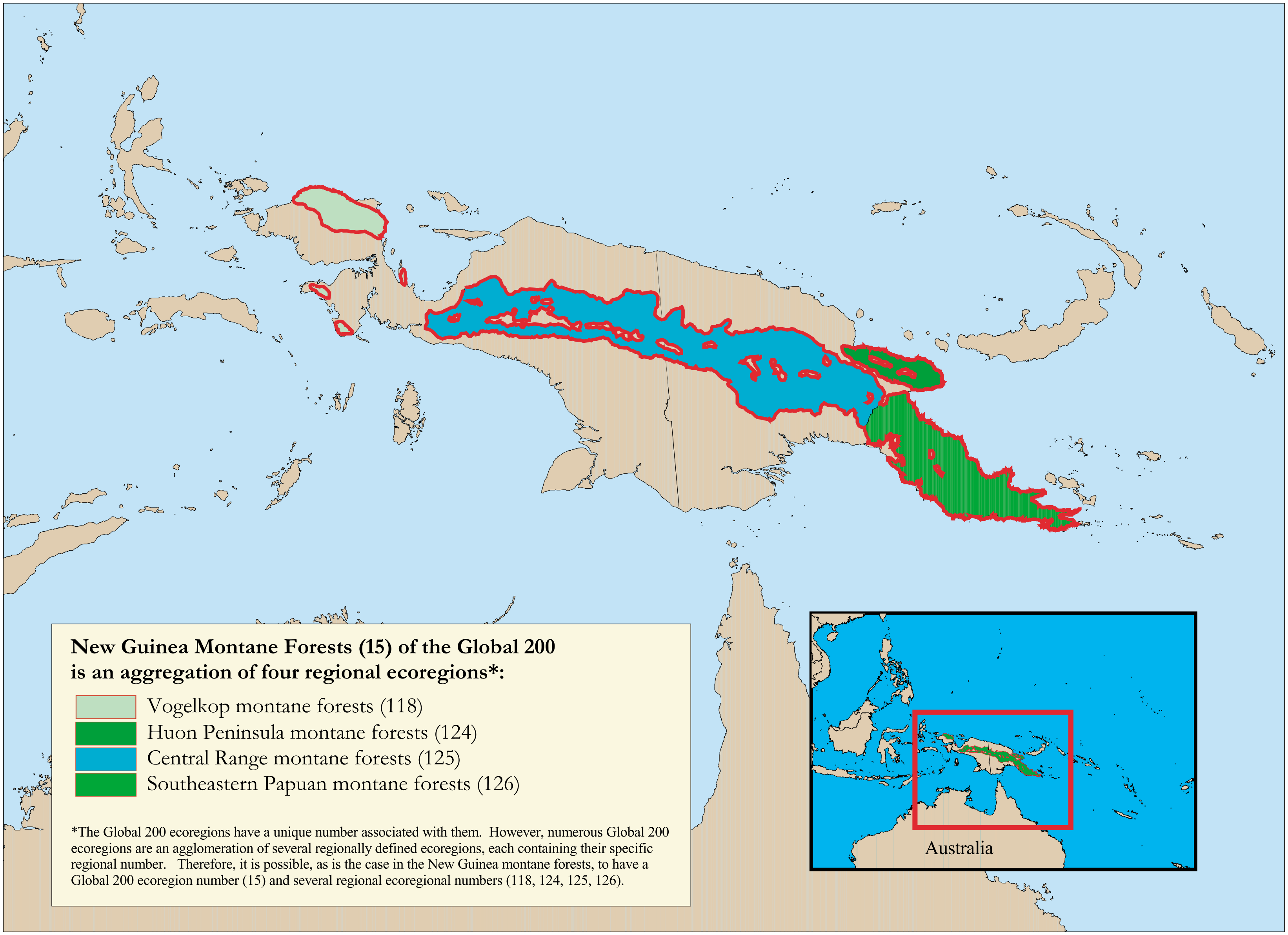


Figure 2.8. The New Guinea montane forests (15) ecoregion delineated in the Global 200 comprises four individual ecoregions, as identified in the Asia-Pacific's regional assessment

Box 2.3. Terrestrial ecoregions, the Global 200 ecoregions, and Global 200 complexes

The Conservation Science Program of WWF-US recently completed a terrestrial ecoregion map of the world delineating 895 ecoregions (Olson et al. in preparation). This map is the result of six years of work to map ecoregion boundaries across all of the continents and biogeographic realms. It was developed in consultation with hundreds of regional experts. This map is now available for the entire globe and is broken down by region (e.g., Latin America and the Caribbean, Africa and Madagascar, etc.). You should consult these maps to determine the boundaries of your ecoregion.

Whereas the map of terrestrial ecoregions of the world depicts all 872 ecoregions, the Global 200 ecoregions are a subset of them, totaling 142 in number. Fifty of the 142 terrestrial Global 200 ecoregions are identical in area to ecoregions that are portrayed on the regional maps or on the ecoregion map of the world. Another 36 were formed when two regional-scale ecoregions were joined together to form a Global 200 ecoregion complex (see annex 1). The remaining 50 terrestrial Global 200 ecoregions consist of agglomerations of several high-priority adjacentv ecoregions with strong biogeographic affinities.

We use the island of New Guinea as an example of one such agglomeration (fig. 2.8). On the Global 200 map, the New Guinea montane forests form a spine across the entire length of the island. The forests in this ecoregion are extensive areas at least 1,000 m above sea level—a defining feature of tropical montane forests. Most importantly, they harbor in many species that live in rather narrow ranges because of dispersal barriers created by steep topography. This overall pattern of endemism along with similar dynamics and environmental conditions justify treating the mountain chain as a single unit at the scale of the Global 200. But at finer scales—such as for our analysis of biodiversity of the Indo-Pacific region (Wikramanayake et al. in preparation) or for a biodiversity assessment of New Guinea ecoregion—we would want to subdivide the montane forests into the four biogeographic subdivisions to ensure representation of each. This finer classification is based on the distribution of endemic birds, mammals, and plants that are restricted to certain parts of the range and on the high rate of turnover of species along the chain.

The point of this section is to clarify the biogeographic target for your ERBC effort. We strongly urge that when developing a conservation strategy, you do so for the entire Global 200 ecoregion, even if, as in the case of the New Guinea montane forests, it consists of more than one ecoregion at the regional scale. We also recommend that you consider biological interactions with adjacent ecoregions as you develop ERBC assessments.

If your Global 200 ecoregion consists of several ecoregions joined together, you will want to consider the component ecoregions as the first level of biogeographic subregions (see box 2.3). Within these component ecoregions themselves, subregions should be established to capture major trends in beta-diversity. Once there is agreement on the subregions, you will be able to digitize them and create a map of draft subregions which you can circulate among experts or present at the full expert workshop.

Step 3. Identify focal species and processes for establishing minimum area requirements and identifying special elements

Concepts

What is a focal species or process?

In line with the primary ERBC objective to conserve all biodiversity, we must determine how much area must be maintained in each habitat to support minimum viable populations of all species. It is important because focal species and processes will be the first biodiversity elements to disappear as habitat and natural conditions are shifted away from their pristine state. This is a conceptually simple goal that is exceedingly difficult to convert into practice. First, no one really knows how many individuals of a species are required to constitute a minimum viable population; we have only rough estimates. Second, for most species, we have no idea how much space they need, so we cannot derive an estimate of their minimum area requirements. In the absence of these critical data, conservation biologists use focal species as proxies to effectively cover area requirements for all other species. The term focal species has been used elsewhere in a broader context to include flagship and economically valuable species.

Species that are selected as focal species are generally wide-ranging or area-sensitive species that because of certain life-history traits—such as specialized diets or breeding requirements—depend on large areas to maintain viable populations. Examples include large carnivores, megaherbivores (elephants, rhinoceros, hippopotamus, and giraffes), raptors such as harpy eagles, giant river otters, large frugivorous birds (hornbills and macaws), African wild dogs, and a host of other species that cannot be maintained in small isolated habitat fragments. These focal species often make the best proxies for establishing minimum areas to protect other species resident in the area. We assume that maintaining viable populations of these focal species serves as an important proxy for maintaining ecologically healthy conditions in the ecosystem as a whole.

As a guide, we have tentatively selected focal species for a sample of 25 terrestrial focal ecoregions (annex 4). Please consider this list as a starting point and feel free to substitute other species that may be more appropriate or for which more data exists. It is important to produce a tentative list of focal species at the orientation meeting because, likely, the spatial requirements of species that are suspected to be area sensitive will not be immediately available. Rather, you will need to extensively search the literature and contact experts to glean sufficient information to make even preliminary conclusions about the area requirements of these species. Sufficient information probably will be unavailable for many, of the proposed focal species. Thus, it will be necessary to make educated guesses regarding area requirements while, at the same time, designing field research to generate the spatial use data needed to verify and refine the educated guesses.

To select a focal species, enough must be known about the organism's natural history to identify an attribute that makes it appropriate for indicating minimum landscape requirements (box 2.4). Unfortunately, many candidate species will be eliminated because we simply do not know enough about them. In general, the most useful focal species tend to be large predatory species that generally require extensive home ranges (and because of their charismatic nature, have been relatively well studied). Often, specialized frugivores that depend on patchily distributed food sources are also candidate focal species.

Identifying outstanding processes and characteristics of your ecoregion

To prepare a draft biodiversity vision, you must identify the ecological characteristics or processes of the ecoregion that elevate it as globally important. These should be the primary focus of the assessment. The group of experts at the orientation meeting will be able to provide invaluable insight into which of these aspects of the ecoregion are most appropriate. Critical processes are defined as ecological processes that are important for maintaining ecosystem integrity (e.g., representative species and habitats, long-term persistence and resiliency). In some ecoregions, maintaining critical processes may be more important than conserving local hotspots of species richness. Classic examples are ecoregions that are categorized as flooded grasslands (e.g., the Everglades, Okavango, Pantanal), where maintenance of the hydrological flow regime is more important to conserving the biodiversity of the ecoregion than are all other possible interventions combined.

Other examples of critical processes are predator-prey relationships, pollination and seed or fruit dispersal relationships, altitudinal movements and migrations, fires in fire-maintained habitats, flood cycles, gap dynamics, fire or storm refuge for animal populations, etc. Even in species-rich environments, such as tropical moist forests, the conservation of critical processes is of fundamental importance. As an example, hornbills play a critical role in fruit dispersal in tropical moist forests of Asia. However, hornbills require mature trees for nesting. If logging operations remove nesting trees, the hornbill populations will be affected as will fruit dispersal and forest regeneration. Clearly, conservation of processes and species are not mutually exclusive. However, it is important to consider processes to ensure that interactions are part of the visionary thinking (see chap. 5).

The shape, configuration, and size of habitat blocks are important determinants of persistence in the face of natural disturbance events. Generally, large habitat blocks are better able to survive perturbations, and more circular habitat blocks are better able to resist edge effects than narrow, elongated blocks. And, all else being equal, habitat blocks that are closer to each other and that have the potential to be linked have greater conservation potential than do isolated habitat blocks. Maintaining the integrity of whole watersheds is a step in this direction and should be an element of the draft vision.

These characteristics should be considered when evaluating habitat blocks for their potential to survive natural and anthropogenic effects. However, different habitat types have different survival abilities and resistance levels. For instance, tropical dry forests can survive and regenerate after fires better than can tropical moist forests. The critical processes and the requirements for maintaining these processes in each ecoregion must be identified by experts.

Box 2.3. Attributes of focal species for ERBC (note that a focal species may meet more than one criterion)

Characteristics
- High demand for space, wide-ranging
- Seasonal/daily population concentration
- Limited dispersal ability
- Low reproductivity or fecundity
- Large body or largest member of feeding guild
- Specialized dietary, habitat requirements
- Reproductive specialization
- Dependence on rare, widely dispersed habitat
- Climatic sensitivity

Population Status
- Small or declining population
- Metapopulations with unique genetic compositions

Human-Effect Factors
- Population threatened by direct exploitation, harassment, or ecological interactions
- Habitat threatened by loss, conversion, degradation, or fragmentation
(Source: Breazley 1998, unpublished document)

Focal habitat types

Focal habitat types represent yet another indicator for determining minimum area requirements for ERBC. Examples of *focal habitat types* include

- riparian habitats
- mangroves
- cloud forests
- old-growth forests
- landscape matrices of different successional phases maintained by natural fire regimes

Ensuring that large enough areas of these habitats are set aside is an important part of ERBC.

Step 4. Determine minimum area requirements for viable populations and processes.

Estimating area and habitat requirements of focal species

Once the focal species have been selected, an estimate of the minimum area requirements should be derived. This process will consist of taking the best estimate of area requirements of a single individual and multiplying by the theoretically accepted values for long-term persistence. However, no one really knows exactly how large a population must be to ensure its long-term persistence without the loss of genetic variability. Soulé (1987) proposes, *"What is the lowest MVP (minimum viable population) that one might expect for a vertebrate? Here, I am assuming a 95 percent expectation of persistence, without loss of fitness, for several centuries. My guess would be in the low thousands. Regarding observation, there isn't a lot of data, but it appears that populations with carrying capacities much smaller than this don't persist for very long except, perhaps in very constant environments, and even then will lose most of their variation."*

Another way to arrive at this figure of several thousand individuals is to consider that a minimum viable population of large vertebrates must consist of about 500 breeding individuals to maintain genetic variability. Those actively breeding individuals make up the *effective population* (sometimes written as N_e), which is usually about 10 to 20 percent of the entire population. Those approximations suggest a rough figure of 2,500 to 5,000 individuals that are required for a population expected to persist with its full complement of genetic variability over the long run. The next step will be to calculate the area that is required to sustain a viable population of up to 3,000 individuals of the focal species. We have inserted a worksheet (table 2.1) in the following Application section to help with that procedure.

Application

A. Focal Species

Included here is a worksheet format to list and identify focal species' range requirements (table 2.1). However, this worksheet is an approximation and should be used only as a guideline. Recognize also that these population goals are intended for survival for a 100-year time frame. In many cases, you may be need to consider intermediate goals of substantially smaller populations that can subsist for decades while the underpinnings for the very long-term goals (likely involving substantial habitat restoration) can be realized. However, do not to lose sight of the fact that what seem to be hopelessly large MVPs are necessary for conservation in perpetuity. Although they may seem like idiocy now, if we are successful in implementing the vision of ERBC, they can become business as usual for our grandchildren's children. Furthermore, remember that you have selected this species as an umbrella for as many as thousands of others that you know little or even nothing about (if they are among the many undescribed species). Thus, making too many sacrifices at this point runs the risk of negating the concept of the focal (umbrella) species.

1. Select as many focal species as expert opinion determines. (We suggest that conservation biologists and ecologists who are familiar with the ecoregion or ecoregions be consulted to identify focal species, either through the orientation meeting or through a commissioned series of research papers.)

2. Once the focal species have been selected, derive an estimate of the minimum area requirements by taking the best estimate of area requirements of a single reproductive unit and multiplyingby the

theoretically accepted values for short-term persistence (50 breeding units), long-termpersistence (3,000 individuals), and short-term source pools (populations of only 10 individuals).

3. Included here is a worksheet format to list and identify focal species' range requirements (Table 2.1). However, this is an approximation, and should be used only as a guideline. It is also important to recognize that these population goals are intended for survival for a 100-year time frame. In many cases, it may be necessary to consider intermediate goals of substantially smaller populations that can subsist for decades while the underpinnings for the very long-term goals, likely involving substantial habitat restoration, can be realized. However, it is important not to lose sight of the fact that those seemingly, hopelessly large, MVP's are necessary for conservation in perpetuity. While they may seem like *unrealistic* now, if we are successful in implementing the vision of ERBC, they can become business- as-usual for our grandchildren's children. Furthermore, it is important to recall that you have selected this species as an umbrella for as many as thousands of others that you know little or even nothing about (if they are among the many undescribed species). Thus, making too many sacrifices at this point runs the risk of negating the concept of the focal (umbrella) species.

4. Fill in Table 2.1 using the best values you can locate for the area requirements of the focal species selected through a literature search or by contacting scientists who have worked within the ecoregion.

5. For focal species that are seasonal migrants, record the habitats they depend on under the heading "Required Habitats or Special Habitat Characteristics." As best you can, estimate the area needs within each habitat.

Table 2.1. Worksheet for estimating area requirements for focal species for the Terai-Duar Savannas ecoregion

Focal Species	Tiger	Rhinoceros	Hog deer
Breeding Units	One M/several F	One M/several F	One M/several F
Home Range Breeding Unit (expressed in km^2)	14	1	0.5
Short-term Source Pool Unit Home Range (km^2 * 10)	140	10	5
Short-term Persistence Unit Home Range (km^2 * 50)	700	50	25
Long-term Persistence Unit Home Range (km^2 * 3,000)	42,000	3,000	1,500
Required Habitats or Special Habitat Characteristics	1. Available surface water 2. Large prey	1. *Saccharum spontaneum* grasslands	1. *Saccharum spontaneum* grasslands

Note: We have filled in the first column based on home ranges of tigers from Royal Chitwan National Park, Nepal. Home ranges of tigers in other parts of their range are much larger.

6. For focal species that depend on rare, widely scattered habitats such as caves, you will need to estimate the total area required to ensure that sufficient critical habitat is included.

B. Evaluating habitat requirements for critical processes

1) During the orientation meeting, identify the critical processes, then estimate the extent of habitat required to conserve and maintain critical processes. We propose (as a rule of thumb) that the conserved area be 10-50 times larger than the average area of the required habitat. Check if the current protected areas meet these requirements. Identify shortfalls. On large-scale maps, identify and draw potential additional areas to meet these shortfalls. If habitat restoration is required, indicate and identify areas for restoration. Attempt to design a system of linked protected areas within the conservation landscapes to optimize protection and conservation of biodiversity. Keep in mind that biodiversity refers to both species and processes.

2) Estimate if the habitat blocks designated for conservation and, especially, for strict protection can survive perturbations over the long run. Identify additional areas, alternate areas, or both for conservation. If none are available, indicate that alternative management may be needed to mitigate effects.

Other tasks to be completed at the orientation meeting

Identifying specific threats and areas as top conservation priorities for action

The process of ERBC will likely require a year or more to complete. During this period, you will rightly conclude that you cannot hold all conservation activities in abeyance. Thus, an important function of this orientation meeting will be to identify critical conservation actions. The top conservation priorities require immediate attention. These actions should target (a) the protection of areas that are recognized by the experts to be fundamentally important for the conservation of biodiversity or ecological processes and that are outstanding to the ecoregion, and (b) areas that are under immediate of growing pressure from socioeconomic or political forces . The proposed activities may be site-specific, such as protecting remaining habitat, or they may be directed at mitigating external threats to the stability of those high priority areas (e.g., a new forest policy).

Compiling a list of tasks that must be completed in preparation for the biological assessment

The orientation meeting will generate a list of tasks that must be completed prior to the biological assessment workshop. By establishing your ERBC team (see chap. 3), you will have the staff in place to make the assessment workshop as productive as possible. Orientation meetings should also provide agreement on the proposed ecoregion and subregion boundaries, a workshop agenda, the scale of and features in template maps, resource maps, the need for desk studies and appropriate topics, a detailed agenda, and the categories to be used for priority status, levels of distinctiveness, representative habitat types, degree of threat, and persistence value.

Determining how much area needs to be protected to conserve biodiversity in an ecoregion

A fundamental question that needs to be discussed at the orientation meeting is how much area needs to be protected to conserve biodiversity in my ecoregion? You may not be able to answer the question immediately, but you can point to analyses that must be carried out prior to the biological assessment workshop. We will cover this

Table 2.2. Estimates of the proportion of a given area needed to meet conservation goals for areas the size of ecoregions or larger (Noss and Cooperider 1994)

Region and authors	Goal	Proportion needed
Australian wetlands (Margules et al. 1988)	Represent each plant species at least once	4.6% of total number of wetlands, but 44.9% of total wetland area
	Represent all wetland types and all plant species at least once	75.3% of total wetland area
Islands in Gulf of California (Ryti 1992)	Represent all bird, mammal, and plant species at least once	99.7% of total area
Canyons (habitat islands) in San Diego County (Ryti 1992)	Represent all bird, mammal, and plant species at least once	62.5% of total area
State of Idaho (Scott et al. in press)	Represent all vertebrate species at least once	4.6% of total area
	Represent all endangered, threatened, and candidate vertebrates and plants at least once	7.7% of total area
	Represent all 119 vegetation types at least once	8% of total area
Northern Rocky Mountains of United States (Metzgar and Bader 1992)	Maintain an effective population of 500 grizzly bears (actual population = 2,000)	32 million acres or roughly 60% of region
Southeastern United States (Noss 1991)	Maintain an effective population of 500 Florida panthers (actual population = 1,000-2,000)	100-150 million acres, or roughly 60-70 % of original range
Oregon Coast Range (Noss 1992, 1993)	Capture all clusters of rare species and community occurrences, protect all remaining primary forest, provide for large carnivore recovery	About 25% of region within each of two categories of reserves and additional 25% in buffer zones
Average region in the United States (Noss 1992)	Maintain viable populations of large carnivores and sustain natural disturbance regimes	Roughly 50% of region
Average region (A. Naess, cited in Sessions 1992)	Optimize human and nonhuman well-being	1/3 wilderness, 1/3 mixed communities of humans and other species, 1/3 intensive human use
State of Georgia (Odum 1970)	Optimize ecosystem services and human quality of life in self-sufficient system	40% natural, 10% urban-industrial, 30% food production, 20% fiber production
South Florida (Odum and Odum 1972)	Optimize ecosystem services and economic and cultural well-being	50% natural, 50% developed

aspect of ERBC in greater detail in chapter 5. For now, we should recognize the need to discuss area conservation requirements prior to developing your vision. Surprisingly little on this subject appears in the conservation biology literature. However, if you rigorously apply the absolute guidelines in this workbook to produce a biodiversity vision, you will not be surprised when your vision calls for large areas to be placed under strict protection and buffer zone categories. In the tropics, Michael Soulé argues that perhaps 30-50 percent of rain forest cover must remain in large habitat blocks to sustain the rich biodiversity of these forests. The target of 50 percent cover in a rain forest may seem like idiocy in some of the most altered tropical forest ecoregions, even over a recovery period of 50-100 years? But aiming for less than this target may prove to be not idiotic but fatal for the conservation of many species, habitats, and ecosystems in high endemism ecoregions.

What if a priority-setting workshop has already been held?

Some ecoregions have already been the subject of priority-setting exercises. In Madagascar, for example, and in parts of the Atlantic forest of Brazil, priority-setting workshops have been held in collaboration with Conservation International, although in the case of Madagascar, the exercises were country and not ecoregion specific. Is it necessary to repeat the process? To decide, consider the following actions and questions.

- Prior to the orientation meeting, ask your biological team to review the methods, assumptions, and outputs of the previous workshop.
- How thorough were the organizers of the previous workshop in addressing the conservation targets described in chapters 1 and 2?
- Did they address patterns of beta-diversity and conservation of large landscapes (see chap. 4)?
- Did they rank priority areas on the basis of biodiversity features, consider linkage habitats and the restoration of habitat blocks or corridors, and evaluate representation of all habitat types and ecological phenomena?
- Did they consider largely biological features in setting conservation priorities or give considerable weight to nonbiological (i.e., human utility criteria) features?

If your team decides that the experts workshop did a reasonable job of addressing those biological features, you may incorporate the findings into your ERBC plan and go on to the next questions:

- Did the workshop create a biodiversity vision that incorporates the consideration of minimum area requirements for focal species and processes?
- Was the vision comprehensive and ambitious?
- Are the priorities based on a detailed biological assessment?
- Do you need to invest in activities to fill critical information gaps?

Where appropriate, the ERBC team should try to incorporate the findings of the priority exercise into a draft biodiversity vision to use for the ERBC planning process.

Step. 5. Create a draft biodiversity vision.

To assemble the draft biodiversity vision, you may first want to answer the following:

1. What biological features are currently missing in your ecoregion today that were abundant previously?
2. What features or populations have been largely depleted, and what are their minimum area requirements? Are you trying to conserve large vertebrate migrations or plant assemblages? Caribou or orchids? Is your main goal to conserve the last source pools of native species for future restoration or to maintain the integrity of large landscapes?

3. Has most of the original native habitat been converted and degraded, and is what little remains distributed in small isolated fragments that are threatened by growing human populations?
4. Have many defining species populations for your ecoregion become endangered or extirpated from parts of their original range?
5. Is the remaining native habitat still mostly intact and is it distributed among habitat blocks large enough in size, frequent enough in number, and in reasonable proximity to one another to allow wildlife populations and ecological processes to fluctuate naturally?
6. How many of the outstanding biological features identified at the orientation meeting will require extensive restoration over the next 10 to 50 years?
7. Are these habitat blocks well protected? Are there many gaps in the protected area system? Has a formal gap analysis been conducted for the ecoregion? Are these gaps well recognized? If an analysis has been done, does it adequately address the issue of connectivity among protected areas?
8. Do major gaps in information on patterns of biodiversity and processes require targeted surveys and analyses to move forward in ERBC"
9. What are the "Berlin Walls" preventing conservation on an ecoregion scale in your ecoregion? Are any cracks developing? How can you or the international community proactively advance conservation to bring down these "walls"?
10. Ask the participants at the biodiversity visioning workshop to write down or outline a draft biodiversity vision or to do so in small groups. Discuss the draft visions in an open session. What data will be required to refine the vision? who can provide such data? How can the vision be shared with other stakeholders or conservation groups in the region? When is the best time to share such a draft vision?

In addition, consider creating a timeline in increments of five or ten year intervals. List your conservation targets. Discuss in a preliminary fashion what needs to be done or accomplished immediately and what will require long-term planning and investment. The order of the conservation targets will vary among ecoregions. For ecoregions where conservation or restoration of ecological processes is more fundamental to ERBC than areas of endemism, processes may be the first priority to be addressed. The purpose of the exercise is to conceptualize where you want to be in 50 years.

You may find it helpful to draft two visions for comparison and discussion. The first will try and predict the state of biodiversity in the ecoregion if business as usual continues. If major threats to biodiversity do not diminish or even if they increase, what will the ecoregion look like in 50 years? You can then contrast the business-as-usual scenario with the draft vision.

The role of socioeconomic, political, and cultural analyses in developing a biological vision

A biodiversity vision is fundamentally based on estimates regarding the requirements to maintain the full range of species and habitats over the long term in an ecoregion. Socioeconomic data is useful as two stages. First, various data layers on infrastructure, threats or pressures, and other trends can be useful as proxys to determine the current and future persistence of highly sensitive biodiversity features suchintact large vertebrate assemblages. Second, socioeconomic data and analyses are critical in determining the best implementation strategy to achieve the goals set forth in a biodiversity vision. They can determine the optimal timing and sequence of conservation action and the level of investment required for success.

Go on to chap. 3 when you feel that you have had a thorough discussion of the elements of a far-reaching vision. You are now ready to prepare for the biological assessment workshop.

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PART II: HOW TO CONDUCT A BIOLOGICAL ASSESSMENT AND DEVELOP A BIODIVERSITY VISION FOR A TERRESTRIAL ECOREGION

PREPARATION: FORMING THE ASSESSMENT TEAM, DESIGNING AND PREPARING FOR WORKSHOPS, AND GATHERING ESSENTIAL DATA *3*

Introduction

ERBC challenges us to bring the best biology into the design of a credible conservation strategy. This strategy and the action toward goals require outside peer review and the scrutiny of agencies involved in doing the work while the ERBC team pushes the "visionary envelope." For ERBC to be a success, expert biologists need to be involved right from the start. The purpose of this chapter is to provide guidance on establishing a team to conduct the assessment and refine the draft biodiversity vision. We review the advantages and disadvantages of staging a biological assessment workshop and the types and qualities of data that are required for the workshops to be worthwhile. This chapter spells out what you need to do to prepare for a successful workshop. It is especially important for those ecoregions that can be classified as Option 2 (see fig. 2.5) from the previous chapter (data-rich but most data unpublished and available from experts).

Forming the assessment team

ERBC is an ambitious undertaking. To be successful, appropriate staff must be appointed to guide the process. A lead biologist who, ideally, will supervise the biological components of ERBC will be foremost among these staff. Linking the assessment team to local universities may also offer some cost savings and establish greater acceptance. However, this team should be confident of its agenda and work plan and should not compromise these with the demands of the other groups. Perhaps the best solution is to draw up a team composed of biologists from several institutions that share WWF's basic approach to ERBC.

Ecoregions differ in the amount of effort required to complete the biological components of ERBC. However, the ERBC coordinator should consider contracting a lead biologist for at our best estimate a period of no less than 18 months to see the process through. Another critical component of the ERBC process is GIS support to assist in analysis of spatial data and to facilitate communication. We devote an entire chapter to this topic (see chap. 13). GIS support needs to be arranged in the early stages to undertake the biological assessment workshop and other steps in ERBC.

Planning for the biological assessment workshop

A biological assessment workshop provides an opportunity to gather a great deal of essential biological information relatively quickly. Even in the best-studied ecoregions, much of the data useful for ERBC assessments are seldom found in books or peer-reviewed journal articles. Rather, much of the data exist in the grey literature, buried in unpublished manuscripts, or in the heads of experts.

What kind of venue is best suited for your situation?

An expert workshop should be used when biodiversity indicator maps or other published sources of information are nonexistent or are considered inadequate for the ecoregion. The decision will call for good judgment because indicator maps are generally available in some form.

Although an expert workshop is an expensive undertaking, it has the additional benefit of being an effective way to engage the scientific community in the ERBC process and to cultivate their acceptance. They will be more likely to support the conservation priorities that are proposed by participating in the planning process. It is better to have a diverse group of scientists debate conservation priorities while they participate in a workshop than to have them launch harsh critiques of the conservation plan at a later stage.

In any type of workshop, the group of experts will generate a series of maps depicting the areas that they consider important for the taxonomic groups with which they are familiar. These maps may then be synthesized into a single map for the ecoregion that will show areas of overlap among characteristic taxonomic groups, areas of high endemism, and other ecological patterns and characteristics that must be conserved to address the biodiversity vision. We will guide you through the steps of the experts workshop in the next three chapters.

Any one of several types of experts workshops may be best for a specific ecoregion. The first is a full-scale workshop similar to that which was staged for the Chihuahuan Desert, with more than 60 participants and held over three days at a cost of approximately $60,000. At the other extreme is a “virtual” workshop, where the ERBC team develops a methodology, prepares draft base maps as data layers, and sends the maps to a select group of experts and indigenous people who then annotate them and provide requested data. This approach is far cheaper but is also far less efficient in gathering the information and garnering support. An intermediate alternative is a small-scale workshop. You might choose this approach if you simply do not have access to many experts or if not much is known about the ecoregion from a biological standpoint.

You need to assess the following factors:

- Is there consensus among scientists that the available biological information offers suitable proxies or adequately depicts the distribution of biodiversity to allow rigorous conservation planning?
- Are adequate habitat or vegetation maps available?
- Is enough published about sensitive species and ecological processes to allow estimation of minimum area requirements for sustaining these elements?
- What is known about past distributions?

Depending on not only the answers to these questions but also your budget and logistics, you can decide which type of workshop is best suited to your situation. The ERBC process in every ecoregion would benefit from some form of biological assessment even if priorities are generated by computer-based algorithms from peer-reviewed publications. Skipping this step altogether poses the following risks:

- Loss of an important opportunity for acceptance
- Loss of access to vital information and expertise
- Promotion of status-quo targets and activities

How long should the workshop last?

We recommend a three-day workshop. We have found that two days is too short to conduct the assessment and refine the draft vision. However, three days is the maximum amount of time you can expect to hold the interest of your audience. Furthermore, most people find it difficult to attend workshops that last longer than three days.

Complications can occur if participants require simultaneous translation. Translation is essential if you intend to have experts who do not speak the native language, and you may want to consider simultaneous translation. Selecting the translators must be done carefully. You may want to include preparation time for the translator to read chapters of this workbook and go over the glossary so he or she will be able to express concepts clearly. If you opt for sequential rather than simultaneous translation, you may need to add an extra day to accommodate the extra time that will be required for conducting the workshop.

Who should you invite to the workshop, and how many experts are enough?

Once the decision to hold a workshop is made, it must be well organized and an appropriate mix of experts must be invited. Consider broadly representing of expertise in the major taxonomic groups that are likely or are known to have relatively extensive distribution data (e.g., birds, mammals, herps, fish, and vascular plants). Try to represent other taxa, even if distributional data are spotty (e.g., invertebrates). One role of the workshop is to promote interest and acceptance for ERBC; therefore, participants should include, whenever possible, local, national, and international experts and also should include representatives of indigenous peoples from the outset. You will also want to include NGOs (who should send their scientists anyway) and social scientists who have been working on threat assessments that were initiated by the orientation meeting.

Among scientists, the most important participants are those who

- are regarded by the other participants as authorities for the ecoregion,
- have a broad biogeographical perspective, and
- have a reputation for building consensus.

We cannot stress enough how important it is to have a few wise, experienced,and respected individuals who support the goals of the workshop and who can help all participants focus on the tasks at hand. Some of these individuals will have been participants at the orientation meeting and can, thus, answer questions or introduce the draft biodiversity vision. We offer tips for conducting the workshop as part of annex 3.

We invited 100 biologists, conservationists, and NGO representatives to the Chihuahuan workshop. Sixty individuals were able to attend. Be prepared to make hard decisions on setting dates for the workshop because participants will always have scheduling conflicts. Decide who the key (10-20) invitees are and pick your dates based on their availability. Some other suggestions follow:

- Select participants to represent as wide a range of major taxonomic groups as possible, but also those with expertise in ecosystem ecology and who study ecological processes.
- Draw on the national and international scientific communities and their knowledge bases. If you

can identify experts at the local or regional level, they should be given special consideration, because local acceptance of the process is extremely important.

- Consider soliciting representation from local, regional, and national governments as well as from nongovernmental organizations that have a scientific mandate as part of their vision.
- Invite social scientists who have a basic understanding of biodiversity conservation to contribute to the process and take the outputs of the workshop to a socioeconomic workshop or other venues that have been planned for the ecoregion.
- Extend invitations to representatives of a few donor agencies, at least for the last day of the workshop when participants present a refined biodiversity vision. Obviously, inviting these donors is at the discretion of the ERBC coordinator who will know if the timing of such invitations is appropriate. The ERBC coordinator already should have briefed major donors (and other groups) beforehand.
- Decide on a venue that is centrally located and one that may lend itself if desirable, to a one-day field trip after or in between the workshop sessions. The ideal workshop site would have dependable electricity and would be located near or in a building that has GIS facilities to generate maps as you move through the stages of the workshop. Hire a workshop coordinator to handle all logistics. Recruit interns from local universities or NGOs to help with data collection and note taking during the workshop. Losing information through poor note taking is costly.

Literature review

The ecoregion coordinator and the lead biologist should organize and complete a literature review for the ecoregion between the orientation meeting and the experts' workshop. A graduate student who can later assist at the workshop can asssist in this task.

Data availability and quality

The acquisition and compilation of data and information into a geographical information system (GIS) are critical. This process can be envisioned as a three-stage approach: preworkshop gathering and preparation, workshop- related (follow-up to the orientation meeting) GIS activities, and the finalization of the data after the workshop.

Ideally, a single GIS coordinator should oversee all of the data collection, analysis, and GIS work that is related to ERBC. Additional assistance can be brought in as necessary, for example, to digitize information during the workshop. Continuity in data management will ensure that data are systematically dealt with and that development of new data layers and improvements are well documented. The minimum estimate of time required for the complete ERBC data and GIS process is eight months (one full-time person per ecoregion).

Preworkshop Data Issues (Estimated time: 5 months)

GIS facilities

A fundamental requirement for researching and gathering data is access to the proper GIS facilities. This access includes unrestricted use of computers with current GIS software, appropriate hardware for inputting acquired data (zip drive, CD-ROM drive), access to the Internet for data searches, and downloading capabilities. Specific hardware and software requirements are described in chap. 13.

Sources of data

The focus of gathering data at this stage is to provide fundamental baseline data for the preparation of workshop materials. All available data layers pertaining to the geophysical and biological aspect of the ecoregion should be gathered. During the search for data, any potential sources for socioeconomic data should be documented, because these will be required at a later stage in the ERBC process. In the acquisition of data, ensure that all metadata is kept. *Metadata* is the information on the source, date, projection, and format of the data. A vast number of sources exist from which to acquire data; these data vary in their cost of acquisition:

- commercially available CD-ROMs (e.g., ESRI's Digital Chart of the World)
- data from the Internet
- data from NGOs, government groups, and other organizations
- hardcopy sources (e.g., maps)
- information gathered from experts

Types of data

An initial distinction can be made between primary (or raw) data and secondary data (the results of analyses performed on the primary data). Both data sets are valuable. However, if using secondary data, ensure that the metadata detailing any analyses are kept with the data.

The format of the data can also vary tremendously. Data can be in either digital or hardcopy format. Digital data exist as raster (e.g., satellite imagery and aerial photos) or vector (e.g., roads and rivers) formats. We discuss data formats in more detail at the end of the workbook (chap. 13). Hardcopy data such as maps will need to be manually digitized (see chap. 13). The data layers for ERBC can be grouped into biotic (pertaining to living organisms) and abiotic (nonliving) features.

Abiotic data:

Elevation
Rainfall
Soil and geology
Rivers and watersheds
Population density
Political and administrative boundaries
Roads
Towns and cities
Protected areas
Railroads

Biotic data:

Species distributions
Vegetation
Breeding areas
Migration routes
Cattle/livestock densities
Patterns of endemism

Classification of data is a critical issue. For example, maps that classify vegetation into timber product classes are inappropriate for biodiversity analyses. Fine-scale data may be useful for ecoregion analyses only if it can be lumped effectively into broader classes.

Temporal and spatial aspects of data

Some degree of discretion has to be used in the search for data. Two key components of data gathering relate to the temporal and spatial scale of the data. Usually, it is preferable to use the most recent data available. However, the financial costs of new versus old data must be considered. For some data themes (e.g., vegetation), it is desirable to have satellite images or aerial photos from different points in time. (e.g., every five years) to assess land use change. The cost of this level of detail may be prohibitive for large ecoregions. We offer some alternatives in table 3.1. Time series data may be of less importance in ecoregions that, in the opinion of experts, have undergone little or no change in the past decade. Use the information in table 3.1 as a guide to help you make decisions. We also recommend that you fill out the data sheets that are provided at the end of this chapter to help you quantify the type of data you need to collect for your ecoregion (see figs. 3.1 and 3.2).

Table 3.1. A conceptual framework for data requirements for ERBC

Data Layer	Ideal	Intermediate	Minimum
Preferred Format for Each Level	Majority of data in digital format	Some important data in digital format	Little or no data in digital format, but team assembled
Land Use	1. Land use over time 2. Satellite imagery 3. Aerial photos 4. Fine-scale base data	1. Recent land use 2. Coarse-scale base data	Hardcopy maps only
Vegetation	1. Classified satellite imagery 2. Time series analysis 3. Potential vegetation	Intermediate-scale vegetation data	Coarse-scale vegetation maps
Population	1. Recent census data accurate to a sub district or county level 2. Population change, past census data 3. Breakdown of population by sex, age, income, religion, etc.	1. Census data at district or county level 2. Past census data at any level	Population estimates for major cities and towns
Rainfall	1. Multiple recording stations with 50+ years of observations at daily or weekly intervals 2. Predicted or estimated precipitation data	Country level precipitation estimated by season	Yearly precipitation data
Soils	1. Validated soil type data 2. Correlation to vegetation types	Coarse-scale data	Local knowledge of soil types that have a major influence on the distribution of communities
Roads	1. All known paths and trails as well as paved and unpaved, logging identified by type paved roads identified by type of road	Major and minor roads	Major interstates and minor paved roads
Rivers and Watersheds	1. Fine-scale river and stream data, identified as perennial or seasonal 2. Fine-scale watershed area	Intermediate-scale river and stream data	Hardcopy maps
Towns and Cities	All towns and cities with population	Major towns and cities	Hardcopy maps
Elevation	Fine-scale digital elevation model (DEM) and contour data	Contour data	Hardcopy maps
Protected Areas	1. All protected areas, with IUCN category, name, year established, and size 2. Proposed protected areas	Protected area data	Hardcopy maps

Consider also the scale of the data in comparison to the scale of the ERBC analyses. Data that are too coarse are unlikely to yield much useful information, whereas detailed data might divert attention away from other data layers. To some extent, the size of the ecoregion and the amount of remaining habitat influences the appropriate scale for your data. An ecoregion that encompasses a large area (e.g., boreal forests) might use data at a 1:1,000,000 scale, but a small ecoregion (e.g., island ecoregions) could require data at as fine a scale as 1:20,000. The more data you have at the appropriate scale, the better the analysis will be.

Analyze available data for gaps

At the orientation meeting you will

- Identify gaps in critical data that are important for the workshop and identify what layers you can collect and prepare before then
- Identify the information gaps you can live with or for which you can substitute proxies in their place

Any preparatory work should be completed prior to the expert's workshop. Biologists should give the ERBC coordinator an accurate estimate of the time required to complete these tasks.

Data analyses and map presentation

Once the available information has been gathered, you must gauge its usefulness. Is the scale appropriate? Are the data recent enough to be relevant? After this step is completed, maps can be produced for the workshop. The tasks might include making simple overlays of the different data sets, compiling basic analyses of the data, or processing data in a user-friendly format (e.g., classifying satellite images). The objective here is to provide

- something for experts to comment on and add their knowledge to
- a medium for experts to work on and add attributes to (notes of importance that can be digitized or added to a database so that these features can be georeferenced, for example, a series of limestone outcrops that are known or suspected to support high levels of endemism of plants and invertebrates),
- a way to help the experts standardize their annotations and evaluations

Suggestions for maps to have prepared prior to the workshop would include:

- species distribution maps, particularly for focal species
- vegetation maps (potential and remaining)
- separate biophysical basemaps for elevation, rainfall, and soils
- basemaps with rivers, elevation, and political boundaries
- human infrastructure maps (basemaps of administrative boundaries, roads, railroads, towns)
- protected area maps, perhaps with indication of size of minimum critical areas for species and processes
- land use capacity maps (used to help identify areas where land is being used unsustainably and land that may require future conservation)

Land-use and current threats

If available in digital format, you will want to present maps of current major threats to biodiversity, including, for example,

- human population
- urban expansion
- logging concessions
- mining concessions
- roads and settlements
- ranges of exotic species
- distributions of cattle and other livestock

If available only in hardcopy, you might want to digitize these maps to have them available for annotation at the workshop. Depending on the size of the GIS lab and the amount of money and time you have allocated to preparation, you may want to send beforehand some of the digitized maps that are listed above to selected experts for initial review.

You will want to provide any draft analyses of conservation priorities that might exist so these can be discussed and refined.The availability of a copy machine for workshop tables, datasheets, and GIS products is critical. The GIS data used to make the maps should be copied onto a medium that can be downloaded to the workshop's GIS system. Accordingly, the GIS data that are produced during the workshop should be copied and brought back for analysis after the workshop.

Workshop (Estimated time: One week including three days of intensive preparation at the GIS site, the three day workshop itself, and one day allotted for cleanup and organization of data)

Providing high-quality GIS facilities at the expert workshop is vital to its success. Dealing with data in a timely and efficient manner at the workshop will minimize the effort afterwards and will also decrease the potential for error. Consider these several important features when choosing a GIS facility:

- compatible software
- additional GIS equipment (digitizing tablet and plotter)
- GIS technical assistance
- proximity to the workshop location

The GIS software used during the workshop should be compatible to the headquarter GIS facility. The compatibility between facilities should be verified well in advance of the workshop. Continuity in the GIS software will allow the efficient transfer of data between the headquarter and workshop GIS facilities.

The GIS facility should have access to at least one digitizer tablet and also a plotter that is capable of printing large-format maps. In the absence of a large format-plotter, a printer will be satisfactory. A digitizer tablet allows the information that has been gathered from the experts to be converted into digital format for immediate review by the experts. Access to multiple digitizers will allow this work to be completed more efficiently.

The GIS facility should provide a technical support person to the GIS coordinator. This person will ensure that all runs smoothly (e.g., providing assistance in the event of a power outage, computer crash, and lack of supplies such as paper and ink). Additional staff need to assist the GIS coordinator in digitizing maps that are produced during the workshop. The staff should have access to the GIS facility at all times. Large sheets of mylar or acetate and a variety of multicolored permanent markers are critical to have on hand in case of emergencies. For some components of the workshop, running ARCVIEW on a laptop computer and displaying it on an LCD projector can allow real-time changes to data and analyses. You may want to try and locate an LCD projector for this purpose.

The expert's workshop and GIS facility should be close to each other to allow quick turn-around time of maps. Often, government agencies and universities have facilities that meet these requirements and provide better support than do conference centers or hotel meeting rooms.

Postworkshop (Estimated time: 2-3 months)

Upon conclusion of the workshop, two main activities are required of the GIS coordinator:

- Download all of the GIS data produced during the workshop onto the headquarer GIS system. In past workshops, not all of the maps or data were digitized and put into the GIS system before the conclusion of the workshop. (This oversight contributed to extensive delays in finishing the Chihuahuan assessment). The GIS coordinator should finish digitizing additional maps, add attributes, and clean up all the errors found in the GIS data layers. The GIS coordinator should provide documentation (metadata) for each data layer, including

    - date coverage was made
    - origin of coverage
    - names (priority sites, nominated sites)
    - number identification system and meaning
    - additional useful information

  The purpose of adding this information is to assist future GIS work done by others. We need to know the meaning and origin of the data in the coverage (e.g., the numbers 1-3 do not have meaning unless it is known that 1 = High priority area, 2 = Intermediate priority area, and 3 = Low priority area). This information should be added immediately upon conclusion of the workshop while the data and their meaning are still fresh in your memory.

- Conduct analyses and produce the maps needed to accompany the report. This activity may not be required immediately after the workshop but in conjunction with the write-up of the workshop results (see chap. 8). The GIS coordinator should produce full sets of maps that were made prior to and during the workshop and should include appropriate baseline information to assist in interpretation. This activity will take up most of the time allocated to postworkshop activities.The GIS coordinator will also be involved in producing any CD or internet products.

Figure 3.1. Example of data sheets used at Eastern Himalayas ecoregion orientation meeting workshop, February 1999: a) abiotic data, b) biotic data

COUNTRY/REGION/AREA COVERED:

A. ABIOTIC DATA

Features	Format: digital hardcopy	Scale	Area of coverage	Source of accuracy	Data	Cost and availability	From where ?	Available when?	Responsible for follow-up	Priority	Remarks
Soil/ geology											
Topography											
River & watersheds											
Demographic data											
Political & admin. boundaries											
Road											
Towns & cities											
Protected areas											
Railroads											
Land use											
Agricultural usage											
Dams											
Grazing areas											
Logging concessions											
Tourists/pa/ month											

Figure 3.1.b

COUNTRY/REGION/AREA COVERED:

B. BIOTIC DATA

Attributes Features	Format: digital hardcopy	Scale	Area of coverage	Source of accuracy	Data	Cost and availability	From where ?	Available when?	Responsible for follow-up	Priority	Remarks
Species distributions:											
Mammals											
Birds											
Reptiles											
Amphibians											
Plants											
Invertebrates											
Fish											
Focal species:											
Tiger											
Elephant											
Rhinoceros											
Sloth bear											
Red panda											
Snow leapard											
Montane ungulate											
Vegetation											
Vascular plants											
Orchids											
Breeding areas											
Migratory routes											

CONDUCTING THE BIOLOGICAL ASSESSMENT: UNDERSTANDING AND MAPPING BIODIVERSITY AT THE ECOREGION SCALE *4*

Introduction

A central goal of ERBC is to satisfy the requirement of full representation—that all distinct ecological assemblages or communities within each ecoregion must be represented in a network of conservation areas. We recognize that full representation may be a daunting task in some biologically complex ecoregions that are heavily converted and degraded. Full Representation will likely require major restoration efforts as well as prolonged, high-level lobbying and leveraging for conservation, which necessitates long-term commitments. If we accomplish less than full representation, we return to business as usual.

Each ecoregion is defined by specific biological characteristics that must be addressed in an ERBC strategy. However, the major elements of a biological assessment—the conservation goals and targets that are presented in chapter 1—are the same for all. The purpose of this chapter is to (1) provide some background concepts on understanding and mapping patterns of biodiversity at the ecoregion scale; (2) walk through the steps involved to incorporate representation and other conservation goals into the vision; and (3) illustrate how this process was used on the Chihuahuan Desert ecoregion (terrestrial part only). We assume that you have completed steps 1-5 (reviewed in Chapters 2 and 3) of the vision process before you begin with steps in this chapter. Also keep in mind the brief discussion on scale in chapter 1, which presented a visual comparison of between-ecoregion analyses to within-ecoregion

Delineating patterns of biodiversity in data-rich vs. data-poor ecoregions (chap.11) will require some different mapping techniques, but the biological goals and targets will be the same. Note that, you will need to go through the steps outlined in this chapter, whether formally in an experts workshop or through a virtual format in which the ERBC team sends out data layers to experts for comment and annotation. For those ecoregions rich in biodiversity data, sophisticated analyses are possible (see chap. 11).

Concepts

Understanding and mapping patterns of biodiversity and ecological processes

The particular emphasis allocated to representation and to the mapping of biodiversity patterns will vary among ecoregions, depending largely on the major habitat type to which these ecoregions belong. For example, accurate mapping of geographic patterns of biodiversity would be given more prominence in biologically complex ecoregions such as tropical moist forests than in ecoregions that are characterized by more homogeneous species distributions, such as those dominated by boreal forests or tundra. Instead of mapping centers of endemism in a tundra ecoregion, one might map a more prominent biological feature in tundra which are also a caribou migrations, used to account for spatial and temporal resource variability.

Perhaps the greatest challenge of ERBC is that most ecoregions suffer from limited data about distribution and occurrences of biodiversity. Because threats to biodiversity are so grave and the need for conservation action is so urgent, conservationists cannot afford to wait until better data becomes available. They must rely on a combination of indicators, predictive models, and targeted surveys to make the best informed decisions with limited time and resources.

Conserving patterns of beta-diversity: essential ingredients of a biodiversity vision

Conducting a biological assessment and developing a biodiversity vision is an intensive, data-hungry process. But it can be guided by an overriding principle that serves as a helpful shortcut: Give most attention both to conservation of patterns of beta-diversity and to large landscapes (J. Quinn, personal communication). We treat the issue of beta-diversity in this chapter and treat large landscapes in chapter 5.

Conserving patterns of beta-diversity

Beta-diversity is defined as the turnover of species within a range or along environmental gradients such as elevation. It contrasts with the more familiar concept of *alpha-diversity*, which the number of species at a given site. Anyone who has walked or climbed in the Andes, the Himalayas, Mt. Kilamanjaro, or Mt. Kinabalu has experienced two biological phenomena: beta-diversity and altitude sickness. The rapid turnover of species is most apparent as you climb through elevational belts of vegetation. Beginning in tropical lowland moist forests at the base, your trek would take you up through tropical premontane and montane broadleaf forests as well as temperate broadleaf and conifer forests on the flanks of the mountains. Beyond the treeline, you may encounter thickets, unique stands of giant shrubs (paramo vegetation), and even higher, you may find yourself in alpine meadows. Many species are restricted to these various belts although others, especially birds and larger mammals, move among these habitats on a seasonal basis. Conservation of these elevational gradients buffers against habitats and is a fundamental component of ERBC.

Pronounced beta-diversity also can occur where plant and animal communities are separated by major dispersal barriers such as high mountains and harsh climatic regimes. In the Eastern Himalayas, for example, five genera of plants show high levels of beta-diversity . They are present in one or more adjacent mountain valleys, but as you move further east or west, they are replaced by other species in the same genera. These include species of *Rhododendron*, louseworts (genus *Pedicularis)*, saxifrages (genus *Saxifraga)* primroses (genus *Primula)*, and poppies (genus *Meconopsis*). In the schematic (see fig. 4.1) imagine the species a-i as representative of Eastern Himalayan alpine plants. As one moves from west to east (left to right) in the figure, the composition of the plant communities changes. The conservation message here is that in montane areas in the tropics and near-tropics, the turnover of species within a range or from one mountain valley to the next may require more intensive conservation efforts to achieve representation than in ecoregions where species have more broadly defined distributions.

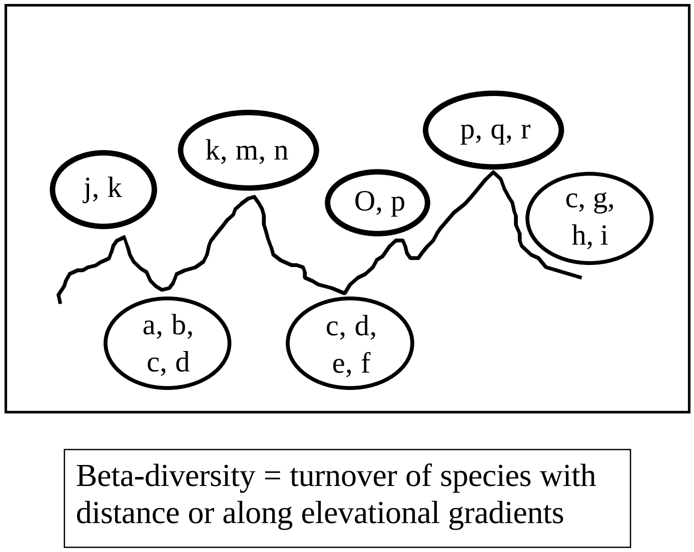

Figure 4.1. A schematic to illustrate the term beta-diversity (note that beta-diversity can be observed moving up and down the elevational gradients created by mountain chains and with distance; observe how species *a-i* replace each other in mountain valleys as one moves from west to east (left to right), and *how j-r* show similar turnover on mountaintops)

Tropical forests are noted for high rates of beta-diversity. High levels of beta-diversity can also occur in arid ecoregions such as the Chihuahuan Desert or Mediterranean-climate ecoregions like the fynbos of South Africa. Madagascar also provides excellent examples of beta-diversity, such as the distribution of endemic primates of the genus *Lepilemur* (fig. 4.2) and the distribution of various mammalian insectivores (e.g., tenrecs). Note the turnover of lemurs along the perimeter of the island among ecoregions (see fig. 4.2); in mammalian insectivores, this phenomenon also occurs within ecoregions.

Beta-diversity is typically high in lowland tropical forests because of the heterogeneity of soil types, high variation in underlying geology, stable environmental conditions, and wide rivers that form effective dispersal barriers for plants and animals. The tropical moist forests of New Caledonia grow on incredibly toxic soils that contain high levels of nickel, cadmium, and other heavy metals (see fig. 4.3). Unfortunately, the protected area system of New Caledonia leaves much of the ultramafic areas unprotected. All ultramafic soils in the tropics typically support high levels of local endemism in plants and invertebrates.

Large rivers can also serve as dispersal barriers. The broad rivers of the Congo Basin, for example, form dispersal barriers for many mammals, plants, and invertebrates. This is also true in the Amazon ecoregions (see fig. 4.4).

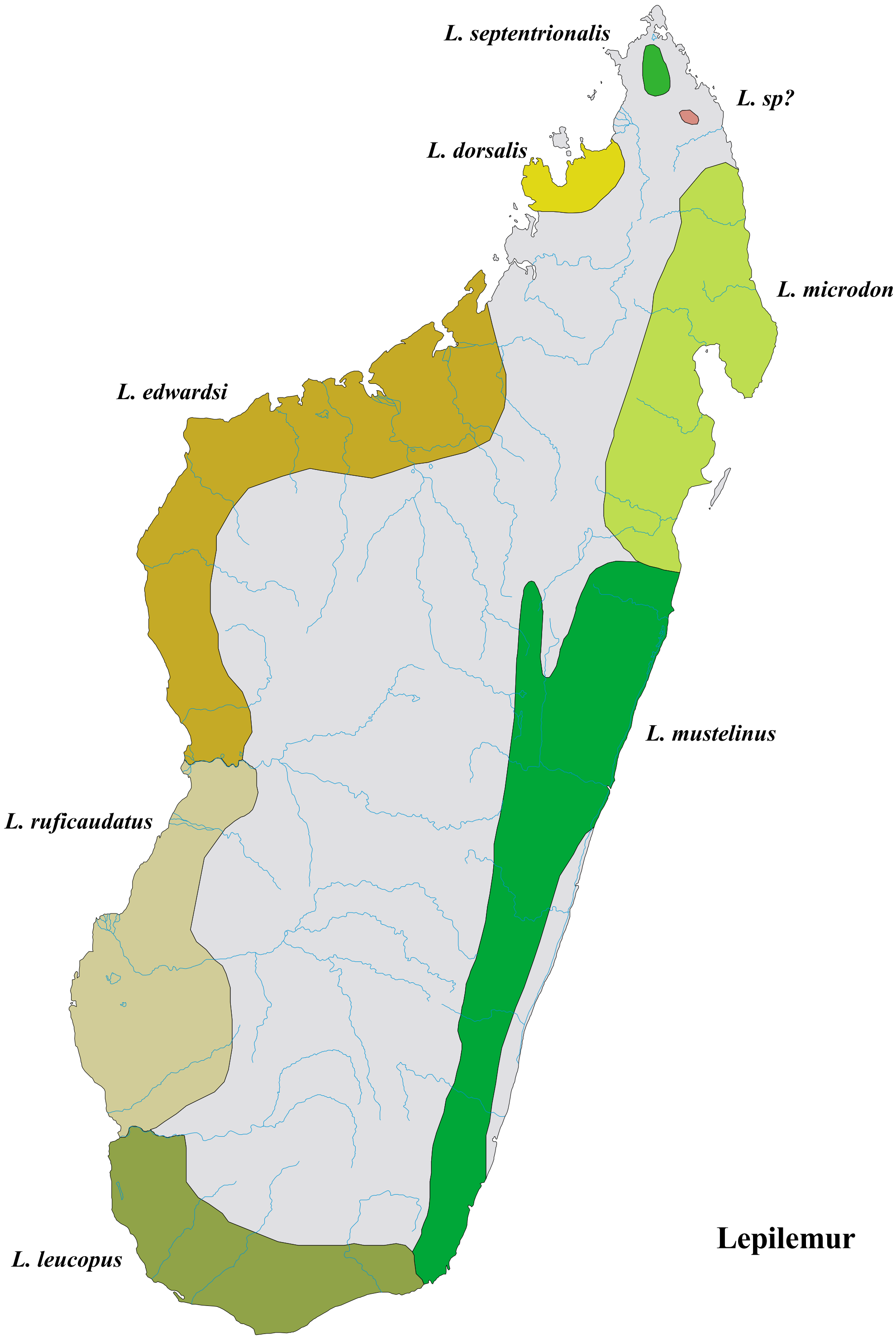

Figure 4.2. Beta-diversity in mammals: The distribution of lemurs in Madagascar

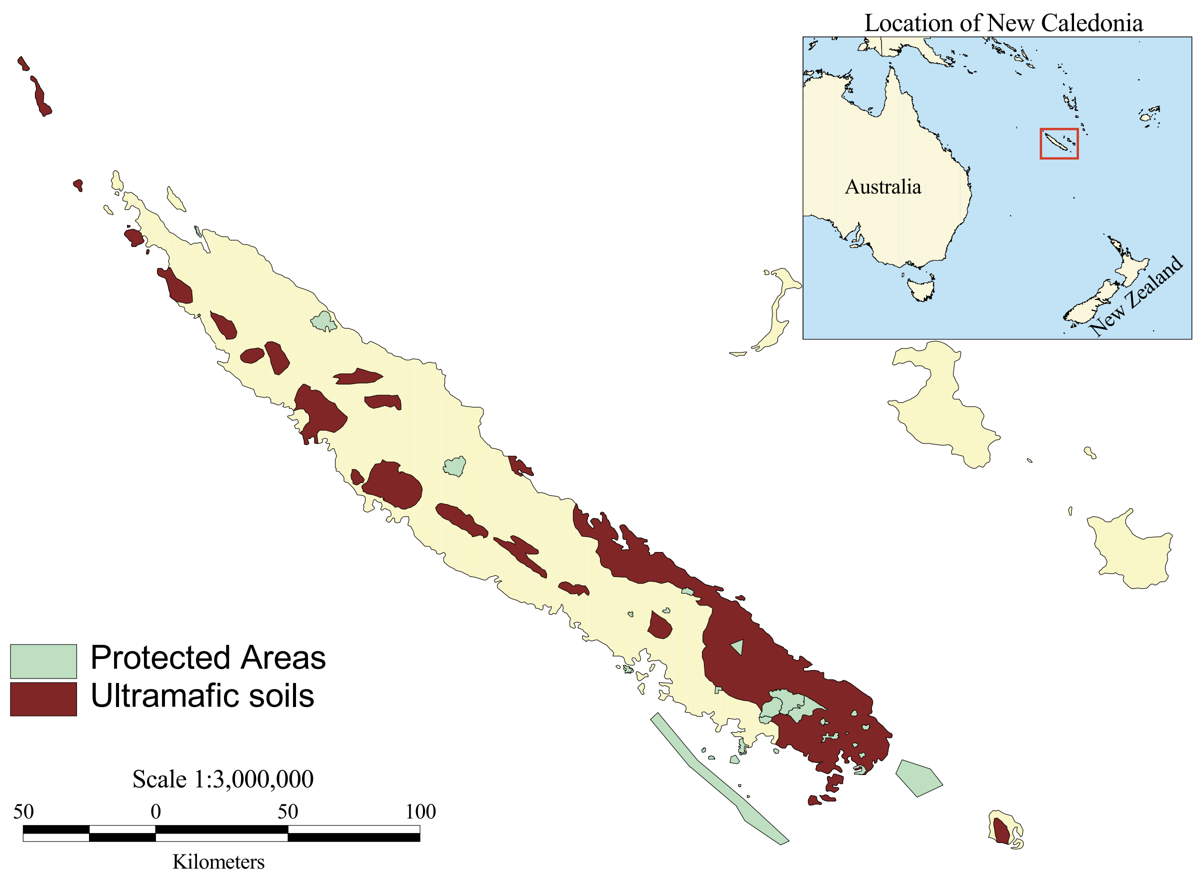

Figure 4.3. The ultramafic soils of New Caledonia contribute to the island's high endemism and beta diversity.

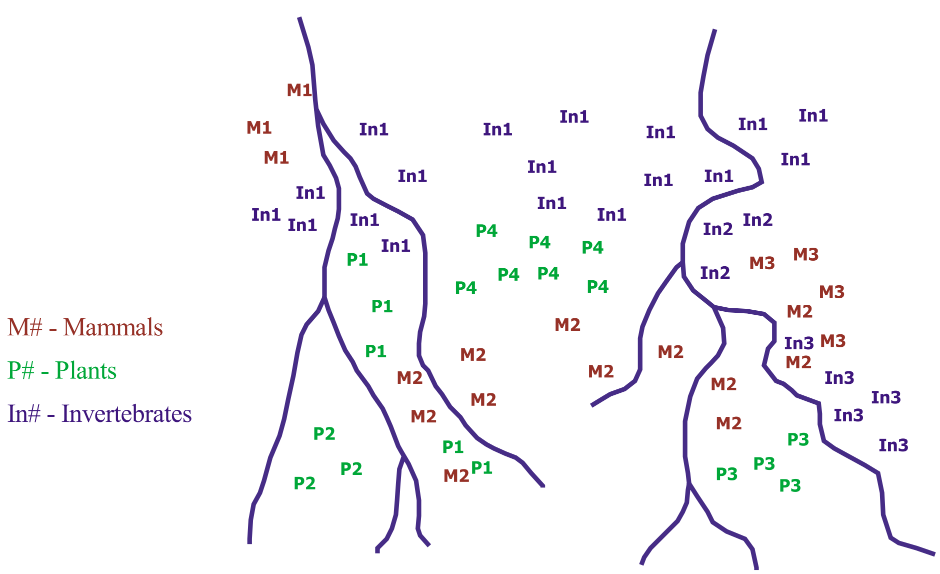

Figure 4.4. In tropical areas large rivers can act as dispersal barriers to many mammals, plants, and invertebrates, increasing an ecoregion's beta diversity. In this example, the letters represent different species, and only species M2 and In1 are dispersed across the rivers.

The message is that if high levels of beta-diversity characterize your ecoregion, much greater effort—more protected areas or managed areas distributed over the landscape—will be required to conserve the full expression of biodiversity. A list of terrestrial Global 200 ecoregions that are characterized by high levels of beta-diversity is included in table 4.1. In ecoregions with lower rates of beta-diversity, more emphasis can be placed on the conservation of the largest possible natural landscapes possible as part of the vision.

Table 4.1. Preliminary analyses indicate that 27 terrestrial Global 200 ecoregions contain exceptional levels of beta-diversity

GLOBAL 200 ECOREGION NOS.	TROPICAL and SUBTROPICAL BROADLEAF FORESTS
3	Chocó-Darién moist forests—Colombia, Panama, Ecuador
4	Northern Andean montane forests—Ecuador, Colombia, Venezuela, Peru
11	Andean Yungas—Ecuador, Colombia, Venezuela, Bolivia, Peru, Argentina
13	Atlantic forests—Brazil, Paraguay, Argentina
15	Cameroonian highlands—Cameroon, Gabon, Republic of Congo, Democratic Republic of Congo, Nigeria, Benin
15	Mount Cameroon and Bioko montane forests—Cameroon, Gabon, Republic of Congo, Democratic Republic of Congo, Nigeria, Benin
21	Albertine Rift montane forest—Democratic Republic of Congo, Rwanda, Uganda, Burundi, Tanzania
23	East African coastal forests—Tanzania, Kenya, Mozambique, Somalia
24	Eastern Arc montane forests—Tanzania, Kenya
25	Madagascar moist forests—Madagascar
46	New Guinea montane forests—Papua New Guinea, Indonesia
49	New Caledonia moist forests—New Caledonia (France)
52	South Pacific Islands forests—Fiji, Samoa, Tonga
53	Hawai’i moist forests—United States
	TROPICAL and SUBTROPICAL CONIFEROUS FORESTS
54	Mexican Pine-Oak forests—Mexico, United States
	TROPICAL and SUBTROPICAL DRY BROADLEAF FORESTS
55	Southern Mexican dry forests—Mexico
63	New Caledonia dry forests—New Caledonia (France)
64	Hawai’i dry forests—United States
	TEMPERATE BROADLEAF and MIXED FORESTS
68	Eastern Himalayan broadleaf and conifer forests—Bhutan, India, Nepal, Myanmar, China
	TEMPERATE CONIFEROUS FORESTS
75	Klamath-Siskiyou Coniferous Forests - United States

GLOBAL 200 ECOREGION NOS.	MEDITERRANEAN-CLIMATE FOREST, (Woodlands and Scrubs)
119	California chaparral and woodlands—United States, Mexico
120	Chilean Matorral—Chile
121	Mediterranean shrublands and woodlands—Portugal, Spain, France, Italy, Monaco, Greece, Yugoslavia, Bosnia and Herzegovina, Croatia, Albania, Turkey, Libya, Lebanon, Israel, Morocco, Algeria, Tunisia, Malta, Cyprus, Macedonia, Bulgaria, Egypt
122	Fynbos—South Africa
123	Southwest Australian shrublands and woodlands—Australia
	DESERTS and XERIC SCRUB
126	Galapagos Islands scrubs—Ecuador
129	Namib and Karoo deserts and shrublands—South Africa, Namibia
131	Madagascar Spiny desert—Madagascar
136	Carnavon Xeric scrubs—Australia

Step 6 . Select taxon priority areas (landscapes) based on species richness, endemism of single taxonomic groups, and other distinctive features (higher taxonomic uniqueness, best examples of intact assemblages, etc.)

After reaching agreement on the ecoregions and ecoregion boundaries and determining minimum area requirements for focal species and processes, you will identify important areas for biodiversity conservation. These areas will be selected on the basis of overall distributional patterns for outstanding or unique biodiversity features and distributions of taxonomic groups or indicator taxa. Criteria will include pronounced richness or endemism, higher taxonomic uniqueness, unusual ecological or evolutionary phenomena (e.g., unique species assemblages, adaptations, or interactions, extraordinary adaptive radiations, highly intact faunas or floras), or critical sites for large-scale phenomena such as migrations.

Selection of areas should be done by a range of experts with knowledge of the biodiversity of the region. This step can be done in the following ways:

- At a workshop setting where the experts assemble to conduct the analysis (as in the Chihuahuan workshop)
- Remotely by asking selected experts to comment on resource papers and preliminary analyses, as well as to provide their interpretations of important areas (relevant to their taxonomic specialty) on large-scale maps of the ecoregions (see chap. 3 for details)
- Remotely by using computer algorithms based on published data (See chap.11).

If you choose to have an experts' workshop, the experts should also be asked to identify areas with poor or no information. This step ensures that these data-deficient areas are not lost in subsequent analyses; some may be as important as data-rich areas. The areas that the experts identify as being important for the conservation of different taxonomic groups are referred to as nominated areas (see box 4.1).

Box 4.1. A glossary of terms related to priority-setting used in this workbook.

Area, Landscape—We deliberately use the terms *area* and *landscape* synonymously rather than use **site** to emphasize the need to invest in conservation activities at larger spatial scales. The size threshold beyond which a site can be considered a conservation area or landscape is not defined in the literature, but we chose an arbitrary figure of 800 km^2. Perhaps a more useful way to categorize the difference is that site-based conservation seldom addresses conservation beyond the boundary of a protected area and its buffer zone. Landscape-scale conservation focuses on the distribution of biodiversity, the configuration, size, and proximity of adjacent habitat blocks, and the maintenance of ecological processes over areas of less restrictive landuse. It also focuses on connectivity, which can be best addressed at scales much larger than the average site.

Taxon priority areas—Areas deemed by taxonomic experts and published accounts as important for conservation of a single taxon. Nominated areas serve as the precursors to identify candidate priority areas. Not all nominated areas end up as candidate priority areas or as priority areas. All nominated areas should be located on maps, named, and entered into a database (see suggested data sheet for nominated areas in annex 2).

Candidate priority areas—Areas deemed important for conservation based on a synthesis of the taxon overlays of nominated areas for each subregion (terrestrial taxa) or for the entire ecoregion. A candidate priority area could be designated as outstanding on the basis of only one taxon, such as invertebrates, but typically, candidate priority areas are selected for their importance for two or more taxa. Candidate priority areas could also be identified if they address gaps in representation of habitats within a subregion or if they contribute to the conservation of areas that maintain keystone ecological processes or phenomena, without qualifying on richness or endemism criteria. The adjective candidate signifies that the area has not been ranked for priority using the integration matrix.

Ranked Priority areas—Areas whose contribution to ERBC have been ranked at various levels of priority using an integration matrix that is based criteria of biological distinctiveness and landscape integrity (ranks 1-4) (see chap. 6).

Step 7. Select candidate priority areas based on synthesis of taxon priority areas. Analyze for representation of : (a) distinct biotic assemblages, (b) habitat types, and (c) ecological processes and evolutionary phenomenta and processes

Conducting representation analyses

One of the most fundamental steps of an ecoregion assessment is a representation analysis. Here we ask two key questions:

- How many conservation units are required to represent all distinct assemblages, distinct processes, and distinct habitats within the ecoregion?
- How should these conservation units be distributed over the ecoregion or linked to areas in adjacent ecoregions?

Biological features used in representation analysis

The biological features used to ensure representation include (a) species assemblages and ecological communities (especially those that are closely associated with the ecoregion), (b) areas of high species richness, (c) endemic species, (d) rare or outstanding ecological and evolutionary phenomena, and (e) critical areas for maintaining large-scale ecological processes.

In ecoregions that are characterized by high rates of beta-diversity and local endemism, representation analyses need to be conducted at a relatively fine level of geographic resolution because these ecoregions may require many core conservation areas to be widely distributed over the landscape. The Australian and South African approaches—emphasizing efficiency, flexibility, and irreplacability (e.g., complementarity, representation, optimality models)—are useful for identifying sets of priority. The effective application of these techniques is largely restricted to data-rich areas (see chap.11).

The nominated areas for each taxon identified by experts in the previous step are then synthesized to identify *candidate priority areas* (see box 4.1 for definition). A set of decision rules to help identify candidate priority areas is provided in (box 4.2).

Box 4.2. Decision rules for elevating nominated areas to candidate priority areas

To address the conservation goals and targets presented in chapter 1, the selection of candidate priority areas is guided by the following decision rules:

- Each terrestrial habitat type must be represented in the portfolio of candidate priority areas.
- Examples of each habitat type in each subregion should be represented.
- Wherever possible, several candidate priority areas (e.g., three sites) for each habitat type within each subregion should be selected to ensure replication and enhance long-term persistence.
- Wherever possible, the larger blocks of intact habitat for each habitat type should be selected as candidate priority areas.
- Areas that harbor distinct ecological or evolutionary phenomena should be identified and included in the portfolio.
- Areas that maintain critical ecological processes should be identified and included in the portfolio.
- Identification of areas for their importance in harboring genetic resources, or their importance for maintaining ecosystem services such as watersheds
- Identification of areas that are in need of biological inventories because of a lack of sufficient biodiversity information for effective conservation planning

The synthesis of nominated areas and review of the candidate priority areas can be done as part of the workshop to obtain immediate feedback. Useful and often spirited discussion was promoted in the candidate areas by the use of ARCVIEW and a LCD projector. If the analysis is done remotely, the experts who identified the nominated areas should be given the opportunity afterward on the candidate priority areas map for review and comment. A set of priority areas will be identified by the workshop facilitators and the experts from the candidate priority areas using a matrix of biological distinctiveness and landscape integrity (see chap. 6)

Assessment of ecological processes and phenomena

After the analyses of biodiversity patterns (representation and important areas), planners need to evaluate the nominated areas to ensure that larger-scale ecological processes and phenomena are considered. Conservation at the scale of thousands and, in some cases, tens of thousands of km^2 is likely to be necessary to adequately address minimum size requirements for some area-limited species and certain ecological processes (this topic is treated in greater detail in chapter 5). At global and continental scales, some specific sites may be particularly important for migratory birds, mammals, or invertebrates. Within ecoregions, certain habitats or linkages may be critical for maintaining seasonal movements of species, promoting ecological processes such as dispersal, or providing spatial and temporal refugia from short-and long-term disturbances. For example, a primary target for some ecoregions may be the conservation of intact altitudinal gradients, or wide blocks of intact habitat or riparian corridors connecting large core reserves. Addressing these issues of scale is one of the primary reasons to undertake ecoregion-scale conservation.

Here is a summary of the steps to include at an experts workshop to achieve representation in the biological assessment.

- Define the boundaries of the ecoregion and biogeographic subregions. This can be done using features such as contours and rivers on finer-scale maps (1:200,000). The boundaries can be reviewed and revised by the experts who will help with the biological assessment either in a workshop setting or through individual contact.
- Ask the experts to draw on basemaps the important areas for the respective taxonomic groups. These should include areas of high species richness and endemism, critical habitat requirements, migration routes, seasonal habitat requirements, and other biological and ecological resources necessary for conservation of the species and assemblages. The areas (nominated areas) can be drawn as simple outline shapes on large-scale habitat maps. They do not necessarily have to follow remaining blocks of natural habitats; some important elements may still be present in degraded habitats, and restoration may become a conservation target.
- Using a GIS synthesized data layers, to create a large map that depicts the degree of overlap of the important areas for all selected taxonomic groups selected. The polygons for each taxonomic group will be represented by a different color. (Minimum area analyses, which ensures that candidate areas relate, is covered in the next chapter.)
- Allow experts (in groups if in a workshop setting) to review these synthesized maps to identify candidate priority areas while also considering the distribution of other taxonomic groups and the distribution of overall biological diversity. In some cases, candidate priority areas can be determined on the basis of outstanding ecological or evolutionary phenomena.
- Evaluate the candidate priority areas for their contribution to the representation of each habitat type within the ecoregion. Habitats that are inadequately represented should be reevaluated and revised to meet representation goals. Completing the checklist below will help to make the representation analysis objective and transparent (see box 4.3). The resolution and classification of habitat types that are used should be agreed upon by experts prior to this step.

Box 4.3. A checklist for evaluating representation

A. Selection on the basis of representation

___ Habitat types are represented from each subregion (if the ecoregion was broken up this way).
___ The largest blocks or group of blocks with intact habitat for each habitat type are included as highest priority areas.
___ Candidate priority areas were selected for each habitat type to ensure replication.
___ Areas that harbor distinct ecological or evolutionary phenomena were identified and included.
___ Areas that maintain critical ecological processes were identified and included.

B. Selection of additional candidate priority areas for reasons other than representation

___ Areas that harbor distinct ecological or evolutionary phenomena, but not previously selected, were added.
___ Areas that maintain critical ecological processes (e.g., migration sites), but not previously selected, were included.
___ Areas noted for their importance in harboring genetic resources were considered.
___ Areas that are in need of biological inventories for effective conservation planning were identified.

- If in a workshop setting, present the revised candidate priority areas portfolio to the experts in plenary. Ask them to evaluate this selection for representation of biodiversity.

Case Study 1

In this section, we present the biological assessment that was conducted for the Chihuahuan Desert ecoregion as an illustration . A similar analysis was done for the freshwater Global 200 ecoregion centered in the Chihuahuan Desert; that analysis presented in more detail in the second workbook (in preparation).

Step 1: Define the ecoregion boundaries

The biogeographic unit was the Chihuahuan Desert ecoregion complex (see figs. 4.5 a-d and annex 1), and the overall boundary of the Chihuahuan Desert in Mexico was developed by the Commisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). The ecoregion boundaries largely follow habitat classifications that were developed by the Mexican geographic and natural resource agencies (SEMARNAP and INEGI) using ground-truthed, remotely sensed data. The ecoregion boundaries for the portion of the Chihuahuan Desert ecoregion in the United States is based on a WWF ecoregion map for the United States that was developed by Ricketts et al. (1999), using a system largely derived from Omernik (1995) and Küchler (1975). The matching of WWF and The Nature Conservancy terrestrial ecoregion classifications with the CONABIO ecoregion map for Mexico was carried out at a workshop sponsored by The Nature Conservancy.

Different interpretations explain what constitutes Chihuahuan biodiversity and where it is distributed. Our desire for a comprehensive look at Chihuahuan biodiversity led us to evaluate two ecoregions together, the Chihuahuan Desert and the Meseta Central, amalgamated as an ecoregion complex. The northwestern Chihuahuan Desert (Apachean section) is considered by some biologists as a distinct unit. From a biogeographic perspective, one can also consider the Madrean Sky Islands as a northern extension of the Sierra Madre Occidental, surrounded by lowland Chihuahuan Desert. The various montane areas of the northeastern Chihuahuan ecoregion are often regarded as a northern extension of the Sierra Madre Oriental.

For the purposes of the ERBC strategy, we considered the Meseta Central, the Madrean Sky Islands, Apachean region, and the montane areas of the northeast as part of the Chihuahuan Desert ecoregion complex because of important biological and ecological linkages (see Dinerstein et. al. 1999). We also considered natural communities outside the Chihuahuan ecoregion that are strongly Chihuahuan in character. One exception was the Tehuacán Valley, an isolated xeric region in the state of Oaxaca that has strong biogeographic linkages to the Chihuahuan Desert and Meseta Central ecoregions. The Tehuacán Valley ecoregion is quite distinct biologically because it supports an extraordinary level of plant richness and endemism in a relatively small area. It warrants its own intensive conservation effort.

Step 2: Define the biogeographic subregions

The variation of habitats within the Chihuahuan Desert suggested the need to further divide the ecoregion into subregions. The assumption was that in very large ecoregions exhibiting a clear latitudinal gradient, subregions exhibiting a clear latitudinal gradient, subregions will support different assemblages of species in similar habitat types. For example, representation rules might dictate at least one example of desert grassland from each subregion in the portfolio of priority sites for the whole ecoregion. The delineation of biogeographic subregions was based on the judgment of experts at the CONABIO workshops, including

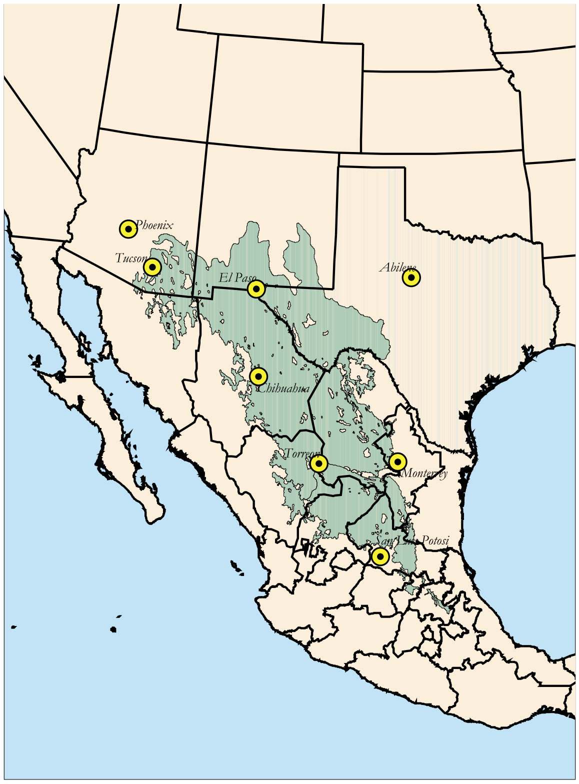

Figure 4.5a. The Chihuahuan Desert ecoregion spanning the United States and Mexico

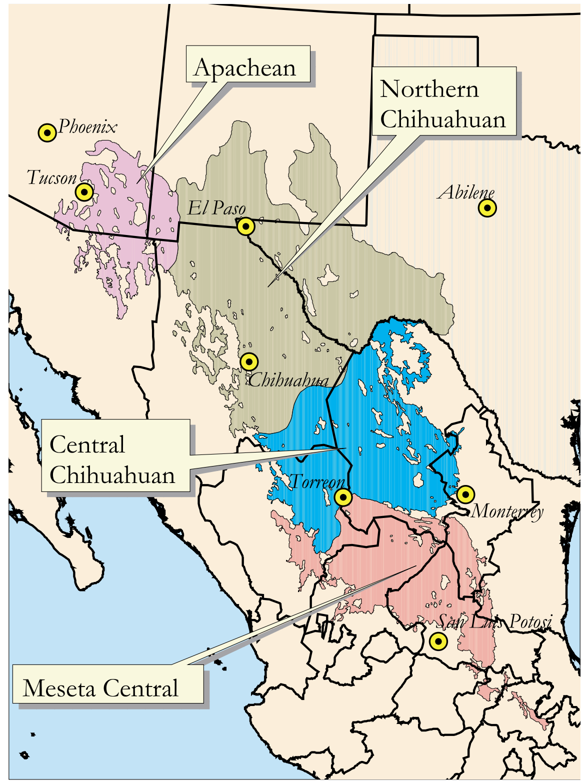

Figure 4.5b. Biogeographic subregions of the Chihuahuan Desert ecoregion

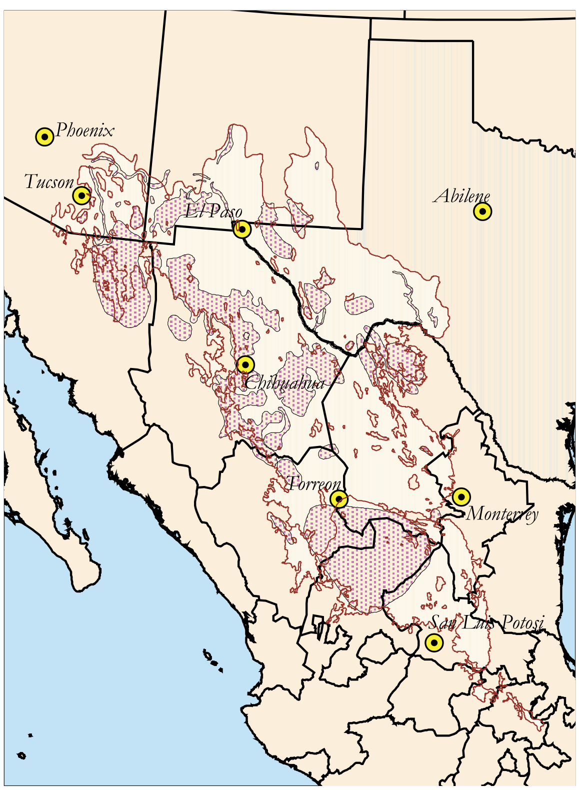

Figure 4.6a. Nominated priority areas - birds

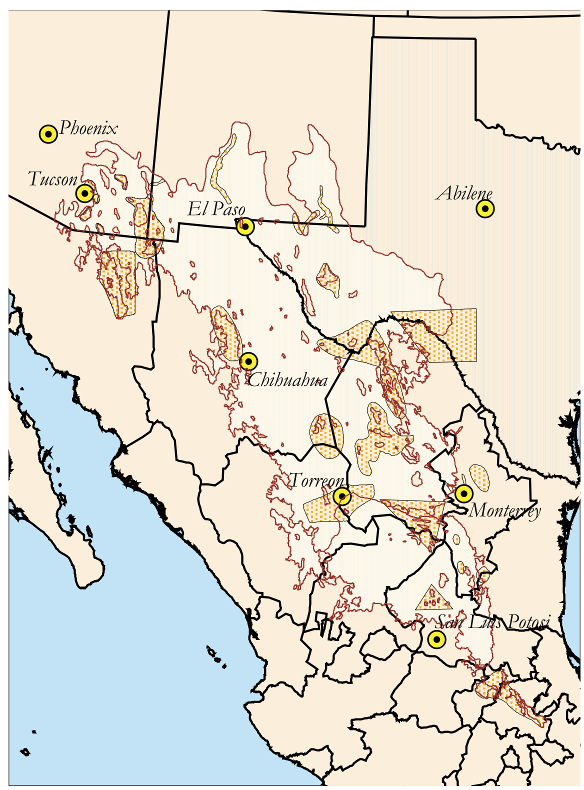

Figure 4.6b. Nominated priority areas - herpetofauna

their evaluation of existing biogeographic analyses of Mexico; subregion boundaries were further revised by experts at the Chihuahuan workshop.

The experts agreed on four terrestrial subregions: the Meseta Central (sometimes referred to as the Saladan), the Central Chihuahuan (also called the Mapimian), the Northern Chihuahuan (sometimes referred to as the Trans-Pecos), and the Apachean (fig. 4.6 a-d). The subregions were then used in the representation analysis.

Experts expressed concern because many disjunct habitats that were Chihuahuan in character fell outside of these areas. However, experts agreed to consider these outside areas in their analysis if they felt it was appropriate. Peripheral areas included sites such as the Devil's River (at the boundary of the Edwards Plateau and the Tamaulipan Scrub ecoregions) and the Mescalero Sands. The experts further agreed not to be bound by ecoregion lines if a site or area of outstanding biodiversity straddled an ecoregion boundary.

The terrestrial biogeographic subregions were unsuitable for the freshwater analysis because they do not adequately represent patterns of freshwater biodiversity, which are more closely tied to catchments. Freshwater ecoregions of the Chihuahuan Desert area, as delineated by Abell et al. (1999), have a combined perimeter that differs from that of the terrestrial Chihuahuan Desert complex.

Steps 3, 4, and 5 were not addressed at the Chihuahuan Workshop. The case study continues with Step 6.

Step 6. Select distinctive or important areas (nominated areas) for indicator taxa

We analyzed patterns of biodiversity across the four subregions: Apachean, Northern Chihuahuan, Central Chihuahuan, and Meseta Central. The terrestrial experts were divided according to five broad taxonomic groups: plants, invertebrates, herpetofauna, birds, and mammals.

The experts first drew polygons on maps around areas they considered to contain outstanding biodiversity features. Examples include foci of species richness and endemism, unique higher taxa, and rare or outstanding ecological or evolutionary phenomena. They also identified areas that experts believed still supported relatively intact assemblages of different taxa. Each group identified distinct sites for its taxon and completed summary description sheets for each site (fig. 4.7 a-d). These sheets contained information on specific biodiversity features and primary threats. Neither the scale of the analysis nor the available time permitted the groups to delineate the exact boundaries of sites. The resulting set of maps showed nominated areas for consideration as conservation priorities.

A summary of some attributes of important biodiversity features that were considered in describing nominated areas follows.

Species richness. Richness foci can occur at the scale of either areas (e.g., whole mountain ranges, subranges, whole or partial basins) or sites (e.g., single valleys or valley complexes, springs, mountain peaks or small ranges, gypsum dunes, smaller areas within basins). We targeted two levels of richness: very high richness (top 10 percent of richest sites) and high richness (top 20 percent of richest sites). The experts made comparisons only among assemblages within the Chihuahuan ecoregion complex and not among assemblages in different ecoregions such as the Sonoran or Tehuacán Deserts.

Species endemism. Experts mapped areas that they considered to possess very high endemism or high endemism. Again, experts made comparisons only among assemblages within the Chihuahuan ecoregion complex. We recommended that experts focus on species that are endemic to biogeographic subregions such as the Meseta Central or endemic to more localized areas such as ranges, basins, or dune systems. Species that are endemic to the whole Chihuahuan ecoregion and are distributed widely across it offer little discrimination among priority areas. An exception would be species restricted to specialized or patchy habitat types, such as gypsum dunes, that have localized distributions wherever such habitats occur.

Unique higher taxa. We asked experts to identify areas that contain unique higher taxa (e.g., families, genera) or representatives of primitive or relict lineages.

Rare or outstanding ecological and evolutionary phenomena. We also considered areas that harbor extraordinary or rare examples of ecological or evolutionary phenomena. Examples might include the pronounced radiations, unusual adaptations, and highly local endemism of the biota of the Cuatro Ciénegas Valley or the presence of relatively intact vertebrate faunas with top predators such as puma, jaguar, and a full range of prey species. Across the Chihuahuan and in many other ecoregions, intact biotas were once widespread but now constitute rare ecological phenomena. Another example of an ecological phenomenon is prairie dog colonies, now restricted to only a few limited areas. The colonies are often associated with a relatively complex assemblage of plants and large vertebrates. We emphasized phenomena that involve many different taxa, rather than a single taxon.

Critical areas for the maintenance of large-scale ecological phenomena. Experts were asked to identify areas that may be particularly important for maintaining large-scale ecological phenomena, such as migrations of raptors, songbirds, shorebirds, bats, or invertebrates. Clearly, many of these phenomena operate over broad landscapes, but this task is intended to identify those areas that may be particularly critical, such as certain wetlands, riparian woodlands, concentrations of flowering plants (for migrating nectar-feeding bats), or forest patches.

Gaps in biodiversity information. We asked the experts to identify areas where data are inadequate to assess the areas biological value. These areas are in need of taxonomic or ecoregion-wide inventories for effective conservation planning.

Step 7. Synthesizing nominated landscapes based on taxonomic priorities

Next, participants reorganized themselves according to subregional expertise and reviewed the nominated areas for each taxon for each subregion. They then synthesized this taxonomic information to identify candidate priority areas. A description of each candidate priority area was written and summarized, emphasizing the conservation targets in their selection. Experts also provided more detailed information for specific areas in terms of their outstanding biodiversity features, habitat status, and short and long-term threats (see Data Sheets, annex 2).

Step 7a. Habitat representation analysis

The experts conducted a coarse analysis to ensure that all habitats were represented by the candidate priority areas. The habitat representation rules we used are listed in box 4.3. If a habitat type was poorly represented within a subregion, the portfolio was reevaluated and revised to meet representation goals.

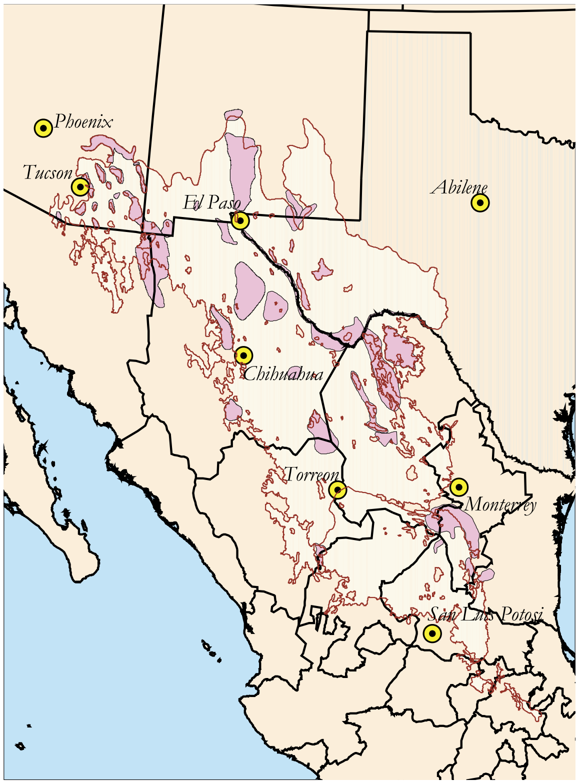

Figure 4.6c. Nominated priority areas - mammals

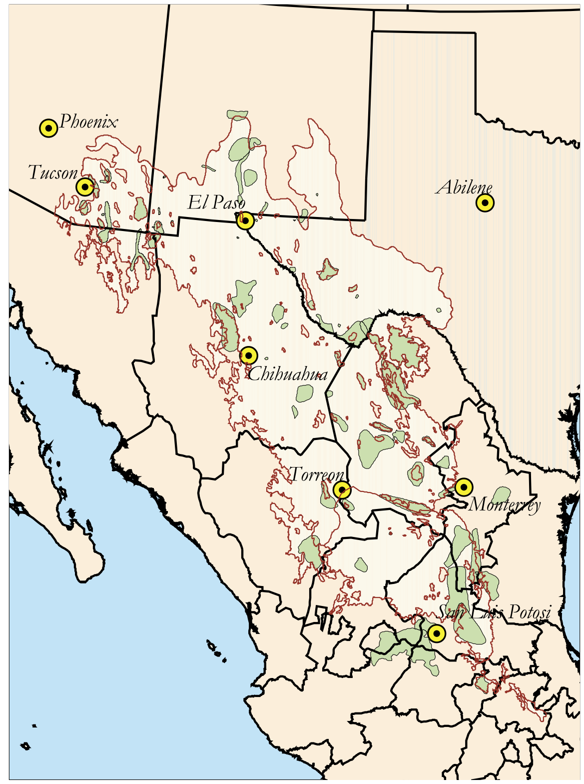

Figure 4.6d. Nominated priority areas - vegetation

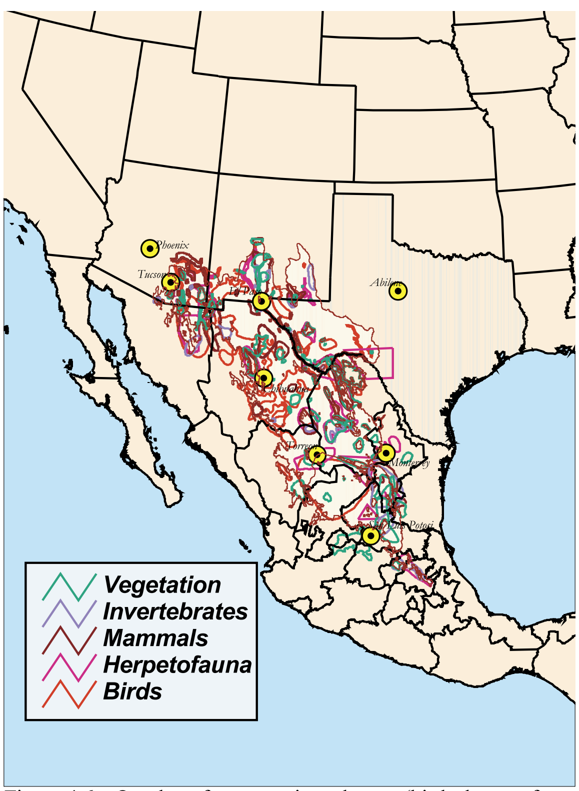

Figure 4.6e. Overlap of taxa nominated areas (birds, herpetofauna, mammals, vegetation, invertebrates)

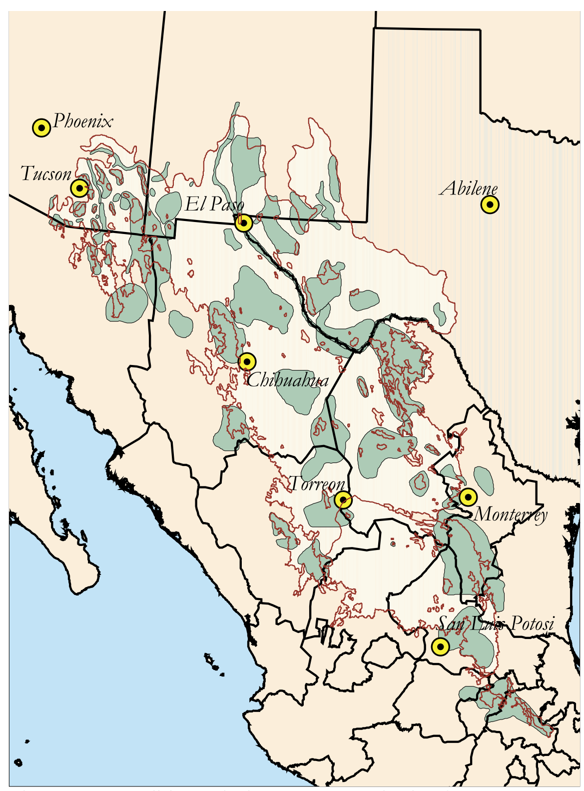

Figure 4.7. Candidate priority areas; a synthesis of taxa nominated areas

Table 4.2. Terrestrial habitat types of the Chihuahuan Desert used in the representation analysis

I. Desert Scrub and Woodlands

A. *Larea* desert scrub (*Matorral desierto micrófilo*)
B. Desert scrub (*lechugillal, matorral desierto rosetófilo con Agave*)
C. Yucca woodland (*izotal, matorral desierto rosetófilo*)
D. *Sotalal*
E. *Prosopis* scrub (*Mezquital*)
F. Alkali scrub (*Matorral halofitico*)
G. Gypsophilous scrub (*matorral gipsofilo*)
H. Cactus scrub (*Matorral crasicaule, M. garambullal*)
I. Lowland riparian woodland (*Bosque ripario*)
J. Playas

II. Grasslands

A. Gramma grassland (*pastizal de grama, navajita*)
B. Sacaton grassland (*zacatonal*)
C. Tobosa grassland (*pastizal de tobosa, baja con tobosal*)
D. Yucca grassland
E. Gypsum grassland

III. Montane Chaparral and Montane Woodlands

A. Montane chaparral (*chaparral montano*)
B. Juniper-pinyon woodland (*bosque de enebros y piñones*)
C. Pine-oak woodland (*bosque de encino, bosque de pino-encino, bosque de encino pino, bosque de pino o pinares*
D. Mixed-conifer forest (*bosque mixto de abetos*)
E. Montane deciduous woodland

Step 7b. Assessment of ecological phenomena and processes

In the Chihuahuan Desert analysis, important ecological and evolutionary phenomena that had to be conserved include: seasonal migrations of songbirds, shorebirds, raptors, and sparrows; migration corridors for monarch butterflies and sphingid moths; seasonal movements of bats tracking flowering cacti; altitudinal movements of birds and larger vertebrates between lowland and montane habitats; and dispersal corridors among mountain ranges for larger vertebrates. Candidate priority areas were evaluated in terms of their ability to conserve these elements of biodiversity.

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EVALUATION OF LANDSCAPE INTEGRITY AND PERSISTENCE OF BIODIVERSITY *5*

Introduction

ERBC requires more than identifying patterns of biodiversity across the ecoregion. Restricting the biological assessment to representing unique communities (chap. 4), for example, would allow us to conserve populations of rare orchids, cycads, or cacti that have minimal area requirements. But by representing only unique communities, we would overlook other important elements of biodiversity. The biodiversity vision and the ERBC conservation strategy must ensure that

- minimum habitat area requirements are met to conserve viable populations of focal species and critical processes,
- blocks of habitat identified as priorities are able to withstand and recover from natural and anthropogenic disturbance events, and
- the landscape integrity of priority habitat blocks is of sufficient quality to conserve important elements of biodiversity (they will require extensive restoration to meet the ERBC objectives).

We begin by introducing the conservation principles used to evaluate landscape integrity. We then provide steps to guide you through the process and explain how to evaluate the status of habitat blocks and how to conduct a persistence analysis. If the biodiversity vision provides us with an opportunity to plan for the ideal scenario, the persistence analysis is the reality check. It tells us the extent to which remaining blocks of natural habitat will conserve critical elements of biodiversity over the long term. In many ERBC efforts, the persistence analysis will help to identify where restoration efforts are most needed.

Concepts

Assessing large landscapes for conservation adequacy

The conservation of large landscapes is an essential part of ERBC. Many sensitive species, wide-ranging species, and certain ecological processes require big blocks of natural habitat to persist over the long run. For some forest-dwelling species such as large carnivores and large herbivores these habitat blocks do not need to be of mature or old growth forest (although many specialist invertebrates and plants are old-growth dependent). However, for other sensitive species, such as some forest primates or other rain forest species that occur at low densities, large blocks of unfragmented forests are essential. In more temperate and polar ecoregions, conservation landscapes need to be very large to address the patchiness of resources, large movements of animals tracking these resources, and the size of disturbance events. A list of terrestrial Global 200 ecoregions that offer good potential for conserving large blocks of unfragmented habitats is in table 5.1.

Table 5.1. Nineteen terrestrial Global 200 ecoregions still harboring large landscapes of relatively intact natural habitat

GLOBAL 200 ECOREGION NOS.	TROPICAL and SUBTROPICAL BROADLEAF FORESTS
6	Guianan Moist Forest—Guyana, Suriname, French Guiana, Venezuela, Brazil
7	Napo Moist Forests—Ecuador, Colombia, Peru
8	Rio Negro-Juruá Moist Forests—Colombia, Brazil, Peru, Venezuela
9	Guyanan Highlands Moist Forests—Venezuela, Brazil
12	Southwestern Amazonian Moist Forests—Peru, Brazil, Bolivia
17	Western Congo Basin Forests—Central African Republic, Cameroon, Republic of Congo
18	Northeastern Congo Basin Forests—Democratic Republic of Congo, Central African Republic, Sudan
19	Southern Congo Basin Forests—Democratic Republic of Congo, Republic of Congo, Angola
41	Central Borneo Montane Forests—Indonesia, Malaysia, Brunei
45	New Guinea Lowland Forests—Papua New Guinea, Indonesia
46	New Guinea Montane Forests—Papua New Guinea, Indonesia
	BOREAL FORESTS and TAIGA
85	Northern Cordillera Boreal Forests—Canada
86	Canadian Boreal Taiga—Canada
89	Central & Eastern Siberian Boreal Forests and Taiga—Russia
90	Kamchatka Boreal Taiga and Grasslands—Russia
	TUNDRA
115	Alaskan North Slope Coastal Tundra—United States, Canada
116	Low Arctic Tundra—Canada
117	Taimyr Tundra—Russia
118	Chukhote Coastal Tundra—Russia

The advantages of large landscapes in an ERBC plan are numerous. Large blocks of intact habitat sustain larger and more viable species populations, and they permit a broader range of species and ecosystem dynamics to persist. They also provide refuge from intensive hunting because they are remote. The presence of multiple large blocks of habitat within a larger landscape is an important conservation target. Factors such as fire, disease, poaching, deforestation, or degradation can eliminate species or natural habitats within individual blocks. The presence of several large blocks with similar communities allows recolonization and persistence of particular habitat types and species. As we introduce the concept of conservation landscapes, we give examples of how the size of a landscape is broadly tailored to the scale of important ecosystem dynamics and the persistence of important biological features within an ecoregion. For example, in boreal forest and taiga, the major disturbance event—periodic large-scale forest fires—can cover tens of thousands of square kilometers. Conservation landscapes in these ecoregions must be large enough to be resilient in the face of these natural disturbance events.

Although we stress the value of making the conservation of large landscapes an important conservation target, we recognize that a number of terrestrial ecoregions (even Global 200 ecoregions) have been so converted and fragmented that conservation of only one or a few large landscapes is possible. These large landscapes should be obvious conservation targets and should figure prominently in the vision and in the ERBC plan. In some ecoregions, conservation of large intact landscapes will be impossible without extensive restoration. Intensive management by humans, such as instigating a program of controlled burns, must be considered as a means to reestablish the integrity of habitat blocks. In others, restablishing integrity may require complete protection from fire in ecoregions where fire is not part of the natural disturbance regime.

Step 8. Assess landscape integrity to estimate long-term persistence of biodiversity

This process requires that the results of the focal species analysis be incorporated into the Draft Biodiversity Vision (Chapter 3) to estimate the minimum numbers and sizes of blocks that are required within conservation landscapes to ensure their viability. The focus of the analysis is on landscape features to evaluate whether these elements can be conserved indefinitely. An analysis of area requirements must also take account of important landscape features such as special soil types, watersheds or migration staging areas, or important refugia such as caves, cliffs or lakes.

To complete the biological assessment, we need to know the amount of each habitat available.

Specifically, we will consider:

- The size, shape, and configuration of remaining blocks (i.e., are they in small fragments or large patches, or both? are the patches evenly distributed or clumped?)
- The distribution of patches between montane and lowland habitats in ecoregions with elevational variation, or the adjacency of riparian and high-ground habitats
- The status of neighboring patches of habitat (how much is intact, how much is degraded)
- The degree of connectivity among habitat blocks
- The degree of fragmentation among habitat blocks
- The level of degradation and isolation
- The adjacent or intervening land use between and among habitat blocks
- The distance from habitat edges where intense hunting pressure diminishes
- The minimum sizes of blocks, and habitat elements required for natural habitats to persist in the face of extreme disturbance events (e.g., fires may completely burn through small reserves).

These data are especially important in ecoregions, because they serve as good indicators for the persistence capacity of an ecoregion's biodiversity in the face of major habitat conversion and degradation. Species distributions are strongly correlated with habitat; thus, fragmentation by human activities will provide a reliable estimate of the changes in species ranges from their original distributions to the present.

The distribution of forest patches can be determined from accurate habitat maps. Forest cover or habitat distribution maps at scales of 1:200,000 (or even coarser) are generally sufficient for evaluating intactness at ecoregion, and priority area scales. The most recent information is best suited for this purpose; use of dated information or inaccurate maps may entail the extra step of ground-truthing the information.

Extensive ground-truthing will be required for ecoregions that are nonforested or only lightly forested such as Mediterranean climate shrublands, savannas, and grasslands. We have no simple method for estimating intactness in nonforested ecoregions**.** Our best suggestion is to use one day of the experts' workshop to identify varying degrees of intactness among natural habitat blocks based on the collective field experience. If the categories of intactness are clearly defined and are applied evenly across the ecoregion by the experts, they will produce a useful estimation.

Evaluating the intactness of habitat is important both to conserve a representative example of biodiversity and to hold on to the last source pools for restoration of biodiversity over the next 50 years. Here, we propose a three-class system in which terrestrial landscapes are categorized as intact, altered (i.e., degraded), or heavily altered.

- *Intact habitat*: represents relatively undisturbed areas that maintain most original ecological processes and communities and that support most of their original suite of native species. Altered habitat represents areas that are more substantially affected by human disturbance but that still have the potential to sustain native species and processes.

- *Heavily altered habitat*: represents areas that have been degraded to the point of retaining little or no potential value for biodiversity conservation without long-term and extensive restoration.

These definitions were discussed, modified, and adopted during the experts workshop for the Chihuahuan Desert and can be applied to other terrestrial ecoregions. General definitions for states of intactness are as follows (Dinerstein et al. 1995):

Broadleaf and conifer forests

- *Intact*: Canopy disturbance through human activities such as logging is restricted to less than 10 percent of the defined habitat block. The understory is largely undisturbed by timber extraction, intensive management, or grazing. Natural fire regimes are still present. Although large mammals and birds may be absent from some blocks of habitat because of exploitation, insufficient area, or diminished resources, such blocks sustain many native communities and populations of plant, invertebrate and vertebrate species, and associated ecological processes.

- *Altered or Degraded*: The canopy and understory are significantly disturbed by human activities, but habitat remains suitable for some native species. Species composition and community structure are altered, and a large proportion of native species are absent but likely to return, given sufficient time for recovery and adequate source pools. Examples include large expanses of selectively logged forests; forests in which natural fires have been suppressed; areas where clearcuts are limited to between 10 percent and 25 percent of the landscape and have been patterned to facilitate natural ecological processes and recolonization; and 100-year old clearcuts that have been allowed to regenerate and contain adequate source pools for restoration.

- *Heavily Altered:* The habitat is almost completely altered. Substrate alteration, exotic species introduction, and distance from source pools make recovery of the original habitat unlikely without large and expensive restoration efforts. Examples include urban and suburban development, forests converted to pastures and cropland, extensive clearcuts, and intensively managed plantation forests of nonnative species or monocultures.

Grasslands, xeric shrublands and deserts

- *Intact*: The habitat remains unplowed or unaltered by major changes in hydrologic patterns. The full suite of native plant species is still present in abundance within its natural range of variation. Successional patterns follow natural cycles (e.g., grazing by domestic livestock has not had a major effect on species composition or several stages). Natural fire regimes are still present. Although large mammals and birds may be absent from some blocks of habitat because of exploitation, insufficient area, or diminished resources, such blocks still sustain many native communities and populations of plant, invertebrate and vertebrate species, and associated ecological processes.

• *Altered*: Heavy grazing has altered dominance patterns of plant species. Some exotic species are present, and surface water patterns may be altered, but the substrate has not been disturbed or plowed. Natural fire regimes have been largely suppressed. The original habitat is likely to return with time, moderate restoration, and adequate source pools.

• *Heavily Altered*: The habitat is almost entirely altered by activities, such as human development, plowing, or crop cultivation. Native species are almost entirely replaced by exotics and crops. Surface water patterns have been extensively altered. Natural fire regimes have been completely suppressed.

Evaluating potential for habitat restoration

A biodiversity vision should be ambitious. Thus, an effort to create conservation landscapes that allow for adequate protection and for providing the habitat area necessary for many species—especially the wide-ranging species—will often require habitat restoration. It behooves us at this stage to start thinking about which areas should become immediate targets for restoration efforts.

Application

Evaluating landscape integrity and persistence of biodiversity over the long term

In this section, we present two possible approaches for evaluating landscape integrity, especially of the candidate priority areas. These analyses are most easily and quickly carried out by experts, conservation biologists with experience in the region. The recommended approach is to use a GIS to sort the candidate priority areas into the following classes of habitat integrity listed in table 5.2, with a brief explanation of the capacity to conserve biological diversity (see also fig. 5.1). The experts will evaluate the classifications. For example, candidate areas that are considered *Intact* (Level 1) should consist of an unbroken, pristine habitat block that is at least as large as the minimum area required for sustaining viable populations of focal species and processes in the ecoregion. A candidate area that is ranked as *Relatively Intact with Multiple Large Blocks* (Level 2) will consist of an area where several blocks of pristine habitat are two-thirds or three-fourths the minimum size necessary for sustaining the ecoregion's biodiversity.

Table 5.2. Landscape integrity categories for ranking candidate priority areas for the Integration Matrix

Level of Landscape Integrity	Examples of elements of biodiversity effectively that is conserved or lost at this level of landscape	Description
1. Intact, contiguous landscape	Conserves top predators, sensitive species, area-limited species, natural disturbance regimes	Habitat blocks greater than minimum required to sustain biodiversity in the ecoregion
2. Relatively intact landscape, multiple large blocks remain	Conserves top predators, sensitive species, area-limited species, natural disturbance regimes	At least one habitat block > ¾ minimum required to sustain biodiversity, total exceeds minimum required area
3. Relatively intact landscape, some large or medium-sized blocks remain	Maintains effective dispersal of wide-ranging species	At least one habitat block ½ - ¾ minimum size required to sustain biodiversity, high level of connectivity among habitats
4. Relatively intact landscape, multiple medium-sized blocks remain	Begin to lose populations of top predators and other area-limited species	Habitat blocks ½ minimum size required to sustain biodiversity, intermediate level of connectivity among habitats
5. Altered landscape; moderately fragmented; some large and medium blocks remain	Conserves mesopredators, continues to lose some area-limited species	At least one block > ½ minimum size required to sustain biodiversity, contains no connected habitats
6. Altered landscape, highly fragmented, some medium-sized blocks remain but no large blocks	Conserves some meso-predators, serves as population sinks for large predators	At least one block ¼ - ½ minimum size required to sustain biodiversity, contains no connected habitats
7. Altered landscape, highly fragmented; mostly small blocks remain,	Conserves populations of plants; invertebrates, small vertebrates; stepping stones; source pools for restoration	All blocks < ¼ minimum size required to sustain biodiversity
9. Heavily degraded but restorable large blocks remain	Conserves populations of plants, invertebrates, small vertebrates; stepping stones; source pools for restoration	At least one block > ½ minimum size required to sustain biodiversity
10. Heavily degraded but restorable medium-sized blocks remain	Serves as potential source pools for restoration	At least one block ¼ - ½ minimum size required to sustain biodiversity

To evaluate landscape integrity, follow this process:

- In the candidate priority areas, use recent maps (ideally the maps should represent interpretations of habitat from satellite images) to evaluate the distribution, configuration, and size of remaining habitat areas.
- Identify and rank habitat within the candidate priority areas using three classes: intact, altered (degraded), and heavily altered .
- For ecoregions where forested-cover data exist, use your GIS to calculate the sizes of remaining habitat blocks.
- Give all remaining areas that are above a certain size threshold (identified by the experts) unique identification numbers using the persistence analysis (see chap. 4).

- If you do not have GIS capability, try to create a grid (based on the scale of the map) using graph paper to estimate the size of landscapes, and assign landscapes to broad size categories (e.g., >3,000 km^2, 1,000-3,000 km^2, 500-1,000 km^2, etc.) rather than determine exact size of the area.

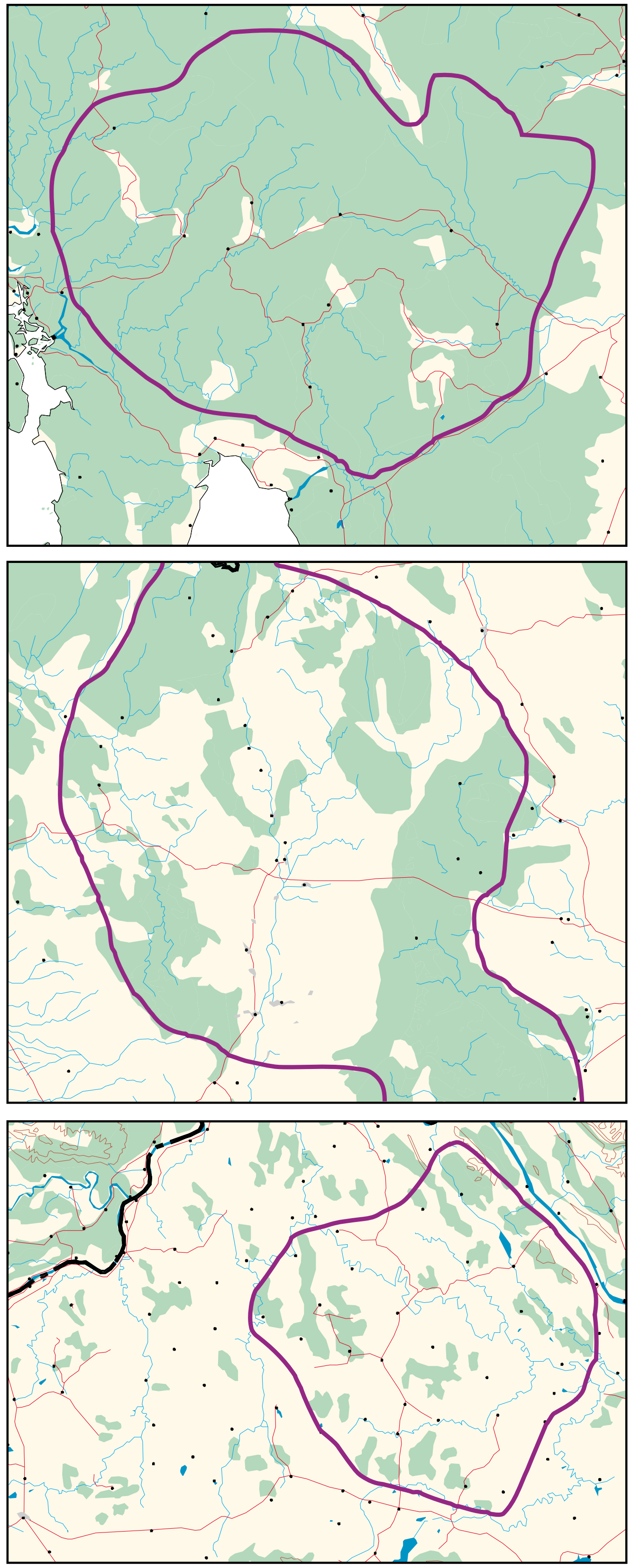
An alternative and more simplified approach is to decide on some arbitrary size thresholds, based on the best available data for the Major Habitat Type to which the ecoregion belongs, and to sort the blocks accordingly. For example, in the Chihuahuan Desert, we decided to classify units of habitat in the following way: >1,000 km^2 is large, 100-1,000 km^2 is intermediate, and <100 km^2 is small.

After these habitat blocks and landscapes are mapped, we can begin to rank candidate priority areas based on habitat integrity; then biological distinctiveness is assigned. This procedure is explained in the next chapter.

Relatively intact landscape; multiple large blocks remain (Category 2)

Altered landscape; moderately fragmented some large and medium blocks remain (Category 5)

Altered landscape; highly fragmented; mostly small blocks remain (Category 7)



LEGEND

- Remaining Habitat
- Degraded Habitat
- Cities and Towns
- Roads
- Rivers
- Limit of nominated priority areas

Figure 5.1. Examples of nominated priority areas illustrating different categories of landscape integrity

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SETTING PRIORITIES AT THE ECOREGION SCALE: INTEGRATING DATA ON BIOLOGICAL DISTINCTIVENESS AND LANDSCAPE INTEGRITY 6

Introduction

The ultimate goal of ERBC is to conserve the full expression of biological diversity in the ecoregion. We cannot embark on the conservation of all areas simultaneously, however, because of the limits of financial and technical resources. Even in small ecoregions, conservationists face the difficult task of setting priorities to determine where to act first. In this chapter, we present a procedure for ranking priority areas based on the principles of conservation biology. The ranking procedure assumes that all candidate areas are neither equal in their contribution to a biodiversity conservation strategy nor equal in their level of threat or resilience. We will illustrate how the analysis to assess biological distinctiveness (already completed chap. 4) can be integrated with the analysis of minimum area requirements for species and processes (chap. 2) and the analysis of landscape integrity (chap. 5). Combined, the results of these analyses define a portfolio of priority areas for ERBC. These priority areas will become key elements of the biodiversity vision (see chap. 8).

Concepts

The process of ranking—setting certain areas as more important than others—is perhaps the most difficult step in developing a biodiversity vision. It requires making value judgments, often, with less than comprehensive information. It is critical to make this process as transparent as possible.

Step 9. Use an integration matrix for integrating biological distinctiveness with landscape integrity analysis to rank candidate priority areas

To identify top priorities, we propose the use of a matrix that will subject each candidate priority area to the same set of criteria and prioritize them on the basis of their integrity and biological distinctiveness. This two-dimensional matrix is then cross-referenced with a third dimension, the representation analysis that was completed earlier (chap. 4). The biological distinctiveness parameter reflects the richness and relative rarity of the biodiversity of a given area within a subregion, the ecoregion, the continent, or even the globe. A landscape integrity analysis combines data on the relative size of habitat blocks—scaled to conservation of features and processes characteristic of the ecoregion(s)—and degree of intactness.

Through the use of the matrix, one can see that different combinations of these parameters can be associated with different levels of priority. For example, an area that contains a large block of intact habitat and that harbors outstanding levels of endemism and richness for a range of taxa would be deemed highest priority, whereas a degraded area that has medium levels of richness for a single taxon would rank lower. Small, highly degraded areas that contain examples of biodiversity commonly occurring throughout the ecoregion might rank lowest of all. However, in an ecoregion where beta-diversity is particularly high, a degraded area with high endemism would tend to be ranked higher than an area with more intact habitat and low endemism.

The matrix helps you to sort these combinations and rank them. The primary purpose of the priority-setting matrix is to highlight

- those areas that harbor the most irreplaceable biodiversity, and
- those areas where biodiversity will have the best chance of long-term persistence (which is typically in more intact, larger blocks).

In general, on the Biological Distinctiveness axis of the matrix (the Y-axis) endemism should be considered a more important indicator than high species richness. However, we also recognize that developing matrices for ecoregions that represent major habitat types characterized by low levels of endemism (e.g., taiga, tundra, mangroves, flooded grasslands) will require putting greater emphasis on other criteria. For example, a matrix designed for a tundra ecoregion might give higher value to candidate priority areas that conserve large migratory mammals, maintain the full complement of top carnivores, and are sufficiently large to accommodate patchy resources, or conserve extraordinary concentrations of breeding birds.

Consequently, the weighting of the different columns and rows of the matrix will depend on your ecoregion. Ecoregions with high beta-diversity but with low overall species richness will rank endemism as being relatively more important than the overall numbers of species. Ecoregions with low beta-diversity but high species richness or species of special concern should rank the intactness of the habitat higher. Knowing the level of beta-diversity and habitat size sensitivity of your ecoregion will help you define the categories for your priority setting matrix.

Application

Construct an integration matrix (see table 6.1) with this procedure:

1. Rank habitat integrity. The value that is the basis for establishing the Landscape Integrity scale for the matrix (Y-axis) is derived by estimating area and habitat requirements of the ecoregion (see chap. 5). You will recall that those values were derived by estimating the area required to support viable populations of a suite of focal species and ecological processes characteristic of your ecoregion. Recall that if obtaining the full goals of minimum viable populations (22,000 individuals) is not possible for decades, you may want to use less rigorous area requirements—perhaps half the area—as an interim step (while retaining the ultimate goal as part of the vision).

2. Ranking biological distinctiveness. A system of categories will enable you to categorize the biological distinctiveness in a relatively rigorous and consistent fashion. For the X-axis of the integration matrix, we recommend five to six columns. These should include categories for

- High representation of endemic taxa, rare communities or unique ecological processes
- Moderate representation of endemic taxa, high richness for taxa, or ecological processes
- Low endemism, high richness
- Low endemism, low richness, but contains a unique habitat
- Low endemism, low richness, but only habitat of a single threatened species
- Low endemism, low richness, assemblage occurs in multiple areas across ecoregion

A system of categories will enable you to categorize the biological distinctiveness in a relatively rigorous and consistent fashion.

3. Fill the integration matrix. To rank candidate priority areas with the integration matrix, you will need to assign rankings to each of the 50 cells in the matrix. We suggest that you use the following five levels of priority:

I = highest priority areas that form the core of an ERBC strategy;
II = high priority areas that also contribute to an ERBC strategy;
III = regional priority areas that should be considered in an ERBC strategy;
IV = areas that are important in local conservation strategies; and
V = areas of lower priority that support occurrences of ubiquitous communities or species assemblages

We also recommend that you do the following:

- Restrict the highest ranking to about 10 percent of the cells. This will restrict the tendency to give all priority areas the same top level of ranking.
- Assign rankings to all of the cells before you begin the ranking process. This avoids the bias that can occur when ranking candidate priority areas that are favorites of individuals involved in the selection process. The process of ranking the candidate priority areas simply involves determining which cell is the best fit for each area. The result will be a ranking of 1 to 5 for each.

Table 6.1. The matrix for ranking candidate priority areas with examples of cell rankings (The ranking provided below is only illustrative.)

Landscape Integrity and Biological Distinctiveness	High representation of endemic taxa, or rare Communities, or unique ecological evolutionary phenomena	Moderate representation of endemic taxa, high richness for taxa	Low endemism, high richness	Low endemism, low richness, but only representative area	Low endemism; low richness, protects a single threatened species	Low endemism; low richness, multiple representa-tive areas
Intact habitat block greater than minimum required to sustain biodiversity in the ecoregion, contains all interlinked habitats	I	I	I	II	II	III
Relatively Intact multiple large blocks, at least one block > ¾ minimum required to sustain biodiversity, total exceeds minimum required area, contains all interlinked habitats	I	I	II	II	III	III
Relatively Intact multiple, medium-sized blocks, at least one block ½ - ¾ minimum size required to sustain biodiversity, contains 75% of interlinked habitats	I	II	II	II	III	V
Relatively Intact multiple, medium-sized blocks, blocks ½ minimum size required to sustain biodiversity	I	II	III	II	III	V
Incomplete large blocks, at least one block > ½ minimum size determined in Step 1	I	II	III	II	IV	IV
Incomplete medium-sized blocks, at least one block ¼ - ½ minimum size	II	III	III	III	V	V
Incomplete small blocks, all blocks< ¼ minimum size	II	III	IV	IV	V	V
Restorable large blocks, at least one block > ½ minimum size	III	IV	IV	IV	V	V
Restorable medium-sized blocks, at least one block ¼ - ½ minimum size	III	IV	V	V	V	V
Restorable small blocks, all blocks < ¼ minimum size	IV	IV	V	V	V	V

Step 10. Reassess representation of priority areas and make adjustments to insure full habitat representation.

The last step in the integration process is an analysis of the preliminary rankings with respect to their representation of habitats and ecological processes. Once we have made a preliminary ranking of all of the candidate areas, we must cross-reference the top priorities (Level I) with the results from the representation analysis to insure that the top rankings include adequate representation according to the criteria presented in box 4.3 (chap. 4).

Using the worksheet with the list of categories developed in the representation analysis, place the number of each Level I area in the category or categories of habitats represented by it. For example, if a Level I area includes gypsum grassland habitat, then the identification number of the Level I area should be written on the worksheet next to the gypsum grassland listing on the worksheet (see worksheet for the Chihuahuan Desert that follows). If that same Level I area also contains lowland riparian hardwood habitat, then write its ID level number next to the listing for the lowland riparian hardwood habitat category. Large Level I areas will likely include several habitat types.

After all of the Level I areas have been indexed according to their representation of habitats, you will need to go through the same process for the Level II areas and index the contribution of each one to the representation of habitats in the ecoregion. You should now revise the representation worksheet and identify any of the habitat categories that do not have a combination of three Level I and II areas (including at least one Level I) listed for them. Habitat categories that are represented by fewer than this combination are underrepresented. Additional priority areas should be selected from the Level III areas that best fill the gaps in representation. These areas should be elevated to Level II. For certain rare habitats, only one or two examples may exist within an ecoregion. The rarity of the habitat automatically elevates it to a core component of the vision.Case Study 2

Designing the priority-setting matrix for the Chihuahuan ecoregion

On the biological distinctiveness axis of the matrix, we decided to weight high levels of endemism much higher than high species richness. Chihuahuan experts broke into the four subregion groups and were asked to assign rankings to the 60 cells in the integration matrix (see table 6.2) before fitting the landscapes data to the matrix. This *a priori* approach reduced bias towards landscapes where individuals were already active. Experts were instructed approximately that only 10 percent of the 60 cells could be assigned as highest priority. The priority rank presented for each cell (see table 6.2) is an average of the rank assigned to each cell by the four subregion groups. Experts reached near concordance in the assignment of levels of priority to each cell among the four groups. We agreed on five levels of priority:

I = highest priority areas that form the core of a Chihuahuan ERBC strategy
II = high priority areas that also contribute to a Chihuahuan ERBC strategy
III = areas of regional priority that should be considered in a Chihuahuan ERBC strategy
IV = areas that are important in state conservation strategies (e.g., Arizona, Coahuila)
V = lower priority areas that support occurrences of ubiquitous communities or species assemblages

Working in subregional groups, experts assigned the subset of the 61 candidate priority areas that fell within their subregion to appropriate cells. The assignments followed a discussion and comparison of the distinctive biodiversity features and the intactness and integrity of habitats and ecosystems of a given landscape in comparison to others. These assignments became the priority landscape list for further analysis (see fig. 6.1)

Step 11. Conduct gap analyses for protected areas

Laying the groundwork for an implementation strategy: evaluating the protected areas system

The timing and sequence of conservation activities in implementing a biodiversity vision will depend on the results of a protected area gap analysis. This step is best conducted after the biodiversity vision is complete and is most useful in developing an implementation strategy and recommendations for actions. We include it here because protected areas gap analyses are commonly associated with habitat representation analyses.

Protected areas are a cornerstone of biodiversity conservation. An important aspect of ERBC is to set our sights higher than the current configuration of protected areas. Conserving the biodiversity of many tropical moist forest ecoregions may ultimately require as much as 30 percent of the ecoregion to be placed under some form of protection. Few ecoregions currently approach this threshold.

If conservation efforts are to be successful over the long run, we must ensure that biodiversity is retained in core protected areas, and that conservation efforts are extended outward to the greater landscape. Core areas will serve as refugia for many species. From here, they will disperse into adjacent areas of low-impact landuse. Such landscapes require good planning and management to develop and implement a network of linked, core reserves that are set within areas of other land-use designations.

Use the data gathered on protected areas (preferably, made available in digital format) to determine how much of the remaining habitat is protected, whether the protected areas coincide with the priority areas for biodiversity that were identified by experts, and if they meet minimum size thresholds for focal species and processes. Any gaps in protection should be highlighted as part of the emerging biodiversity vision. The existing protected areas system should be evaluated in relation to possible linkages, inclusion of different habitats and ecosystems, adequate habitat areas for wide-ranging species, overall species richness, and endemism hot spots. Any gaps and inadequacies can be rectified by developing plans to enlarge and extend existing protected areas. In some cases, creating additional protected areas may include (a) land exchanges that involve reclassifying redundant or ineffective protected areas and exchanging them for more critical conservation areas, and (b) the linking of proximal protected areas.

A Process to Evaluate the protected areas system

To start, see if the existing protected areas meet these criteria:

- provide adequate coverage for the different habitat types within the ecoregion
- conserve focal species and their habitat requirements
- coincide with areas of high species richness and endemism
- protect other areas of conservation significance, such as important migratory stop-over sites, rare habitats and communities, large-scale movements of terrestrial ungulates, etc.
- conserve areas exhibiting high beta-diversity (where appropriate)
- conserve large landscapes, and
- conserve intact large vertebrate faunas.

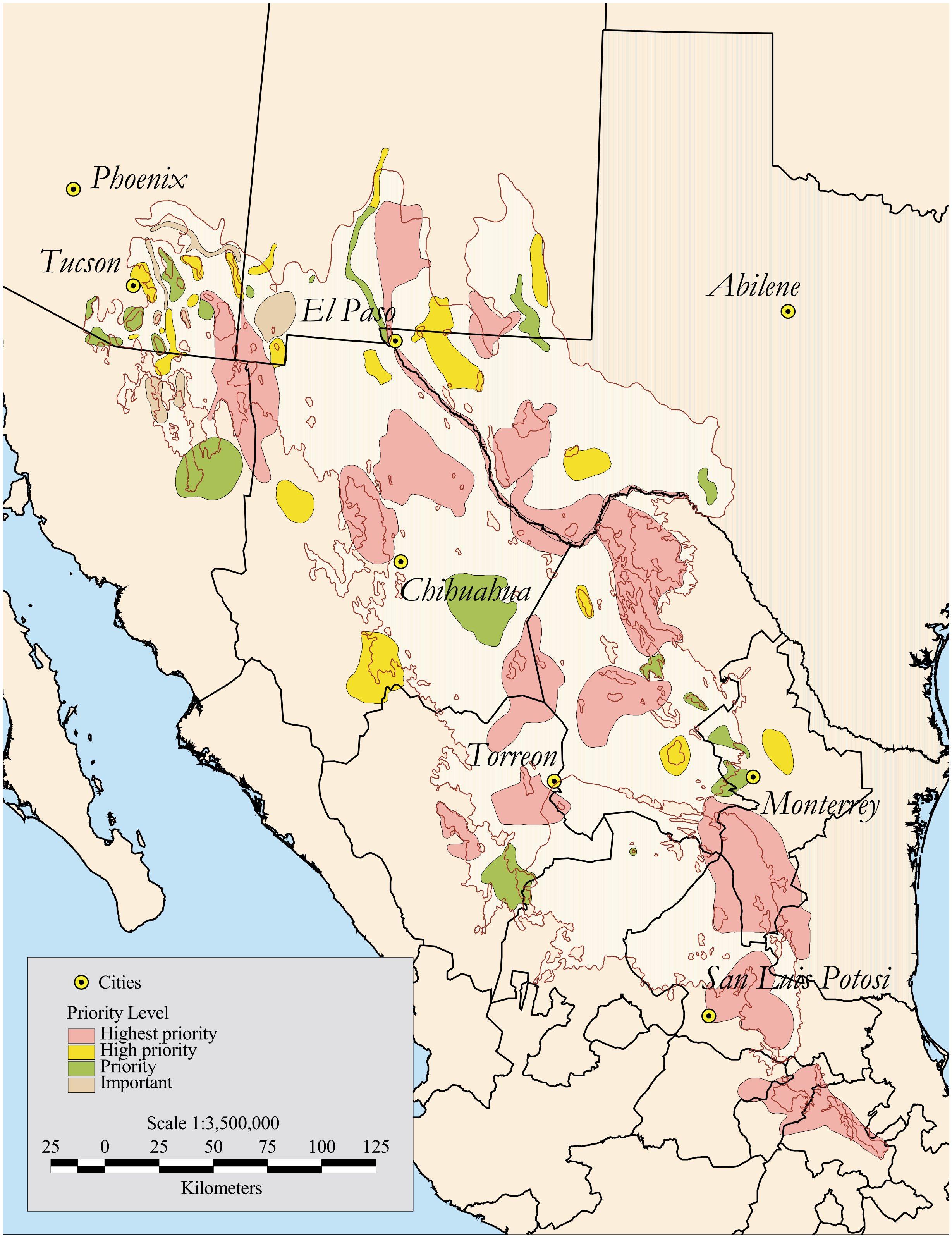

Figure 6.1. Terrestrial priority areas in the Chihuahuan Desert, ranked by priority level

- Identify the gaps in protected areas coverage. Maps depicting the priority areas and remaining habitat, with proteected areas overlayed, are essential tools for evaluating the protected areas system. Use these data to refine the biodiversity vision.
- Prepare a large-scale map showing the priority areas. The map should address gaps in protection andshould indicate protected areas as well as proposed and potential conservation areas, restorationareas,andpotential corridors and linkages. On this map, also show degraded and altered habitat areas.
- Prepare a series of small-scale maps showing (a) the distribution of focal species and where viable populations can be conserved and (b) the distribution of critical processes and where they can be conserved. Overlay the existing protected areas system on these maps.

Step 12. Overlap analyses with other priority-setting exercises

Comparing your ranking of priorities with previous efforts

A second type of overlay analysis is also useful: the comparison of priority areas that were selected by previous workshops or assessments. In some ecoregions, one or more published or unpublished exercises exist to help you set conservation priorities. These can be useful even if, they are expressed at different scales. The development of an ERBC biodiversity vision should build on such efforts, but clearly, any differences in methodology, conservation goals, targets, or scale need to be taken into consideration.

Case Study 3

Overlap analysis of protected areas and priority areas

The Chihuahuan Desert ecoregion contains few protected areas that are designed primarily for conservation of biodiversity, namely, those classified as International Union for the Conservation of Nature and Natural Resources (IUCN) categories I-IV (see table 6.4). Only 1.1 percent (6,900 km^2) of the ecoregion is under formal protection, a remarkably low total for such a large, sparsely populated ecoregion. Analysis of overlap between the 98 highest priority terrestrial and freshwater areas and the 28 protected areas shows minimal coverage (see fig. 6.2, table 6.3). Within the 16 highest priority terrestrial areas (Level I), the amount of total protection does not exceed 3 percent.

The U.S. portion of the desert (Apachean region) holds eight of the ten protected areas that fall within the highest priority areas. However, note that: (a) 75 percent of the ecoregion is in Mexico, and (b) the Apachean subregion contains only one highest-priority area. The U.S. side also contains a number of wilderness study areas, military installations, and NASA facilities. These areas offer wildlife and habitat protection for some species, but do not meet IUCN standards of categories I-IV. The areas do not meet these standards largely because cattle grazing is permitted in wilderness areas. The analysis does not include the large Mapimi Biosphere Reserve in the Central Chihuahuan subregion because biosphere reserves do not fall under IUCN categories I-IV and because looser regulations govern biosphere reserves.

A biological skew is also evident: None of the protected areas has been designed to conserve freshwater priorities. Thus, a glaring omission is the lack of effort to protect freshwater rivers, streams, ponds, or basins, even though the Chihuahuan Desert may be the most globally distinct arid ecoregion in terms of freshwater biodiversity (Olson and Dinerstein 1998).

Representation of protected areas throughout the four subregions is obviously lacking. The Central Chihuahuan subregion, home of both a terrestrial and freshwater priority area, Cuatro Cienegas, contains no formal protected areas in categories I-IV, with the exception of the city of Monterrey. Because most of the protected areas occur within the United States, eight of the ten fall within the Apachean (Subregion Number 3) and Northern Chihuahuan subregions (see table 6.3). The protected areas are also clumped; thus they effectively protect only a few priority sites. For example, among the 16 highest priority terrestrial conservation areas, only 7 overlap with the 10 protected areas.

In summary, the current configuration of protected areas does little to address some fundamental goals of ERBC: giving greater attention to patterns of beta-diversity and conserving large landscapes (chap. 5 and 6). The extraordinary beta-diversity of the Chihuahuan—distributed along basins, isolated springs, gypsum habitats, and mountain ranges—requires a network of reserves widely distributed to capture the complex distributional patterns of many narrow-range endemic species. The need to conserve large landscapes is equally ignored: The median size of the ten protected areas that overlap with priority sites is 215 km^2.

Table 6.3 Multiscale analysis of protected areas in the Chihuahuan Desert ecoregion designated as IUCN categories I-IV (areas expressed in km^2)

	Entire Ecoregion	Apachean subregion	Northern Chihuahuan subregion	Central Chihuahuan subregion	Meseta Central subregion	16 highest priority terrestrial areas
Size of region	629,000	64,000	295,000	150,000	120,000	195,000
Total number of protected areas	28	10	17	0	1	10
Size of protected areas	6,900	2,220	4,560	0	120	5,000
Percent of area protected	1.10%	3.47%	1.55%	0.00%	0.10%	2.56%
Mean size of protected areas	250	222	266	0	120	500
Median size of protected areas	74	63	75	0	120	215

Case Study 4

Overlap analysis of CONABIO sites and priority areas

There is a relatively high degree of overlap among CONABIO and the priority sites and priority areas that are identified in this assessment, despite differences in scale (all of Mexico versus one ecoregion complex). Here, we summarize patterns of overlap for terrestrial biodiversity.

Of the 16 highest-priority areas (red polygons in fig. 6.2), 13 of them occur in Mexico and 11 eleven of those contain at least one CONABIO site (table 6.4, fig. 6.3). Two priority areas (North-Central Chihuahuan Grasslands (priority site no. 2.08) and Cuenca del Rio Nazas (priority site no. 4.07) do not overlap with any CONABIO sites. A total of 26 CONABIO sites overlap with the 11 highest-priority areas.

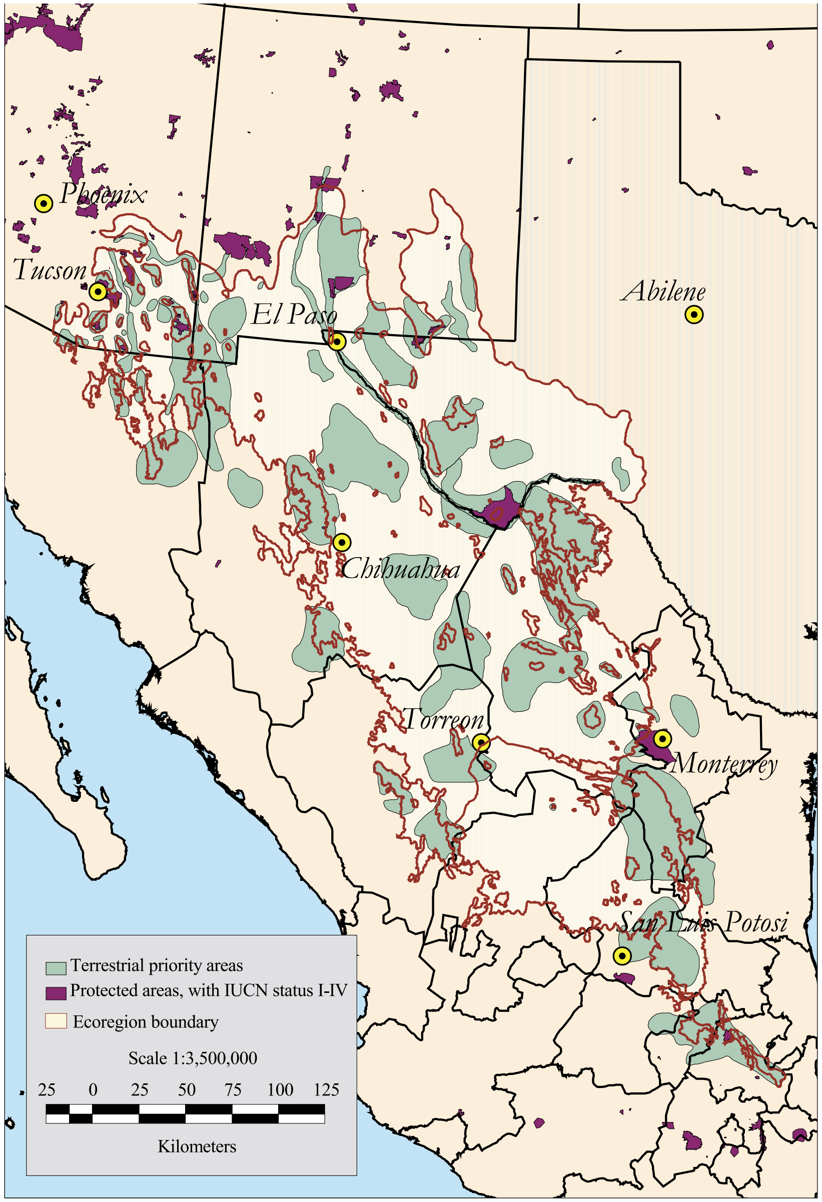

Figure 6.2. Overlap of terrestrial priority landscapes with protected areas designated as IUCN categories I-IV

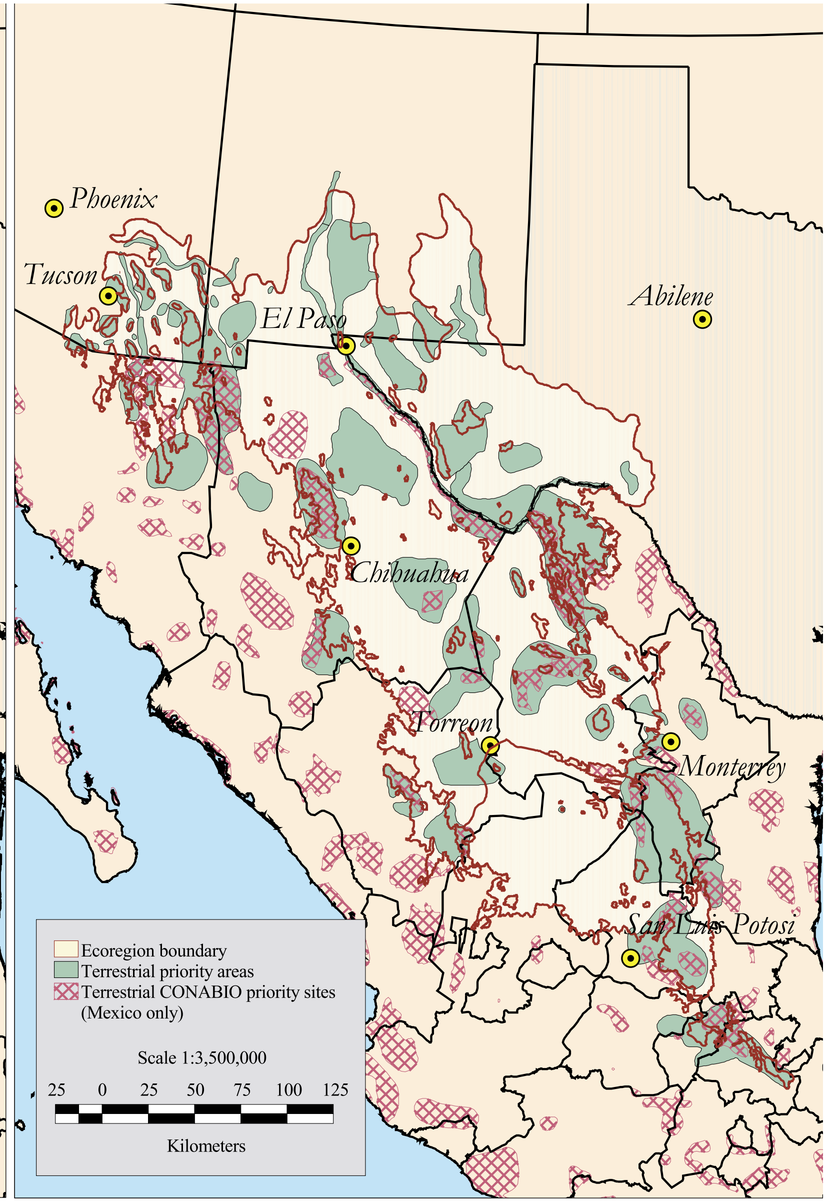

Figure 6.3. Overlap of terrestrial priority areas with terrestrial CONABIO priority sites for Mexico

A majority of these CONABIO sites occur in the Central Chihuahuan (priority site no. 9) and Meseta Central (priority site no. 12) subregions; accounting for 21 CONABIO sites 7 of the 16 highest-priority areas—yet these sites contain only one protected area. This finding further strengthens the need for increased protection in areas where CONABIO sites overlap with highest-priority areas.

Table 6.4. Overlap between terrestrial priority areas (Level I) and CONABIO terrestrial priority sites

Subregion	Terrestrial Candidate Priority Site Name–Number	CONABIO Priority Site–Number
Apachean	Chiricahua-Peloncillo–1.20	Sierra de San Luis-Janos–34
Apachean	Chiricahua-Peloncillo–1.20	Rio Bavispe–35
Northern Chihuahuan	Sierra del Nido–2.01	Sierra del Nido-Pastizal de Flores Magon–39
Northern Chihuahuan	Lower Rio Grande–2.02	Boquillas del Carmen-Rio Grande–40
Northern Chihuahuan	Lower Big Bend–2.07	Canon de Santa Elena–41
Central Chihuahuan	Mapimi Complex–3.01	Lagunas de Jago–57
Central Chihuahuan	Mapimi Complex–3.01	Mapimi–58
Central Chihuahuan	Mapimi Complex–3.01	(portion of) Cuchillas de la Zarca–81
Central Chihuahuan	Sierras del Carmen and Santa Rosa–3.02	Sierra Maderas del Carmen–49
Central Chihuahuan	Sierras del Carmen and Santa Rosa–3.02	Sierra de Santa Rosa–50
Central Chihuahuan	Sierras del Carmen and Santa Rosa–3.02	(portion of) Rio San Rodrigo-El Burro–51
Central Chihuahuan	Cuatro Cienegas–3.03	Sierra de la Madera–54
Central Chihuahuan	Cuatro Cienegas–3.03	Cuatro Cienegas–55
Central Chihuahuan	Cuatro Cienegas–3.03	Sierra la Fragua–56
Meseta Central	Altiplano Mexican Nordoriental–4.01	(portion of) Sierra de Artega–61
Meseta Central	Altiplano Mexican Nordoriental–4.01	Tokio–62
Meseta Central	Altiplano Mexican Nordoriental–4.01	San Antonio Pena Nevada 63
Meseta Central	Altiplano Mexican Nordoriental–4.01	Puerto Purificacion–64
Meseta Central	Altiplano Mexican Nordoriental–4.01	Valle de Jaumav–69
Meseta Central	Huizache-Cerritos–4.02	(portion of) El Huizache–65
Meseta Central	Huizache-Cerritos–4.02	(portion of) Sierra de Alvarez–93
Meseta Central	Huizache-Cerritos–4.02	Llanura del Rio Verde–94
Meseta Central	Queretano–4.03	Cerro Zamorano–102
Meseta Central	Queretano–4.03	(portion of) Canones de Afluentes del Penuco–103
Meseta Central	Queretano–4.03	(portion of) Huayacocotla–105

Step 13. Designing Conservation Landscapes

Review the distribution of the core conservation areas in your ecoregion, and ask the following questions:

- Are you faced with managing metapopulations?
- Which focal species require complete connectivity, and which species are able to use stepping stones to achieve dispersal?

Chapters 9 and 10 provide additional background information on the design of corridors for wide-ranging and area-limited species (see also box 6.1 for a summary). You may want to consult these chapters—particularly, if your ecoregion contains wide-ranging carnivores—to help guide your thinking about connectivity in the landscapes that surround core conservation areas. Once you have added the element of connectivity to your vision, you are now ready to begin the write-up of the assessment and the vision.

Box. 6.1. The role of conservation landscapes in biodiversity visions

Biodiversity visions must promote the creation of conservation landscapes that incorporate core conservation areas and, wherever possible, include large wilderness areas. Such areas can be adjacent to or surrounded by buffer zones that permit managed resource use. They should also be linked, where possible, by corridor habitats that allow for the movement of species among core areas.

Corridors are most important for linking smaller reserves where species' populations have lower probabilities of persistence in isolation, or linking larger reserves that still maintain populations of area-limited larger vertebrates or those that are sensitive to even low levels of human disturbance. Some areas may require restoration to enhance the ecological integrity of existing habitat blocks, provide additional habitat area for species with large area requirements, or to link core conservation areas. Many approaches to establishing core, buffer, and linkage habitats exist, such as the establishment of national, state, and private protected areas; multiple-use areas; and interventions to mitigate disturbance and fragmentation of corridors. Any combination of these approaches will work as long as the critical biological concerns are addressed.

Guidelines are available on the most effective designs of linkage areas for conserving different phenomena (e.g., Noss 1994, Soulé and Noss 1998). For example, some dispersing large predators of the Chihuahuan Desert (e.g., wolves, bears, pumas, and jaguars) will not survive in linkage areas if there are insufficient resources or habitat available, or they will be inhibited from entering corridor habitats if certain features such as preferred or sufficient prey are absent or if disturbances are too great. Typically, higher elevation and riparian areas are identified as potential corridors because they are often most feasible to designate for conservation purposes. However, lowland habitats are likely to be equally or more important corridors in many ecoregions. Wherever possible, conservation landscapes should combine lowland and montane areas, even if the lowland elements require extensive restoration.

Step 14. Developing a biodiversity vision

You are now ready to create a biodiversity vision for your ecoregion. Key components of the biodiversity vision are as follows:

- Ecoregion boundaries and subregions
- Identification, mapping, ranking, and description of core conservation areas
- Identification, mapping, and ranking of critical corridors or linkage zones
- Conditions required for their persistence over the long term
- Identification of outstanding biodiversity features and conservation targets
- Biological benchmarks for achieving the biodiversity vision over 1, 10, and 50 year periods

An important goal of ERBC is to define what success looks like from a biodiversity conservation perspective. The data you have collected and analyzed by working through the previous chapters should provide you with the elements needed to define successful conservation over large spatial scales and over the next few decades. These elements will become the specific features of your biodiversity vision for the ecoregion. They include the following:

- a portfolio of important areas and landscapes that conserve characteristic communities and processes in core conservation areas, and also potential natural habitats for linkages or corridors
- key activities to increase protected area coverage, establishment of conservation landscapes (box 6.1), and key restoration areas
- types of resource use that are compatible both with biodiversity conservation and in habitats outside conservation areas
- mitigation of overarching threats to avoid further erosion of biodiversity

One of the best ways to incorporate the views of a diverse array of experts into the vision is to formally set aside the last day of the workshop to achieve this task. To encourage greater participation in formulating the biodiversity vision for the Chihuahuan Desert (see Case Study 5 on chap. 8), we asked each subregional working group and the freshwater group to develop their own visions and share them with the entire workshop. We requested each group to present the following (you may be able to present the vision using more standard project design terminology, such as objectives or indicators; do not let the word choice distract you)

- the outstanding biological features of the subregion
- key areas for conservation
- major threats to biodiversity that must be mitigated
- a draft biodiversity vision that defines what success looks like from a biodiversity perspective
- potential partners in developing and achieving the vision
- milestones to know if you are making progress

The biodiversity vision for the entire ecoregion synthesizes of the results of these presentations and also incorporatesdetails of the assessment itself. This vision must reflect the original conservation targets and overarching conservation targets. Use the biological assessment and biodiversity vision to generate suggestions for outstanding and immediate conservation targets. We urge you to tape record the presentations of the rapporteurs of each group. These recordings will be used by WWF and its partners to encourage leaders of governments, industries, and private individuals to offer Gifts to Earth—actions that change the course of conservation in an ecoregion.

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Introduction

Major threats to biodiversity affect multiple sites simultaneously. Certain threats may affect habitats, species, and communities either directly or indirectly. For example, poaching or overhunting of top predators directly reduces predator populations but may also have cascading effects on the size and stability of herbivore populations (potential prey). The introduction of invasive species into native habitats is seldom successful, but when combined with other forms of habitat degradation such as overgrazing or altered fire regimes, they can change permanently the structure of affected habitats. Our relative ignorance of the cumulative effects of some threats is a major handicap in undertaking ERBC.

A hypothesis of ERBC is that addressing threats that occur over large spatial scales is a more cost-effective approach than addressing threats on a site-by-site basis. This hypothesis seems appropriate when you consider the effects of large-scale commercial logging, suppression of natural fire regimes, the too frequent burning of natural habitats, or the introduction of invasive species to native biodiversity. Rarely are any of these threats confined to a single site.

The purpose of this chapter is to explain how to undertake an assessment of overarching threats and to assess threats at the landscape scale. We focus exclusively on terrestrial threats but recognize that many land-based threats have severe consequences for freshwater and marine biota and habitats. The freshwater and marine workbooks that follow will offer threat analyses that encompass both land-based threats and those specific to freshwater and marine ecoregions.

Concepts

If threats are so important, why put the biological analysis first?

Many of the conservation efforts undertaken by WWF and other NGOs are largely in response to threats to biodiversity. Why not begin the ERBC analysis by looking at threats? If biodiversity were evenly distributed across an ecoregion or among ecoregions, we could focus almost exclusively on mitigating the most severe threats. However, biodiversity is unevenly distributed in most ecoregions. Some landscapes and areas that are truly threatened have much less distinctive biodiversity than others, so diverting scarce resources to these places without some analysis to determine biological priorities of the ecoregion would be misguided. Using the results from the integration matrix as a framework and then incorporating the results of the threat assessment offers the most rigorous approach. If a series of small electrical fires broke out in the Louvre Museum and it was your responsibility to save its priceless art, you would not try to put out the fires in an ad hoc manner but would first try to extinguish the fires that threatened the Mona Lisa.

Another problem is that threats are more fluid or ephemeral than patterns of biodiversity, which are much more fixed. This point is best illustrated by an example. A number of years ago, many conservationists questioned the wisdom of devoting scarce resources to equatorial moist forests of Gabon because they were minimally threatened. Logging was uncommon, and the country's economy was rich in oil. Had WWF been guided solely by a cursory threat assessment, we would have ignored the extraordinary biodiversity of this area—part of, perhaps, the richest moist forests in Africa. We would also have failed to see the intense logging pressures in other parts of the same ecoregion that were poised to hit Gabon. Instead, we based our actions upon biodiversity considerations, and now we are successful at minimizing the damage to native forests in Gabon.

The integration matrix used in the previous chapter has already incorporated important elements of a threat analysis. Important landscape features that directly influence the persistence of species, habitats, and processes have been examined. The biota found in landscapes that are highly fragmented, isolated, or long and narrow (i.e., that have lower persistence values) are *a priori* more threatened than are the biota in more intact landscapes.

How does an analysis of overarching threats to biodiversity differ from a root causes analysis?

Threats to the biodiversity of an ecoregion may be viewed both from a biological and socioeconomic perspective. Both are necessary, each offering different perspectives on the same concern: biodiversity loss. For example, economists on their own would not discover the threats to biodiversity that are posed by the fragmentation of natural habitats or the decline of species that are dependent on widely separated habitats during parts of their life cycle. Economists might even view the invasion of alien species as the substitution of one form of biodiversity for another. Alternatively, most biologists are unaware of the linkages between habitat conversion and either trade agreements or macroeconomic policies.

The root causes of biodiversity loss in many terrestrial ecoregions are straightforward: poverty, lack of alternatives, overpopulation, and human greed. Biologists who are gathered at an assessment workshop would shed little light on these threats. However, the biologists' effect is extremely useful in the identification of overarching threats that affect the biota directly. For example, in an ecoregion where overgrazing is a problem, they can identify which sites contain more endemic plant species and which sites would face the greatest threat from poor livestock management. In ecoregions where logging of tropical forests is a serious threat, they can identify blocks of forest habitat that are considered to be of higher conservation value and, therefore, should not be logged.

Step 15. Conduct a threat assessment

Conduct an assessment of threats to priority areas

The next step is to conduct a threat assessment of priority areas, which is intended to gauge the urgency of conservation action. It can also help determine the kinds of interventions that may be needed and a timetable for them

- We first categorize threats into three broad classes: conversion, degradation, and wildlife exploitation. Some of the sources of threats that fall under the different categories include
  - *Conversion threats*
    - intensive logging and associated road building
    - intensive burning or grazing that leads to habitat loss (particularly in riparian areas)
    - agricultural expansion and clearing for development and settlement

- permanent alteration from burning
- diversion of water and lowering of groundwater tables

- *Degradation threats*
    - pollution (e.g., oil, pesticides, herbicides, mercury, heavy metals, defoliants)
    - burning frequencies and intensities that are outside the natural range of variation
    - degradation of habitat, resources, or individual organisms caused by introduced species
    - firewood extraction
    - unsustainable extraction of nontimber products
    - patterns and intensity of grazing by native or introduced herbivores that are outside the natural range of variation
    - road building and associated erosion and landslide damage
    - off-road vehicle damage
    - selective logging
    - excessive recreational impacts
    - unsustainable levels of shifting cultivation
    - a spread in cover or an increase in dominance of invasive plant species along with accompanying changes in habitat structure
    - the spread of invasive mammalian herbivores, carnivores, or invertebrates

- *Wildlife exploitation*
    - hunting and poaching
    - unsustainable extraction of wildlife and plants as commercial products
    - harassment and displacement by commercial and recreational users.

The above list is far from exhaustive. Workshops or other reviews will reveal other threats, a few of which may be unique to your ecoregion.

- For terrestrial habitats, we recommend an index of 0-100 points to rank the predicted effect of threats to an area. Each category is assigned points based on the severity and the time frame over which the threat is expected to occur. This analysis is a coarse assessment that treats only the combined effects of the threats in each class, not individual sources such as individual timber sales or proposed mine sites.
- Points can be attributed as follows (Table 7.1):
    - conversion threats (maximum 50 points)
    - degradation threats (maximum 30 points)
    - wildlife exploitation threats (maximum 20 points)

  Conversion threats are weighted most heavily because the effects of habitat conversion are generally more far-reaching and difficult to reverse than either degradation or wildlife exploitation.

- Experts assign the appropriate points for each of the threat types to each area based on table 7.1. The general level of threat is estimated by summing the point totals across the three categories:

    - 70-100 High Threat
    - 20-69 Medium Threat
    - 0-19 Low or Unknown Threat.

Table 7.1. Point distribution to assess threats to candidate priority areas for terrestrial ecoregions

Category	Description	Points
Conversion threats		
	Very high: Threat(s) may alter 25% or more of remaining habitat within 20 years.	50
	High: Threat(s) may alter between 10% and 24% or more of remaining habitat within 20 years.	20
	Moderate: Threat(s) may alter between 5% and 9% or more of remaining habitat within 20 years.	10
	Low-Unknown: No conversion threat(s) are recognized for ecoregion.	0
Degradation threats		
	High: Many populations of native plant species are experiencing high mortality and low recruitment because of degradation factors. Succession and disturbance processes are heavily altered. Habitat quality is too low to maintain sensitive species. Abandonment and disruption of seasonal, migratory, and breeding movements. Pollutants, linked effects or both are widespread in the ecosystem (e.g., recorded in several trophic levels).	30
	Medium: Populations of native plant species are experiencing high mortality and poor recruitment because of degradation factors. Succession and disturbance processes are modified. Habitat shows some abandonment and under use by seasonal migratory, and breeding movements by species. Pollutants, linked effects or both are commonly found in target species or assemblages.	15
	Low-unknown: Degradation threats are low or do not exist.	
Wildlife exploitation		
	High: Intensity of wildlife exploitation is occurring in region and local populations of most target species have been eliminated or face imminent elimination.	20
	Moderate: Wildlife is moderately exploited. Populations of game or trade species persist but in reduced numbers.	10
	Low-Unknown: Wildlife exploitation is occurring minimally or not at all.	0

- The threats to each priority area are scored using the criteria on table 7.1. Each is assigned a threat ranking of High, Medium, Low-Unknown.

- Areas that are considered a Level I or II priority (see chap. 6) and are assigned a threat ranking of High are obvious places to consider both for immediate action in the biodiversity vision, and for the longer-term ERBC strategy.

Step 16. Identify overarching threats

If the expert's workshop is part of the ecoregional planning process, ask participants to break into subregion working groups. They should then do the following.

- List and rank threats to biodiversity that they consider pervasive throughout the ecoregion.
- Focus on primary threats rather than those that are conditions or results caused by major threats.
- When the subregional groups are reassembled in a plenary session, a rapporteur should list all of the major threats identified in the subregional groups.
- All participants should then vote for their top five overarching threats to biodiversity in the ecoregion.
- They should also highlight the top five threats for in-depth treatment at a second workshop or other venue focused exclusively on how these threats and socieconomic factors affect conservation of priority areas, landscapes, and processes.

This can be as useful exercise as biodiversity often have the best insights into the threats affecting biodiversity in an ecoregion. Indeed, the threats and where they occur as identified by biodiversity specialists have often been quite different from those identified by socio-economic specialists in our experience. This section has been dropped at workshops due to time considerations.

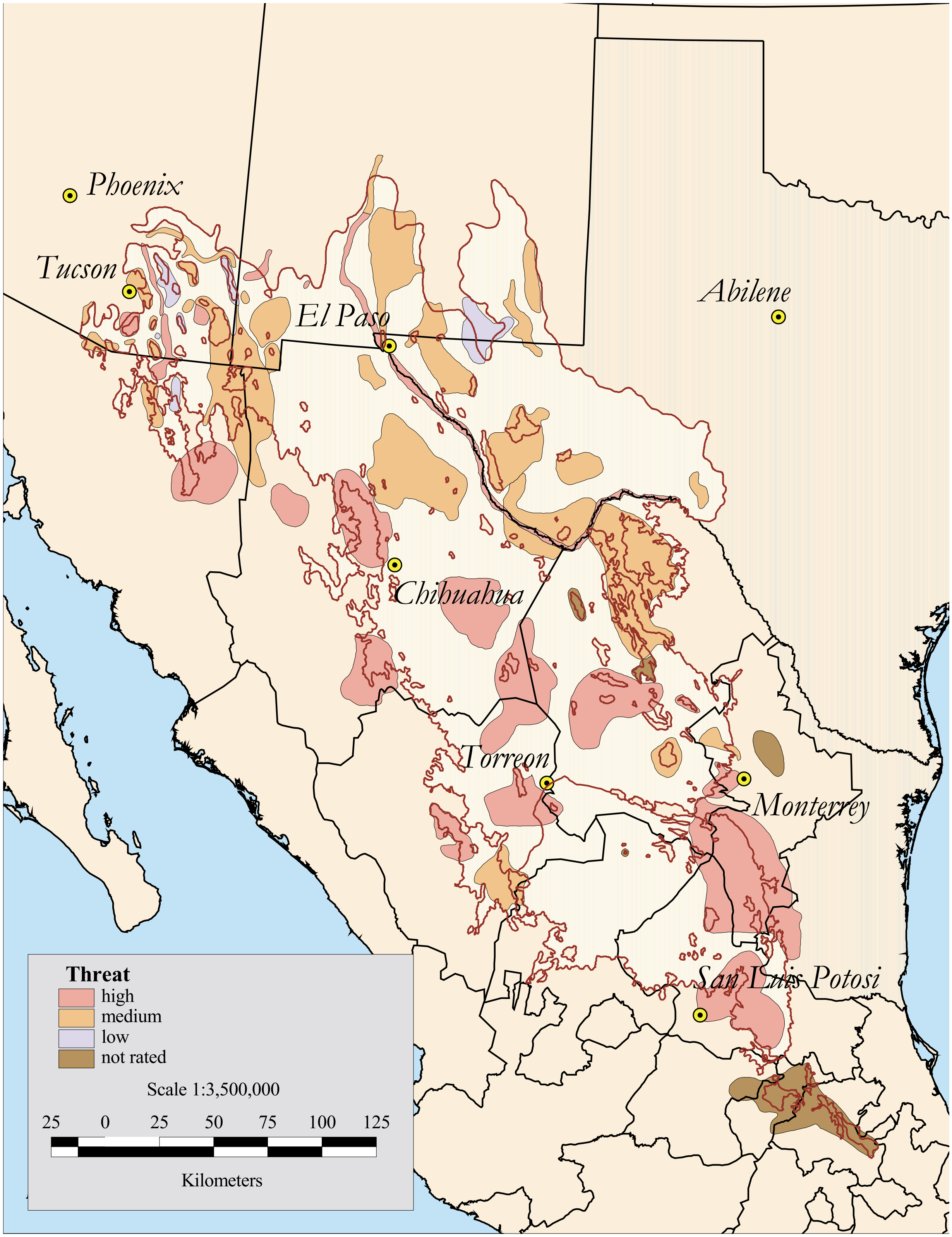

Figure 7.1. Levels of threat for terrestrial priority areas in the Chihuahuan Desert ecoregion

Table 7.2. Overarching threats to biodiversity in the Chihuahuan Desert

Threat	Votes received	Threat	Votes received
Water mismanagement	Unanimous	Illegal poaching	9
Growing human population	Unanimous	Unsustainable harvest of native species	9
Overgrazing and overbrowsing	41	Altered fire regime	7
Agricultural expansion	29	Pesticides	5
Lack of law enforcement	24	Loss of indigenous knowledge	5
Introduced and exotic species	22	Road construction, road density	4
Lack of perspective in land-use planning	18	Pathogens, disease, parasites	3
Lack of environmental education	16	Fuel wood harvest	2
Overcollection of biota	14	El Niño	1
Air and water pollution	11	Mining	0
Urbanization	10	Uncontrolled recreation	0
Logging	10	Toxic waste disposal	0
		Inadequate laws	0

Levels of threat at terrestrial priority areas

Although a particular threat may operate over many areas, the cumulative effect of several threats at a single location can place the biodiversity it contains in grave danger. A summary of priority ranks and threat levels (high, medium, low-unknown) shows that a high percentage of Level I and II priority areas have a high or medium level of threat (see table 7.3). Overall, 24 percent of priority sites have a high level, 43 percent have a medium threat level, and 25 percent of priority sites have a low-unknown threat level. The biodiversity vision should take note of the 16 Level I and of the 2 Level II priority areas that are classified as high threat. A map of the levels of threat that are applied to terrestrial priority areas shows that Mexican areas are, on average, more threatened than U.S. areas (see fig. 7.1).

Table 7.3. Summary of priority ranks and threat levels in the Chihuahuan Desert analysis

Priority rank	Threat level	Number of sites	Priority rank	Threat level	Number of sites
I	High	16	**III**	High	3
I	Medium	12	**III**	Medium	13
I	Low	1	**III**	Low	10
I	Unknown	1	**III**	Unknown	1
II	High	2	**IV**	High	3
II	Medium	14	**IV**	Medium	3
II	Low	9	**IV**	Low	5
II	Unknown	3	**IV**	Unknown	2

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FINAL WRITE-UP AND PEER REVIEW OF THE ASSESSMENT AND VISION *8*

Introduction

Congratulations. Having reached this chapter, you are almost ready to prepare the draft biological assessment and refine the draft biodiversity vision based on the analyses described in chapters 1 - 7. One analytical step remains: to identify ecoregion-scale linkage zones and corridors among core conservation areas. If conservation biology is the science of the 1990s, then "corridor biology" is likely to become one of the most important sub-disciplines in the next century. Because many high-priority areas may be too small by themselves to support viable populations of focal species, we may need to link them through corridors that pass through buffer zones. Essentially, we are managing populations that are linked by dispersal—a group known in the scientific lexicon as a *metapopulation*. You will want to make sure that your vision addresses the issue of connectivity among core conservation areas, whether existing or proposed.

By completing the workbook through chapter 8, you have essentially prepared the groundwork for the main chapters of the final report. The workbook was deliberately designed with this purpose in mind. In this chapter, we offer an outline for you to follow while writing the assessment. We also include an outline and checklist for preparing and evaluating the final biodiversity vision. We stress the critical step of arranging for peer review of the assessment and vision. Without this important step, you risk minimizing the effect of the assessment and losing an opportunity for widespread acceptance to the goals and conservation targets of the ERBC effort as a whole.

You may also want to add a few other pieces of information to the assessment. These will be covered in this chapter; the most important is a section describing priority areas. Case studies for this chapter include: (a) the Chihuahuan Desert biodiversity vision to illustrate how the analyses that was conducted in chapters 4-8 led to the creation of a vision (b) the draft vision and accompanying map for the Himalayas, and (c) an example of a description for a Level I priority area from the Chihuahuan Desert analysis.

Concepts

Dispersal is a fundamental ecological process of great conservation importance. Some species disperse over very short distances (a few meters) while others disperse over hundreds of kilometers. Some species such as wolves may be highly vagile and cross hundreds of kilometers over human-altered habitats whereas tigers rarely cross human-altered landscapes that lack vegetative cover an area greater than 5 km. Birds and bats are able to use stepping stones, or blocks of habitat that are in proximity but not fully connected, whereas many invertebrates view a road as a barrier to dispersal. In short, the degree to which you must address connectivity of core conservation areas will depend upon the life-history characteristics of your focal species and the nature of the ecological processes that operate in your ecoregion.

Step 17. Developing an assessment outline

We offer the following outline of the Chihuahuan Desert ecoregion assessment as a starting point for presenting your ecoregion's assessment and vision. We encourage you to adapt this outline to your own ecoregion.

Box 8.1 Outline for the assessment report of the Chihuahuan Desert

Executive Summary	
Acknowledgments	
Chapter 1:	Introduction
Chapter 2:	The Chihuahuan Desert: A brief biological overview
Chapter 3:	Summary of approach
	Box 3.1. Conservation targets for the Chihuahuan Desert
	Box 3.2. A glossary of terms related to priority setting used in this assessment
	Box 3.3. Decision rules for elevating nominated areas to candidate priority areas
Chapter 4:	Biological distinctiveness of the Chihuahuan Desert
Chapter 5:	Conservation status (landscape integrity) of the Chihuahuan Desert
Chapter 6:	Setting priorities for conservation action
Chapter 7:	Gap analysis: Degree of overlap of terrestrial and freshwater priority areas with U.S. and Mexican protected areas and CONABIO priority areas
Chapter 8:	Threat analysis
Chapter 9:	Toward generating a biodiversity vision for the Chihuahuan Desert
	Box 9.1 Designing conservation landscapes in the Chihuahuan Desert
Literature cited	
Appendix 1:	Contributors
Appendix 2:	Summary of approach
Appendix 3:	Nominated areas
Appendix 4:	Threat assessments
Appendix 5:	Description of priority areas
Appendix 6:	A conservation audit of the Chihuahuan biological assessment and biodiversity vision (response to peer review)

For a list of the tables and figures that were included in the Chihuahuan Desert assessment, please consult the vision document titled *Ecoregion-Based Conservation in the Chihuahuan Desert: A biological assessment and Biodiversity*, 1998. An example of a detailed table of contents for workshop proceedings is given in annex 5.

After completion of the workshop, you will want to meet with your GIS staff to determine the maps that will be required for each chapter and to develop a timetable for their production. You may want to follow the Chihuahuan assessment as an example. If you do not have a copy, one can be obtained from Sheila O'Connor, ERBC Coordinator, at World Wildlife Fund, 1250 24 Street, N.W., Washington DC, USA 20037-1175 or at <sheila.oconnor@wwfus.org>.

Websites, CDs, and maps are other important products derived from workshops. They require much preliminary planning and a careful analysis of budgets. Every ecoregion workshop should have a report, map and, CD with data as products.

Step 18. Describing priority areas and landscapes

One of the important sections you will want to add to the document is an annex containing the description of priority areas and landscapes. This component requires a substantial effort by the team of ERBC biologists and experts from the workshop. It will likely be the longest section of the document. We offer an example of a priority area description for a Level I area from the Chihuahuan Desert at the end of the chapter. We urge you to give greatest effort to completing detailed descriptions for Level I and Level II areas because they will form the core conservation strategy. The detail provided in these descriptions will guide the ERBC team by providing a thorough description of the area and what needs to be conserved within it. We suggest the following outline:

Box 8.2 Outline to describe a priority area or subregion

Name and number of the priority area or subregion:
Location: General area, country(s) and state(s) in which the priority area occurs
Size: Expressed in km^2
Priority rank: Level I-V
Level of threat: High, Intermediate, Low-Unknown
Ownership: Percentage of public versus private owners and owners or agencies who are stakeholders
Outstanding biological features: Major endemics, unique habitats, assemblages, ecological processes, phenomena, seasonal value for migrants, etc. (give Latin names for species mentioned)
Conservation status: Degree of intactness, degree of fragmentation, degree of degradation, degree of protection, land tenure
Description of threats: Conversion, degradation, wildlife exploitation
Reasons for selection as a priority area: Why is this area so important to include in the portfolio, what makes it so distinct? How does it contribute to conservation of biodiversity at the ecoregion, continental, or even global scale?
Other priority-setting efforts that identify the site as important (optional):
Conservation partners in area: (Give name of organization—address can come in another annex.
Literature cited:

Application

Refining the draft biodiversity vision

- We recommend that you ask the participants at the experts workshop to break into their subregion working groups.
- Ask them to revisit the draft biodiversity vision that was a product from the orientation meeting. Ask them to review the vision in light of the following issues: the outstanding biological features of the subregion; key areas for conservation of species habitats and processes; major threats to biodiversity that must be mitigated; a definition of success over the next 20-50 years that is based on their representation and minimum areas analyses; and potential partners they might have to develop and achieve the vision. Allow about one hour for this task.
- Return to the plenary and ask a member of each subregional group to present its refined biodiversity vision.
- Lead a discussion on what successful biodiversity conservation would look like over the next 20 years for the ecoregion as a whole and for each subregion.
- Review how important biological features that are identified by the workshop fit into a long-term vision. This step requires a discussion of what one means by the term *original habitat* or *biota* and

how far back one wants to go in restoration efforts.

- By the end of the workshop, push for consensus on a map of priority areas to be a framework for the ERBC strategy.
- Return to the theme of the Berlin Walls coming down. What has to happen to achieve a major advance in conservation biodiversity in the ecoregion?
- Identify major conservation targets that will have a global effect on biodiversity conservation. (WWF refers to these as “Gifts to the Earth”.
- Identify the lead organization or organizations to take responsibility for follow-up, monitoring, and sustaining conservation over time. The lead organization today could become a facilitator or an observer tomorrow.

Use the following checklist (see box 8.3) to test the rigor of your vision and assessment.

Box 8.3. A checklist of important questions prior to submitting the biodiversity vision and assessment for peer review

___ Are you satisfied that you have conducted planning at large enough spatial scales such as landscape scales to conserve area-limited species and to maintain ecological processes?

___ Did you address conservation planning on long enough temporal scales to allow for restoration of degraded habitats, ecological processes, and depleted species populations?

___ Did you develop an ambitious template to ensure the conservation of the full expression of the biodiversity of the ecoregion?

Does your biodiversity vision explicitly address

___ Habitats that are critical for maintaining ecological processes during different seasons, such as mangroves, cloud forests, and riparian forests?

___ Habitat and minimum area requirements for large, wide-ranging species or major disturbance events?

___ Spatial patterns of species turnover (beta-diversity)?

___ Local-scale phenomena that are distinctive of the ecoregion (altitudinal migrations, riparian corridors, wallows, leks, nesting sites, roosts and rookeries, etc.)?

___ Larger-scale phenomena that are included within the ecoregion (i.e., critical habitats and linkages for regional migrants and movements, etc.)?

___ Did you address pervasive threats at the scale over which they operate—often across several ecoregions—rather than deal only with local threats at a handful of sites?

Designing the peer review process

- Begin by sending the document to all invited workshop participants for feedback. The chances are that some of the most knowledgeable people invited to the workshop were unable to attend.
- Include a subset of these individuals as peer reviewers of a revised document that incorporates the comments and suggestions of those who attended the workshop.
- We also urge you to send the document to those experts who might be some of the strongest critics. You benefit more to hear from them early on than much later when it becomes very costly and frustrating to make major changes.
- Allow approximately one month for peer review. To expedite the review process, you may want to provide honoraria for reviewers’ services.

Step 19. Develop an adaptive implementation strategy

You have a biodiversity vision. But the real success in this process comes from real advances in conservation on the ground based on the guidance a vision provides. To achieve the biological goals outlined in a vision, we must develop an adaptive implementation strategy. This strategy takes into the social, economic, political, and cultural situation and determines the most effective timing sequence of conservation actions each year and several years in the future. This strategy must be adaptive because the human situation can change quickly. Threats and opportunities will vary considerably from year to year. Good conservationists will have a mechanism in place to adapt to these changes while at the same time keeping their eye on the biodiversity goals outlined in the vision. This workbook focuses on developing the biological vision and not the implementation strategy. Different experts and data are needed to create a robust implementation plan.

Case Study 5

Biodiversity Vision for the Chihuahuan Desert

" The core of a biodiversity vision for the Chihuahuan Desert's terrestrial landscape, its rivers, and springs must be visionary, focusing on what this ecoregion should look like 50 years hence. It does not accept that which remains on the map today. Creating a vision requires conservationists to define what success looks like on spatial and temporal scales more grand than they normally consider. This step also requires a definition of what the term "original habitat or biota," means and how far back we want to go to guide restoration efforts. In the case of the Chihuahuan, the biodiversity vision developed by the steps and processes described in this workbook requires nothing short of the return of the full complement of large mammals, because they played a prominent role in ecosystem structure and functioning.

A biodiversity vision is essential because it helps us to move beyond a "business-as-usual" approach; it centers the conservation strategy. It serves as a touchstone to ensure that the biologically important features identified in this assessment remain the core conservation targets throughout the ERBC process. Even when we respond to local emergencies, a biodiversity vision provides a useful framework for interpreting threats to the integrity of the entire ecoregion rather than to individual sites.

Crafting a biodiversity vision is a daunting task. However, there are several important characteristics of the Chihuahuan that make construction of a biodiversity vision a plausible activity rather than an exercise in idiocy. For example, much of the ecoregion is sparsely populated. The likelihood that remote areas will become increasingly depopulated over coming decades as people relocate closer to cities and towns may reduce pressures on the more intact and vulnerable sites. The resiliency of some of these habitats, particularly in the face of overgrazing by livestock, suggests that better stewardship could lead to rapid positive changes in habitat quality. With bold political leadership, restoration of grasslands and other terrestrial habitats could occur on a time scale much faster than expected.

Defining success and the elements of a biodiversity vision

Defining success for the Chihuahuan Desert begins with the conservation in perpetuity of its most distinctive biological features: areas of high endemism for cacti and other endemic plants, globally rare assemblages of freshwater fish species, and representation of all major plant communities in the four biogeographic subregions of the desert. The restoration of landscapes and communities builds on these core features. This includes restoration of flora and fauna associated with prairie dog colonies, desert springs altered by the presence of exotic species, desert plant communities affected by overgrazing and overbrowsing, and gypsophyllous habitats that have been degraded. Another element of the vision is to manage large conservation landscapes of sufficient size and connectivity to maintain important ecological processes and wide-ranging species. This includes restoration of populations of Mexican wolves, mountain lion, jaguar, pronghorn antelope, and aplomado falcons. Through the protection of these large conservation landscapes, managed in collaboration with a variety of stakeholders, important gaps in the protected area network of this ecoregion will be addressed. Linkage of priority areas by wildlife corridors will be an important component of the conservation strategy. Finally, conservation of sites important to hemispherical and regional migrants that spend part of their lives in the Chihuahuan Desert and other parts of their life histories in adjacent or distant ecoregions (e.g., migratory birds, bats, and butterflies) will be addressed.

For conservation at an ecoregion scale to succeed, the overarching threats identified in this assessment—mismanagement and diversion of water resources, overpopulation in sensitive areas, overgrazing and overbrowsing of native plant communities, and lack of enforcement of existing laws— must be addressed and mitigated in a timely manner. Within a decade, educators, officials, local leaders, and NGOs must sensitize and win support from a cross-section of communities who understand and value the biodiversity in their backyard because of the ecological services it provides as well as its intrinsic value.

Specific elements of the vision

In this section we elaborate on the specific biological elements of the biodiversity vision.

Areas of high endemism for cacti and other endemic plants are a top priority for protection because such foci represent one of the most outstanding biodiversity features of the Chihuahuan Desert at a global scale. Adequate reserves may have to encompass whole basins or ranges for area endemics or complexes of local endemics. At other sites, very local endemics are restricted to single valleys, dunes, or hillsides. Hernandez and Barcenas (1995) have identified two highest priority areas for endemic cacti, Huizache and Tolimán in the Meseta Central, containing 13 and 14 endemic species, respectively. Four high priority areas were also identified—Cuatro Ciénegas, Matehuala, Doctor Arroyo, and Mier y Noriega—holding 10-12 species each. All six of these localities are captured within the priority sites identified in this assessment.

Gypsum dunes and other communities on gypsum *soils* harbor a large number and proportion of unusual endemic plants and invertebrates. Thus, the cessation of mining activities and strict conservation of these rare and limited habitats is a critical conservation goal. The major gypsophyllous communities are included in priority areas.

The globally rare assemblages of freshwater fish and snail species inhabiting the Cuatro Ciénegas basin are a critical priority. No other freshwater system, particularly one found in deserts, displays the extraordinary local endemism, adaptations, and radiations seen in the basin's fauna. The Chihuahuan Desert's freshwater biota as a whole is also unusual in that it has many localized faunas restricted to individual springs, streams, and rivers spread throughout the region. The great age of the area and isolation of basins has contributed to this pattern. A majority of the region's desert springs and streams suffer from a host of threats including water extraction and the invasion of exotic species, both problems that need immediate action to forestall any further extinctions.

The conservation community should champion the restoration of flora and fauna associated with prairie dog colonies. The Chihuahuan Desert is one of the last places in North America to conserve this formerly widespread, but distinctive, ecological phenomenon. Several priority areas still harbor a number of habitats and biotic elements that can act as source pools for restoration of these extraordinary ecosystems. It is hard to imagine a Chihuahuan biodiversity strategy being assessed as successful without at least a few extensive prairie dog colonies and their associated flora and fauna (e.g., buffalo, pronghorn, falcons, etc.) restored to an original state.

Representation of all major plant communities in the four biogeographic subregions has been largely addressed through the selection process for priority areas. If conservation areas are designed within each of these priority sites, additional attention to representation of habitat types and associated distinctive biotas should occur.

Effective conservation of representative desert plant communities can occur only if pervasive overgrazing and overbrowsing by domestic livestock are controlled, and riparian and aquatic habitats restored.

Management of large "conservation landscapes" of sufficient size and connectivity will maintain the important ecological processes and wide-ranging species characteristic of this region. This includes restoration, where appropriate, of populations of area-limited species such as the Mexican wolf, mountain lion, jaguar, ocelot, pronghorn antelope, and aplomado falcon. Through the protection of these large conservation landscapes, managed in collaboration with a variety of stakeholders, important gaps in the protected area network of this ecoregion will be addressed.

Finally, the vision will include conservation of areas important to hemispherical and regional migrants that spend part of their lives in the Chihuahuan desert and other parts of their life histories in adjacent or distant ecoregions, such as migratory birds, bats, and butterflies.

Where to focus first

In any priority-setting effort, the most fundamental question to ask is, How does this exercise guide us to be more strategic in our efforts to conserve biodiversity?

- From a list of 299 nominated areas, we were able to identify 61 terrestrial and 37 freshwater priority areas that address the conservation targets outlined in the approach (Chapter 3).

- Among the 61 terrestrial areas, we can prioritize even further to identify 16 areas, many of which overlap with CONABIO sites, that are of continental and global importance.

- Few of these 16 priority areas are offered effective protection. Thus, immediate efforts shouldconcentrate on designing large conservation landscapes around these 16 areas that conserve distinctive elements of biodiversity and maintain connectivity. These landscapes should possess large core areas that protect biodiversity, and buffer areas and corridors that allow for limited use depending on the sensitivity of the local biotas.

- The extremely low level of protection requires that another immediate task is to undertake a comprehensive effort to plan an ecoregion-scale network of protected areas that conserves patterns of beta-diversity and maintains linkages to adjacent ecoregions.

- For freshwater biodiversity, an immediate goal is to better control the management of water resources in and around the highest priority areas.

- Another freshwater target would be to remove alien species from isolated pozas and other habitats where possible, and where they pose an immediate threat to rare native biotas.

All of these immediate measures are designed to save source pools for future restoration efforts. A good place to start would be in intact areas exhibiting the greatest degree of overlap of highest priority terrestrial and freshwater areas. Conservation efforts made today will pay huge dividends by increasing the probability of successful restoration.

A priority for the coming decade

To maintain terrestrial biodiversity, a set of restoration targets with a clear timetable must be formulated within the next few years. For the long-term persistence of biodiversity, degraded lands outside of the core areas need to be able to sustain ecological processes such as dispersal or seasonal movements of larger vertebrates. A long-term vision for conservation of the Chihuahuan Desert will promote the application of "biodiversity friendly" land use and wildlife practices and conservation of keystone habitats (e.g., riparian habitats, springs) in matrix areas. This effort will help sustain ecological integrity across landscapes and within core areas.

Defining success by subregion and for freshwater biodiversity

Local experts and conservation biologists with broad experience in the ecoregion are invaluable stakeholders in the process of creating a biodiversity vision. To this end, we built our draft vision by synthesizing summary reports from biologists and conservationists representing each of the four subregions (and freshwater biodiversity which is covered in the second workbook on freshwater ecoregions). These are presented below. Each group was asked to summarize the outstanding biodiversity features and priority areas, how these areas contribute to conserving distinct aspects of Chihuahuan biodiversity, the threats impinging on these areas or across the subregion, conservation activities most needed, what a vision should include based on a 20-year time-table, and potential partners in implementing the biodiversity vision. These presentations were invaluable as they provided regional perspectives and helped inform everyone of the most salient conservation issues affecting the ecoregion. They also provide a finer level of resolution for crafting a biodiversity vision.

Apachean subregion (presented by Dr. Charles Curtin, Biology Department, University of New Mexico.)

The outstanding biodiversity features of the Apachean are the Madrean Sky Islands (particularly the Chiricahua and Peloncillo mountains), the playas, and the wetlands complexes of the Gila River.

The subdivision has very high mammal, reptile, and arthropod diversity, with many endemics. Habitats range from Chihuahuan desert scrub to subalpine. Extremely high levels of beta-diversity occur due to elevation and topography, ranging from desert scrub and ciénegas in lowlands, to woodlands and grasslands in midelevations, to montane forest in the highest elevations. Threats to biodiversity in the Apachean subdivision include altered fire regimes, introduction of exotic species (particularly salt cedar in the riparian areas), home construction, and ground water depletion. Another problem is that the long-time land stewards in the U.S. section of the subregion are aging, presenting the danger that their intimate knowledge and care of the land could give way to increased exploitation.

The biodiversity vision for this subregion includes restoring the ecological role of fire throughout the area, rewatering wetland complexes, maintaining habitat linkages in the core areas, stopping subdivisions for housing, and establishing a seamless integration of resource management on both sides of the border. Potential partners in developing and achieving this vision are

The Nature Conservancy, Santa Fe, NM
New Mexico Natural Heritage Program, Albuquerque, NM
Animas Foundation Rodeo, NM
Wildlands Project, Albuquerque, NM
Quivera, Las Cruces, NM
Southwest Environmental Center, Las Cruces, NM
Malpai Borderlands Group, Anima, NM
Southwestern Center for Biological Diversity, Tucson, AZ
Forest Guardians, Santa Fe, NM
Center for Ecologia, Sonora, NM
GilaWatch, Silver City, NM
Society for Range Management NM Chapter
People for the West, NM
New Mexico Cattlegrowers

Northern Chihuahuan subregion (Delivered by John Karges, The Nature Conservancy of Texas)

The outstanding biodiversity features of the Northern Chihuahuan include riparian areas/gallery forests, montane habitats, springs-ciénegas, grasslands, headwaters of watersheds, range limits and boundaries of many species, migratory and wintering birds, and flyway boundary interfaces with Central Plains and Rocky Mountains flyways.

Threats include air pollution, agriculture, lack of surface water quality and quantity, overgrazing, fuel wood collection, altered fire regimes, exotic game introductions, and urban expansion.

Important components of a long-term vision include the sustainable use of water resources, enlightened management of range lands, improved funding for resource management on public lands, better environmental education and technology transfer in rural areas, effective monitoring of keystone species and the suite of species dependent on them, effective stewardship and law enforcement, improved monitoring of migratory bird species, and provision of economic incentives, such as tax credits, for conservation.

Some information gaps include knowledge of concentrated food resources for migratory birds, missing keystone species, an information exchange across the border, a mollusk inventory, and a Big Bend to Juárez inventory of the Rio Grande (Rio Bravo).

The biodiversity vision for this subregion is based on no net loss of biodiversity and genetic variation; no net loss of grasslands; restoration of critical habitats, particularly streams and cienégas; and the establishment of eight conservation preserves, regardless of ownership. There is great potential for a reserve system from Sevilleta Refuge, near Albuquerque, through the Turner Ranches, White Sands Missile Range, Fort Bliss, the Jornada Experimental Range, and the Davis Mountains. This very large conservation landscape would anchor conservation of biodiversity in this subregion.

Potential partners in developing and achieving this vision are:

ProFauna, Bavicora
The Nature Conservancy of Texas and New Mexico, Santa Fe, NM & San Antonio, TX
National Park Conservation Associations for Big Bend, Guadalupe Mountains, White Sands, and Carlsbad Caverns, TX
Sierra Club, NM
Southwest Environmental Center, Las Cruces, NM
Rio Grande Restoration, Taos, NM
El Paso Audubon Society, El Paso, TX
Rio Bosque, Mexico
Forest Guardians, Santa Fe, NM
Peregrine Fund, Boise, ID
Ducks Unlimited, Mexico
Turner Foundation, NY
T&E, Inc.
Unidos para Conservacion Barrengo, Mexico
Texas Organization for Endangered Species, TX
Watchlist, TX
Environmental Education, TX
Colorado Bird Observatory, Brighton, CO
El Paso Native Plant Society, TX
NM Native Plant Society, Las Cruces, NM, and
Mesilla Valley Audubon Society, Las Cruces, NM.

Central Chihuahuan subregion (Delivered by Dr. Tom Wendt, Herbarium Curator, University of Texas, Austin)

This subregion contains desert scrub habitat of the highest quality in the ecoregion. Several priority areas contribute to a core ERBC strategy. Of these, Cuatro Ciénegas had the highest rating. The bolson and gypsum features along with the upland habitats of the Sierra de la Madera create a site supporting many endemics. Cuatro Ciénegas was a refugium during the Pleistocene for desert species. Another priority area, the Sierra del Carmen-Sierranillos Burros-Valle Encantada complex, approaches Cuatro Ciénegas in distinctiveness. The complex is characterized by high species richness and an interesting phytogeography. Species of the eastern deciduous forests, northern grasslands, and western pine forests converge in this complex. There is a mosaic of habitats and some impressive grasslands. A third core area is the Bolson de Mapimi, a largely intact area with high rates of endemism. This site contains good examples of *tobosa* grasslands, pine forest, gypsum flats, and montane communities of the Sierra de Paila create a mosaic of habitats. There are also some degraded blocks within the Bolson, but it remains extremely interesting for biodiversity. There are no major riparian areas in this subregion.

Currently, threats and habitat alteration are relatively low compared to subregions with higher urban densities. Over the long term, the growing industrial pressure in Coahuila and Nuevo Leon are the greatest threats. These are the most important industrial centers in Mexico. Data gaps are hindering proper management of natural resources. Exotic species, salt cedar in particular, threaten the area. Illegal hunting and collection of reptiles and cacti are also problems. Mining and human-caused fires are visible impacts. Lack of continuity of conservation programs has hampered protection of biodiversity.

The biodiversity vision for this subregion includes many of the core priority areas that are refugia for endemism. Because a number of areas are still relatively intact, a vision of success might be to keep the sites looking like they do today. For this to occur, efforts must be made to keep urban growth from affecting the surrounding natural resources. Decreasing grazing pressure by goats would help in restoration of degraded blocks. Improved grazing management and restriction in sensitive areas is essential in Cuatro Ciénegas and Mapimi. Conservation strategies should emphasize restoration of benign grazing regimes, protection and maintenance of freshwater habitats and riparian areas, and the development of corridors and linkages among priority areas.

On a more local scale, the control of gypsum mining, and its relocation away from known areas of endemism is an imperative. Increased public education and involvement at the local level is a priority. The Sierra del Carmens could be a model for protected areas across the ecoregion. Potential partners in developing and achieving this vision are

Profauna, Mexico
Ducks Unlimited, NM
Ducks Unlimited of Mexico, Mexico
Institute Nacional Ecologia, Mexico
Friends of Mesquite, TX
The Nature Conservancy, NM
Sierra Club, NM
National Park Conservation Association, and
Desert Fishes Council.

Meseta Central subregion (Delivered by Julian Trevino Villareal, Universidad Autonoma de Tamaulipas)

Outstanding areas for biodiversity include the Altiplano Mexicano, which covers numerous habitat types of the Chihuahuan Desert including grasslands, halophytes, scrub, and gypsophiles; the canyons of Sierra Madre Oriental with endemic gypsophyllous plants; prairie dog towns in grasslands; and endemic cacti throughout. Huizache-Cerritos has many freshwater resources and is high in cacti endemism. There have been few studies of this area. Queretaro has high cacti diversity. Originally, this zone was not included in the Meseta Central. Sierra Picacho is a classic example of true Chihuahuan Desert communities. The corridor between Monterrey and Saltillo has a great diversity of plants and is an obvious conservation target.

Not enough experts were present for a completely informed discussion of the Altiplano Mexicano. There are large data gaps in Zacatecas and Durango. These areas, including Rio Nazas, need inventories.

Threats include agriculture, goat grazing, cattle grazing, cacti removal, and pressures from increasing human population.

The biodiversity vision for this subregion includes conservation of the richest foci for endemism of cacti in the world, protection of extensive desert scrub, and conservation of freshwater assemblages. Potential partners in developing and achieving this vision are

Private landowners
UANL
UAC
State governments
Associacion de Ecologia de Sierra Madre
CONABIO
CONACYT
SEMARNAP
UNAM, and
Bioconservacion, A.C.

As partners in the conservation of one of the world's most biologically rich warm deserts, citizens of the United States and Mexico have a joint global responsibility before them. Conserving the biological features outlined in this document forms the foundation of a biodiversity vision and will set an example for other nations to follow in the long-term conservation of arid ecosystems. ***(taken directly from Ecoregion-Based Conservation in the Chihuahuan Desert: A biological assessment and biodiversity vision, (Chapter 9 pages 139-163)***

Case Study 6

An example of a write-up for a Level I priority area from the Chihuahuan Desert

"*Apachean Subregion: Highest Priority Landscapes*

Name: Chiricahua-Peloncillo-Sierra Madre Complex (1.20)
Location: southeast Arizona, southwest New Mexico, and northeast Sonora
Approximate Size: 19,156 km^2
Priority Rank: 1
Level of threat: high

Ownership: Animas Foundation, ejidos; Phelps-Dodge Mining Company, private; State of Arizona, State of New Mexico; U.S. Bureau of Land Management-Safford and Las Cruces Districts; US Fish and Wildlife Service-San Bernadino National Wildlife Refuge; US Forest Service-Coronado National Forest, U.S. Park Service.

Description of site: The Chiricahua-Peloncillo-Sierra Madre Complex comprises an extensive landscape of sky island mountain ranges and intervening basins in a sparsely populated area. A broad range of Apachean vegetation communities exists: Rocky Mountain conifer forest, Madrean evergreen woodland, semidesert grassland, plains and great basin grasslands, Chihuahuan desert scrub, and riparian deciduous forest. With adequate protection, this region can act as a corridor for many vertebrate species that migrate across the international boundary, repopulating the Sierra Madre Occidental, the Mogollon Plateau, and portions of the southern Rocky Mountains. Habitats for wide ranging carnivores and predators extirpated from this region, such as Mexican gray wolf (*Canis lupus baileyi*), grizzly bear (*Ursus horribilis*), ocelot (*Felis pardalis*), and jaguar (*Panthera onca*) still exist. Specific areas within the region are described below.

The Yaqui headwaters are located in a valley at 1,130 m in elevation, and are surrounded by limestone hills. This area has been heavily degraded over the past 200 years. The basin once supported lush grasslands and ciénegas on which cattle and sheep grazed intensively during the 1800s. Now Chihuahuan desert scrub grows where grama (*Bouteloua* sp.) and curly mesquite grass (*Hilaria belangeri*) once flourished. Marshland areas formed by seepage of surface artesian flows have been drained and plowed for farmland or pasture. Other marshes are now invaded by mesquite (*Prosopis glandulosa*) and snakeweed (*Gutierrezia* sp.) (USDI-USFWS 1995).

San Simon Valley is an area north of the Yaqui headwaters. Although contiguous topographically with the Yaqui, the San Simon Creek drains northward to the Gila River. This valley is regarded as one of the most seriously disturbed environments in the SW United States. Overstocking and channelization of San Simon Creek transformed a lush grassland into a highly eroded, gullied landscape of impoverished vegetation types. At least 10 percent of the area has extremely high sedimentation yields and 42 percent of the area has moderate to high rates of erosion. Most of the rangeland (91 percent) is in poor or fair condition. A steep-walled trench, caused by sediment-loaded flood waters, stands where a marshy, unchannelled stream once flowed. Perennial stream flows are now only intermittent. Mesquite, acacia (*Acacia* sp.) and creosotebush (*Larrea tridentata*) dominate the floodplains and alluvial fans that once supported grasslands (USDI-BLM 1990).

The Chiricahuas-Dos Cabezas is the most massive of the Sierra Madre sky islands. This range experiences cool temperatures and periodic snowfall and, subsequently, supports a large expanse of montane forests. The range rises up to 3,000 meters to the west of the San Simon Valley. Most of the range is characterized by Madrean oak woodland. The higher elevations support pinyon-juniper woodland, pine-oak woodland, mixed-conifer forest, and montane deciduous woodland. The lower elevations are influenced in character by the Chihuahuan grama grassland, desert scrub, and lowland riparian woodland habitat types. Riparian woodlands of velvet leaf ash (*Fraxinus velutinus*), desert willow (*Chilopsis lineraris*) Arizona walnut (*Juglans major*), netleaf hackberry (*Celtis reticulata*), Fremont cottonwood (*Populus fremontii*), and Goodding's willow (*Salix gooddingii*) occur in the well-watered canyons. Pine-oak woodlands typically contain Mexican blue oak (*Quercus oblongifolia*), Emory oak (*Q. emoryi*), sliverleaf oak (*Q. hypoleucoides*), Arizona white oak (*Q. arizonica*), Chihuahua pine (*Pinus leiophylla*) and Apache pine (*P. engelmannii*). Chaparral components include pointleaf manzanita (*Arctostaphylos pungens*) and silktassel (*Garrya wrightii*). Mexican pinyon (*P. cembroides*) and alligator juniper (*Juniperus deppeana*) are the typical pinyon-juniper dominants. The highest montane woodlands are comprised of ponderosa pine (*P. ponderosa*), Douglas fir (*Pseudotsuga menziesii*), limber pine (*P. flexilis*), white fir (*Abies concolor*), and quaking aspen (*Populus tremuloides*) (Pase and Brown 1994).

The Peloncillo Range of the Peloncillo-Animas area rises to the east of the San Simon Valley. The Animas Range lies to the east of the Peloncillo, and together they flank the Animas Valley. Both ranges are dominated by Madrean evergreen woodland. The most common community associations are dominated by alligator juniper, gray oak (*Q. grisea*), and Chihuahua pine. Within the montane woodlands, the prevalent plant community associations are dominated by ponderosa pine, quaking aspen, and Douglas fir. The interior chaparral has primarily point-leaf manzanita and mountain mahogany (*Cercocarpus montanus*) associations. Along the lowest slopes, desert scrub associations of ocotillo (*Fouquieria splendens*) and mesquite are most common. The canyons with perennial water sources support riparian woodlands of Arizona sycamore (*Platanus wrightii*) and Fremont cottonwood associations (Bourgeron et al. 1995).

The Animas Valley-Chihuahua Grasslands are flanked by the Animas Mountains to the east and the Peloncillo Mountains to the west. This high valley (1,533 m) contains a largely intact expanse of grassland. The most common vegetative associations in the valley are Plains grassland, dominated by blue grama (*Bouteloua gracilis*) and semi-desert grassland, typically black grama, tobosa grass, or giant sacaton (*Sporobolus wrightii*). The Animas valley is a closed basin but is coterminous with the Hatchita Grassland priority site to its northeast. Towards the south of Animas Valley, the grasslands extend into Chihuahua, along the eastern face of the Sierra Madre Occidental. Several wetlands in this northern portion of Chihuahua are seasonally inundated. Ciénegas are also scattered through the Animas Valley (Bourgeron et al. 1995).

Information is sparse for the Sierra San Luis and Sierra Huachinera of the Mexican Sierra Madre. They are principally Sierra Madre encinal woodland and probably support plant and animal species very similar to the Chiricahua mountains.

Outstanding biological features: *Yaqui Headwaters.* Despite its degraded condition, the Yaqui headwaters is still home to rare and endemic plants and animals. Pronghorn antelope (*Antilocapra americana*), badger (*Taxidea taxus*), kit fox (*Vulpes macrotis*), white-tailed kite (*Elanus caeruleus*), and Lincoln sparrow (*Melospiza lincolni*) are among the grassland inhabitants. Ciénegas contain endangered riparian and aquatic herpetofauna, fishes, and invertebrates such as the Mexican garter snake (*Thamnophis eques*), Chiricahua leopard frog (*Rana chiricahuensis*), longfin dace (*Agosia chrysogaster*), Yaqui catfish (*Ictalurus pricei*), Yaqui chub (*Gila purpurea*), Yepomera springsnail (*Fontelicella* sp.), Yepomera tryonia (*Tryonia* sp.), and San Bernadino spring snail (*Fontelicella* sp.). Among the wetland bird species are Virginia rail (*Rallus limicola*) and green kingfisher (*Chloroceryle americana*). In the riparian woodlands are gray hawk (*Buteo nitidus*), blue grosbeak (*Guiraca caerulea*), and summer tanager (*Piranga rubra*). Other herpetofauna throughout the valley are lowland leopard frog (*Rana yavapaiensis*), massasauga (*Sistrurus catenatus*), Dixon's spotted whiptail, canyon spotted whiptail (*Cnemidophorus burti*), and bunchgrass lizard (*Sceloporus scalaris*) (USDI-USFWS 1995).

The degraded San Simon Valley contains remnants of grassland and wetland species assemblages such as the kit fox (*Vulpes macrotis*), Bendire's thrasher (*Toxostoma bendirei*), painted and varied buntings (*Passerina ciris* and *P. versicolor*), Bell's vireo (*Vireo bellii*), and black-tailed gnatcatcher (*Polioptila melanura*). The valley continues to serve as a corridor for the movement of grassland species such as pronghorn antelope and Cassin's sparrow (*Aimophila cassinii*) (McClaren and VanDevender 1995; USDI-BLM 1990).

While the Chiricahuas-Dos Cabezas mountains are renowned in the US for their high richness of birds, they also support a notable diversity of other taxa. At least two endemic land snails have been described from the Chiricahuas. Several rare reptiles are found here, including ridge-nosed rattlesnake *(Crotalus willardi*) and twin-spotted rattlesnake (*Crotalus willardi*). These mountains could provide corridors of movement and prey for extirpated large predators such as jaguar (*Panthera onca*), Mexican gray wolf (*Canis lupus baileyi*) and grizzly bear (*Ursus horribilis*). Other mammals documented in these mountains are Sanborn's longnose bat (*Leptonycertis nivalis*), Chiricahua fox squirrel (*Sciurus apache*), mountain lion (*Felis concolor*), black bear (*Ursus americanus*), and porcupine (*Erethizon dorsatum*). In addition to the occurrence of more tropical bird species such as the greater pewee (*Contopus pertinax*), elegant trogon (*Trogon elegans*), magnificent hummingbird (*Eugenes fulgens*), and buff-bellied flycatcher (*Empidonax fulvifrons*), montane species such as Mexican spotted owl (*Strix occidentalis lucida*) and Mexican chickadee (*Parus sclateri*) also occur at higher elevations. This range supported thick-billed parrots (*Rhynchopsitta pachyrhyncha*) until 1938, although unsuccessful reintroduction attempts were made in 1986 and 1995. Riparian woodlands support zone-tailed hawks (*Buteo albonotatus*), as well as the Chiricahua leopard frog (*Rana pipiens chiricahuensis*). Montezuma quail (*Cyrtonyx montezumae*) and Strickland's woodpecker (*Picoides stricklandi*) are commonly found within the oak-pine woodlands (Taylor 1995).

The Peloncillo-Animas area still contains intact habitats that may provide corridors of movement for wide ranging mammals such as the Mexican gray wolf (*Canis lupus baileyi*). In 1997 a jaguar was photographed in the Peloncillo Mountains. Once locally extinct, the desert bighorn *(Ovis canadensis mexicana*) have been reintroduced into the Peloncillo Mountains (USDI-BLM 1993). At least 638 species of plants occur in the Animas mountains (Wagner 1977). The area is considered to have the highest diversity of cacti in the state of New Mexico. Pine-oak woodlands support endangered mountain snakes such as ridge-nosed rattlesnake (*Crotalus willardi*) and two endemic land snails, *Ashmunella animasensis* and *Sonorella animasensis*. The riparian woodlands are unusual for their escape from extensive salt cedar (*Tamarix chinensis*) invasion, particularly in Guadalupe Canyon. The woodlands support the Chiricahua leopard frog (*Rana pipiens chiricahuensis*), northern beardless tyrannulet (*Camptostoma imberbe*), and thick-billed kingbird (*Tyrannus crassirostris*). The desert scrub and pine-oak woodlands are also home to whiskered screech-owl (Otus trichopsis), violet-crowned hummingbird (*Amazilia violiceps*), Lucifer hummingbird (*Calothorax lucifer*), Sanborn's longnose bat (*Leptonycteris nivalis*), and eight other species of bat.

The Animas Valley is home to the Gray Ranch, 300,000 acres of deeded land with a conservation easement. Within the ranch and its neighboring properties are large expanses of sacaton (*Sporobolus airoides*) and grama (*Bouteloua sp*.) grasslands. The grasslands provide a corridor for the movement for pronghorn antelope (*Antilocapra americana*) and bison (*Bison bison*) across the international border into Mexico. Dozens of species of wintering grassland birds are found here, including McCowan's longspur (*Calcarius mccownii*), Smith's longspur (*Calcarius pictus*), western and eastern meadowlarks (*Sturnella neglecta* and *S. manga*), and Baird's sparrow (*Ammodramus bairdii*). During breeding season, declining grassland birds such as Botteri's sparrow (*Aimophila botterii*) utilize the sacaton grasslands. Fire is used as a management tool in the area. The ciénegas on Gray Ranch and in surrounding areas support endangered or aquatic herpetofauna, including the Chiricahua leopard frog (*Rana chiricahuensis*). Antelope Pass, in the Animas Valley, has the highest lizard species diversity in the continental US (USDI-BLM 1993). The grasslands in the Mexican state of Chihuahua are home to the largest remaining black-tailed prairie dog (*Cynomys ludovicianus*) town in North America. The black-tailed prairie dog towns provide suitable wintering habitat for ferruginous hawk (*Buteo regalis*) and mountain plover (*Charadrius montanus*). Year round residents associated with the prairie dog towns include kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), golden eagle (*Aquila chrysaetos*), and burrowing owl (*Athene cunicularia*). Prairie dog towns are found throughout the Chihuahuan grasslands, and were at one time coterminous with the Hatchita Grassland prairie dog towns that are now extirpated (McClaran and VanDevender 1995). This area may contain the highest diversity of graniverous mammals in the United States. Kangaroo rats (*Dipodomys sp*.) play a functional role in the maintenance of grasslands through seed caching, seed distribution, and soil movement. The grasslands once supported breeding populations of Aplomado falcon (*Falco femoralis*) and Worthen's sparrow, now endangered in the United States and Mexico.

Biological information about the Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera) area is lacking. However, invertebrate inventories on the Río Piedras Verdes, flowing eastward from the Sierra Huachinera, show that the intact riparian woodland contains the viceroy butterfly (*Limenitis archippus obsoleta*), a very local lycaenid butterfly, *Apodemia phyciodoides*, lampyrid beetles, and the rare bee, *Heteropogon divisus*. Another lepidoptera, *Speyeria nokomis corulescensis*, is also dependent on this riparian zone. An undescribed Formica ant has been collected in this portion of the Sierra Madre. The area is a probable corridor for predators with large ranges, such as the Mexican gray wolf (*Canis lupus baileyi*), grizzly bear (*Ursus horribilis*), and jaguar (*Panthera onca*).

Conservation status: Most of this region is intact; however, portions are degraded almost beyond restoration. Nevertheless, as a whole, the region plays a critical role in migration, movement, and permanent habitat for a wide assemblage of species representing Chihuahuan, Sierra Madre, Rocky Mountain, and Sonoran ecoregions (Turner et al. 1994).

Yaqui Headwaters: 2,000 hectare (ha) managed by the San Bernadino National Wildlife Refuge. The refuge has proposed an additional 9,700 hectare (ha) as a protected area (working with private landowners and the USDI-BLM). Cattle were removed from the refuge in 1980, but degradation is considerable (USDI-USFWS 1995).

San Simon Valley: This area is not protected by any special management designations. However, a long-term ecological study site has produced detailed information about the past and current environmental conditions. Several rangeland revegetation studies have also been conducted here. The watershed is considered to be highly degraded by groundwater pumping, historic grazing practices, and conversion to farming (USDI-BLM 1990).

Chiricahua-Dos Cabezas: These mountain ranges have several special management designations. National Forest Service lands serve as an ecosystem management model. US Forest Service manages the Dos Cabezas Wilderness Area (4,851 ha), and the Chiricahua Wilderness Area, (35,506 ha). The National Park Service manages Fort Bowie National Historic Site (404 ha), and Chiricahua National Monument (4,850 ha). Dos Cabezas Area of Critical Environmental Concern (ACEC), designated by BLM, is only 10 ha. Scattered parcels of private land are a small segment of the total area. The area has experienced low levels of fragmentation through timber harvest and road building (USDA-Forest Service 1986).

Peloncillo-Animas: The land status through this area ranges from wilderness to private commercial livestock and mining companies. However, a large portion of the ranges are protected through special management areas and conservation easements. Within the Peloncillos, the BLM-Safford District manages Guadalupe Canyon ACEC (1,677 ha), and Baker Canyon Wilderness Study Area (WSA) at 1,692 ha. The BLM Las Cruces District manages an adjacent Guadalupe Canyon ACEC in New Mexico (1,687 ha), the Granite Gap ACEC (708 ha), Central Peloncillo Mountains ACEC (5,160 ha), and the Gray Peak WSA (7,041 ha). The Coronado National Forest manages Bunk Robinson Wilderness (6,459 ha), and Whitmire Wilderness (5,196 ha). Scattered parcels of private land are managed under a range of strategies. The Malpais Borderlands group, comprised of ranchers in the Peloncillo and Animas mountains and the Animas Valley, manage livestock in a manner intended to improve the fire regime, provide grassbanks during times of poor forage production, and restore degraded lands. However, many private land owners in the area do not participate in the Malpais group. Some private parcels interspersed with federal and state lands are deeded Gray Ranch properties (USDI-BLM 1993).

Animas Valley-Chihuahuan Grasslands: Gray Ranch (130,191 ha) supports the Malpais Borderlands Group with conservation easements. Cowboy Springs ACEC is 2,728 ha. Antelope Pass Research Natural Area (3,524 ha) was designated to protect the 19 known lizard species (USDI-BLM 1993). The prairie dog town in the Chihuahuan Grasslands has been proposed as a United Nations Man in the Biosphere Reserve.

Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera): No known formal protection. All private and ejido lands.

Description of threats

Yaqui Headwaters: The economy of the area at one time was based almost solely on smelting operations from large copper mines in Bisbee, Arizona, which began to close in the early 1980s. Agua Prieta, Sonora, has 80,000 people and Douglas, Arizona, has 19,000. An estimated 180,000 people live in the area. Ore processing is a continuing problem in Mexico. Heavy grazing, downcutting of channels, water depletion through agriculture, and municipal and mining uses on the Mexico side of the border are issues. Within wetland and aquatic habitats, exotic bullfrogs (*Rana catesbeiana*) threaten native herpetofauna and fish populations (USDI-USFWS 1995). The high topographic relief of some of the headwaters areas provides a measure of protection against development. Depletion of spring flows from excessive groundwater pumping, stream diversion and streambank erosion are primary threats to native fish in the smaller tributaries, as is the introduction of nonnative fish species (Williams et al. 1985).

San Simon Valley: Continued livestock grazing, groundwater pumping, and subdivision of ranch lands into private home sites are the primary threats.

Chiricahua-Dos Cabezas: Timber harvest is an ongoing threat to the Chiricahua mountains. Biological supply companies threaten native herpetofauna and invertebrate populations through over-collection of rare species. Mismanaged fire policies for prescribed fire and fire suppression are a threat to the woodlands and grasslands.

Peloncillo-Animas: Overcollection of herpetofauna threatens local native populations. Grazing mismanagement continues to occur on private, state, and federal lands. Mining and minerals exploration also threaten to fragment this largely intact landscape.

Animas Valley-Chihuahuan Grasslands: Water diversions for agriculture disrupt ciénega vegetation and in many cases eliminate the wetlands. Continuous livestock grazing in periods of drought damages grasslands and riparian areas. Poisoning of prairie dogs in Mexico occurs but it is not known to what extent. Subdivision and commercial development fragment the landscape in the Animas Valley.

Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera): Pesticides associated with agriculture in Casas Grandes and Colonia Juarez are threats to riparian woodlands. Woodcutting regulations are not enforced.

Reasons for selection as a priority site: This is a large, intact ecosystem with top carnivores, high plant and animal diversity; high endemism; contiguous, intact grassland habitats; and intact shrub and montane systems with adequate corridors.

CONABIO Sites: Nearly half of the area is within Conabio sites 34 and 35.

Freshwater Sites: Upper Yaqui (priority site 5.02) and San Pedro-Aravaipa (priority site 5.03) overlap to the northwest, and Guzman Basin (priority site 5.13) and Bavispe (priority site 5.07) intersect in the southern regions of the site.

Active conservation groups: Animas Foundation, Desert Laboratory at the University of Arizona, Malpais Borderlands Group, Museum of Natural History Southwest Research Station, The Nature Conservancy of Arizona, USDA Natural Resources Conservation Service.

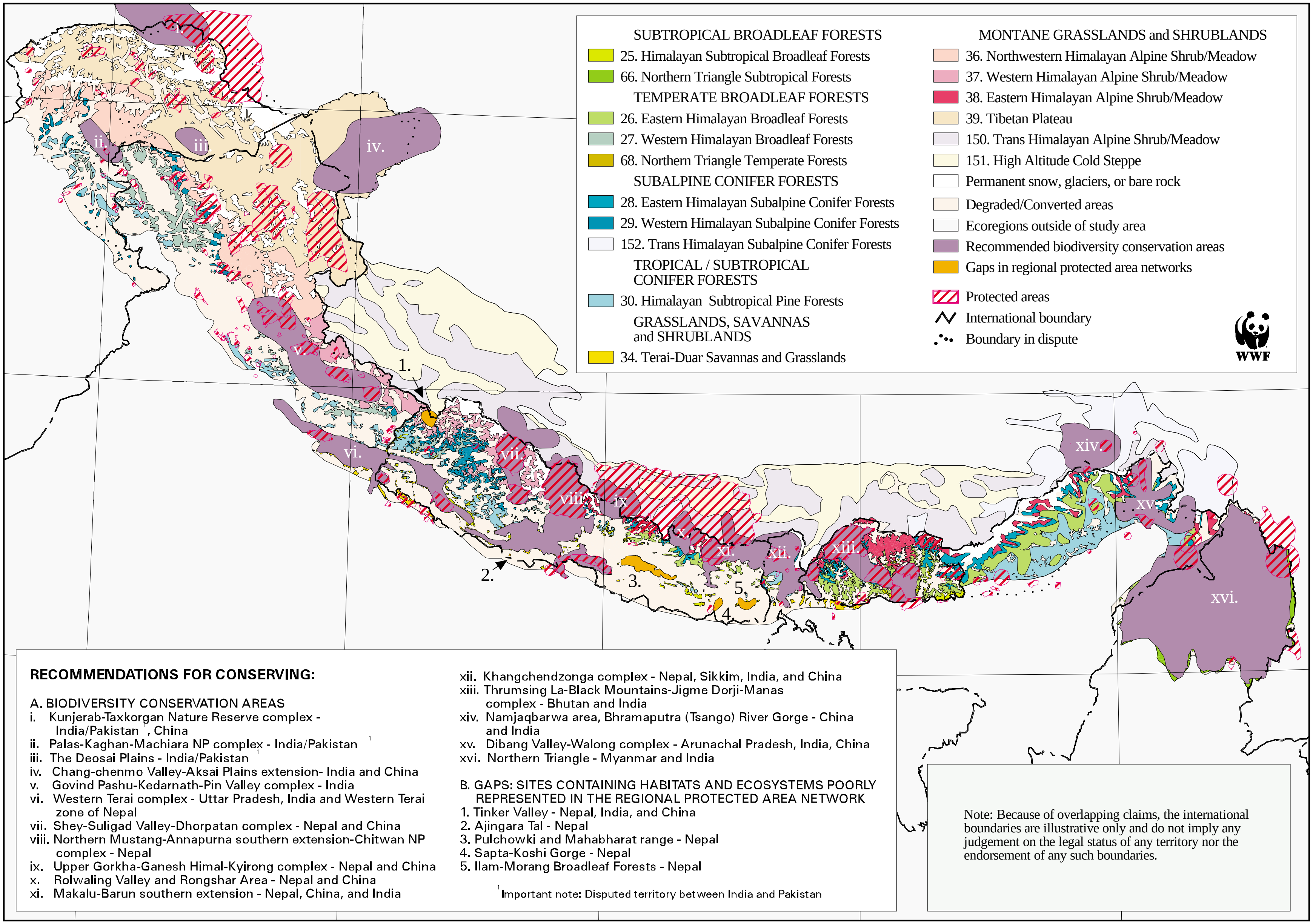
Contributors: C. Curtin, G. Forbes, M. Hakkila, R. List, B. MacKay, D. Richman. ***(taken directly from Ecoregion-Based Conservation in the Chihuahuan Desert: A biological assessment and biodiversity vision, (Appendix V, pages 231-235)***

Case Study 7

A biodiversity vision for the Himalayas

The biodiversity vision for the Himalayas explicitly targets the connectivity of protected areas (see fig. 8.1). Many species in the Himalayas move up and down mountainsides. Thus, conservation of elevational gradients is a critical biodiversity target. So is the need to conserve east-west wildlife corridors in the lowlands at the base of the Himalayas to promote dispersal of wide-ranging species such as tigers and elephants. We include the map of priority conservation landscapes for the Himalayas as an example of how a biodiversity vision can address linkages among protected areas. For a copy of the Himalayan Assessment, please contact Sheila O'Connor at WWF-US, 1250 24 St. NW, Washington D.C., 20037-1175 or at <sheila.oconnor@wwfus.org>.

Figure 8.1. Important biodiversity conservation areas in the Himalayas.



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PART III: DESIGNING CONSERVATION LANDSCAPES AND OTHER ADVANCED TOPICS

DESIGNING CONSERVATION LANDSCAPES FOR FOCAL SPECIES 9

Concepts

A biodiversity vision for an ecoregion typically includes a map identifying high priority areas for conservation action (See fig. 6.5 for the Chihuahuan Desert and fig. 8.1 for the Himalayas). Some of these priority areas are often very large, exceeding 20,000 km^2, and give the appearance of large colored blobs (polygons) on a map. The large size is partly a reflection of educated or rough approximations of a) the boundaries of minimum critical areas for populations of focal species to persist over the long run, b) the geographic area occupied by distinct communities, c) relatively intact areas, or d) areas over which certain ecological processes operate. To move conservation forward, we must progress from advocating for the preservation of habitat blobs on a map, toward making detailed recommendations for the conservation of key landscapes. The purpose of this chapter is to illustrate a case study that attempts to accurately design and map a conservation landscape—consisting of core protected areas, proposed reserve extensions, wildlife corridors, buffer zones, multiple-use areas, and human settlements as well as infrastructure—based on principles of conservation biology and landscape ecology. In many ecoregions, addressing spatially intensive processes such as climate change and the persistence of wide-ranging species can be accomplished better by designing conservation efforts at the landscape scale.

Case Study 8:

Designing conservation landscapes for the giant panda (*Ailuropoda melanoleuca*) in the Qinling Mountains, China, a high priority area in the Southwest China Temperate Forests Ecoregions

Introduction

The Southwest China Temperate Forests (SCTF)—a Global 200 ecoregion—are the most biologically rich temperate forests in the world. They are best known as home to the giant panda (Fig. 9.1). Many rare and endangered species live in the SCTF besides the giant panda. Rare mammals include the red panda (*Ailurus fulgens*), golden monkey (*Rhinopithecus roxellana*), takin *(Budorcas taxicolor*), and snow leopard (*Uncia uncia*). The forests are also the center of diversity for pheasant species and include the blue-eared pheasant (*Crossoptilon auritum*), silver pheasant *(Lophura nyctherma*),and golden pheasant (*Chrysolophus pictus*). Endangered tree species include the Chinese yew (*Taxus chinensis*), dawn redwood (*Metasequoia glyptostroboides*) and the locally endemic Qinling fir (*Abies qinlingensis*).

Over the past 2,000 years logging and conversion of forests to agricultural land have destroyed large tracts of the temperate forests of southwestern China. Subsequently, the giant panda's habitat has also been compressed to several remote mountain ranges in central China. Many of these remaining blocks of habitat have been further fragmented into smaller segments. For the giant panda and the myriad other forest-dwelling species to survive well into the next century, the core remaining habitat must be identified and protected.

Specifically, we identify the remaining potential habitat for the giant panda across its entire range in the Qinling Mountains. We also identify core remaining habitats for pandas through an analysis of seasonal movement and potential habitat. We then compare the core habitat to the existing protected area network to identify the portion of remaining habitat that should be protected. We assess current and future threats to the unprotected habitats and recommend future conservation actions to contribute to biodiversity conservation of the ecoregion.

Description of study area: The Qinling Mountains

The range of the giant panda has been compressed into several habitat patches on a series of mountain ranges in central China. The majority of the remaining population lives in the predominantly north—south running mountain ranges at the edge of the Tibetan plateau in Sichuan and Gansu Provinces. The disjunct Qinling Mountain range extends 400-500 km in an east-west direction through southern Shaanxi Province (see fig. 9.2). The forests of the Qinling Mountains, and their panda populations are geographically isolated from the rest of the panda's range and a linkage zone—normally a key conservation objective for a wide-ranging species—is infeasible.

Over the past 2,000 years humans have encroached on this area and converted the forests to cultivated land. Unfavorable climatic and edaphic conditions restrict cultivation above 1,400 m. Below 1,400 m, the fertile soil and favorable climate allowes for year-round agriculture. Subsequently, a vast majority of the habitat below 1,400 m was converted to permanent cultivation. In the past 200 years, demand for firewood, human development, and commercial logging have depleted the remaining forests above 1,400 m at an alarming rate.

The Qinling Mountains support more than 200 of the estimated 1,000 wild pandas in less than 10 percent of the total remaining panda habitat and are, thus, a priority for conservation action in China. The high number of giant pandas in this area combined with other distinct elements of forest biodiversity identifies the Qinling Mountains as a centerpiece of an ERBC strategy and as a priority area of global importance.

Giant pandas live primarily on the southern, moderately undulating slopes of the Qinling Mountains. The Qinling Mountain's ridgeline acts as a natural screen to the cold, dry air currents that sweep down from the north. At the same time, the broad, undulating southern slopes capture the warm rains and moisture from the southeastern monsoons. The warmer, wetter climate of the south slope of the Qinling Mountains provides the proper climatic conditions for various species of bamboo to grow in the understory. To a much lesser degree, bamboo grows at the highest elevations on the northern slope of the Qinling Mountains, which also receives adequate precipitation. Bamboo is distributed along an elevation gradient from 800 to 3,100 meters.

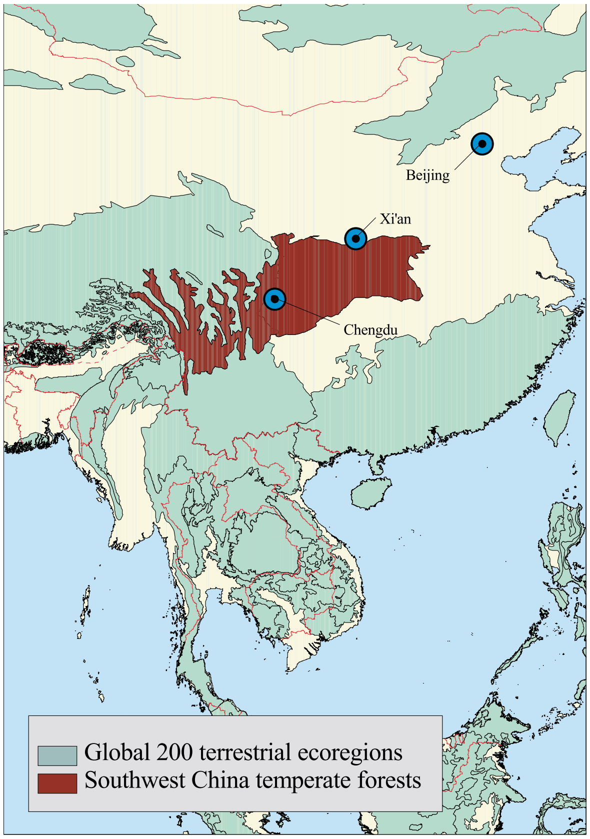

Figure 9.1. The Southwest China temperate forests, one of the Global 200 ecoregions, are home to the giant panda

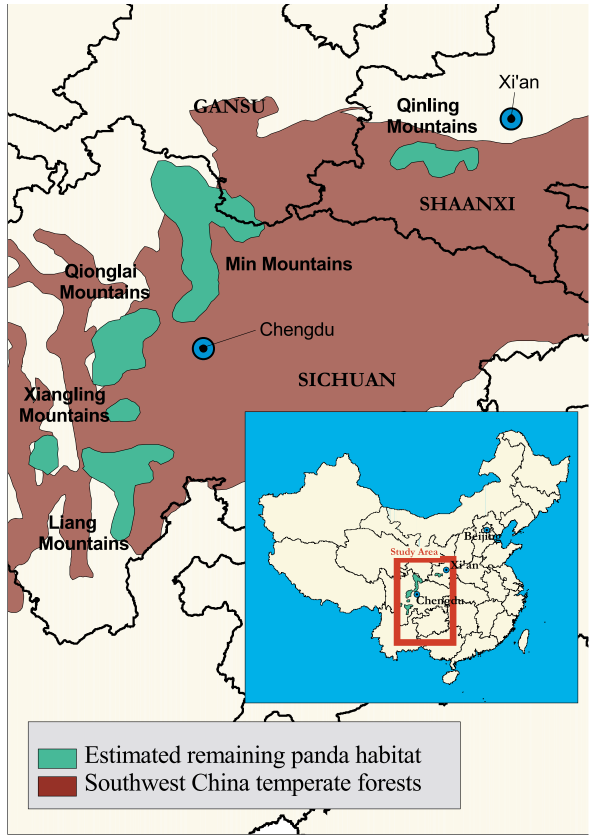

Figure 9.2. Approximate extent of remaining panda habitat (the Qinling Mountains in the northeast part of the range are geographically isolated from the remaining habitat to the southwest)

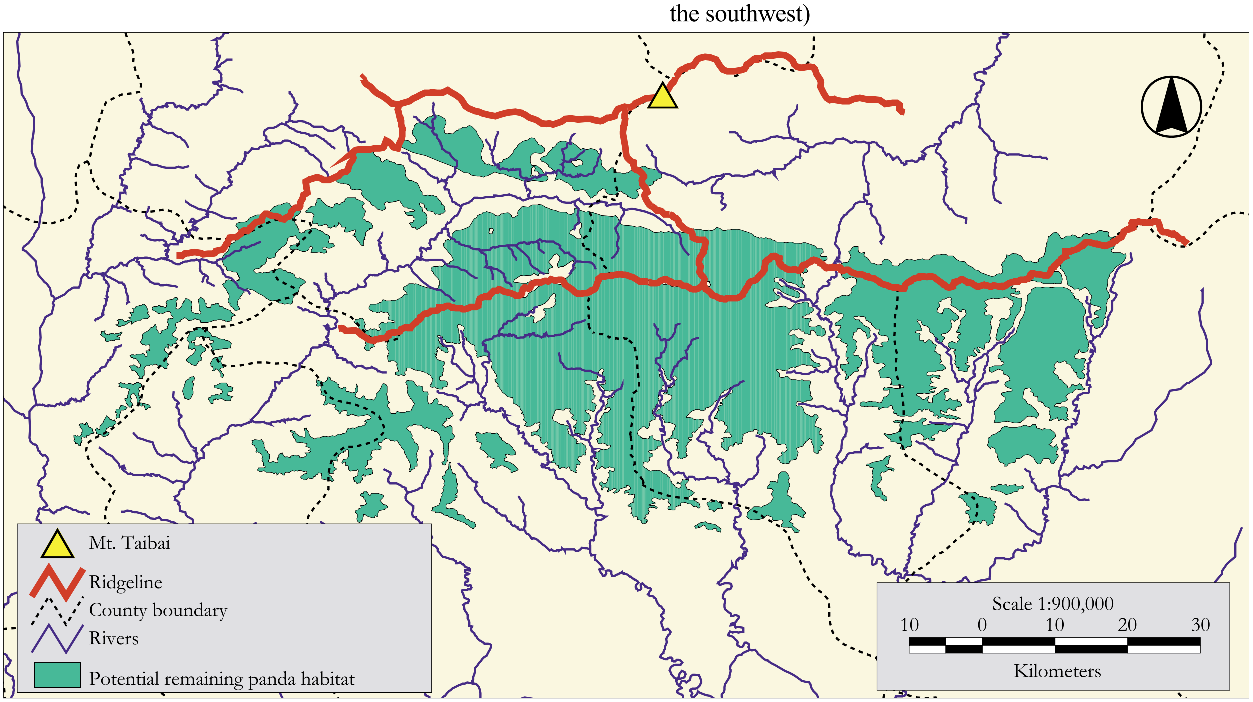

Figure 9.3. Potential remaining panda habitat in the Qinling Mountains (the potential habitat was delineated from satellite images obtained in 1996, 1997)

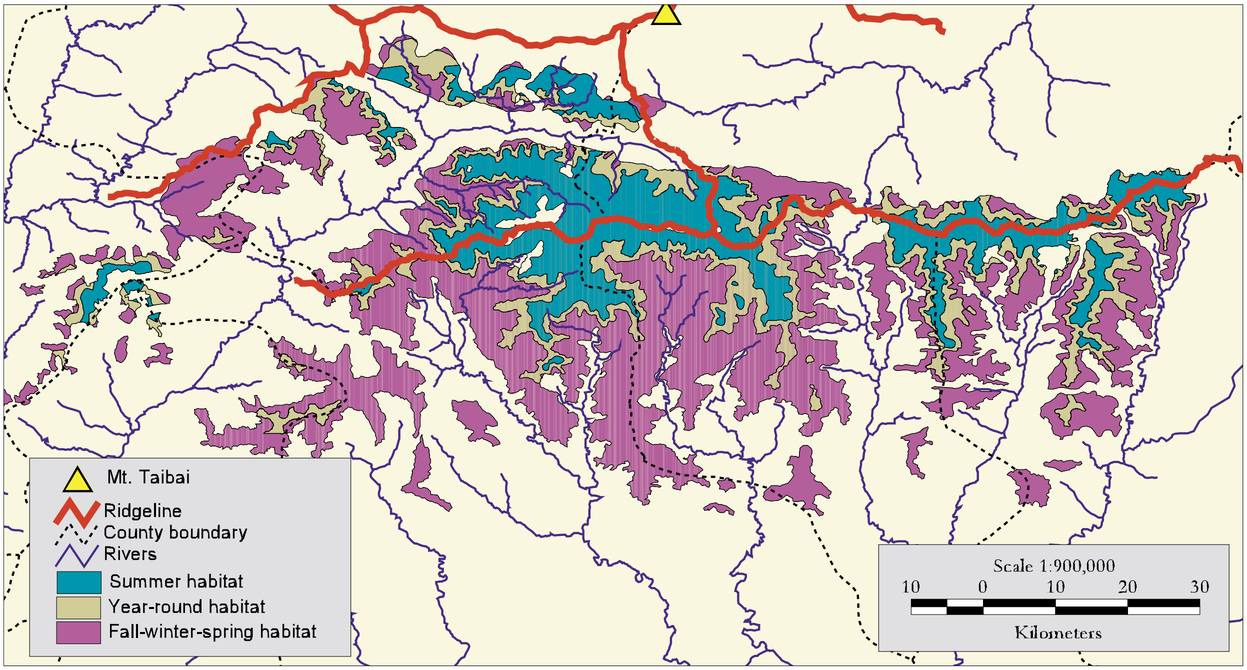

Figure 9.4. In the Qinling Mountains pandas eat different bamboo species throughout the year. Pandas travel to higher elevations during the summer to eat *Fargesia spathacea* bamboo and then to lower elevations during the winter months to eat *Bashania fargesii* bamboo

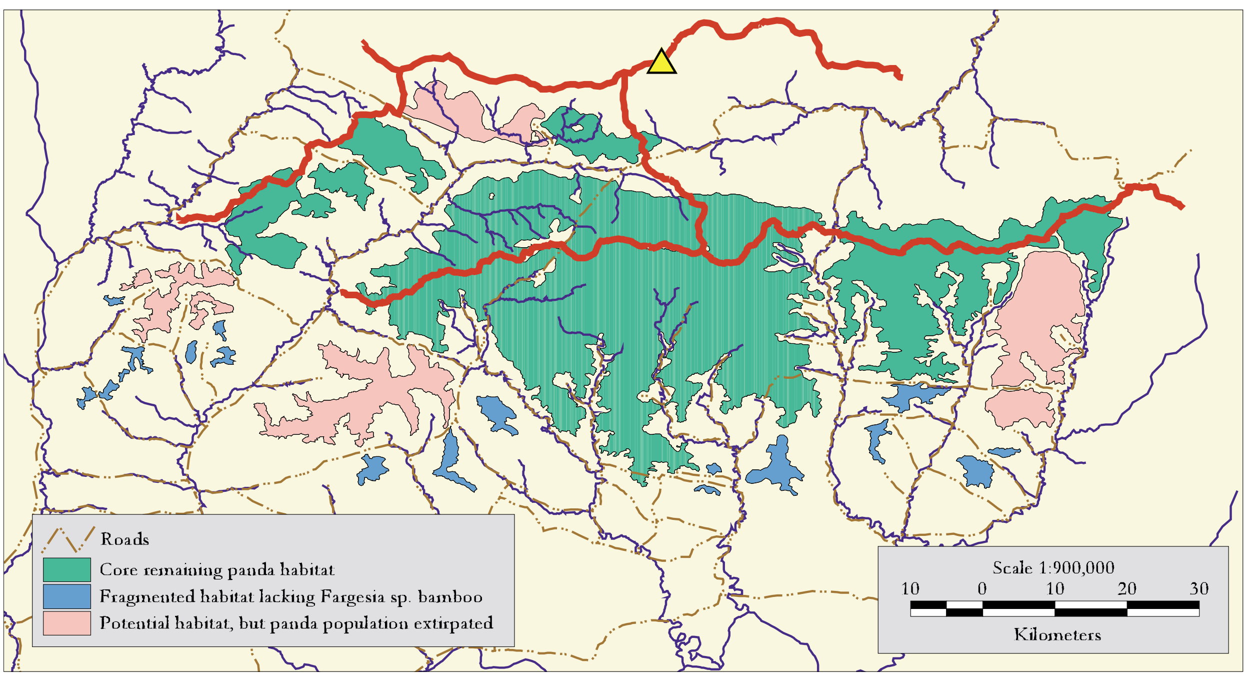

Figure 9.5. Not all of the potential habitat can provide long-term support of panda populations (some habitat blocks lack the requisite bamboo species, while other habitat blocks have had their panda populations extirpated)

Methods of Analysis

Geographic information systems (GIS), satellite, and global positioning systems (GPS) technology were the primary methods used in the habitat analysis. Four SPOT satellite images covering the entire Qinling Mountain range were obtained from the French Centre National d'Etudes Spatiales (CNES). The images have a 20 m pixel resolution (i.e., one pixel is equal to a 20 m x 20 m square). They provided vegetation and land-use information of the region. Additional GIS layers such as protected areas, elevation, contour intervals, rivers, roads, and administrative boundaries also assisted in the analysis. Complementing the GIS analysis were on-the-ground field observations, interviews with local populations, and satellite imagery validation (ground-truthing).

Results

Potential remaining habitat

The total area of the potential remaining habitat is 2,250 km^2 (see fig. 9.3). The potential habitat represents forested regions in which major road networks, human settlements, or clearings are absent and excludes small patches of isolated and fragmented forests.

Seasonal habitat preferences

Pandas are extreme dietary specialists, consuming only bamboo. There are five genera and nine species of bamboo that grow on the south slope of the Qinling Mountains, but only two species of bamboo comprise the bulk of the panda's diet. The primary food species are *Fargesia spathacea* and *Bashania fargesii*. Each of these species is distributed along different elevational gradients and provides the primary food source for the pandas at different times of the year.

From June to September (summer) pandas eat *F. spathacea*, which grows between 1,900-3,000 m. From October to May, during colder weather, pandas tend to move to lower elevations between 1,400-2,100 m to concentrate their diet on *B. fargesii*.

Effects of habitat seasonality, fragmentation, and humans on potential habitat

The availability of both *B. fargesii* and *F. spathacea* is essential to the long-term survival of the panda. Using the relatively disjunct elevational distributions of these two species, we could identify the potential distribution of each in relation to the aforementioned potential remaining habitat (see fig. 9.4).

By overlaying the bamboo's elevational distributions on the potential remaining habitat, we identified patches of habitat that contain only a single species of bamboo. In these habitat blocks, the panda would be unable to continue seasonal movements or to switch its diet to alternative bamboo species in the case where bamboo had a mass flowering and a resulting dieback. Many of these habitat patches are fragmented from the larger habitat block to the north. These fragmented habitat blocks would not be able to support self-sustaining breeding populations of pandas over the long run but, rather would act as population sinks. These smaller habitat fragments are typically at lower elevations, are frequently disturbed by humans, and are the first to be converted to other land uses.

Other habitat blocks are more favorable for pandas because they contain the full complement of bamboo species and a range of elevations, but these blocks do not contain pandas (see fig. 9.5). Panda populations may have been extirpated from these habitat blocks for a variety of reasons, such as road building, logging activities, poor habitat quality, bamboo flowering events, fragmentation, human disturbances, or poaching. Poaching activities in the recent past were usually not focused directly on pandas but, rather, on setting snares for musk deer (*Moschus chrysogaster*). Pandas would inadvertently get caught in these traps and die before the poachers were able to rescue them. Over a 10-year period in the Qinling Mountains, poachers killed at least six pandas.

Determination of core habitat

By removing the habitat blocks that fail to meet the panda's requirements, remaining potential habitat could be defined as core habitat that is critical to the long-term survival of the giant panda in the Qinling Mountains (see fig. 9.6). This core habitat covers approximately 1,750 km^2.

Protected areas gap analysis

The protection of core habitat is vital to the survival of the giant panda in the Qinling Mountains. Any forested region that is not formally protected in nature reserves belongs to the respective state forestry bureaus and can be logged. Currently, there are five nature reserves on the south slopes of the Qinling Mountains (see fig. 9.7).

A comparison of the spatial overlap of the current protected area system with the core habitat identified Changqing, Foping, and Laoxiancheng Nature Reserves as being well positioned in the panda's remaining range to protect the full elevational distribution of habitat (Figure 9.8). In total, the reserve system protects 815 km^2 (45 percent) of the core remaining habitat.

Road Building

The expanding human population into the Qinling Mountains has coincided with the development of additional and improved roads throughout the area. Besides the logging roads, an increasing network of access road.

Analyzing the satellite imagery and using additional data sources, we identified several roads that have fragmented some of the last remaining habitat. One road, in particular, has severely fragmented the last large block of remaining habitat. National Road 108, which runs in a north-south direction across the eastern portion of the mountain range, effectively cuts off the eastern portion of the habitat from the last remaining large block of contiguous habitat. This road is heavily used and acts as a barrier to panda migration. Further exacerbating the situation is the relative lack of nature reserve protection to the isolated eastern block of habitat (see fig. 9.8). Without further habitat protection, the potential extirpation of all the pandas from this block is likely.

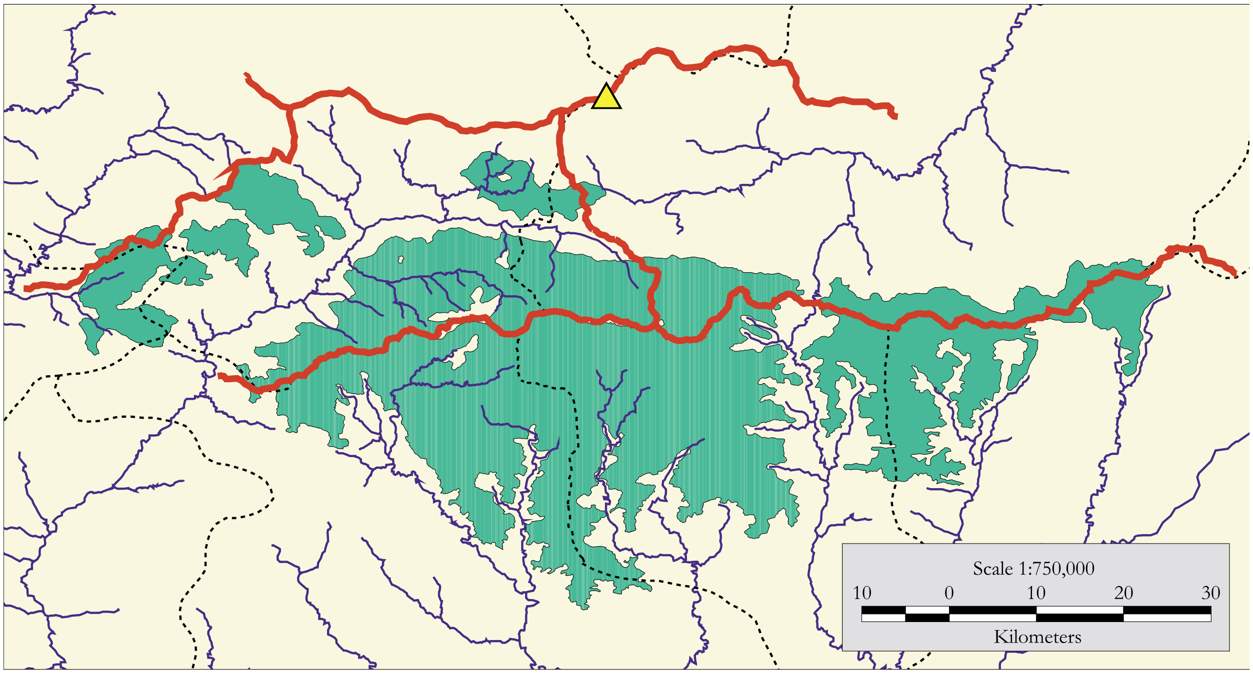

Figure 9.6. Core remaining habitat critical to the long-term survival of the panda in the Qinling Mountains

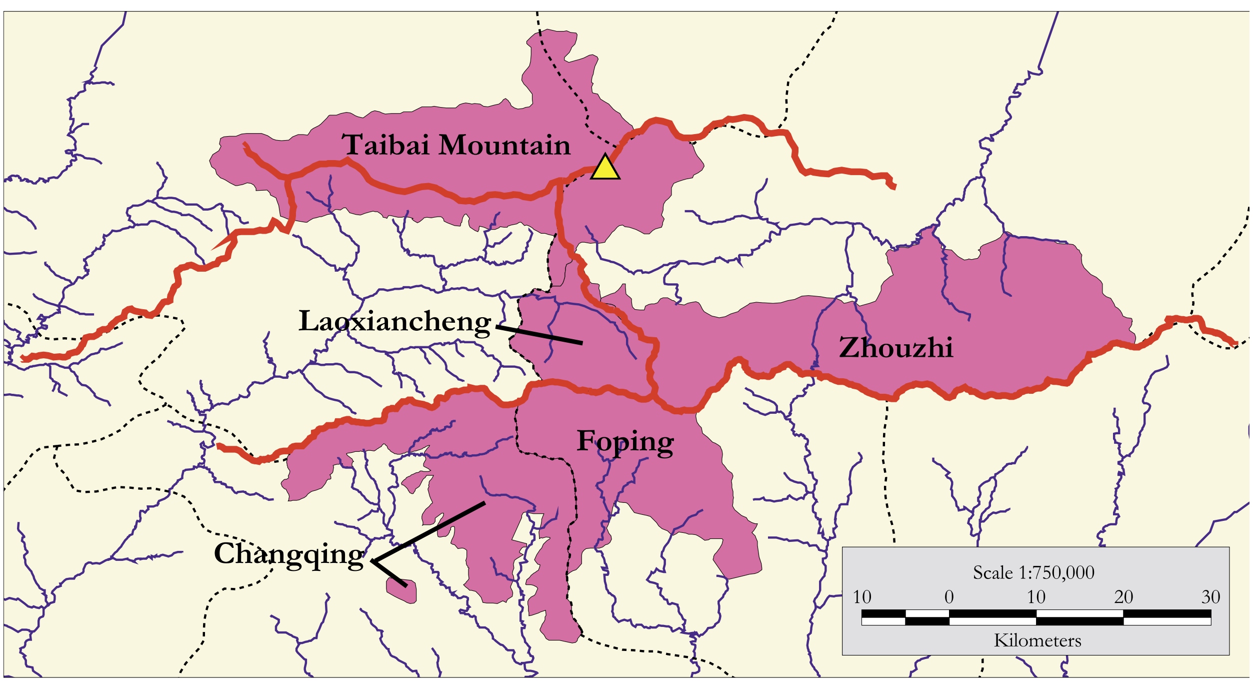

Figure 9.7. Nature reserves in the Qinling Mountains that overlap the panda's range

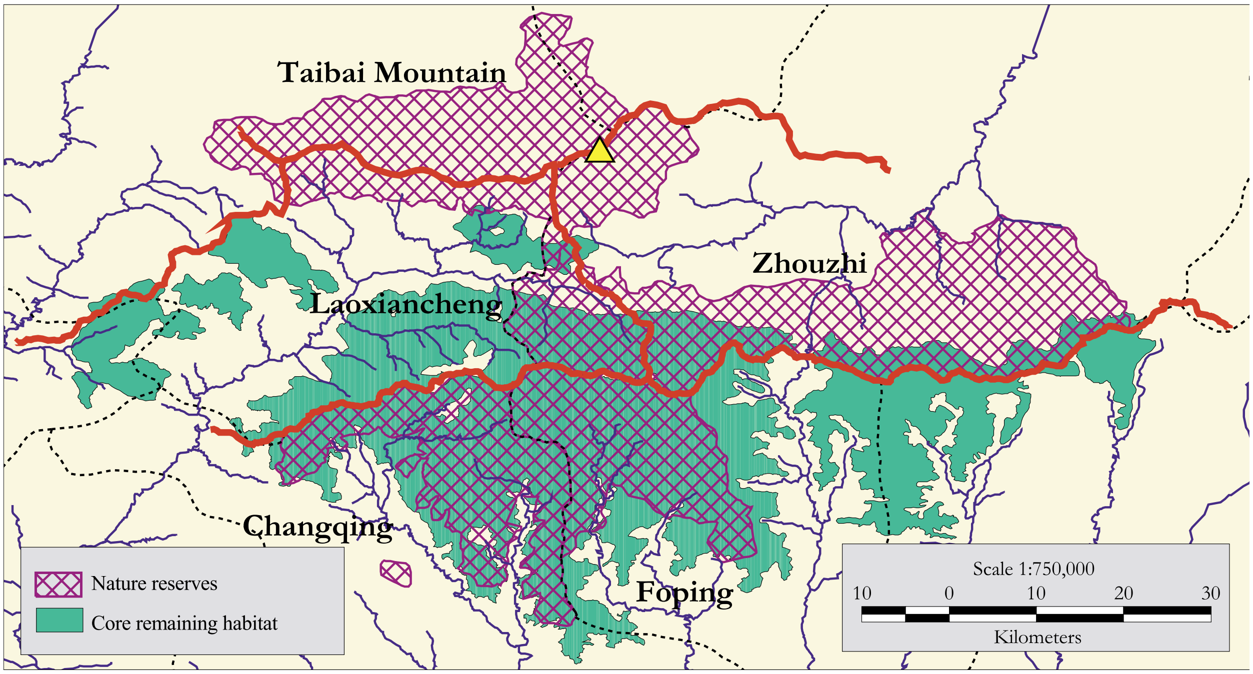

Figure 9.8. Overlap of nature reserves with panda's core remaining habitat in the Qinling Mountains to identify gaps in the protected areas network

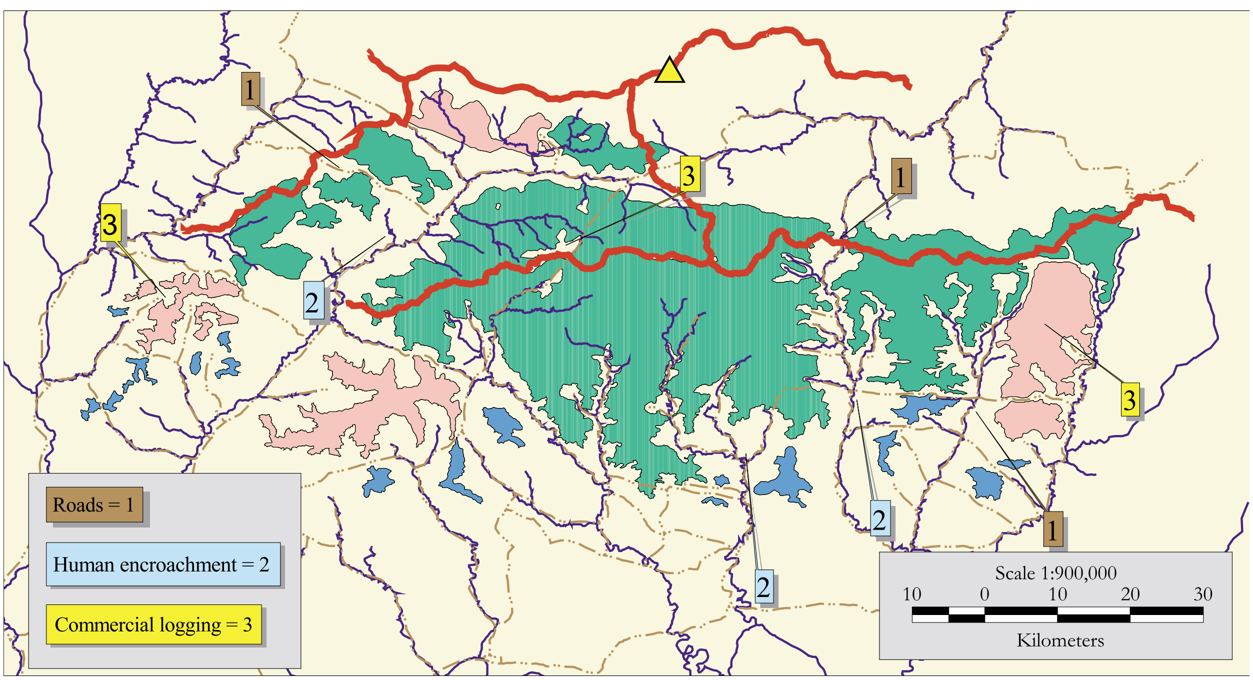

Figure 9.9. Three primary threats to the panda's remaining habitat: road building, human encroachment, and commercial logging (for each threat, three specific areas are identified where the loss or degradation of habitat or extirpation of panda populations has resulted)

Threats

More than 50 percent of the core habitat remains unprotected. A variety of factors threaten the integrity of these forests, including commercial logging, fuel wood collection, road building, and human encroachment.

Commercial Forestry

All forests that do not fall within nature reserves belong to the state and national governments of China and are, therefore, susceptible to commercial logging. The standard forest management practice in the Qinling Mountains is timber clearcuts. Research in the Wolong Nature Reserve found that bamboo did not recover in large gaps created by clearcuts. Although bamboo may initially dominate clearcuts, these areas will be devoid of bamboo in the future because seedling mortality is high. Therefore, clearcut areas represent lost habitat because bamboo will fail to regenerate (see fig. 9.9).

Many of the commercial logging enterprises move entire families into the region to allow for greater worker efficiency. Additional pressure is placed on the surrounding forests to provide fuel wood, food, and arable land.

Human Encroachment

The development of advanced agricultural practices, modern communications, roads, electricity, and other technological advancements has allowed people to utilize more land. As a consequence, they have moved further up river valleys, often, to above 1,400 m in elevation (see fig. 9.9). The major factors affecting the local population fluctuations are sociopolitical policy changes, access to the region, and natural disasters. The population density in the Qinling region, although relatively low and concentrated along roads in sporadic towns, has been expanding. A high percentage of the local population consists of temporary forestry workers and their families.

Road Building

The expanding human population into the Qinling Mountains has coincided with the development of additional and improved roads throughout the area. Besides the logging roads, an increasing network of access roads into and between the river valleys has carved up the remaining habitat (see fig. 9.9). As the remaining habitat becomes increasingly fragmented, the ability to support giant panda populations decreases.

Recommendations for protection and future actions: Creating a conservation landscape for giant pandas

The remaining habitat for pandas in the Qinling Mountains is a fraction of its potential extent. Although climatic changes over several thousand years have altered and restricted the panda's range throughout China, human induced habitat loss is the most serious threat to the panda's survival today. In the Qinling Mountains, core habitat identified in this analysis represents less than 15 percent of the potential habitat. The majority of the habitat destruction over the past 2,000 years can be attributed to human actions. We must take steps to alleviate the threats to habitat integrity and make specific recommendations for habitat protection.

This analysis has identified a significant amount of core remaining habitat that remains unprotected and is, therefore, susceptible to logging and related effects. The addition of these areas into existing or new nature reserves would provide invaluable protection for the panda and other wildlife that are unique to the Qinling Mountains. Our analysis identified three vital areas for protection or for classification as environmental protected areas (see fig. 9.9).

The top priority is the forests to the east of National Road 108 (see fig. 9.10). This habitat block represents 330 km^2, or approximately 20 percent of the core remaining habitat. The block has been completely fragmented from the remainder of the habitat to the west of the road. Zhouzhi Nature Reserve offers minimal protection. The reserve protects only the limited amount of habitat falling on the northern slope of the Qinling Mountains. We recommend that this habitat be designated as an extension of the Zhouzhi Nature Reserve, or a new nature reserve should be created to encompass this region. An attempt should be made to establish a corridor across the road on the southern slope to allow panda migration between habitat blocks. In the immediate future, these forests should be classified as a "core zone" of protection under the new forest policy. The new forest policy affords complete protection of forests classified as "core zone," partial protection to those classified as "buffer zone," and no protection to the remaining forests.

A large block of forest habitat exists at the far eastern edge of the potential habitat (see pink area in fig. 9.10) and does not currently contain a large panda population. However, this habitat should also be classified as core or buffer zone protection under the new forest policy. Through proper sustainable forest management, this habitat could be restored to support pandas in the future. A change in forest management practices from clearcuts to selective harvesting would allow bamboo seedling establishment and, thus, provide habitat to pandas in the future. Selective harvesting also would ensure a long-term supply of softwoods from the land. In contrast, clearcuts revert to persistent hardwood forests and have little future commercial value as timberland.

A second priority area for conservation lies to the north of Changqing Nature Reserve and to the west of Laoxiancheng Nature Reserve (see fig. 9.10). This block of habitat remains as the only piece of core remaining habitat in the central portion of the Qinling Mountains that is not protected. The addition of this block of habitat as a new nature reserve or extensions of existing nature reserves would benefit all the reserves by restricting access along their boundaries and providing an essential link between reserves. The additional protection of this habitat would allow pandas to migrate between Changqing and Laoxiancheng Nature

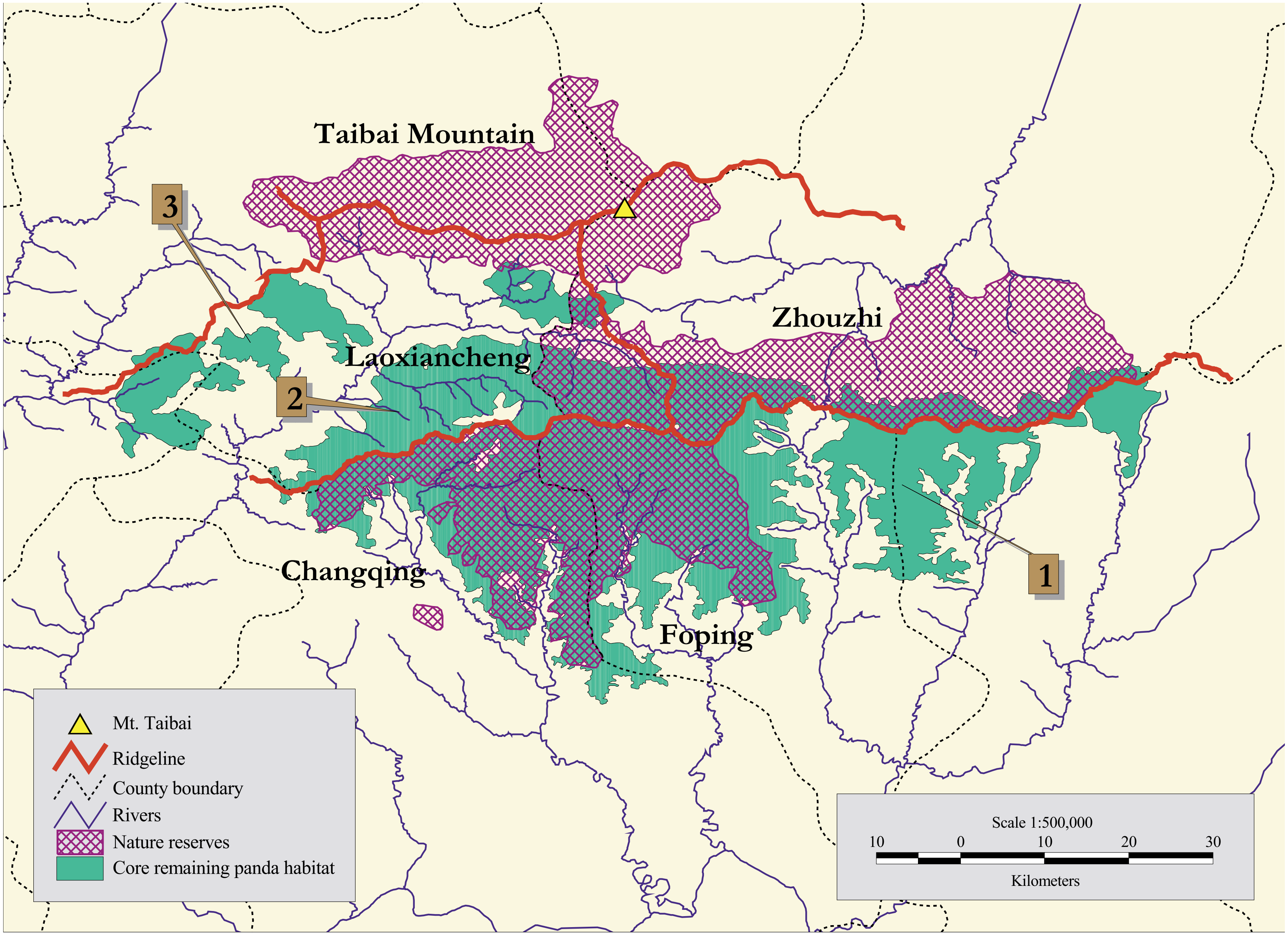

Figure 9.10. Three recommended areas for conservation action in the Qinling Mountains, China (areas that should be incorporated into the protected area system or be classified as protected forests, which would prevent them from being logged, while providing watershed protection, and conserving habitat, pandas and other species)

Reserves. Perhaps the most important reason for the protection of this habitat block would be its role in acting as a stepping stone of core habitat from the isolated western patches of habitat to the contiguous habitat in the central part of the range. In the short run, this habitat should be classified as "core zone" protected habitat under the new forest policy.

The third priority area encompasses three disjunct habitat blocks along the western edge of the range (see fig. 9.10). These forests, although presently disjunct, could be restored to a contiguous habitat block for protection. The reserve should also be positioned to allow the migration of pandas from these habitat blocks to the stepping stone habitat identified previously. These forest blocks should be classified as "core zone" protected forests under the new forest policy.

The core remaining habitat represents the highest priority habitat for protection. Remaining habitat that was not classified as core habitat because of its fragmentation, limited bamboo species or lack of pandas , represents habitat that has restoration potential. Through sustainable forestry practices or classification as "core or buffer zone" protected forests under the new forestry policy, this habitat can be restored to support the ecological processes and wildlife presently absent from it.

This analysis has demonstrated the steps to design a conservation landscape for the giant panda in the Qinling Mountains. We have progressed from important habitat blobs on a map to detailed identification of remaining habitats, threats, and potential future conservation actions. Properly designed conservation landscapes will take into account large-scale ecological processes (panda's elevational movements), keystone species habitat requirements (several bamboo species, access to water, elevational gradients), and extreme natural events (fires, bamboo flowering and dieback). Similar analyses for other wide-ranging or habitat-limited species will help define the conservation actions that are needed and can provide a blueprint for future conservation action.

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ADDRESSING DISPERSAL AND CONNECTIVITY CONCERNS FOR AREA-SENSITIVE SPECIES IN ERBC *10*

Concept

As the natural habitat of many ecoregions becomes increasingly fragmented, a direct negative effect occurs on the persistence of large wide-ranging vertebrates. Global examples are numerous, including the fragmentation of Miombo woodlands on elephant and rhinoceros populations and fragmentation of giant panda habitat in the southwest China temperate forests to name a few. This chapter focuses on a third example—the disturbance of grizzly bear habitat in the American Rockies. For wide-ranging vertebrates, we must maintain landscape linkages between secure blocks of habitat for three major reasons. First, it will help distribute species populations from source pools, thus, reversing localized population declines that occur because of recolonization and facilitated genetic interchange. Second, such linkage zones can provide access to potentially suitable and yet currently unoccupied habitat resources. Third, during severe disturbances, such as prolonged droughts, fires, volcanic eruptions, etc., populations may need to move to find resources that are still available at considerable distance.

Conservation landscapes within ecoregions must be designed to provide the necessary links between suitable habitats. Ensuring possible linkages throughout the landscape for keystone species such as grizzlies will also benefit to other large vertebrates (e.g., wolves and lynx). The methodology introduced in this chapter describes a technique for addressing connectivity of habitats—a critical component of biodiversity visions and ERBC strategies.

Case Study 9:

Identification of potential linkage zones and applications of conservation strategies for grizzly bears in southwestern Montana

Introduction

The grizzly bear (*Ursus arctos*) population of the Greater Yellowstone ecosystem in southwestern Montana (USA), represents one of the last strongholds of grizzlies in the southern Rockies. National Parks, such as Yellowstone, provide a source population of grizzlies to the surrounding area; however, because of their small size, such populations are not viable over the long run. The future of grizzly populations depends on providing additional secure habitat and connecting currently isolated populations. Southwestern Montana is also one of the few areas where grizzlies are still able to use grassland areas because these lands have relatively low levels of disturbance. This ecological phenomenon of large bears in open grasslands was once common in the United States and across the range of the brown bear, but is now restricted to only a few examples.

Conservationists have identified a potential corridor habitat that stretches between Yellowstone and the Salmon River drainage in Idaho. As a starting point for evaluating the ecological and cultural characteristics of this larger region, the analysis described here focuses on one segment of the potential corridor known as the Gravelly Landscape (see fig. 10.1).

Description of study area: The Gravelly Landscape

The Gravelly Landscape is characterized by high grasslands and arid shrub-steppes. Although these habitats offer grizzlies relatively few opportunities for food, they are somewhat attractive because they are secure from logging and farming developments. Riparian corridors at lower elevations, such as the Madison Valley, provide valuable protected passages for grizzlies to move along the valley floor. Also, certain wetlands (e.g., the Centennial Valley) already have some degree of protection because of their status as nature reserves. Numerous mountain ranges contain the bulk of the remaining forest, which is likely to contain nutritious white bark pine seeds (*Pinus albicaulis)* for consumption.

The region experiences a significant human disturbance. This includes clearcutting and associated logging roads, private home development in valuable riparian areas, and widespread cattle grazing. Human-related infrastructure also represents an important feature of the landscape, which can be evaluated as a surrogate for distribution of humans.

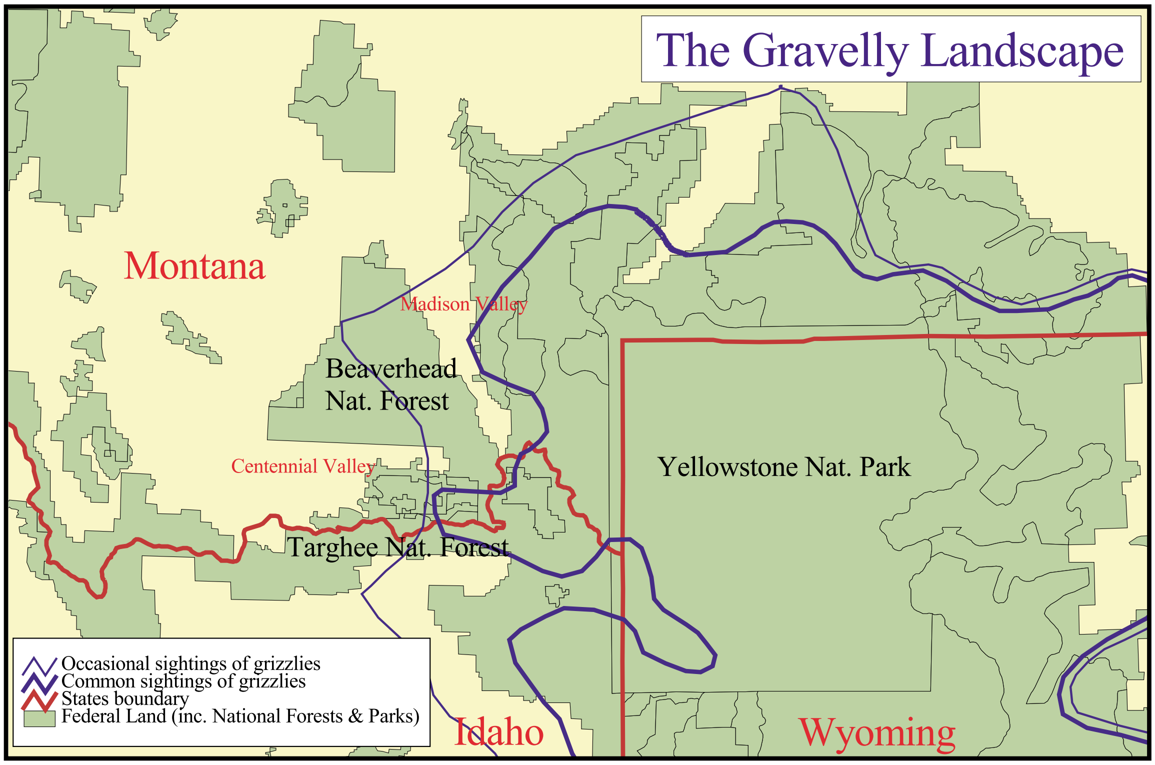

Figure 10.1 The potential corridor of Gravelly landscape, preferred habitat of grizzly bears in Yellowstone National Park

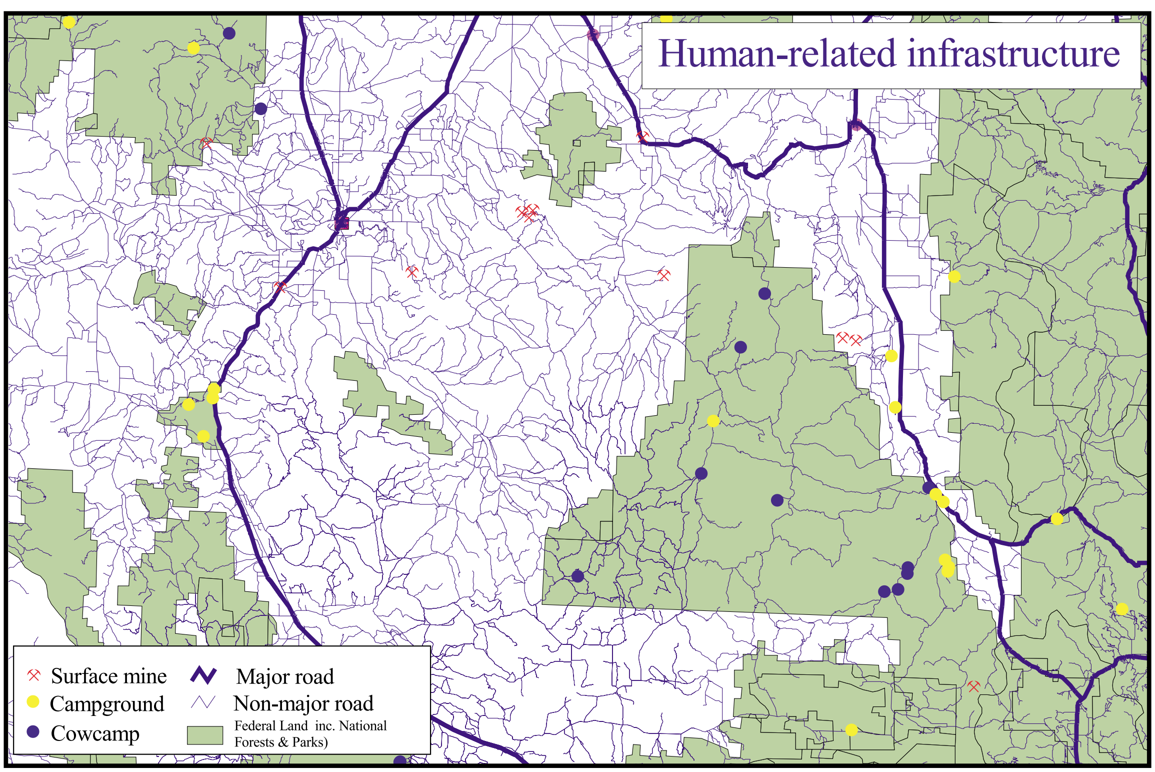

Figure 10.2 Human-related infrastructure layers inhibiting the dispersal of grizzlies

Methodology

Data layers of landscape features inhibiting the dispersal of grizzlies

A series of data layers of the region's infrastructure were gathered and modeled using GIS to assess the amount of disturbance in the landscape (see fig. 10.2).

***Roads*.** We treated roads as distinct geographical features in the landscape, in contrast to other modeling approaches that have taken road density as the primary indicator of road disturbance.

***Towns*.** We classified towns according to size and estimated their disturbance to a grizzly crossing the landscape.

***Surface mines, campgrounds, and cowcamps*.** We included these features as potential sources of disturbance. Cowcamps are where cattle owners spend the summer months.

Identifying potential linkage zones

The GIS modeling of bear behavior was loosely based on the approach and findings of the displacement submodel of the Cumulative Effects Model (CEM) (Weaver et al. 1986). Modeling emulated the behavior of a wary or unhabituated bear moving though the landscape. Thus, features such as towns were taken to be disturbances rather than areas of attraction as sources of bear food (e.g., garbage dumps). The amount of disturbance caused by human-related infrastructure was modeled to decrease in a linear fashion away from the feature.

Once features have been categorized according to size, a zone of influence of disturbance and a disturbance coefficient (or intensity of disturbance) is assigned to each landscape feature. Consideration was also given to whether the feature exists in forest or open cover. For example, a major road in an open area has a disturbance distance of 2,000 m and an intensity of disturbance of 40 percent (i.e., the area's ability to support bears is 40 percent of its potential). The model also accounted for the effect that the topography of the area is likely to exert by masking disturbances such as noise.

Results

The associated disturbance of all features was calculated, ranked, and combined creating what can be visualized as a 3-dimensional surface of disturbance (see fig.10.3 shows an image for part of the Targhee National Forest). The highest peaks represent the greatest amount of disturbance, for example, the intensity of disturbance associated with towns. The linear disturbances are associated with roads within the National Forest, and the gray, flat areas can be considered relatively undisturbed habitat for grizzlies.

It is then possible to identify the least disturbed paths through the landscape, that allow for the movement of grizzlies between secure habitat blocks. Once a starting and finishing point have been identified, the paths are disturbance driven; that is, they are determined sequentially as each new disturbance in the landscape is encountered while attempting to move in the direction of the selected endpoint.

Fig.10.4 shows three different least distributed paths that were plotted when we input three different start-finish points to the computer. Our aim was to identify potential crossing points over the developed Madison Valley (Route 287) and, thus, critical areas to which we must direct attention. Figs. 10.5 - 10.7 indicate the nutritional vegetation, calving areas and ungulate winter range, as well as the potential density of nutrition of the various habitats in the forest.

Recommendations

Recommendations, or tools, that could effectively minimize conflicts between human use and carnivores include appropriate sanitation and food storage at public and private facilities, seasonal closures of recreational areas, obliteration of unnecessary roads and trails, and, finally, information and education. More specifically for private lands, a mix of economic incentives can play a useful role in protecting important habitats, for example, purchasing conservation easements or developing ranch tourism.

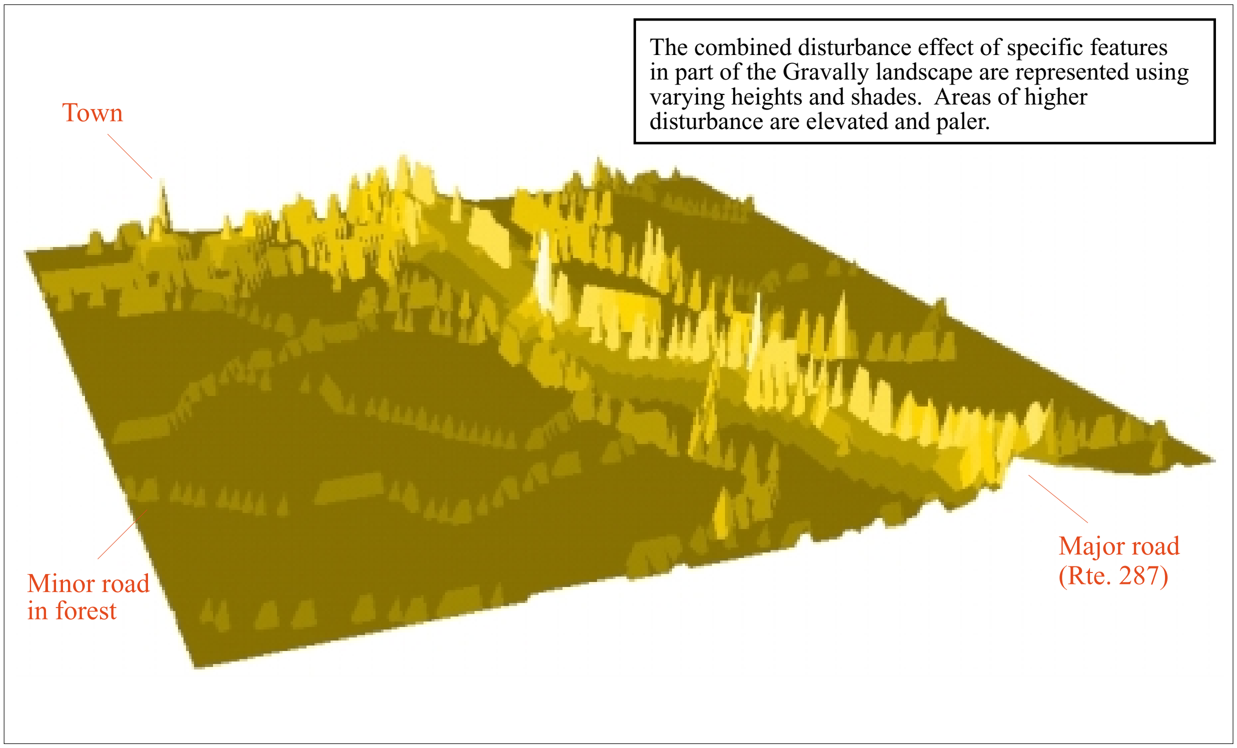

Figure 10.3 3-D representation of disturbance caused by human-related features on gravelly landscapes

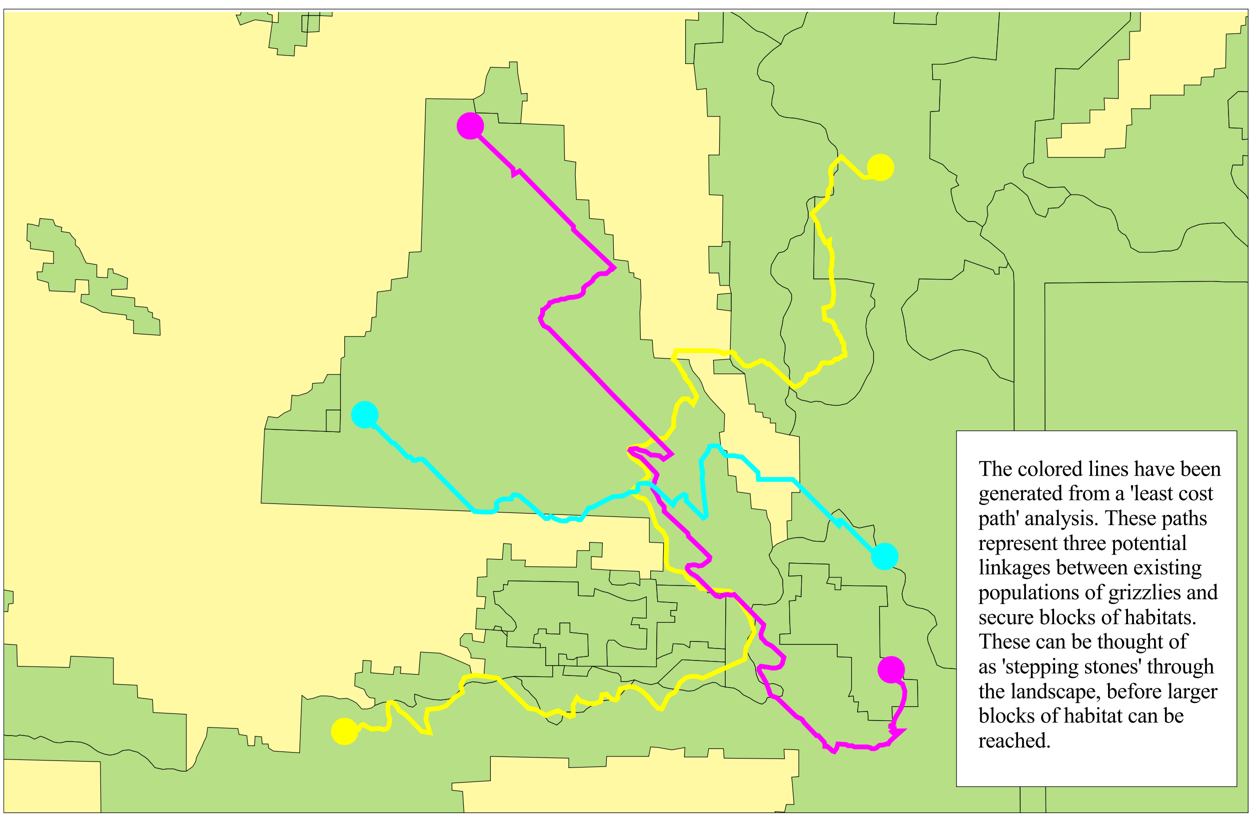

Figure 10.4 Dispersal paths with least disturbance for populations of grizzly bears

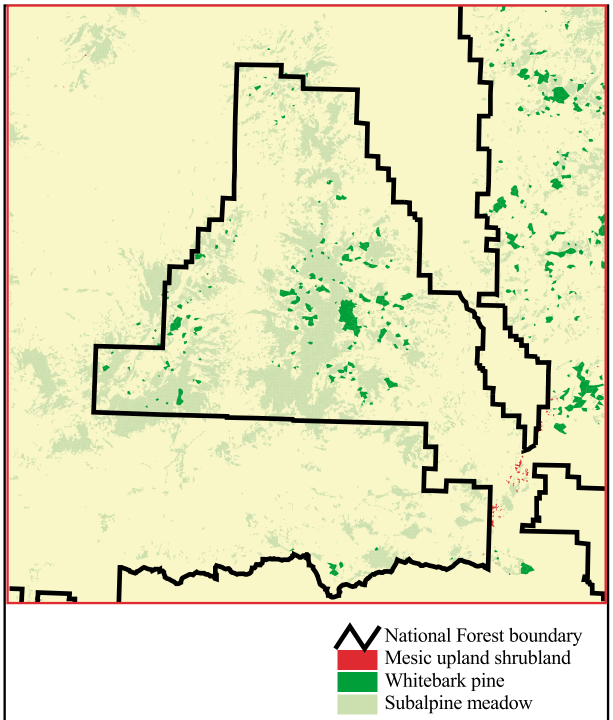

Figure 10.5 Appropriate nutritional vegetation

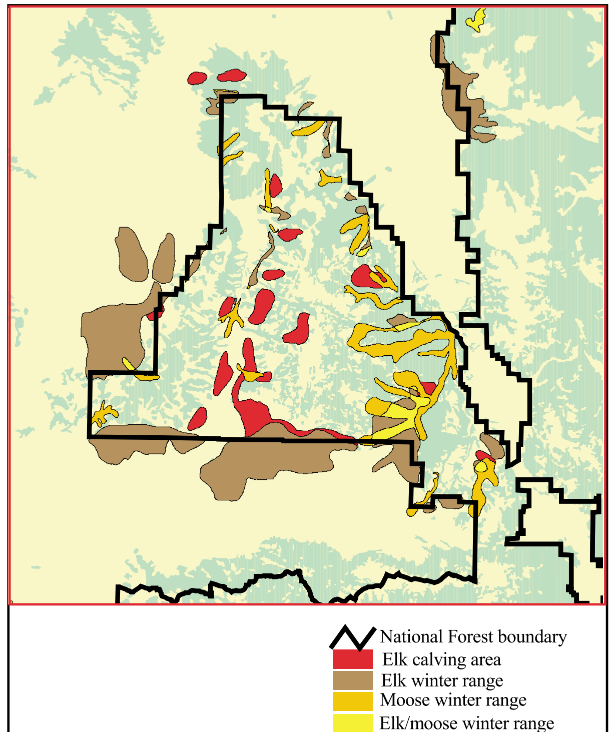

Figure 10.6 Calving areas and ungulate winter range

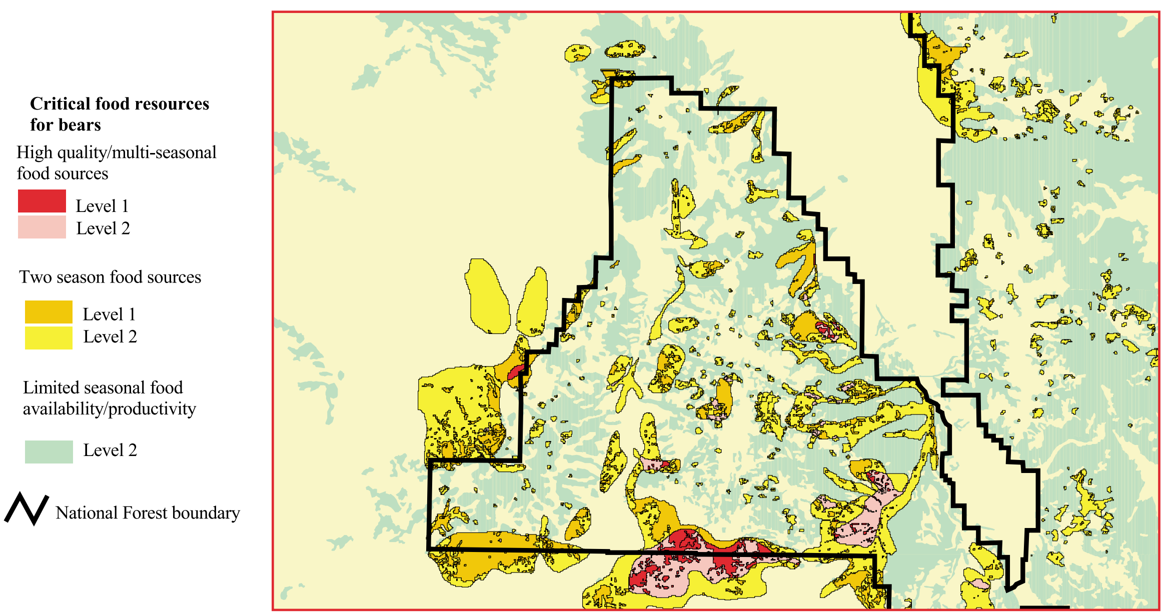

Figure 10.7 Potential nutritional density of various habitats

Significance for ERBC

Larger landscapes of secure habitat blocks connected by linkage zones are critical for the survival of rea-sensitive species such as grizzlies, tigers, jaguar, elephants, and some primates. The model can also be applied to carnivores in other ecosystems, which are negatively affected by similar, human-related disturbances in the landscape. Such an analysis does not necessarily require hi-tech GIS equipment; effective indications of disturbance can be achieved by using hardcopy maps, mylar overlays, and simply drawing buffers around human-related features.

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REPRESENTATION OF BIODIVERSITY IN DATA-RICH ECOREGIONS: COMPUTER ALGORITHMS AS NEW TOOLS 11

Introduction

We have repeatedly stressed two main themes throughout this workbook that are central to effective biodiversity conservation. First is the importance of representing species, habitats, etc. to ensure the conservation of the full diversity of life in an ecoregion. Second is the need to be strategic and efficient in our conservation efforts, because the resources and time available for conservation are severely limited. In most parts of the world, the lack of quantitative data on species' distributions forces conservation assessments to rely on expert opinion and other forms of subjective information to set priorities. In some ecoregions, however, conservationists are fortunate to have relatively abundant data on species distributions. In these ecoregions, it can be helpful to use one of a number of reserve selection algorithms—based on the idea of complementarity—that are designed to formalize the process of achieving representation in the most efficient manner possible. Indeed, these algorithms have been successfully employed in a number of ecoregions around the world to assist in setting priorities.

In this chapter, we introduce the basic concepts of complementarity and review several key features and variations of the most popular algorithms. We then present an example of complementarity analysis being put to practical use in the Cape Province of South Africa, a Global 200 ecoregion. Finally, we discuss several limitations to this approach and some cautionary notes about relying exclusively on computer methods to select reserves.

Concepts of Complementarity and Algorithm Design

Complementarity algorithms provide a way of selecting a set of reserves or management areas that, together, represent the greatest possible biodiversity in the least possible amount of area. They can be used with any measure of biodiversity (e.g., species, higher taxa, habitat types) and also with focal groups of interest, such as rare or endangered species. In general, any feature that can be recorded as present or absent in a geographic area (e.g., grid square, county, existing reserve) can be analyzed with complementarity algorithms.

We will illustrate the selection procedure of a typical algorithm using a simple example dataset (see table 11.1). The algorithm begins by selecting the site that contains the most species—in this case, site A. In the second step, the algorithm selects the site containing the most species that are not already represented in the first site, in other words, the site most complementary to the first. In our example, the second site chosen is site C, even though it contains the lowest absolute number of species. A third site is then chosen that is most complementary to the first two—in this case, site D. At this point, each species has been represented at least once, and the program stops. Although the process appears quite straightforward with this simple example, analyses become more complex with thousands of species to represent and hundreds of sites to choose from.

For example, two sites are often equally complementary to those already chosen. Algorithms differ on what to do in this case, but many break the tie by selecting the site that contains the rarest species (i.e., the species found in fewest sites and, therefore, is least likely to be represented again if not "captured" in this site). Also, it is common that several combinations of the same number of sites will achieve full representation. In our example, sites A, C, and D represent all species but so do sites B, C, and D as well as sites E, C, and D (see Table 11.1). This situation represents a degree of flexibility : Other factors such as land ownership, land value, and political realities help decide which combination of sites is most feasible to protect in reserve networks or other conservation activities.

The other side of the flexibility coin is the notion of irreplaceability. One can examine all possible site combinations that represent all species and determine which sites are included in all combinations. These sites are necessary to include no matter what other sites are selected; in this way, they may be considered "irreplaceable" in any set of representative sites. In the three possible sets in our example above, sites C and D are irreplaceable because they contain at least one species found nowhere else. Large datasets often include hundreds of equally efficient combinations, and a measure of irreplaceability can be calculated for a site based on the percentage of combinations that include it. These sites are clearly of high priority, because they represent the only opportunities within the ecoregion to conserve certain species and habitats.

Example from South Africa

The Cape Floristic Region of South Africa is perhaps the world's richest ecoregion for endemic plants. It is a clear global priority in which species distribution data are abundant, and therefore, it is an ideal candidate for explicit complementarity analysis. Rebelo and Siegfried (1992) have studied the distributions of plant species in the *Proteaceae* in a 12 x 13 km grid-square system covering the province. They used a complementarity algorithm to select grid squares that most efficiently represented the species (see fig. 11.1) and compared their results to the current configuration of nature preserves, to sites chosen at random, and (most interestingly) to three historical prescriptions for the placement of reserves (see figs. 11.2 - 11.4).

Table 11. 1: Example data set of distributions of 8 species among 5 sites (A-E) (1 indicates presence of the species in that site, and 0 indicates absence).

	A	B	C	D	E
Species 1	1	1	0	0	1
Species 2	1	1	0	0	1
Species 3	1	1	0	0	1
Species 4	1	1	0	1	0
Species 5	1	0	0	1	0
Species 6	0	0	0	1	0
Species 7	0	0	1	0	1
Species 8	0	0	1	0	0

Figure 11.1. Minimum set of areas (1 x 1 degree grids) in the Afrotropical region that would represent all birds, mammals, amphibians, and snakes (3,913 species) twice, identified using complementarity.

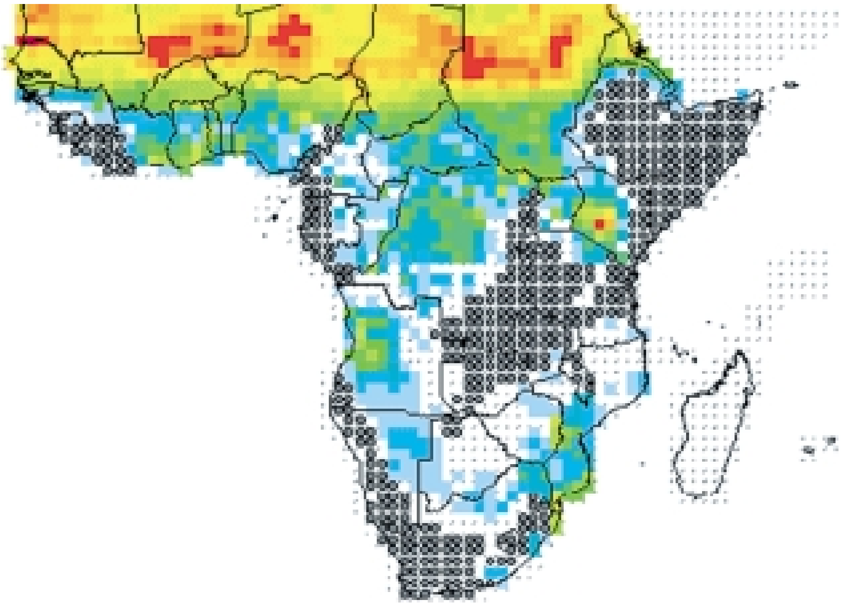

Figure 11.2. Species richness scores of 1 x 1 degree grids containing species not covered by WWF Global BDI ecoregions (in grey dots). Red = high richness, blue = low richness, white = no species not already covered in grey cells.

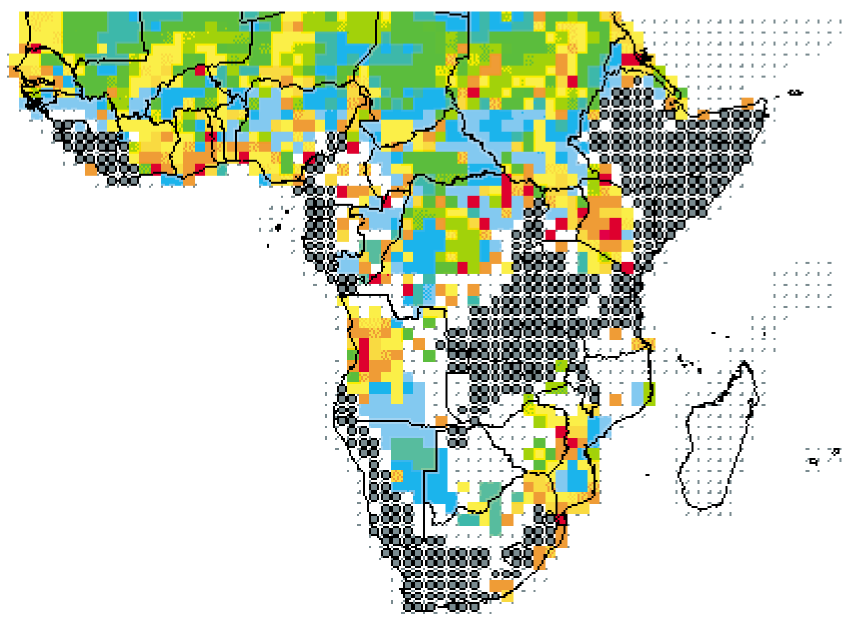

Figure 11.3. Species endemism scores of 1 x 1 degree grids containing species not covered by WWF Global BDI ecoregions (in grey dots). Red = high endemism, blue = low endemism, white = no species not already covered in grey cells.

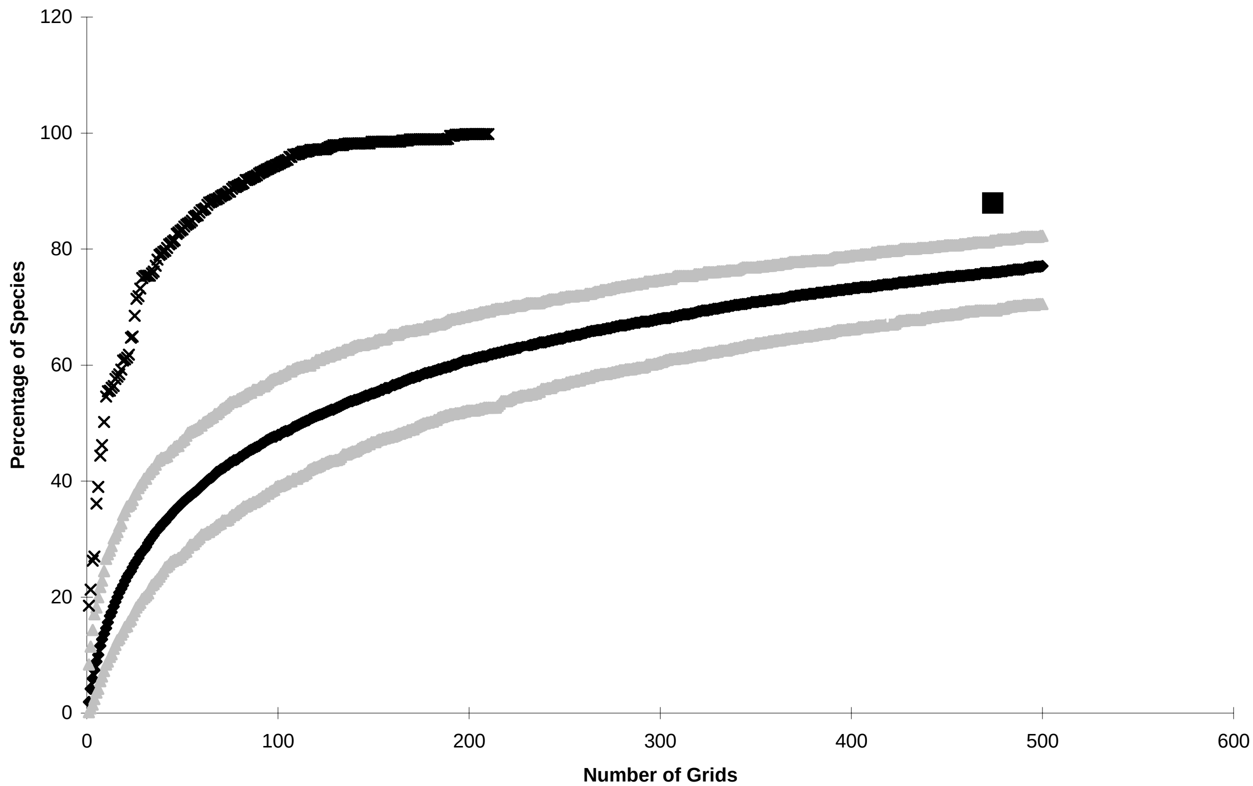

Figure 11.4. Species representation in WWF Global BDI ecoregions (black square) when compared with selecting 1 x 1 degree grids using complementarity to represent species three times (black crosses, upper left), and by choosing areas at random from the same database. black line is random curve, and grey triangles represent the upper 5% confidence limits (above) and the lower 5% confidence limits (below).

Rebelo and Siegfried found that

- the complementary methods are much more efficient than simply choosing cells at random (one would certainly hope this was true!);
- the current and prescribed reserve systems contained many fewer species than an equal number of cells that were selected using complementarity; and
- the current system of reserves was probably assembled largely opportunistically, and the prescribed reserves probably were based heavily on species richness, this example illustrates the efficiency advantages of complementarity over opportunistic, "hotspot" approaches to biodiversity conservation .

Limitations to Complementarity

Complementarity analyses offer a new way to be formal and explicit about representation and reserve selection process. However, like all formal computer methods, this approach contains a number of assumptions and simplifications that need to be carefully tempered with human common sense.

First, the simplest algorithms regard a species as protected if it is represented by a single location. This approach ignores the numerous benefits of maintaining many populations of each species, including reduced species extinction risk and genetic diversity among populations. Algorithms can be modified such that each species is represented in two, three, or any number of locations. Usually, the number of equally efficient sets (or flexibility) increases rapidly with these modifications. However, irreplaceable sites are more difficult to determine, making priorities less clear.

Second, the analyses incorporate no information about area requirements of species or the likelihood of persistence (see chap. 5). Clearly, a reserve that is large enough for one species (e.g., freshwater mussel) may be inadequate for another (e.g., jaguar). Therefore, conclusions could be limited, even misleading, if there is no explicit treatment of whether the location is large enough or of sufficient quality to ensure long-term viability of the population. Similarly, the analyses are not able to address ecological phenomena or species interactions as conservation targets in a computer-based algorithm.

Third, because these algorithms search for the most complementary sites, they are likely to choose widely-spaced, single units. However, ensuring connectivity among reserves is a major goal of ecoregion-based conservation. Therefore, we must be careful to ensure connectivity in the landscape by preserving areas that connect priority sites, even if maximal efficiency (in the sense of complementarity) is somewhat sacrificed.

Fourth, if two sites are both extremely rich but contain similar species assemblages, the algorithm will choose only one for preservation. Once the slightly more diverse site is selected, the second offers few unrepresented species. Therefore, opportunities to conserve a second population of many species may be missed in a narrow effort to select only complementary sites.

Finally, these analyses, like all conservation assessments, rely on the distribution patterns of only one or a few indicator taxa—groups of organisms whose distributions are well-known — to serve as surrogates for the distributions of biodiversity overall. In the South African example, the researchers selected reserves based on the distributions of a single dominant family of plants that exhibit remarkable levels of endemism, the *Proteaceae*. Clearly, the goal of the reserves is to conserve not only these plants but also biodiversity in general. However, even in relatively data-rich ecoregions, distribution data for only a small fraction of species are known well enough to allow reliable analyses. We must then assume that fully representing these species in a reserve system will also effectively represent at least the majority of species in other taxa. Some evidence from Uganda suggests that complementarity sets of sites that are chosen for one group can also effectively represent other taxa but, for the most part, this assumption is untested (Howard et al. 1998). We must accept this assumption but recognize its limitations.

Conclusions

Despite several of the limitations discussed above, complementarity analyses can be an extremely useful tool to select conservation priorities as long as they are used in conjunction with expert opinion and common sense. Among the factors that must be considered alongside the results of these analyses are political feasibility, land ownership, land cost, minimum size of reserves, reserve connectivity, existing distribution of reserves, and likely future patterns of anthropogenic threats.

Recently, researchers have begun to incorporate some of these other factors into the formal complementarity algorithms. For example, Ando et al. (1998) included data on land values in a complementarity analysis of endangered species in the United States. Their results substantially differed from those of Dobson et al. (1997), who considered only the distributions of the species themselves. These differences occurred because the two studies defined the term efficient differently. Dobson et al. attempted to minimize the *area* required to represent each species once whereas Ando et al. focused on minimizing the financial cost required to achieve representation.

One powerful interactive method to incorporate additional factors is to manually “preserve” one site and then run the algorithm with those species already represented. This may be useful if a certain site is already under biodiversity management or is a likely site for a new preserve. For instance, if site E in Table 11.1 were manually selected prior to running the algorithm, sites A and B would no longer be needed, and the complementarity choices would be clear: sites C and D. Complementarity analyses can be used in this way, to formally and rigorously explore options for the sequence of conservation action.

For the most part, it will not be possible to incorporate into algorithms the wide variety of factors that are necessary to set conservation priorities. Complementarity analysis, therefore, is best carried out as a heuristic tool, to explore possibilities, indicate irreplaceable areas, and focus the thinking of the people who are attempting to both maximize conserved biodiversity and minimize the effort and money required to do it.

Note that several complementarity analysis software packages exist with varying levels of public accessibility. WORLDMAP, one such program, is described and demonstrated on the web at http://www.nhm.ac.uk/science/projects/worldmap/index.html.

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ERBC ON TROPICAL ISLANDS: ASSESSING THE EFFECTS OF INVASIVE SPECIES ON LONG-TERM PERSISTENCE OF SPECIES ASSEMBLAGES AND HABITATS *12*

Introduction

The spread of species into new habitats has been a fundamental process in the development of ecological communities since life began. Recently, however, humans have facilitated an unprecedented global redistribution of species that has had significant negative ecological and economic effects worldwide. Nearly every habitat, from continental-scale ecosystems to isolated island chains, has been modified by human-mediated species introductions. Today, conservation biologists consider the invasion of alien species to be among the most serious threats to biodiversity.

The threat is especially pronounced on islands and island-like ecoregions—areas typically high in endemics. The geographic and long temporal isolation of these islands has led to their high biological distinctness and conservation value. This same isolation, however, also makes them particularly vulnerable to nonnative species introductions (Loope et al. 1988). The animal fauna on some islands, for example, evolved in the absence of predators and, therefore, can quickly be wiped out by a handful of feral dogs or cats. Furthermore, many island ecosystems are relatively simple when compared to their continental relatives and may, therefore, be quickly dominated by species, such as many successful weeds, that evolved in more intensely competitive environments.

Many ecoregions are experiencing catastrophic biodiversity losses because of human-mediated species introductions. In Hawaii, for example, exotic species and their diseases have already caused several extinctions and are the primary threat to 84 percent of federally listed native bird species (Wilcove 1999). The predatory snail *Euglandina rosea*, introduced to the Hawaiian islands in a futile attempt to control the giant African snail (*Achatina fulica*), has devastated populations of several native Hawaiian snails. In Guam, a single introduced species has caused the extinction of several species of birds and lizards (D 'Antonio and Dudley 1995). The culprit, the brown tree snake (*Boiga irregularis*), has recently reached Hawaii several times and will likely spread to other endemic-rich Pacific islands.

Invasive species are the major threat to several Global 200 ecoregions, including the Galápagos Islands scrubs, the Hawaiian moist forests, and the African Rift Valley lakes (Olson and Dinerstein 1998). Despite this, few tools exist to adequately address this major threat to biodiversity. Traditional, species-by-species remedies have proven to be extremely expensive and, often, ineffective, as in the case of the kudzu vine (*Pueraria thunbergiana*), and the zebra mussel (*Dreissena polymorpha*) in North America. Prevention, not control, is a better solution.

Effective ecoregional planning must identify management options that are likely to prevent or reduce the introduction of nonnative species. One contribution to this may come in the form of models to help identify those activities that are contributing most to nonnative species introduction. Unfortunately, available models and theories are generally limited to single species or to small components of the invasion process and thus, are not useful for conservation planning.

Model Concept

To address this threat from nonnative species, WWF's Conservation Science Program has developed a model to predict the trajectory and effects of human activity on nonnative species introduction and spread in the Galápagos archipelago. Three interrelated factors are directly responsible for introducing and spreading species within the Galápagos: population growth and movement, agriculture, and tourism. The model simulates the effect of these activities on the introduction and spread of nonnative species over the course of 50 years in several potential scenarios: no change in activity, moderate increase in activity, and high increase in activity. The model also allows one to keep one or several factors constant to gauge the relative effect of a single factor against the others.

Although the model has been developed specifically as a component of the Galápagos Islands biodiversity vision (Powell, G. et al. in preparation.), its structure and the general pattern of invasions are such that, with local data driving the specifics of the model, it could be applied to any island or island-like ecoregion.

Model Structure and Data Sources

The model depicts two root aspects of the species invasion process: introduction to the archipelago and spread among the islands. The core of the model is a matrix of islands and the number of non-native species on each. The levels of human activity on a given island determine the rate of introduction and spread. For each island in a given year, the model shows a given number of nonnative species, and a given level of population, agricultural use, and tourism. The model steps at one-year intervals, updating the species-island matrix at each step.

The model starts at "current conditions" with the current number of nonnative plants, animals, and invertebrates on each island. The current base rate of introduction from the mainland is taken to be one arrival and establishment per year (Mauchamp 1997). Variation in this rate is assumed to be directly proportional to the human population size or the area of the agricultural land, depending on the model scenario. Information on these variables is derived from the most current national census information available. Thus, arrival is restricted to populated islands, and current population or agriculture levels yield one successful introduction to the archipelago per year. Increases in these variables increase the number of introductions.

The rate of spread of nonnative species within the archipelago, however, is modeled as a separate step. Spread is modeled as a function of tourist boat traffic, and tour itineraries. Other vectors of spread, such as fishing encampments and science-management camps, could not be modeled because data were lacking. In the model, each tourist visit has a fixed likelihood of bringing in a nonnative species from the island where the tour originated. Further, the probability (per year) that a given unpopulated island will be infected with a species from another island that has already been infected is

$$1- (1 - p)^n \text{, where}$$

- ***p*** is the probability of a transfer per visit (see below), and
- ***n*** is the number of visits from islands that have been infected.

The variable *p* is derived from historical data. The total number of tourist landings between 1964 and 1974 (1,510,000) is multiplied by the two (of 40 for which there are data) nonnative introductions that are known to have moved from a populated to an unpopulated island. This yields a rate of $3.3 * 10^{-8}$ successful introductions per tourist visit.

Connectivity of tour visits is modeled with the following assumptions:

- All tourists depart from Baltra or San Cristobal, depending on their port of entry.
- Tourists visit other islands in proportion to the carrying capacity set by the park.
- The average tourist visits six islands.

These are, by necessity, generalizations that are derived of the schedules from several tour operators and data from the National Park. They do, however, account for the bulk of the tour traffic within the archipelago.

Running the Model: Management Scenarios

At the Galápagos biodiversity vision workshop (Powell, G. et al in preparation) the model was run to simulate four scenarios, although many more are possible. In each, the arrival rate of the nonnative species is proportional to either population or agriculture whereas spread is proportional to tourism only.Scenario

Scenario1: *Arrival rate of nonnative species is proportional to population size*
Population grows at 0% or 3% or 8% per year
Tourism grows at 0% or 5% or 10% per year

Scenario 2: *Arrival rate of nonnative species is proportional to agricultural area*
Agricultural land use does not grow
Tourism grows at 0% or 5% or 10% per year

Scenario 3: *Arrival rate of nonnative species is proportional to agricultural area*
Agricultural land use grows at 0% or 3% or 8% per year
Tourism grows at 0% or 5% or 10% per year

Scenario 4: *Arrival rate of nonnative species is proportional to agricultural area, with no population on Isabela.*
Tourism grows at 0% or 5% or 10% per year

The results (see fig.1- 4) dramatically show the effect of the various activities on nonnative introduction and spread. The final scenario in which the human population is relocated from just one of four of the inhabited islands demonstrates the strong influence of the presence of human communities on nonnative species introduction.

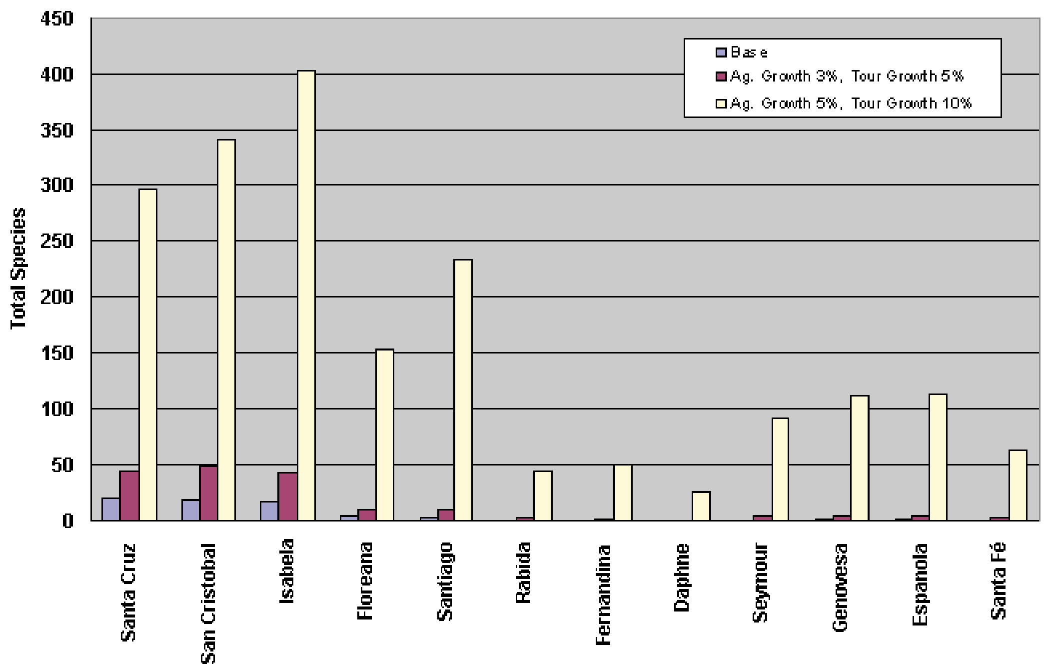

Figure 12.1. Nonnative species establishment as a function of agriculture and tourism over a 50-year period

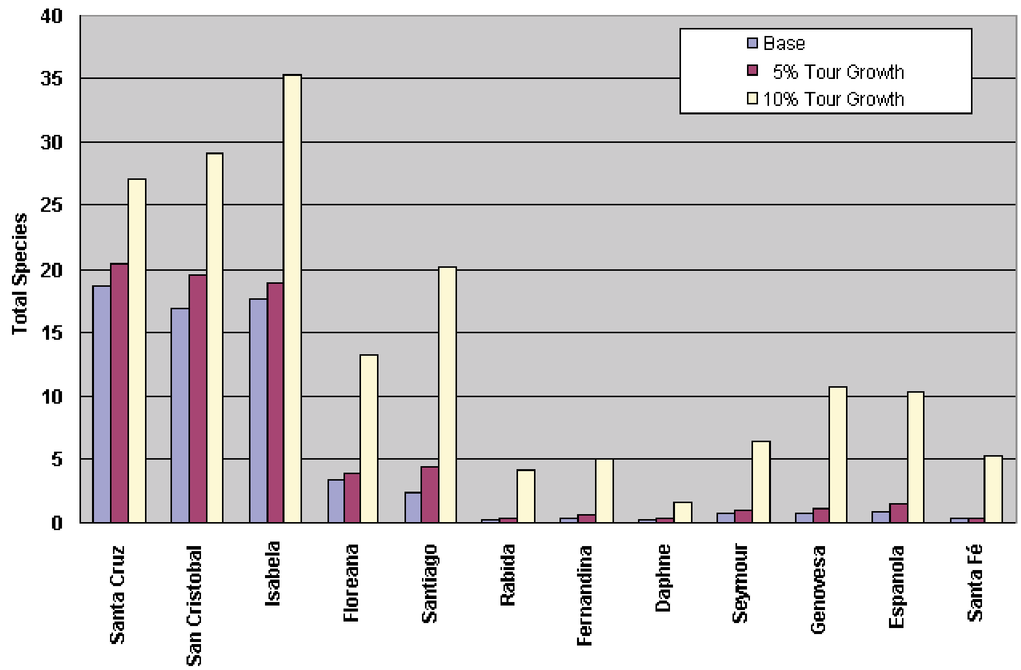

Figure 12.2. Nonnative species establishment as a function of tourism only over a 50-year period

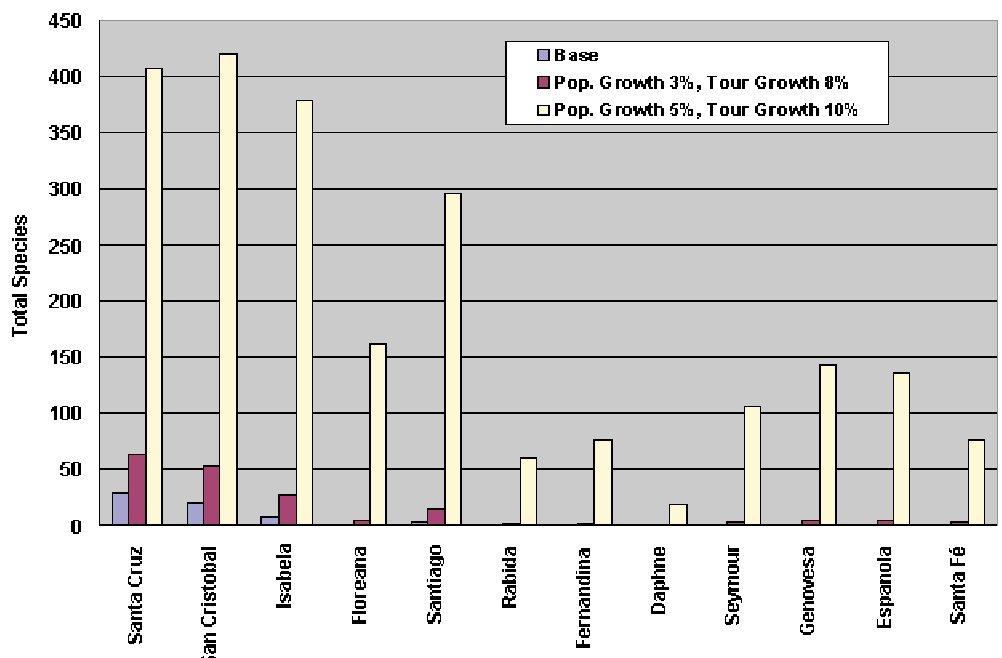

Figure12.3. Nonnative species establishment as a function of population and tourism over a 50-year period

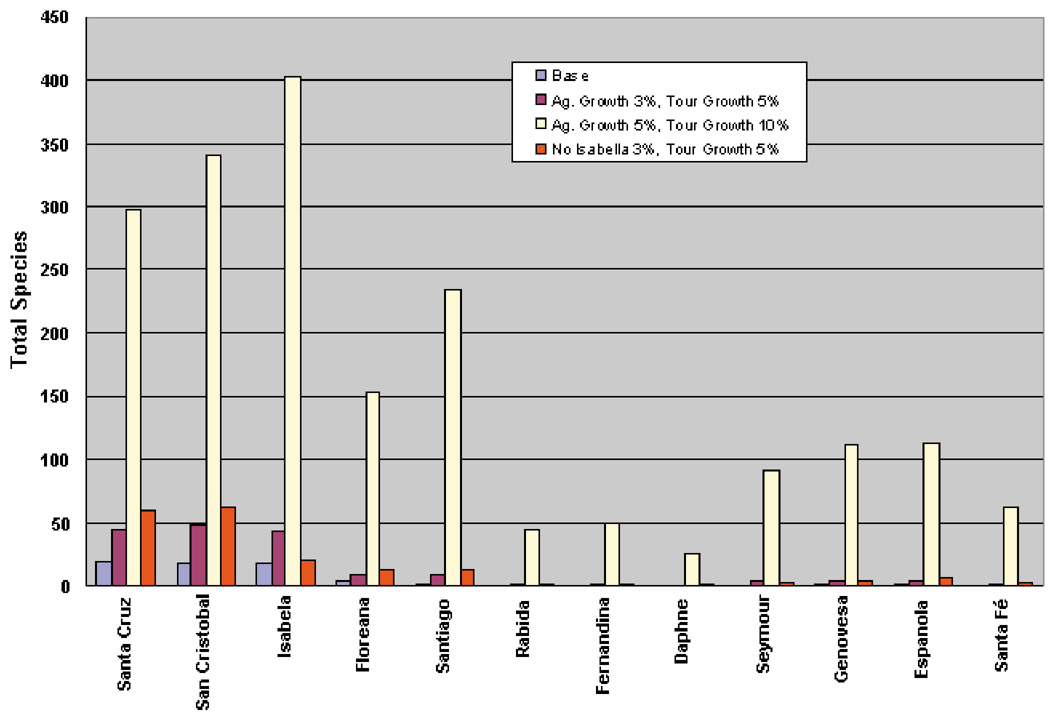

Figure 12.4. Nonnative species establishment as a function of agriculture and tourism, with no population on Isabela, over a 50-year period.

Conclusions

The spread of nonnative species is the number one component of biotic change in the world today, and the number two-threat to native biodiversity after habitat destruction (H. Mooney, personal communication). The recent establishment of a class of animals (Amphibia) never before known in the Galápagos bears grim testimony to the truth of this statement.

Hopefully, models such as this one can help combat this threat by pinpointing management actions that will most effectively reduce the influx and spread of nonnative species in this ecoregion and many others.

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GIS NEEDS AND DECENTRALIZATION OF GIS IN THE WWF NETWORK 13

Introduction

GIS is an essential tool for ERBC. A GIS system is a powerful means of

- Providing base maps for conducting the assessment
- Synthesizing expert assessment to determine and locate priority areas
- Analyzing minimum habitat requirements for focal species and ecological processes
- Identifying potential habitat
- Representing the correlation between physiographic and socioeconomic data.

In the past, functional GIS analysis could be conducted only by using expensive computer hardware and software. The high cost of the equipment limited the number of offices and programs that could afford a full-fledged GIS lab. This constraint has virtually disappeared over the last couple of years. Computers have become more powerful and less expensive, and today, more offices are able to afford a computer system that can handle GIS analysis. The Conservation Science Program (CSP) at WWF-US has been working hard to bolster the use of GIS by helping to decentralize its use within the WWF network.

The purpose of this chapter is to provide information about the data, software, and hardware requirements that are needed when using GIS to create a viable conservation plan. The chapter includes information on how the Conservation Science Program can help to decentralize the use of this important tool by providing training and data along with knowledge gained from ERBC workshops.

Concepts

The purchase of a computer does not automatically create a GIS lab. You will also need data, software, and personnel with the ability to use it. To this end, WWF has developed an agreement with Environmental System Research Institute, Inc. (ESRI), the maker of ArcView, one of the leading GIS software packages. This agreement allows for the purchase of ArcView, along with Spatial Analyst, a software that adds functionality to Arcview, and a module that allows to do conservation analyses relevant to ERBC, at an extremely reduced rate of US $350 compared to a list price of US $4,000. This agreement also allows CSP to purchase other ESRI software such as PC- ArcInfo and add-ons for ArcView.

ESRI GIS software is by no means the only GIS software available, but it is the most widely used by conservation planners. Because of its worldwide availability and CSP's arrangement to offer the software at reduced prices, it is the software we recommend you use in your headquarter GIS lab. It is also the software used at CSP. There are several different versions of the software, and these vary greatly in price.

The top-of-the-line software is called ArcInfo. The ArcInfo software runs on either UNIX or Windows NT computers. ArcInfo is very powerful, but it is also very expensive and complicated to use. CSP does not receive any discounts on ArcInfo, although ESRI does sometimes provide discounts on a case-by-case basis. Thus, we recommend it only for large, centrally located labs with full-time staff trained in use of the software.

ESRI's intermediate-level software package is PC-ArcInfo**.** This software runs on computers running Windows 95 or higher. It is not as powerful as ArcInfo but has a few more features than ArcView. The key feature that ArcInfo and PC-ArcInfo provide that ArcView does not is digitizing. ArcView can be used for digitizing, but it is slow and awkward. Because of this limitation, ArcView is not recommended as the software package to use during the ERBC workshop. Except for digitizing, ArcView handles almost all other ERBC requirements as well as or better than ArcInfo and PC-ArcInfo, and is therefore recommended for the headquarter GIS lab. ArcView is one of the most widely used GIS software packages, it can run on almost any computer that can run Windows 95 or higher, and it can be learned quickly.

GIS headquarter Lab Hardware Requirements

ArcView and PC-ArcInfo will work on most PCs. But both programs are memory- and hardware intensive so the faster and better the machine, the quicker and more efficiently you will be able to complete your work. The minimum requirements and the suggested requirements are listed in table 13.1. The minimum requirements should be used only if your budget precludes purchase of the ideal package. The money you spend today will quickly be recouped by increased productivity, so try to spend as much as you can afford to get a faster quality system at the onset.

Table 13.1 Computer Requirements*

Hardware Component	"Ideal" Center Cost Estimate — US $3,000	Minimum Cost Estimate — US $1,700
CPU	Pentium III 500MHZ or better CD-Recorder	Pentium 200MHz or better
CD-ROM	CD-Recorders (CD-Rs) allow you to save your data on CDs—a nice feature for exchanging data.	CD-ROM required
Hard Drive	Two hard drives with a total of 15 GBs or higher (GIS datasets can be very large).	4GBs or larger
RAM	64-128MB (The more RAM, the quicker your computer will run).	32MB or more
Operating System	Windows 95 or higher	Windows 95 or higher
Monitor	17-21 inches (Large monitors will improve work performance).	15-17 inches
Mouse	Required	Required
Printer	See Paragraph below	Inkjet color printer
Tape Backup Device	1GB of capacity or more. There are many different types. Our suggestion is to find a type that others in the area also use so that you can use the tapes to exchange data.	Not required but a good investment to ensure data protection.

*Computer prices and equipment are rapidly changing. This list is shown as an example of different systems. These configurations and prices are current as of March 1, 2000.

Printer and Additional Hardware Information

Many different types of printers are on the market. From our experience, the major brands (HP, Epson, and Canon) perform similarly among equally priced printers. The type of printers to look for is an Ink jet printer. These printers range in price from US $150 to US $1,500. The more expensive models print faster with a higher resolution. However, remember that when buying a printer for GIS, most maps need to be larger than 8½ by 11 inches, so look for printers that can print on larger sheets of paper (these will range in price up to US $1,000). There are reasonably priced printers that can print up to 13 by 22 inches. Plotters are large printers that can print on rolls of paper. They allow for maps that are up to 36 inches wide and 52 inches long. They are quite expensive and cost approximately US $10,000, but they are essential for producing basemaps and template maps used in ERBC planning exercises.

Additional hardware that is necessary for use with GIS follows:

- Scanner: US $120-US $400. Scanners digitize pictures and graphics, which allows you to add them to maps.
- ZIP drive: US $100-US $200. These drives hold between 100mb and 250mb. They are a popular disk drive that is used for exchanging data. They are a good purchase only if the people with whom you exchange data also have ZIP drives, so ask around before purchasing.

Workshop GIS lab Requirements

During the workshop, the GIS requirements become more intense. After each day of expert work, the GIS analyst will need to input data into the GIS database and print maps. These maps will be reanalyzed by the experts the following day to locate errors or to detect areas they might have missed. Because of the quick turn around time needed, it is often important for the GIS analyst to have one or two assistants. These assistants can come from anywhere, but CSP has found that universities often have students who are interested in helping and who can do the work inexpensively. Make sure when hiring someone for the workshop that they have the proper skills for the GIS software being used and that there are no language obstacles.

The workshop lab should have one or two digitizing tablets. These tablets are the means of converting the expert data into digital data. Depending on the number of assistants, several workstations (computer terminals) should be available at all times during the day. The workshop lab also needs a large size plotter for printing large maps.

Decentralization of GIS and related technologies

CSP's decentralization efforts have focused on assisting WWF programs in acquiring the right tools, skills, and data to conduct ERBC workshops, develop biodiversity visions, and implement ERBC. This assistance occurs on a variety of levels, from actually conducting the workshop to facilitating the acquisition of hardware, software, and satellite imagery to providing technical support and training for field staff. Decentralization will help in two ways. Once field offices have acquired the necessary equipment and expertise, they will also be able to conduct workshops independently. They will be able to collect their own data and conduct analyses. Second, by decentralizing data and transferring the skills needed to produce maps, we will be able to send the maps' messages out to a broader audience in a more timely and efficient manner.

Our long-term vision is a three-tiered network. The field offices will make up the first tier. Here is where the majority of the ERBC process will occur. Data will be collected and analyzed by people who have a wealth of local knowledge. The second tier will be a system of regional hubs. At these centrally located hubs, field personnel will be able to use larger, more powerful computers to perform data intensive analyses. Also at the second tier, efficient equipment such as large digitizers and plotters that are unavailable in field offices will be on hand to perform tasks. The second tier-labs will also have the personnel and equipment to be used for ERBC workshops. The third tier will consist of one or two labs, such as CSP, that can provide software and training to both the first and second tier.

Another way CSP has promoted the decentralization of GIS is by developing a file transfer protocol (FTP) site where we can store our data. Others working in the ecoregions can download data across the internet to use in their own analyses. This storehouse of GIS data will make it easier for people to begin the ERBC process. The address for the CSP website is <http://www.worldwildlife.org/wwfus-ftp/pub/>.

Data Requirements

The data you collect is an integral part of the ERBC process. If you collect inaccurate data, you will come up with inaccurate results. Often, the data you collect have been produced by others. You may have to pay for their data, or they might give it to you. Either way, you must make sure that the data are compatible with your system and that the quality of the data meets your needs. The following list describes a brief set of guidelines to ensure that you are getting your money's worth and that the data are compatible with your computer system.

1. ***Obtain the information in a digital format.*** Although the ultimate product may be hardcopy maps, try to obtain digital copies of all the data layers you will need (i.e., soil; land use; vegetation; towns; state, provincial, and country boundaries; topography etc.). Obtaining the data in digital formats will save you the trouble of having to digitize the data and enter it into the computer.

2. ***Obtain background information (metadata) about each digital data layer.*** This should include at minimum

   - ***Scale*.** For each data layer find the scale of the original data. Many data layers are digitized (i.e., tracing the lines on a paper map with a special mouse, which makes it show up on the computer as a digital copy) and the scale of the original map determines the scale of the digital version. The boundaries of any country will look completely different when closely viewing a map produced at the scale of 1:25,000 than when viewing a map at a scale of 1:1,000,000. The accuracy of a map increases as the second number in these ratios decreases, so that a 1:25,000 map is much more accurate than a 1:1,000,000 map, but it will also cover a much smaller area and take up more computer memory.

   - ***Projection*.** The earth is round, but most maps are flat. Therefore, representing a round earth on a flat map produces some distortion, and different ways of projecting the earth on flat maps are better for different parts of the world. It is important to know the projection of the digital map. Common projections include Lambert, UTM, Geographic, Conical, and Albers; however, the standard and oftentimes most useful projection is Geographic. Additional information usually accompanies each projection, and this information is termed *projection parameters*. These parameters are as important as the projection name, so be sure to ask for them. Different projections have different parameters. Some examples of parameters include datum, central meridian, zone, false northing, false easting, spheroid, and units.

   - ***Source data.*** For each data layer try to obtain information about the source of the digital data. If an analysis was done, then obtain information on the data that were used in the analysis. Who created it (government organization, NGO, military, etc.)? What year was the original map or digital data produced? This information is important for levels of accuracy, especially with land use or vegetation, which are constantly changing with time. When dealing with vegetation data, be sure of the origin of the data (e.g., hardcopy map, satellite image, aerial photo). If it is from a satellite image, the type of classification (supervised or unsupervised) and the type of sensor it was derived from (TM, MSS, radar, SPOT) are critical to any mapping work and analysis.

3. ***Obtain the digital data that are compatible to ArcView or ArcInfo.*** ArcView and ArcInfo are two software packages that perform GIS. ArcView is used with a PC and ArcInfo is usually used on UNIX systems. They are both made by ESRI and are compatible and interchangeable. The Conservation Science Program of WWF-US uses these programs almost exclusively, as do a large majority of other organizations throughout the world. By obtaining digital information that are compatible to these formats, you can exchange and share various GIS data layers more easily. These two software packages are the most common, but other GIS software exists, and you may obtain information in their formats. Additional GIS softwares are Mapinfo, IDRISI, ErMapper, and ERDAS.

4. ***Keep a contact name, address, and phone number associated with the data.*** If the data cannot be interpreted properly, if you find errors, or if additional maps or digital layers are needed, this contact information makes finding those answers much easier.

ANNEX 1. ECOREGION MEMBERSHIP OF TERRESTRIAL GLOBAL 200 ECOREGIONS (1:1 ECOREGIONS IN BOLD)

Terrestrial Global 200 ecoregion	*Ecoregion Name*
Alaskan North Slope coastal tundra	Arctic coastal tundra
	Arctic foothills tundra
Albertine Rift Montane Forests	**Albertine Rift montane forest**
Altai-Sayan montane forests	Altai alpine meadow and tundra
	Altai montane forest and forest steppe
	Great Lakes Basin desert steppe
	Sayan alpine meadows and tundra
	Sayan intermontane steppe
	Sayan montane coniferous forests
Annamite Range moist forests	Northern Annamites rain forests
	Southern Annamites montane rain forests
Appalachian and Mixed Mesophytic forests	Appalachian mixed mesophytic forests
	Appalachian/Blue Ridge forests
Arabian highland woodlands and shrublands	Al Hajar al Gharbi montane woodlands
	Arabian Peninsula coastal fog desert
	Southwestern Arabian foothills savanna
	Southwestern Arabian montane woodland
Atacama-Sechura desert	Atacama desert
	Sechura desert
Atlantic dry forests	**Atlantic dry forests**
Atlantic forests	Araucaria moist forest
	Atlantic Coast restingas
	Bahia coastal forest
	Bahia interior forest
	Bahia mangroves
	Caatinga Enclaves moist forest
	Campos Rupestres montane savanna
	Ilha Grande mangroves
	Parana-Paraiba interior forest
	Pernambuco coastal forest
	Pernambuco interior forest
	Rio Piranhas mangroves
	Rio Sao Francisco mangroves
	Serra do Mar coastal forest

Borneo lowland and montane forests	Borneo montane rain forests East Borneo rain forests Northeast Borneo rain forests Southwest Borneo rain forests West Borneo rain forests
California chaparral and woodlands	California coastal sage and chaparral woodlands California interior chaparral and woodlands California montane chaparral and woodlands
Cameroon Highlands forests	Cameroonian Highlands forest Mount Cameroon and Bioko montane forest
Canadian taiga	Eastern Canadian shield taiga Northwest Territories taiga Western Canadian Shield taiga
Cardamom Mountains moist forests	**Cardamom Mountains rain forests**
Carnavon xeric shrubs	Carnavon xeric shrublands Pilbara shrublands
Caucasus-Anatolian-Hyrcanian temperate forests	Caspian Hyrcanian mixed forests Caucasus mixed forests Elburz Range forest steppe Euxine-Colchic deciduous forest Northern Anatolian conifer and deciduous
Central and E. Siberian taiga	**East Siberian taiga**
Central and Eastern Mopane and Miombo woodlands	Central Zambezian Miombo woodland Eastern Miombo woodland Zambezian Baikiaea woodland
Central Andean dry puna	**Central Andean dry puna**
Central Andean yungas	Bolivian yungas Peruvian yungas Southern Andean yungas
Central Asian deserts	Central Asian northern desert Central Asian riparian woodlands Central Asian southern desert
Central Congo Basin moist forests	Central Congolian lowland forest Eastern Congolian swamped forest
Central Range subalpine grasslands	**Central Range subalpine grasslands**
Cerrado woodlands and savannas	**Cerrado**
Chhota-Nagpur dry forests	**Chhota-Nagpur dry deciduous forests**
Chihuahuan and Tehuacan deserts	Chihuahuan desert Meseta Central matorral Tehuacan Valley matorral
Chilean matorral	**Chilean matorral**
Chiquitano dry forests	**Chiquitano dry forests**

Choco-Darien moist forests	Choco-Darien moist forest Eastern Panamanian montane forest Magdalena-Uraba moist forest Western Ecuador moist forests
Chukote coastal tundra	Chukchi Peninsula tundra Wrangel Island arctic desert
Coastal Venezuela montane forests	**Cordillera La Costa montane forest**
Congolian coastal forests	Atlantic Equatorial coastal forest Cross-Sanaga-Bioko coastal forest Sao Tome and Principe moist forest
Daurian steppe	Daurian forest steppe Mongolian-Manchurian grassland
Drakensberg montane woodlands and grasslands	**Drakensburg montane grasslands, woodlands, and forests**
East African Acacia savannas	Northern Acacia-Commiphora bushland and thicket Serengeti volcanic grasslands Southern Acacia-Commiphora bushland and thicket
East African coastal forests	**Northern Zanzibar-Inhambane coastal forest mosaic**
East African mangroves	**East African mangroves**
East African moorlands	East African montane moorlands Rwenzori/Virunga montane moorlands Ethiopian montane moorlands
Eastern Arc montane forests	**Eastern arc forest**
Eastern Australia temperate forests	Australian Alps montane grasslands Eastern Australian temperate forests Southeast Australia temperate forests Tasmanian temperate forest
Eastern Deccan plateau moist forests	**Eastern Deccan plateau moist deciduous forests**
Eastern Himalayan alpine meadows	**Eastern Himalayan alpine shrub and meadows**
Eastern Himalayan broadleaf and conifer forests	Eastern Himalayan broadleaf forests Eastern Himalayan subalpine conifer forests Northeastern Himalayan subalpine conifer forests Northern Triangle temperate forests
Ethiopian Highlands	Ethiopian montane grasslands and woodlands Ethiopian montane moorlands

European-Mediterranean montane forests	Alps conifer and mixed forests
	Appenine deciduous montane forests
	Carpathian montane coniferous forests
	Crimean submediterranean forest complex
	Dinaric Mountains mixed forests
	Meditrranean conifer forests
	Pyrenees conifer and mixed forests
	Rodope montane mixed forests
Everglades flooded grasslands	**Everglades**
Fynbos	Lowland Fynbos and Renosterveld
	Montane Fynbos and Renosterveld
Galápagos Islands scrub	**Galapágos Islands xeric scrub**
Great Sandy-Tanami-Central Ranges desert	Central ranges xeric scrub
	Gibson desert
	Great Sandy-Tanami desert
Greater Antillean moist forests	Cuban moist Forest
	Hispaniolan moist Forest
	Jamaican moist Forest
	Puerto Rican moist forests
Greater Antillean pine forests	Cuban pine forests
	Hispaniolan pine forests
Greater Sundas mangroves	**Sunda Shelf mangroves**
Guianan and Amazon mangroves	Guaianan mangroves
	Maranhao mangroves
	Para mangroves
	Ampa mangroves
Guaianan Highlands moist forests	Guaianan Highlands Moist Forest
	Tepuis
Guianan moist forests	Guianan moist forest
	Orinoco Delta swamp forest
	Paramaribo swamp forest
Guinean moist forests	Eastern Guinean Forest
	Guinean montane forest
	Western Guinean lowland forest
Gulf of Guinea mangroves	**Central Africa mangrove**
Hawaii dry forest	Hawaiian tropical dry forests
	Hawaiian tropical high shrublands
	Hawaiian tropical lowland shrublands
Hawaii moist forest	**Hawaiian tropical moist forests**
Hengduan Shan conifer forests	Hengduan Mountains alpine coniferous forests
	Nujiang Langcang Gorge alpine conifer and mixed forests
	Qionglai/Minshan coniferous forests
Horn of Africa Acacia savannas	**Somali Acacia-Commiphora bushland and thicket**

Indochina dry forests	Central Indochina dry forests Southeastern Indochina dry evergreen forests
Kamchatka taiga and grasslands	Kamchatka mountain tundra and forest tundra Kamchatka/Kurile meadows and sparse forests Kamchatka/Kurile taiga
Kayah-Karen/Tenasserim moist forests	Kayah-Karen montane rain forests Tenasserim-South Thailand semievergreen rain forests
Kinabalu montane shrublands	**Kinabalu montane alpine meadows**
Klamath-Siskiyou coniferous forests	**Klamath-Siskiyou forests**
Llanos savannas	**Llanos**
Lord Howe and Norfolk Island Forests	Lord Howe Island subtropical forest Norfolk Island subtropical forest
Low Arctic tundra	**Low Arctic tundra**
Madagascar dry forests	**Madagascar dry deciduous forest**
Madagascar forests and shrublands	Madagascar lowland forests Madagascar subhumid forest
Madagascar mangroves	**Madagascar mangroves**
Mediterranean conifer forests	**Mediterranean moist conifer forest**
Mediterranean forests, woodlands and scrub	Aegean & West Turkey sclerophyllous and mixed forests Anatolian conifer and deciduous mixed forests Canary Islands dry woodlands and forests Central Anatolian deciduous forests Central Anatolian steppe Corsican montane broadleaf and mixed forests Crete Mediterranean forests Cyprus Mediterranean forests Eastern Anatolian deciduous forests Eastern Mediterranean coniferous-sclerophyllous- broadleaf forests Iberian conifer forests Iberian sclerophyllous and semideciduous forests Illyrian deciduous forests Italian sclerophyllous and semideciduous forests Mediterranean Acacia-Agania dry woodland Mediterranean dry woodland and steppe Mediterranean high atlas shrubland Mediterranean woodland and forest Northeastern Spain & Southern France Mediterranean forests Northwest Iberian montane forests

	Pindus Mountains mixed forests South Appenine mixed montane forests Southeastern Iberian shrubs and woodlands Southern Anatolian montane conifer and deciduous forests Southwest Iberian Mediterranean sclerophyllous and mixed forests Tyrrhenian-Adriatic sclerophyllous and mixed forests
Mesoamerican pine-oak forests	Central American montane forest Central American pine-oak forest Chimalapas montane forest Sierra Madre de Oaxaca pine-oak forest Sierra Madre del Sur oine-oak forest Trans-Mexican volcanic belt pine-oak forest
Middle Asian montane woodlands and steppe	Alai/Western Tian Shan steppe Gissaro/Alai open woodlands Hindu Kush alpine meadows Pamir alpine desert and tundra Tian Shan alpine meadow and tundra Tian Shan foothill arid steppe Tian Shan montane coniferous forests
Moluccas moist forests	Halmahera rain forests Seram rain forests
Muskwa/Slave Lake boreal forests	Muskwa/Slave Lake forest Northern cordillera forest
Naga-Manapuri-Chin Hills moist forests	Assam hills subtropical forests Chin Hills-Arakan Yoma montane rain forests Mizoram-Manipur-Kachin rain forests Northeast India-Myanmar pine forests Northern Triangle subtropical forests outside
Namib-Karoo-Kaokoveld deserts and shrublands	Kaokoveld Desert Nama Karoo Namib Desert Namibian savanna woodland Succulent Karoo
Nansei Shoto Archipelago forests	**Nansei Islands subtropical evergreen forests**
Napo moist forests	Napo moist forest Ucayali moist forests
New Caledonia dry forests	**New Caledonia dry forests**
New Caledonia moist forests	**New Caledonia rain forests**
New Guinea mangroves	**New Guinea mangroves**

New Guinea montane forests	Central Range montane rain forests Huon Peninsula montane rain forests Southeastern Papuan rain forests Vogelkop montane rain forests
New Zealand temperate forests	Fiordland temperate forests Nelson Coast temperate forests Northland temperate forests Northland temperate kauri forests Richmond temperate forests Southland temperate forests
North Indochina subtropical moist forests	North Indochina subtropical forests Yunnan Plateau subtropical evergreen forests
Northeastern Congo Basin moist forests	**Northeastern Congolian lowland forest**
Northern Andean montane forests	Cauca Valley montane forest Cordillera Oriental montane forest Eastern Cordillera real montane forest Magdalena Valley montane forest Northwestern Andean montane forest Santa Marta montane forest Venezuelan Andes montane forests
Northern Andean paramo	Cordillera Central paramo Cordillera de Merida paramo Northern Andean paramo Santa Marta paramo
Northern Australia and Trans-Fly savannas	Arnhem Land tropical savannas Cape York tropical savannas Carpentaria tropical savannas Einasleigh upland savannas Kimberly tropical savannas Trans-Fly savanna and grasslands
Northern Indochina subtropical moist forests	**Northern Indochina subtropical forests**
Northern Prairies	Nebraska Sand Hills mixed grasslands North short grasslands
Nusu Tenggara dry forests	Lesser Sundas deciduous forests Timor and Wetar deciduous forests
Pacific temperate rainforests	Central Pacific coastal forests British Columbia mainland coastal forests Northern California coastal forests Northern Pacific coastal forests Queen Charlotte Islands
Palawan moist forests	**Palawan rain forests**
Panama Bight Mangroves	Esmeraldes-Pacific Colombia mangroves Gulf of Guayaquil-Tombes mangroves Gulf of Panama mangroves Manabi mangroves
Pantanal flooded savannas	***Pantanal***

Patagonian steppe and grasslands	**Patagonian steppe**
Pennisular Malayasia lowland and montane forests	Peninsular Malaysia montane rain forests Peninsular Malaysia rain forests
Philippines moist forests	Luzon montane rain forests Luzon rain forests Luzon tropical pine forests Mindanao montane rain forests Mindanao-Eastern Visayas rain forests Mindoro rain forests Greater Negros-Panay rain forests
Queensland tropical forests	**Queensland tropical rainforests**
Rann of Kutch flooded grasslands	**Rann of Kutch seasonal salt marsh**
Rio Negro-Jurua moist forests	Caqueta moist forest Japura-Solimoes-Negro moist forest Negro-Branco moist forest Solimoes-Japura moist forest
Russian Far East temperate forests	South Sakhalin/Kurile mixed forests Ussuri broadleaf and mixed forests
Fennoscandia alpine tundra and taiga	Kola Peninsula tundra Scandinavian montane birch forest and grasslands
Seychelles and Mascarenes moist forests	Granitic Seychelles forest Mascarene forests
Sierra Madre Oriental and Occidental pine-oak forests	Sierra de la Laguna pine-oak forests Sierra Madre Occidental pine-oak forests Sierra Madre Oriental pine-oak forest
Sierra Nevada coniferous forests	**Sierra Nevada forests**
Socotra Island desert	**Socotra Island xeric shrublands**
Solomons-Vanuatu-Bismarck moist forests	New Britain-New Ireland lowland rain forests New Britain-New Ireland montane rain forests Solomon Islands rain forests Vanuatu rain forests
Sonoran-Baja deserts	Baja California desert Gulf of California xeric scrub San Lucan xeric scrub Sonoran desert
Southeast China-Hainan moist forests	Hainan Island monsoon rainforests Jian Nan subtropical evergreen forests South China-Vietnam subtropical evergreen forests
Southeastern conifer and broadleaf forests	Southeastern conifer forests Southeastern mixed forests

Southern Australia mallee and woodlands	Eyre and York Mallee Mount lofty woodlands Murray-Darling woodlands and mallee Naracoorte woodlands
Southern Mexican dry forests	Bajio dry forests Balsas dry forests Chiapas Depression dry forests Jalisco dry forests Sierra de la Laguna dry forests Sinaloan dry forests Southern Pacific dry forests
Southern New Guinea lowland forests	Southern New Guinea lowland rain forests Vogelkop-Aru lowland rain forests
Southern Pacific Islands forests	Cook Islands tropical moist forests Fijian tropical dry forests Fijian tropical moist forests Marquesas tropical moist forests Samoan tropical moist forests Society Islands tropical moist forests Tongan tropical moist forests Tuamotu tropical moist forests Tubuai tropical moist forests
Southern Rift montane woodlands	**Southern Rift montane forests-grassland mosaic**
Southwest China temperate forests	Daba Mountains evergreen forests Qinling Mountains deciduous forests Sichuan Basin evergreen broadleaf forests
Southwestern Amazonian moist forests	Jurua/Purus moist forests Madeira-Tapajos moist forest Purus-Madeira moist Forest Southwest Amazon moist forest
Southwestern Australia Forest	Southwest Australia savannas Southwest Austalia woodlands Coolgardie woodlands Esperance mallee Jarrah-Karri forest and shrublands Kwongan heathlands
Southwestern Ghats moist forest	South Western Ghats moist deciduous forests South Western Ghats montane rain forests
Sri Lankan moist forest	Sri Lanka montane rain forests Sri Lanka lowland rain forests

Sudanian savannas	**East Sudanian savanna**
Sudd-Sehelian flooded grasslands	**Saharan flooded grassland**
Sulawesi moist forests	Sulawesi lowland rain forests Sulawesi montane rain forests
Sumatran Islands lowland and montane forests	Sumatra montane rain forests Sumatra rain forests Sumatra tropical pine forests
Sundarbans mangroves	**Sundarbans mangroves**
Taimyr and Russian coastal tundra	Northeast Siberian coastal tundra Taimyr/Central Siberian tundra
Taiwan montane forests	South Taiwan monsoon rainforests Taiwan subtropical evergreen forests
Talamancan and Isthmian Pacific forests	**Talamancan montane forest**
Tasmanian temperate rainforests	Tasmanian central highland forests Tasmanian temperate rainforests
Terai-Duar savannas and grasslands	**Terai-Duar savanna and grasslands**
Tibetan Plateau steppe	Central Tibetan Plateau alpine steppe Southeast Tibet shrublands and meadows Tibetan plateau alpine shrublands and meadows Yarlung Zambo arid steppe Karakoram-West Tibetan Plateau alpine steppe
Tumbesian and North Inter-Andean Valleys dry forests	Cauca Valley dry forests Ecuadorian dry forests Magdalena Valley dry forests Maranon dry forests Patia Valley dry forests Tumbes/Piura dry forests
Ural Mountains taiga and tundra	**Urals montane tundra and taiga**
Valdivian temperate rainforests	Juan Fernandez temperate forests Valdivian temperate forests
Western Congo Basin moist forests	Northwestern Congolian Lowland forest Western Congolian swamp forest
Western Himalayan temperate forests	Western Himalayan broadleaf forests Western Himalayan subalpine conifer forests
Western Java montane forests	**Western Java montane rain forests**
Zambezian flooded savannas	**Zambezian flooded grassland**

ANNEX 2. SAMPLES OF USEFUL DATA SHEETS FOR VARIOUS STEPS IN THE BIOLOGICAL ASSESSMENT WORKSHOP

Form 1. Nominated Important Areas for Taxa

Authors:

Area Name:

Taxonomic Group:

- Birds
- Herps
- Invertebrates
- Mammals
- Plants
- Freshwater
- Other (specify at right)

Area Number:

Please specify a unique number for each area. Precede the number with the first letter of your working group. Example: Birds = b1, b2, etc.

General description of area locations (nearest village/town, administrative districts, river basin, etc.)

General description of area features, including habitat type

I. Primary Biodiversity Targets
Please check 1-3 targets that most distinguish this area and fill out corresponding information below.

Richness ☐ **Ecological phenomena** ☐ **Large-scale ecological phenomena** ☐ **Other (Specify at right)** ☐

Endemism ☐ **Evolutionary phenomena** ☐

Species richness (mark one)

- Outstanding for region of analysis
- Outstanding at subregion scale
- Outstanding at ecoregion scale
- Not outstanding for richness
- Not enough information to evaluate

Richness descriptions

Please go to next page

Form 1. Nominated Important Areas for Taxa (contd.)

Species endemism

Outstanding for region of analysis
Outstanding at subregion scale
Outstanding at ecoregion scale
Not outstanding for richness
Not enough information to evaluate

* Endemic or near-endemic to a biogeographic subregion or smaller unit. Species restricted to specialized or patchy habitat types throughout the region of analysis may also be considered endemic.

Endemism description:

II. Ecological Phenomena Intact biotas ☐ Highly unusual asssemblages ☐ Highly unusual Interactions ☐

Migration, feeding, or resting site, or important seasonal habitat ☐ Other ☐

Evolutionary Phenomena Extraordinary radiations in a range of taxa ☐ Major relict or primitive taxa ☐ Other ☐

Description of ecological and/or evolutionary phenomena

Other biodiversity targets Please describe other biodiversity targets below

III. Information quality

Level of scientific understanding:

High
Medium
Low
Not known by group

Need for biological inventories:

High
Medium
Low
Not known by group

Specific studies needed/additonal notes:

Form 2. Candidate Important Areas for Subregions

Authors:

Subregion name:

Candidate Area Number:

Please specify a unique number for each candidate area. Precede the number with the letter assigned to your subregion.
Example: Subregion W= W1, W2

Area Name:

Component taxon areas from Day 1 (list area numbers):

General description of candidate area locations (nearest village/town, administrative districts, river basin, etc.)

General description of candidate area features, including habitat type

I. Primary Reasons for Selection
Please check 1-3 reasons for selection of this cadidate area. Use information from Day 1 nomination forms as needed.

Richness ☐
Endemism ☐
Ecological phenomena ☐
Evolutionary phenomena ☐
Habitat representation (Specify habitat type)
Other ☐ **(Specify below)**

Please give supporting information for reasons checked above. Include specific biodiversity features (take information from Day 1 nomination forms as needed.)

Form 2. Candidate Important Areas for Subregions (contd.)

II. Ranking of candidate areas based on biological distinctiveness

The workshop group will develop a ranking system based on bioloigical distinctiveness. A suggested approach follows :

Highest biological importance: Area has high representation of endemic taxa, rare communities, and/or unique phenomena
High biological importance: Area has moderate degree of endemism and /or high richness
Moderate biological importance: Area has low degree of endemism and moderate richness, or supports species of special concern

Relative ranking of candidate area (mark one):

Highest biological importance
High biological importance
Moderate biological importance

Ranking notes:

III. Information Quality

Consult nominated area forms from Day 1

Level of Scientific understanding:

High
Medium
Low
Not known by group

Need for biological inventories:

High
Medium
Low
Not known by group

Information gaps/additional notes:

IV. Bibliography/Information Sources (Including experts)

V. Contact Information for Conservation Partners for the Area (including e-mail addresses)

Form 3. Terrestrial Habitat Type

The following is a list of broad terrestrial habitat types suggested for the region. These will be used for the representation analysis. An area of biological importance may contain more than one habitat type.

Habitat Type	Code	Habitat Type	Code
Montane moist forest	MMF	Savanna	SAV
Lowland moist forest	LMF	Flooded savanna	FSV
Montane shrubland	MSH	Mangrove	MAN
Lowland dry forest	LDF	Other	OTH
Swamp forest	SWF		

Please review this list for any omissions. All major terrestrial habitats occurring in te region of analysis should be included in this list. Working together, the group will develop a final list of habitat types. The space below is provided for you to record the final list for your use.

Modified terrestrial habitat type list

Habitat Type	Three-letter code

Form 4. Habitat Integrity Assessment

Authors:

Candidate Area Number:

Area Name:

Habitat Integrity

The "Threats" working group will present a suggested approach for assessing the habitat integrity of candidate areas. One potential approach looks at the size of intact habitat blocks -- an example is below.

1. Highly Intact	Intact habitat block size is greater than minimum required to sustain target species/processes. Habitat is unfragmented and connected to other intact areas. Intact species assemblages, including large vertebrates, are present.
2. Relatively Intact	Some medium to large intact habitat blocks remain. Habitat is unfragmented. Connections with other intact areas may exist, and intact assemblages may be present.
3. Altered	Small to medium intact habitat blocks remain. Some blocks are unfragmented, and some connections exist among blocks and with other intact areas outside. Area is restorable.
4. Highly degraded	Little intact habitat remains, with no intact assemblages. Area is highly fragmented and isolated from other habitats. Area will need considerable restoration.

Based on the approach developed, please choose a level of intactness for this candidate area.

Habitat integrity level (mark one):

- Highly Intact
- Relatively Intact
- Altered
- Highly degraded

Habitat Integrity notes:

Form 5. Future Threats

Candidate Area Number: ☐ **Authors:** ☐

I. Conversion Threats

Examples include:
- **urban expansion**
- **intensive logging and associated road building**
- **agricultural expansion**
- **permanent alteration from burning**

Please select one level of conversion threats by checking the appropriate box. Corresponding points will be assigned automatically.

Threat(s) may significantly alter 50% or more of remaining habitat within 20 years (50 points) : ☐ ☐

Threat(s) may significantly alter between 25% and 50% of remaining habitat within 20 years (20 points) : ☐ ☐

Threat(s) may significantly alter up to 25% of remaining habitat within 20 years (10 points) : ☐ ☐

No conversion threat(s) recognized for area (0 points): ☐ ☐

II. Degradation Threats

Examples include
- **loss of top predators**
- **alien species**
- **burning**
- **firewood extraction**
- **selective logging**
- **grazing**
- **excessive recreational impacts**
- **unsustainable extraction of non-timber products**
- **road building and associated erosion and landslide damage**
- **pollution (e.g., oil, pesticides, herbicides, mercury, heavy metals, defooliants)**
- **loss of large herbivores, frugivores**

Please select one level of degradation threats by checking the appropriate box. Corresponding points will be assigned automatically.

High: Within 20 years, many populations of native plant species expected to experience high mortality and low recruitment due to degradation factors. Succession and disturbance processes significantly altered. Low habitat quality for sensitive species. Abandonment and disruption of seasonal/migratory/breeding movements. Pollutants and/or linked effects widespread in ecosystem (e.g., recorded in several trophic levels). (30 points) ☐ ☐

Medium: Within 20 years, populations of native plant species expected to experience significant motality and poor recruitment due to degradation factors. Succession and disturbance processes significantly altered. Low habitat underuse of seasonal/migratory/breeding movements by species. Pollutants and /or linked effects commonly found in target species or assemblages. (15 points) ☐ ☐

Low: no degradation threats anticipated for area within 20 years. (0 points) ☐ ☐

III. Exploitation Threats

Examples include:
- **hunting and poaching**
- **harassment and displacement by commercial and recreational users**
- **unsustainable extraction of wildlife and plants as commercial products**

Please select one level of exploitation threats by checking the appropriate box. Corresponding points will be assigned automatically.

Within 20 years, high intensity of wildlife exploitation expected with elimination of local populations of most target species imminent or complete. (20 points) ☐ ☐

Within 20 years, moderate levels of wildlife explloitation expected, with populations of game/trade species persisting but in reduced numbers. (10 points) ☐ ☐

No wildlife exploitation expected for area within 20 years. (0 points) ☐ ☐

Form 5. Future Threats (contd.)

Continued from Previous page

IV. Overall future threat level

Total points: 0

Threat level: low

70-100	High future threats
20-69	Medium future threat
0-19	Low future threats

Expanded comments on future threats. Describe specific threats, impacts on different biodiveristy features, estimated severity, irreversibility, spatial extent.

Form 6. Candidate Priority Areas-- Additional Information

Authors:

Candidate Area Number:

Area Name:

I. Most urgent and appropriate conservation activities

List specific activities and give time frame in which they should be implemented.

II. Land tenure, use, ownership

Please give specific details for candidate area and surrounding land.

III. Linkages

Area is currently linked with other intact habitat through corridor ☐

Area could be linked with other intact habitat if corridor were created ☐

Comments concerning linkage of this candidate area. Include information on restoration potential of corridors.

Form 7. Integration Matrix

Subregion: name [ ] **Authors of form :** [ ]

Please put numbers (I, II, or III) corresponding to priority levels in matrix cells below. I = Highest priority, II = High priority, III = Priority. See descriptions below of biological importance and habitat integrity levels.

Biological Importance / Habitat Integrity	Highly Intact	Relatively Intact	Altered	Highly Degraded
Highest				
High				
Moderate				

Biological Importance

Highly Intact:	Area has high representation of endemic taxa, rare communities, and/or unique phenomena.
High:	Area has moderate degree of endemism, and/or high richness.
Moderate:	Area has low degree of endemism and moderate richness, or supports species of special concern or other targets .

Habitat Integrity

1. Highly Intact	Intact habitat block size is greater than minimum required to sustain target species/processes. Habitat is unfragmented and connected to other intact areas. Intact species assemblages, including large vertebrates, are present.
2. Relatively Intact	Some medium to large intact habitat blocks remain. Habitat is unfragmented. Connections with other intact areas may exist, and intact assemblages may be present.
3. Altered	Small to medium intact habitat blocks remain. Some blocks are unfragmented, and some connections exist among blocks and with other intact areas outside. Area is restorable.
4. Highly degraded	Little intact habitat remains. Area is highly fragmented and isolated from other habitats. No intact assemblages remain. Area is not practically restorable.

Notes on matrix:

Sample introductory letter and agenda for biodiversity workshop participants taken from the Congo Workshop of March 2000

Memorandum

TO: Congo Basin Workshop Participants
RE: Congo Basin Biodiversity Workshop, Libreville, Gabon
FR: David Olson, Workshop Facilitator
Date: 11.02.00

Dear Workshop Participants,

The Congo Basin Biodiversity Workshop is intended to offer an opportunity for biodiversity and conservation specialists to work together to analyze patterns of biodiversity, ecological requirements, and trajectories of biodiversity loss in order to develop a Congo Basin-wide long-term biodiversity conservation strategy. A strategic biological vision for the region can greatly enhance the effectiveness of conservation activities throughout the region. It can help us understand the relative significance of different sites and activities in terms of their contribution to a regional strategy. In some cases we can act quickly to focus attention on overlooked areas, or we can keep an eye on challenging priorities as the conservation opportunity landscape changes. In all situations, a long-term strategy can help us understand the biological tradeoffs of different conservation decisions.

We ask you at the workshop to take a step back and look at conservation issues within the context of the entire Congo Basin, and over a longer time scale (50-year) than we typically think about. We ask you to think about what “success” would look like in the basin in half a century. Your detailed knowledge of species, sites, and conservation issues will be very important in this process as well, and there will be many opportunities to contribute and integrate this information. We shall develop a biological vision for both terrestrial and freshwater biodiversity. We understand that there exist significant gaps in biodiversity and threat information in the region. We ask you to help create a short- and long-term conservation strategy for the region using the best available information and your collective expertise and insight. Significant information gaps will be identified and highlighted.

We provide here a more detailed summary of the workshop approach. We describe the kinds of questions we hope to ask at each step and the specific tasks that are proposed. A full explanation and discussion of the issues and tasks will take place at the beginning of each section. We try to use a flexible and adaptive approach in order to benefit from your regional perspectives on biodiversity and threats. Minor modifications will be made during the workshop process with the consensus of the group. We use the first part of the draft agenda as a framework to expand our discussion of the process. The new comments are not indented like the agenda subheadings. Please send me an email if you have any comments prior to the workshop.

What should you do prior to workshop or bring to the workshop? We ask you to look over the agenda, this summary, the regional map(s), and data sources being assembled. We hope that a review of this information will give you a better sense of the 1) biogeographic area being assessed, 2) the kinds of questions being asked, 3) the level of biogeographic resolution we will focus on, 4) the kinds of biodiversity features and targets we will look at, and 5) the overall goals and products of the workshop. As you can see, we cannot go into great detail for particular sites or issues because of the scale and scope of the analysis. The data sheets do offer an opportunity to record detailed information for specific sites, areas, or issues. If you have any comments on the workshop goals or approach, or can suggest some important data that we might have missed please contact...

Please feel free to bring any publications, data, maps or sources of information that you feel could be useful for answering the questions outlined here. Regional and subregional scale information on patterns of biodiversity, threats, or opportunities are especially useful. Information on transition zones and areas of endemism are particularly useful too. Site-level biodiversity surveys or analyses can be useful for characterizing priority areas, or pointing future programs to valuable data. There will be no opportunities during the workshop days to give presentations although arrangements can be made in the evening for slideshows or discussions for interested participants to attend.

Thank you again for your interest and participation in this important work.

Conservation Science Program
World Wildlife Fund

EXPANDED AGENDA

Day 1: March 30

*plenary activity

7:30-8:30 Breakfast

8:30-9:00 Welcome *
(sit at appropriate working group tables)
Introduction of participants *

In order to conserve time, we will try to limit introductions to each participant's name, affiliation, and very brief statement of each participant's area of focus (e.g., mammals, protected areas, etc.).

9:00-10:30 Ecoregion-based conservation *

A brief presentation of the broad goals of ecoregion-based conservation, what makes it distinctive from other priority-setting approaches. A discussion of fundamental goals of biodiversity conservation goals (representation, viable populations, sustain ecological processes, large blocks of natural habitat to retain resiliency and integrity) and seven tractable conservation targets: 1. distinct assemblages, communities, and habitats; 2. large blocks of intact habitat; 3. intact biotas; 4. keystone species, habitats, phenomena; 5. large-scale ecological phenomena; 6. species of special concern; 7. minimize impact of alien species.

More specifically:

1. The conservation of distinctive biotas (assemblages of plants and animals), communities, and ecosystems (the first goal of representation).
2. Large blocks of intact forest and freshwater habitats (i.e., forest frontiers, forest wilderness, wild rivers) that are the only regions capable of supporting area-sensitive species and ecological processes (the last three goals). Certain species and ecological phenomena, such as fires, migrations, and rainfall regimes, can only persist within vast blocks of relatively undisturbed forest. Forest ecosystems can only be resistant and resilient in the face of intense and large-scale disturbance if they are large and intact.
3. Intact forest and freshwater biotas, particularly assemblages of the complete larger vertebrate fauna or tree communities with populations distributed and varying in abundance within natural ranges (the second and fourth goal). The ecological phenomena of intact biotas is increasingly rare today throughout the world, and the last refuges typically occur only within large landscapes of remote forest or river wilderness. Large-bodied animals, including predators, large frugivorous birds, crocodiles, and primates are particularly at risk of extirpation outside of remote forests and rivers.
4. Keystone species, habitats, and ecological processes are those whose ecological influence far outweigh their relative abundance (the third and fourth goal). Mangroves, cloud forests, riparian forests, forest elephants, floods, leopards and other top predators are all examples of critically important keystone features.
5. Large-scale ecological phenomena such as hemispheric-scale migrations of birds, the seasonal movements of hornbills and elephants, or the response of larger vertebrates can

only be conserved through concerted efforts to conserve connected natural landscapes and critical habitats (all four goals).

6. Species of special concern are those that are at high risk of extirpation or extinction due to human activities and for which actions to conserve sufficient habitat are insufficient for their survival (the second goal). Examples include forest elephants, crocodiles, chimpanzee, gorilla, orchids, and gray parrots.
7. Native forest biotas can only be maintained if alien or exotic species can be effectively prevented from causing extensive and permanent ecological damage (the last three goals). Many non-native plants, invertebrates (fire ants) , and invertebrates represent significant threats to the native species, communities, and natural processes of the world's forests, rivers, and lakes.

CERTAIN KINDS OF THREAT DATA CAN BE VERY USEFUL AS PROXYS FOR ASSESSING HOW WELL DIFFERENT AREAS CAN SUPPORT DIFFERENT BIODIVERSITY TARGETS (SEE ABOVE). FOR EXAMPLE, DATA ON ROADS AND AGRICULTURAL EXPANSION CAN HELP US UNDERSTAND WHERE THE MORE REMOTE BLOCKS OF FOREST ARE THAT MAY STILL HARBOR INTACT LARGE VERTEBRATE ASSEMBLAGES.

All the questions and analyses of the workshop can be linked back to one or more of these targets and ultimately the four major goals. These seven features represent primary biodiversity targets of global ecoregions. We assume that effective conservation of these features around the world will have innumerable and significant benefits to human societies from local to global scales. These include local ecosystem services such as flood control, rainfall generation, erosion control, temperature amelioration, healthy rivers and streams, and water retention. Diverse forest and freshwater resources from food plants, fibers, medicines, and animals for hunting are also conserved for long-term use. Genetic resources for food and medicine will be made available for generations to come. Amelioration of regional rainfall changes and global temperature variations through water and carbon sequestration and modulation are benefits to humans at all scales.

Ecoregions are ecosystems of regional extent. They encompass distinctive assemblages of plants and animals and communities. They better match the distribution of biodiversity than political units. Ecoregions define the boundary over which key ecological processes most strongly interact. Ecoregion-based conservation recognizes the we must conduct conservation planning over larger spatial scales and longer time frames than ever before, while still acting locally to implement these plans. Only at ecoregion scales can we effectively address the fundamental goals of conservation mentioned above. The last three fundamental goals emphasize conserving processes as well as species and communities. They focus on such biological features as maintaining gene flow, local and hemispheric-scale animal migrations, predator-prey interactions, animal dispersal, and natural areas of sufficient size to accommodate natural disturbance regimes and provide refuge to species vulnerable to human activities. The scale at which these processes operate require conservation planning and efforts at landscape and ecoregion scales. Ecoregions occur at a spatial scale that corresponds to the major driving ecological and evolutionary processes that create and maintain biodiversity. It is a scale that addresses the maintenance of populations of the species and processes that need the largest areas, elements of biodiversity that cannot be accommodated at the site scale. Ecoregions enable us to determine the best places to invest and to better understand the role that specific projects play in regional conservation strategies. Ecoregion analyses help us understand where investments are additive, redundant, or complementary. They help us to better understand the tradeoffs of conservation decisions by identifying the relative importance of different goals and the biological thresholds of habitats, populations, and landscapes necessary to maintain the full range of biodiversity over the long-term.

Briefly, the ecoregions for the Congo Basin workshop were developed by using White's vegetation zones as a gross indicator of distinctive habitat types and assemblages. We then divided these zones up into distinctive biogeographic units. We evaluated existing information on species distributions, endemism foci and barriers, and biophysical parameters (rainfall, seasonality, topography, large rivers), and consulted with many regional biodiversity specialists to identify large-scale ecoregions harboring distinctive biotas and areas where important large-scale ecological processes most strongly interact. The freshwater ecoregions were developed by freshwater specialists at a previous workshop. These are largely biogeographically modified watersheds.

Goals of the workshop *

Summary of general and specific goals of the workshop. We have found in other parts of the world that developing a long-term biological vision for ecoregions or ecoregion complexes (e.g., Congo Basin) is a very useful tool for promoting and strengthening conservation efforts. A biodiversity vision outlines what "conservation success" should look like in fifty years for each region. The answer, based on the collective evaluation of biodiversity experts using the best available data (usually through a workshop process), may seem overly ambitious given current scenarios and threats. But we have found that such visions can catalyze debate over critical conservation questions and scales, and in some cases, have triggered significant strengthening of protected area networks and other conservation activities. Some of these initially "crazy" visions have begun to approach business-as-usual in some ecoregions through establishment of new protected areas and restoration programs. The conservation dialogue in some ecoregions has become infused with biological discussions focusing on more appropriate issues and scales than before. Without a long-term biodiversity vision in these areas, one that addresses large-scale issues of representation, intact predator-prey assemblages, landscape-scale linkages or long-term disturbance, we risk the continuing loss of biodiversity at a few protected sites, a situation typical of current conservation networks in many parts of the world.

Major elements of a biological vision for the Congo Basin include an identification and prioritization of representative core conservation areas (areas that harbor particularly important biodiversity features or targets). These areas are evaluated in terms of their relative contribution to a regional strategy based on the nature of biodiversity targets they harbor and their overall habitat integrity (size and other features that promote the persistence of different biodiversity features). An important task is to estimate the minimum area or condition requirements for different focal species or processes, ones that require the largest areas for their long-term persistence. Major linkage areas promoting the flow of populations, genes, and processes across landscapes or along rivers are also identified and ranked. Priority short-term actions are identified for different subregions, as well as the most significant threats to focus conservation attention.

Review of approach *

A summary of the workshop steps and approach is presented here:

1. Summary, discussion, and modification of approach.
2. Group develops general "vision statement" for the Congo Basin, which we return to at the end to see how well the workshop analyses have achieved anticipated goals.
3. Discuss and agree on the definition, extent, and distribution of the target biogeographic unit and level of biogeographic resolution to be used in the analysis.
4. Identify biogeographic subregions to enable us to conduct habitat representation analyses and assess the relative significance of different biodiversity features at different biogeographic scales (i.e., an endemism level outstanding at a subregional, but not a basin wide, scale). In some workshops we suggest to use widely published subdivisions, in others we have different taxon groups develop different units and synthesize them (we suggest the latter here).
5. Agree on methods and approaches of dealing with and documenting uncertainty and data gaps.
6. Standardization of broad target biodiversity features and a relative valuation system (critical step).
7. Taxon working groups identify priority areas for their particular taxa, describing the specific features and their relative importance. These areas are mapped. Some thought on the minimum requirements for different focal species can be used to assess the value of different areas. Each taxon group will tailor the standardized biodiversity features to best fit the particular characteristics and biodiversity features of their taxon. A number of resources will be available to the groups including Worldmap species distribution data and minimum-set analyses, plant endemism areas, IUCN priority sites, IBAs, bird endemism areas, etc. Data gap information can be recorded at this stage for different areas. Data sheets on each priority area are filled out.
8. Different taxon priority areas are overlaid and subregional working groups identify candidate priority areas (these are different from taxon areas as they look at a number of taxa and biodiversity features). Some thought on the minimum requirements for different focal species and processes can be used to assess the overall value of different areas. All the groups will try to standardize the method by which the overall biological importance for different areas is assessed. Candidate priority areas are described and ranked. Data gap information can be recorded at this stage for different areas. Data sheets on each area are filled out.
9. A habitat representation is conducted to ensure that each major habitat type is included in a priority area for each subregion where that habitat occurs (the assumption being that different subregions harbor different habitat-specific assemblages of species with different adaptations and histories).
10. Any important ecological or evolutionary phenomena occurring in particular areas that may have been missed are identified at this point and may mean inclusion of a new priority area.
11. Priority information gaps areas are identified. We suggest these be nominated only in areas with very poor information and that experts try to describe biological features in priority areas to some level wherever possible to ensure these areas receive both conservation and survey attention. Data sheets on each area are filled out.

12. The relative level of future threat is estimated for each priority area using threat information and biodiversity knowledge by subregional groups (the threat working group is reincorporated at this stage into subregional groups). Information from the threat working group is considered at this stage. This threat ranking is used during the short-term action analysis but it is useful to focus on this issue while the group is considering individual priority areas. This is not the same analysis as the habitat integrity analysis (see below).
13. The persistence value (habitat integrity) of each priority area is assessed. Basically, this is an attempt to evaluate those features that will promote the long-term persistence of different biodiversity elements. For example, only in very large blocks or relatively intact forest will larger vertebrate populations persist over the long-term. This is not a current or future threat analysis, rather it takes a snapshot look at the natural landscapes within and outside of priority areas and estimates their overall ecological integrity (e.g., larger areas are better than smaller for some features, unfragmented is better than fragmented, etc.). Each priority area is characterized and ranked. Data sheets on each priority area are filled out.
14. Each subregion working group then discuss a blank priority-setting matrix, with biological importance on one axis and habitat integrity on the other. The groups are asked to rank each cell (with different combinations of importance and integrity) into four or five priority classes. The different group approaches are then synthesized in plenary (usually with plenty of debate) to develop an integration matrix. The actual rankings for each priority area are then applied to the matrix and the resulting prioritization of core conservation areas is viewed. Any major gaps in habitat representation by subregion are hopefully caught at this stage and new priority areas can be elevated.
15. The subregional working groups, working together with their adjacent subregional working group colleagues, then identify priority landscape (aquascape) linkages (e.g., corridors), buffer habitats, or restoration areas. Information on threats, infrastructure, tenure and other socio-economic-cultural-political features and trends will be made available to assist experts in identifying effective linkages, however, the primary linkage factors should be biological at this step. These priority linkage areas, restoration areas, or buffer areas are described, mapped, and ranked in terms of their relative importance. Data sheets are prepared. We synthesize the work of the subregional groups in plenary to eliminate overlaps, ensure subregional connectivity, and develop a "seamless" map. This step, combined with the core area analysis, provides critical information for developing conservation landscapes within and among subregions. A discussion of trans-boundary conservation issues may take place here or be a separate evening session.
16. A plenary discussion of overarching threats and opportunities (threats or opportunities that operate over multiple sites and subregions) is conducted. We list and synthesize the major overarching threats in the region and rank them through a voting process. Opportunities are discussed in a similar fashion. This is a broad, fast, and simple procedure, but it typically produces good results and provides information on the general threat and opportunity perspective of biodiversity specialists in the region.
17. At several steps throughout the process, we ask representatives from the taxon on subregional working groups to summarize their findings, maps, and prioritizations in brief presentations.
18. Subregional working groups, consisting of both biodiversity and socio-economic-threat/opportunity specialists work to develop a draft implementation strategy of the biological

vision for their respective subregions. Short-term actions (both sites and activities) are identified for 1 year, 3 year, and 10 year periods. Threat, socio-economic-cultural-political, opportunity information is provided as a resource. The thinking and maps of the threat/opportunity working group is critical for this analysis. A formal protected area gap analysis can be done at this stage and incorporated (overlay of priority areas and existing protected areas).

19. Presentation by each subregional group and the freshwater group are made on the biological vision, conservation landscapes, and short-term actions developed for each subregion.
20. A discussion of basic elements of an adaptive implementation strategy in the face of evolving conservation scenarios over the next decade. (How do we alter a long-term strategy if new biodiversity information becomes available, for example?)
21. A final discussion of major data gaps and research/survey/training needs for biodiversity conservation is conducted. This will benefit from the previous workshop analyses and discussions.
22. We revisit the results within the context of the vision statement and see how successful we have been.
23. We then discuss next steps-timing and production of reports and maps, proprietary data, availability of data and maps, how the results will be used, etc.
24. We rest.

I will stop here. There will be many opportunities during the workshop to discuss each of these steps. I hope that this gives you a better sense of the scale, level of resolution, biodiversity goals and targets, and kinds of questions we hope to ask at the workshop. The rest of the agenda follows.

	The vision statement *
	Brief summary of databases and other resources *
	Discussion *
	Addressing and documenting data gaps and uncertainty *
10:30-10:40	Coffee break
10:40-12:00	Biogeographic units
	(remain in working groups)
	Region of analysis (discussion extent of region & ecoregion boundaries)*
	Biogeographic subregions suggested by each group (ecoregions & subregions)
	Synthesis of group aggregations of ecoregions into 4-6 major basin subregions*
	Biodiversity features
	Identification and standardization of broad target biodiversity features*
12:00-1:00	Lunch
1:00-5:30	Biological importance analyses: taxon priority areas
	(taxon working groups: invertebrates, plants, herps, mammals, birds)
	Discussion of process (and mapping guidelines)*
	Discussion of available databases and other resources (e.g., Worldmap)*
	Identification of priority areas for different taxa
	Discussion and standardization of viability and threshold goals for focal species, assemblages, and processes relevant to each group's taxon
	Delineation of priority areas and gaps for different taxa

Preparation of data sheets for each taxon priority area
Synthesis of integrity and threat databases for upcoming analyses by threats working group
(threats group concurrent session)
Preliminary synthesis of threat data layers to produce zonation of threats throughout basin with information on nature of threats, impact on biodiversity features, intensity, irreversibility, and estimated urgency

3:00-3:15	Coffee break
3:15-5:50	Continue taxon and threat analyses
6:30-8:00	Hosted reception

Day 2: March 31

7:30-8:30	Breakfast
8:30-9:30	Taxon working group reports (includes freshwater group) *
9:30-10:30	Biological importance analyses: candidate priority areas (subregion working groups) Agreement on broad habitat types for representation analysis (8-10 broad habitats associated with distinctive biotas or phenomena)* Groups overlay taxon priority areas and delineate candidate priority areas Ecoregion and habitat representation (may add priority areas) Ecological process analysis (may add priority areas) Biodiversity data gap analysis (may add priority gap areas) Rank priority areas in terms of relative importance Preparation of biodiversity data sheets for all priority areas
10:30-10:45	Coffee break
10:45-12:00	Continue priority area analysis
12:00-1:00	Lunch
1:00-2:00	Complete priority area analysis
2:00-3:30	Habitat integrity & future threat analyses (subregion working groups) Discussion of current habitat integrity and future threat criteria and analyses * (Discussion and standardization of broad habitat integrity features and viability and threshold goals for focal species, communities, and processes considering the entire biota)* Presentation of integrity and threat datasets available as resources* Assess present habitat integrity of different candidate priority areas Conduct future threat analysis for each priority area
3:30-3:40	Coffee break
3:40-5:30	Continue habitat integrity and future threat analyses

Day 3: April 1

7:30-8:30	Breakfast
8:30-10:00	Prioritizing candidate areas

	Discussion and agreement on priority-setting matrix*
	Apply matrix to actual candidate priority areas*
	Relative ranking among priority areas
	Revisit representation and elevate areas, if necessary
10:00-10:15	Coffee Break
10:15-12:00	Linkages & priority landscapes
	Discussion of linkage considerations*
	(subregion working groups)
	Group identification of linkage habitats, buffer habitats, restoration areas, etc.
	Prioritize linkage areas, future threat analysis of priority linkages
	Synthesis of group linkage analyses to create consensus map*
	Discussion of trans-boundary conservation issues*
12:00-1:00	Lunch
1:00-1:30	Overarching Threats & Opportunities
	Identification, synthesis, and ranking of overarching threats and opportunities*
1:30-3:00	Assessment of short-term priority actions (1, 3, 10 year actions) for each subregion based on synthesis of biological priorities, future threats, socio-economic trends, opportunities, and trajectory of overarching threats (subregion working groups)
3:00-3:15	Coffee break
3:15-5:30	Complete short-term action analysis

Day 4: April 2

7:30-8:30	Breakfast
8:30-10:00	Presentations of conservation landscapes (e.g., core conservation areas-biological importance, integrity, threat-and landscapes (linkages, buffers) and short-term priority actions, with identification of potential actors, by subregion group representatives & freshwater group (overlay of terrestrial and freshwater priorities)*
10:00-10:15	Coffee break
10:15-11:00	Continue presentations
11:00-11:15	Revisit critical data gaps and priority inventory and research needs*
11:15-12:00	Review and discussion of biodiversity vision for the Congo Basin (terrestrial & freshwater)*
12:00-12:30	Next steps*
	Closing*

ANNEX 3. SOME SUGGESTIONS FOR CONDUCTING SUCCESSFUL ECOREGION WORKSHOPS

The Conservation Science Program has carried out a number of workshops for continental—and ecoregion —scale conservation analyses. We have gained useful experience regarding how to effectively engage participants, gather and synthesize data, and achieve workshop goals. Here, we offer some general suggestions about logistics, agendas, protocols, and other workshop details that we feel can contribute to a successful meeting. Every workshop is a learning process, teaching as much from mistakes as from successes. Here are some overriding suggestions followed by some more specific recommendations.

General Suggestions

- One must be flexible and adaptive during workshops while keeping the broad goals in mind.
- Try to think about your minimum information needs and focus on these.
- Regularly consult with the participants during the workshop to ensure that the approach and synthesized information are deemed robust and useful for conservation planning at this scale.
- Treat the comments and critiques of workshop participants with the utmost respect. Allow people to have their say, but gently steer the workshop along to reach its overall goals.

Specific recommendations

Before the Workshop

Participants

We have found that workshop participants who have knowledge of patterns of biodiversity and conservation issues for a variety of taxa and ecosystems across whole ecoregions contribute a great deal to these analyses. We have often scheduled workshops around the availability of such key experts. It is also important that the collective group of invited experts be able to cover a wide range of taxa, subregions, and threats to help develop a broad, long-term perspective on the conservation vision for an ecoregion.

Preliminary Packets

We typically send out preliminary packets to participants in advance of the meeting. These packets present a more detailed description of the goals and level of biogeographic resolution of the workshop. We also outline a proposed agenda. The general sequence of our workshops is as follows: introductions, presentation of workshop goals and approach; discussion, patterns of biodiversity analyses; summary presentations from each subregion; presentation of status and threat analyses, discussion, priority-setting discussion and analysis; discussion of overarching threats; development of a biodiversity vision for each subregion and synthesis for the entire ecoregion; summary presentations from each subregion; and final discussions. We always try to give participants an idea of how much time we will devote to different questions and issues. Three days is the typical length of our workshops, two days offering too little time to accomplish all of our goals, and four days being too exhausting for all involved.

We also provide a proposed approach to answering the questions required for the development of biodiversity visions. Participants greatly appreciate the advanced briefing on the types of questions, level of resolution, and approach. This allows them to gather relevant information at appropriate scales. In many cases, we also send maps with proposed biogeographic subdivisions and other biodiversity information. It is extremely useful to send these out in advance as it allows experts time to review and react to these maps and data. During the workshop, it is unrealistic to expect the experts to develop biogeographic maps within the timeframe available. We have found it is much better to research existing biogeographic views and synthesize these into a preliminary classification for experts to evaluate. In some cases, we have sent out maps on richness and endemism patterns as well as habitat loss and protected areas for experts to review. We also provide sources for all of our information and ask experts to consider other data that may prove to be useful. It is helpful to remind participants that they will not be asked to give formal presentations as is the case in many other meetings.

During the Workshop

Introductions

We typically try to keep the introductions brief, with participants stating their name and affiliation only. We once tried to have each person discuss his or her expectations and this went on for a very long time, exhausted everyone, and cut deeply into our timetable.

Seating Arrangements and Table Configurations

We have found that the optimal configuration for tables at a workshop is approximately four to five square or rectangular tables. Different groups of experts representing different taxa or subregions can assemble around these tables. There should be no tablecloths or water glasses on the table (the ink on most maps runs if wet). Cracks in tables should be taped so that drawing on the maps does not tear them. We usually have a small table to the side that holds resource material. An overhead projector and flipchart are essential. One might consider a microphone and a slide projector useful.

Data Sheets

Preparing useful and understandable datasheets is a critical step. It is extremely important to be explicit about what kind of information you want on each datasheet and the standard format for its input. For example, datasheets for each nominated priority area should have information on the precise location of the area and the reasons for its nomination within the context of a standardized set of biodiversity features. Prior to filling in datasheets, experts should agree upon biodiversity features and valuations and should use a standardized approach to record descriptors for each area. We have found that this works best if the datasheets themselves have specific fields for different features and levels; otherwise, you may end up with a diverse set of answers at the end of the day. This makes comparisons difficult. Make sure that the experts who write each description put their name on the datasheet, write legibly, and provide specific locality information for each area. We usually assign a person to be responsible for collecting the fully completed datasheets from each group to the workshop team. Copies of the full set of datasheets are made right away. Experts will often provide additional sources of information. It is very important to get the full citations of these or, perhaps, full copies at the time of the workshop.

Map Guidelines

We ask experts to draw very carefully on the template maps because their lines are exactly how it will look on the finished products. Circles should be completed. It is critical that experts identify on the maps what each line or polygon means. A key on the side of the map is very helpful, or area names and numbers can be entered within each circle. We ask experts not to fold template maps, because, when folded they are difficult to digitize into a GIS. In many workshops, we use Mylar that is overlaid onto template maps. Ensuring that the Mylar and template maps stay aligned is very important (we use registration points). Although it is useful and highly recommended to have GIS products produced overnight, this is not necessary and can be challenging to the workshop staff to achieve.

Priority Setting

Regional experts often have a difficult time with priority setting for conservation. This is a difficult task that all of us still wrestle with. It is important to discuss priority setting and the potential uses and implications of the results of the workshop. We try to explain that the experts whom we have brought together have the best knowledge of patterns of biodiversity in the ecoregion. They also have the most detailed understanding of how different threats affect species and the integrity of ecosystems. It is far better that they weigh in on these issues than to leave priority setting to politicians, bureaucrats, nonspecialists, or others less familiar with the region and its biology. We acknowledge that we may synthesize the information gathered at the workshop to conduct a priority setting analysis, but we also remind experts that they will have opportunities to review and comment on the reports and maps.

Addressing Uncertainty

Uncertainty in conservation planning can stem from natural variability in patterns and processes in a particular ecoregion or from a poor level of knowledge. When we develop approaches for workshops, we try to address natural uncertainty issues as they apply to the status of habitats, populations, and processes. We also try to understand the nature of the available information in terms of its biogeographic and taxonomic coverage as well as its datedness, accuracy, precision, and the appropriateness of its classifications for biodiversity analyses. Importantly, during each section of the analysis, we ask experts to identify gaps in information for which we should consider investing in either targeted fieldwork or consultations with experts.

Field Trips

We have found that participants work extremely hard to assist us in gathering biodiversity information and in developing a conservation vision. Some form of field trip to experience native habitats around the workshop location is greatly appreciated.

Information Exchange

Experts will often request copies of maps and databases, and they will be curious to know the schedule for completing the reports. The workshop team should consider these issues in advance as well as the best format and mechanism for disseminating data and maps.

After the Workshop

Thank you letters

We try to send thank you letters within two weeks after each workshop. An estimated schedule for providing draft reports and maps to participants is appreciated in these letters.

Draft Report and Maps

Draft reports and maps typically go out between three and five months after each workshop. We ask that experts review these and send comments to us within a month.

Final Report and Maps

The workshop team should consider, prior to the workshop, what the final products will be and in what format they should be presented. These decisions will determine to a great extent the effort and costs required to publish a final report and maps.

Data Dissemination

Many different people and organizations will request both hard-copy and digital formats of the databases, reports, and maps. The workshop team should carefully consider, prior to the workshop, the format, media, restrictions, costs (if any), and persons responsible for this process. Experts at the workshop will ask about data availability.

ANNEX 4. LIST AND RATIONALE FOR SELECTION OF FOCAL SPECIES AND PROCESSES FOR PERSISTENCE ANALYSIS IN FOCAL ECOREGIONS

Focal 25	Major Habitat Types	Candidate Focal Species	Focal Processes
Atlantic forests	1. Tropical moist forests	1. Muriqui 2. Cotingids 3. Large parrots 4. Jaguar	1. Altitudinal movements of movements of primates and parrots
Congo Basin forests	1. Tropical moist forests	1. Elephant 2. Gorilla 3. Hornbills	1. Riverine-upland forest seasonal movements 2. Long-distance migrations of elephants and hornbills 3. Altitudinal movements 4. Flood patterns rainfall
Congolian coastal forests	1. Tropical moist forests	1. Mandrill 2. Hornbill 3. Crowned eagle	Seasonal movements (altitudinal, riverine-upland)
New Guinea moist forest	1. Tropical moist forests	1. New Guinea harpy eagle 2. Palm cockatoos 3. Tree kangaroos 4. Cassowaries	1. Altitudinal migrations 2. Seasonal habitat use
Southwestern amazonian moist forest	1. Tropical moist forests	1. Jaguar 2. Harpy eagle	1. Altitudinal migration 2. Seasonal movement among riverine and upland habitats
Southwestern amazonian moist forest	1. Tropical moist forests 2. Tropical large rivers	1. White-lipped peccary 2. Great river otter 3. Fruit crow 4. Catfish spp 5. Tambaqui *6. Arapaima gigas*	1. Flood regimes 2. Rainfall
Eastern Indochina monsoon and dry Forests	1. Tropical dry and monsoon Forests	1. Elephant 2. Tiger 3. Hornbills 4. Gibbons	1. Altitudinal movements 2. Seasonal movements 3. Rainfall
Madagascar dry/spiny forests	1. Tropical dry xeric shrublands	1. Sifaka lemur 2. Fossa 3. Ring-tailed lemur	1. Fire regimes 2. Seasonal movements of birds

Focal species and processes in focal ecoregions

Eastern Himalayas	1. Montane grasslands 2. Temperate broadleaf forests 3. Temperate grasslands, savannas, and shrublands 4. Temperate conifer forests	1. Tiger 2. Hornbill 3. Takin 4. Elephant 5. Rhinoceros	1. Altitudinal movements 2. Fire regimes 3. 50-100 snowfalls per yrs.
Russian Far East Temperate Forests	1. Temperate conifer forests 2. Temperate broadleaf forests	1. Tiger 2. Brown bears	1. Fire regimes 2. Altitudinal movements among habitats 3. Severe winters
Klamath-Sikiyou forests	1. Temperate conifer forest	1. Fisher 2. Cougar 3. Pine marten 4. Wolverine	1. Altitudinal movements 2. Fire regimes 3. Heavy snowfalls
Valdivian temperate forests	1. Temperate conifer forests	1. Pudu 2. Alerce 3. Huemul 4. Kokod cat 5. Slender-billed conure 6. Rufous-legged owl	1. Altitudinal movements 2. Fire regimes
Sichuan-Yunnan temperate forests	1. Temperate broadleaf forests	1. Giant panda 2. Golden monkey 3. Pheasants 4. Takin	1. Altitudinal movements 2. Fire regimes
Tibetan plateau steppe	1. Montane grasslands	1. Tibetan antelope 2. Snow leopard 3. Kinag (wild ass)	1. Seasonal migration 2. Refugia during severe winters and drought
Zambezian Woodlands and Savannas	1. Tropical grasslands, savannas, and shrublands	1. Elephant 2. Marchal eagle 3. Lions 4. Wild dogs	1. Fire regimes 2. Seasonal movements among habitats 3. Refugia during extreme drought and floods
South Florida ecosystem	1. Flooded grasslands	1. Cougar 2. Alligator 3. Roseate spoonbill	1. Water flow 2. Drought refugia 3. Flood refugia 4. Hurricane alteration of communities 5. Eutrophication
Northern Andean montane forests	1. Montane grasslands 2. Tropical moist forests	1. Spectacled bear 2. Cotingids 3. Macaws 4. Quetzal 5. Mountain tapir 6. Cougar	1. Altitudinal movements 2. Intact watersheds

Focal species and processes in focal ecoregions

Chihuahuan and Tehuacan deserts	1. Deserts and xeric shrublands	1. Pronghorn 2. Black bear 3. Jaguar 4. Prairie dog	1. Fire and drought regimes 2. Refugia for extreme events 3. Altitudinal and seasonal movements
Rift Valley lakes	1. Tropical large lakes	1. Mbuna 2. Deep water fish	1. Freshwater inputs
Southeastern rivers and streams	1. Temperate rivers and streams	1. Mussels 2. Paddlefish 3. Shiners	1. Riparian buffers
Bering Sea	1. Polar and subpolar marine ecosystems	1. Beluga 2. Walrus 3. Bowhead whales 4. Eider ducks	1. Seasonal migration 2. Ice edge movement 3. El Niño conditions
East African marine ecosystems	1. Coral reef and marine ecosystems	1. Dugong 2. Large groupers 3. Sharks 4. Complexes of coral, seagrass and mangroves	1. Coastal movements of larger fish and mammals 2. Seasonal movements among habitats
Galapágos Islands	1. Tropical upwelling marine ecosystems 2. Xeric shrublands	1. Penguins 2. Dolphins 3. Booby 4. Sharks	1. El Niño extreme fluctuations in rainfall and productivity 2. Variability in upwelling
Mesoamerican Caribbean reef	1. Coral reef and associate marine ecosystems	1. Spiny lobster 2. Sharks 3. Complex of coral seagrass and mangroves	1. Hurricane damage and regeneration 2. Siltation/eutrophication from land
Sulu/Sulawesi Sea	1. Coral reef and associate Marine ecosystems	1. Sharks 2. Napolelan wrasse 3. Complex of coral, seagrass, and mangroves	1. Typhoon damage and regeneration 2. Siltation from land

ANNEX 5: A DETAILED EXAMPLE OF A TABLE OF CONTENTS FOR PROCEEDINGS OF A BIOLOGICAL PRIORITY-SETTING WORKSHOP

- Title Pages
- Acknowledgments
- Table of Contents
- List of Tables
- List of Figures
- Executive Summary

Chapter 1 Introduction

- Biodiversity in the Region/Ecoregion
- Benefits of Conserving Biodiversity in the Region/Ecoregion
- The Biogeography of the Region/Ecoregion
- Threats and Opportunities for Biodiversity Conservation in the Ecoregion
- Why is a Biological Vision Important for Conservation?

  Box 1.1 Ecoregion-based Conservation

Chapter 2 The Extraordinary Biodiversity of the ______ Ecoregion

Chapter 3 Summary of Approach

- Defining Goals and Targets
- Gathering Biodiversity Information
- The Expert Workshop
- Dealing with Uncertainty and Data Gaps
- Documenting the Geographic Fieldwork of Workshop Participants
- The Ecoregion
- Subecoregions
- Freshwater Ecoregions
- Standardizing Biodiversity Features and Definitions
- Important Taxon Areas
- Subregional Important Areas
- Focal Species and Phenomena
- Habitat Representation
- Phenomena and Processes
- Relative Biological Value of Important
- Persistence Value of Priority Areas

The Application of Threat Data to Persistence Analyses

- Setting Priorities among Important Areas
- Future Threat of Important Areas

- Designing Conservation Landscapes

• Habitat Networks
• Designing for Change

Building the Foundations of an Implementation Strategy
• Adaptive Strategies
• Socio/Economic/Political/Cultural Analyses
• Short-Term Responses
• Mid-Term Actions and Benchmarks
• Long-Term Milestones and Major Challenges
Box 3.1 Conservation Targets for the ______ Ecoregion
Box 3.2 Biodiversity Features Used to Identify Taxon Important Areas
Box 3.3 Biodiversity Features Used to Identify Subregional Important Areas
Box 3.4 Delineation Thresholds for Priority Areas: Minimum Requirements

Chapter 4 **Terrestrial Ecoregion Definition, Boundaries, and Subregions**
Freshwater Ecoregion Definition, Boundaries, and Subregions

Chapter 5 **Important Areas for Biodiversity**
• Biodiversity Features
• Addressing Data Gaps
• Important Taxon Areas
• Subregional Important Areas
• Habitat Representation
• Ecological and Evolutionary Phenomena
• Relative Biological Importance of Areas
• Freshwater Biological Importance Analyses

Habitat Integrity and Resilience (Persistence Value) of Terrestrial Priority Areas
• Terrestrial Focal Species and Phenomena
• Persistence Value of Important Freshwater Areas

Chapter 6 **Setting Priorities Among Terrestrial and Freshwater Priority Biological Areas**

Chapter 7 **Future Threat Analysis of Terrestrial and Freshwater Priority Areas**
Box 7.1 Logging and biodiversity loss
Box 7.2 Bushmeat hunting and biodiversity loss
Box 7.3 Major threats to freshwater biodiversity

Chapter 8 **Protected Area Gap Analysis of Terrestrial and Freshwater Priority Areas**

Chapter 9 **Freshwater Conservation Priorities**

Chapter 10 **Freshwater and Terrestrial Conservation Priorities Overlap**

Chapter 12 Designing Conservation Landscapes and Aquascapes in the Ecoregion

Chapter 13 Building the Foundations of an Implementation Strategy

- Summary of Socio/political/economic/cultural factors
- Key Threats and Opportunities
- Logging
- Roads and Bushmeat Hunting
- Agricultural Expansion
- Mining, Oil, and Gas Projects
- Long-term Support for Conservation Programs
- Dams and Irrigation
- Fishing
- Exotic Species

Integrating the Biodiveristy Vision with the Conservation Scenario

- Terrestrial
    - Short Term Actions
    - Midterm Benchmarks
    - Major Challenges and/or Milestones
- Freshwater
    - Short Term Actions
    - Midterm Benchmarks
    - Major Challenges and/or Milestones
- An Adaptive Strategy

Addressing Gaps in Knowledge

Chapter 14 Recommendations

Literature Cited
Appendix 1: Contributors
Appendix 2: Workshop Participants' Research Sites
Appendix 2: Descriptions of Priority Areas
Appendix 3: Preliminary Assessment of the Status of Protected Areas in the Ecoregion
Appendix 4: Preliminary List of Protected, Endangered, Threatened, and CITES Species
Appendix 5: Information and Data Sources
Appendix 6: Glossary
Appendix 7: List of Acronyms

GLOSSARY

adaptive radiation	The evolution of a single species into many species that occupy diverse ways of life within the same geographical range
alpha diversity	Species diversity within a single site
amphibian	A member of the vertebrate class Amphibia (frogs and toads, salamanders, and caecilians)
amphipod	Any of a large group of small crustaceans with a laterally compressed body, belonging to the order Amphipoda
anadromous	Species that spawn in freshwater and migrate to marine habitats to mature (e.g., salmon)
analysis of variance	A test to confirm the hypothesis that means from several samples are equal; generally, ANOVA is a statistical procedure used to determine whether means from two or more samples are drawn from populations with the same mean
anthropogenic	Human induced
aquatic	Growing in, living in, or frequenting water
aquifer	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs
arctic	Referring to all nonforested areas north of the coniferous forests in the Northern Hemisphere
artesian spring	A geologic formation in which water is under sufficient hydrostatic pressure to be discharged to the surface without pumping
assemblage	In conservation biology, a predictable and particular collection of species within a biogeographic unit (e.g., ecoregion or habitat)
barrens	A colloquial name given to habitats with sparse vegetation or low agricultural productivity
basin	See *catchment*
beta-diversity	Species diversity between habitats (thus reflecting changes in species assemblages along environmental gradients)

biodiversity	(also called biotic or biological diversity) The variety of organisms considered at all levels — genetic variants belonging to the same species through arrays of species to arrays of genera; families and still higher taxonomic levels— and includes the variety of ecosystems, which comprise both communities of organisms within particular habitats and the physical conditions under which they live.
biodiversity conservation	The effort to identify erosion of biodiversity in different ecoregions and to cooperate with governments an donors to respond to threatened systems
biogeographic unit	A delineated area based on a biogeographic parameter
biogeography	The study of the geographic distribution of organisms, both past and present
biological distinctiveness	Scale-dependent assessment of the biological importance of an ecoregion based on species richness, endemism, relative scarcity of ecoregion, and rarity of ecological phenomena; biological distinctiveness classifications are "Globally outstanding", "Regionally outstanding", "Bioregionally outstanding", and "Nationally important"
biome	A global classification of natural communities in a particular region that is based on dominant or major vegetation types and climate
bioregion	A geographically related assemblage of ecoregions that share a similar biogeographic history and, thus, have strong affinities at higher taxonomic levels (e.g., genera, families)
bioregionally outstanding	Biological distinctiveness category
biota	The combined flora, fauna, and microorganisms of a given region
biotic	Biological, especially referring to the characteristics of faunas, floras, and ecosystems
bog	A poorly drained area rich in plant residues that is usually surrounded by an area of open water and that has characteristic flora
boreal forest	Type of major habitat occurring in the temperate and subtemperate zones of the Northern Hemisphere that characteristically has coniferous trees with some types of deciduous trees
canebrake	A thicket of cane
catadromous	Diadromous species that spawn in marine habitats and migrate to freshwater to mature (e.g., eels)

catchment All lands that are enclosed by a continuous hydrologic-surface drainage divide and that lie upslope from a specified point on a stream ; in the case of closed-basin systems, all lands draining to a lake

centinelan extinction The phenomenon of species becoming extinct before they have been discovered or described by the scientific community

chaparral The type of sclerophyllous scrub occurring in the southwestern region of North America that has a Mediterranean or xeric climate

clearcut A logged area where all or virtually all of the forest canopy trees have been eliminated

community A collection of organisms of different species that coexist in the same habitat or region and that interact through trophic and spatial relationships

conifer A tree or shrub in the phylum Gymnospermae, whose seeds are borne in woody cones; there are 500-600 species of living conifers

conservation biology A relatively new discipline that manages the content of biodiversity, the natural processes that produce it, and the techniques used to sustain it in the face of human-caused environmental disturbance

conservation status Assessment of the status of ecological processes and of the viability of species populations in an ecoregion; the different status categories used are extinct, critical, endangered, vulnerable, relatively stable, and relatively intact; the snapshot conservation status is based on an index that is derived from values of four landscape-level variables; the final conservation status is the snapshot assessment modified by an analysis of threats to the ecoregion over the next 20 years

conversion Habitat altered by human activities to such an extent that it no longer supports most characteristic native species and ecological processes

creek The smallest size class of a lotic system, typically associated with headwater

critical A conservation status category characterized by low probability of persistence of remaining intact habitat

deciduous forest A habitat type dominated by trees whose leaves last a year or less; a habitat of trees that drop and replace their leaves over periods sufficiently distinct that they are leafless for some portion of the year

degradation	The loss of native species and processes because of human activities such that only certain components of the original biodiversity still persist, often including significantly altered natural communities over distance and predator-prey dynamics, pollination and seed dispersal, nutrient cycling, migration, and dispersal
disturbance	Any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment
ecological processes	The complex mix of interactions between animals, plants, and their environment that ensures that an ecosystem's full range of biodiversity is adequately maintained; examples include population and predator-prey dynamics, pollination and seed dispersal, nutrient cycling, migration, and dispersal
ecoregion	A large area of land or water that contains a geographically distinct assemblage of natural communities that (a) share a large majority of their species and ecological dynamics, (b) share similar environmental conditions, and (c) interact ecologically in ways that are critical for their long-term persistence
ecoregion-based conservation	Conservation strategies and activities whose efficacy are enhanced through close attention to larger (landscape-aquascape-level) spatial and temporal scale patterns of biodiversity, ecological dynamics, threats, and strong linkages of these issues to fundamental goals and targets of biodiversity conservation
ecosystem	A system resulting from the integration of all living and nonliving factors of the environment
ecosystem service	Service provided free by an ecosystem or by the environment such as clean air, clean water, and flood amelioration
endangered	A conservation status category characterized by a medium to low probability of persistence of remaining intact habitat
endemic	A species or race native to a particular place and found only there
endemism	The degree to which a geographically circumscribed area, such as an ecoregion or a country, contains species not naturally occurring elsewhere
endorheic	Referring to a closed basin with no natural watercourses leading to the sea
enduring feature	A landform complex or geographic unit within a natural region that is characterized by relatively uniform origin and texture of surficial material, and topography-relief patterns

environmental gradients	Changes over distance in biophysical parameters such as rainfall, elevation, or soil type
evolutionary phenomenon	Within the context of WWF regional conservation assessments, patterns of community structure and taxonomic composition that are the result of extraordinary examples of evolutionary processes, such as pronounced adaptive radiations
evolutionary radiation	See *radiation*
exotic species	A species that is not native to an area and has been introduced intentionally or unintentionally by humans; not all exotics become successfully established
extinct	Describes a species or population (or any lineage) with no surviving individuals
extinction	The termination of any lineage of organisms from subspecies to species and also from higher taxonomic categories from genera to phyla; extinction can be local, where one or more populations of a species or other unit vanish but others survive elsewhere, or total (global), where all the populations vanish
extirpated	Status of a species or population that has completely vanished from a given area but that continues to exist in some other location
extirpation	Process by which an individual, population, or species is totally destroyed
family	In the hierarchical classification of organisms, a group of species of common descent higher than the genus and lower than the order; a related group of genera
fauna	All the animals found in a particular place
fire regime	The characteristic frequency, intensity, and spatial distribution of natural fire events within a given ecoregion or habitat
flooded grassland	A grassland habitat that experiences regular inundation by water
flora	All the plants found in a particular place
fragmentation	A landscape-level variable that measures the degree which remaining habitat is separated into smaller discrete blocks; process by which habitat are increasingly subdivided into smaller discrete blocks resilient to short-term disturbance but not to prolonged, intensive burning, or grazing. In such systems larger vertebrates, birds, and invertebrates display extensive movement to track seasonal or patchy resources

genus (pl. genera) — A group of similar species with common descent, ranked below the family

glade — An open space surrounded by forest

Global 200 — A set of approximately 200 terrestrial, freshwater, and marine ecoregions around the world that support globally outstanding or representative biodiversity as identified through analyses by World Wildlife Fund-United States; one component of the Living Planet Campaign

globally outstanding — A biological distinctiveness category for units of biodiversity whose biodiversity features are equaled or surpassed in only a few other areas around the world

grassland — A habitat type with landscapes that are dominated by grasses and with biodiversity that is characterized by species with wide distributions, communities being relatively resilient to short-term disturbances but not to prolonged, intensive burning, or grazing. In such systems, larger verteberates, birds, and invertebrates display extensive movement to track seasonal or patchy resources

guild — A group of organisms, not necessarily taxonomically related, that are ecologically similar in characteristics such as diet, behavior, or microhabitat preference or similar with respect to their ecological role in general

gymnosperm — Any of a class or subdivision of woody vascular seed plants that produce naked seeds that are not enclosed in an ovary; conifers and cycads are examples of gymnosperms

habitat — An environment of a particular kind, often used to describe the environmental requirements of a certain species or community

habitat blocks — A landscape-level variable used to assess the number and extent of blocks of contiguous habitat that are required for populations and ecosystems to function naturally; it is measured by a habitat-dependent and ecoregion size-dependent system

habitat loss — A landscape-level variable that refers to the percentage of the original land area of the ecoregion that has been lost (converted); it underscores the rapid loss of species and the disruption of ecological processes that are predicted to occur in ecosystems when the total area of remaining habitat declines

habitat type — In this study, the structure and processes that are associated with one or more natural communities; an ecoregion is classified under one major habitat type, but may encompass multiple habitat types

herpetofauna	All the species of amphibians and reptiles inhabiting a specified region
hibernacula	Microhabitats where organisms hibernate during the winter
indigenous	Native to an area
intact habitat	Relatively undisturbed areas that are characterized by functionality of most of their original ecological processes and by communities with most of their original native species still present
introduced species	See *exotic species*
invasive species	Exotic species (i.e., alien or introduced) that rapidly establish themselves and spread through the natural communities into which they are introduced
invertebrate	Any animal lacking a backbone or bony segment that encloses the central nerve cord
isopod	A member of the crustacean order Isopoda; a diverse group of flattened and segmented invertebrates; pillbugs are an example
Keystone species	Species that are critically important for maintaining ecological processes or the diversity of their ecosystems
Landform	The physical shape of the land reflecting geologic structure and processes of geomorphology that have sculpted the structure
landscape	An aggregate of landforms together with its biological communities
landscape ecology	Branch of ecology concerned with (a) the relationship between landscape-level features, patterns, and processes and (b) the conservation and maintenance of ecological processes and biodiversity in entire ecosystems
late-successional	Species, assemblages, structures, and processes associated with mature natural communities that have not experienced significant disturbance for a long time
life cycle	The entire lifespan of an organism from the moment it is conceived to the time it reproduces

Living Planet Campaign	An ambitious public engagement effort launched by World Wildlife Fund-United States in conjunction with the WWF international network in April 1997, that was designed to make the final 1,000 days before the year 2000 a turning point in the conservation of some of Earth's most outstanding endangered species and spaces; the campaign tries to engage everyone to take part in leaving our children a living planet—particularly relating to approximately 232 natural habitats recently identified by WWF as the most outstanding ecoregions on earth, a list that we call the Global 200
macroinvertebrates	Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods)
major habitat types	Set of ecoeregions that (a) experience comparable climatic regimes (b) have similar vegetation structure (c) display similar spatial patterns of biodiversity, and (d) contain flora and fauna with similar guild structures and life histories; ten major habitat types (MHTs) are defined
marine	Living in salt water
mesic	Moist, wet areas
mesophytic	Applying to plants that grow under conditions of abundant moisture
mesopredators	Intermediate-sized predator, typically about 5-25 kg in body size
mollusk	An animal belonging to the phylum Mollusca, such as a snail or clam
nationally important	A biological distinctiveness category
natural disturbance event	Any natural event that significantly alters the structure, composition, or dynamics of a natural community; Floods, fire, and storms are examples
natural range of variation	A characteristic range of levels, intensities, and periods that are associated with disturbances, population levels, or the frequency of undisturbed habitats or communities
neotropical migrant	Birds, bats, or invertebrates that seasonally migrate between the Nearctic and Neotropics
nonnative species	See *exotic species*
obligate species	A species that must have access to a particular habitat type to persist
old growth forest	A late-successional or climax stage in forest development exhibiting characteristic structural features, species assemblages, and ecological processes

oribatid	The largest and most abundant group of free-living mites
Pearson correlation	A measure of linear association between two variables; values of the correlation coefficient range from -1 to 1; the absolute value of the correlation coefficient indicates the strength of the linear relationship between the variables, with larger absolute values indicating stronger relationships (The sign of the coefficient indicates the direction of the relationship)
phylum	Primary classification of animals that share similar body plans and development patterns
population	In biology, any group of organisms belonging to the same species at the same time and place
population sink	An area where a species displays negative population growth, often because of insufficient resources and habitat or because of high mortality
prairie	An extensive tract of flat or rolling grassland; a term especially used to refer to the plains of central North America
predator-prey system	An assemblage of predators and prey species and the ecological interactions and conditions that permit their long-term coexistence
protection	A landscape-level variable that assesses how well humans have conserved large blocks of intact habitat and the biodiversity they contain; it is measured in this study by the number of protected blocks and their sizes in a habitat-dependent and ecoregion size-dependent system
pyrogenic	Pertaining to communities or habitats that develop after fire events
radiation	The diversification of a group of organisms into multiple species, because of intense isolating mechanisms or opportunities to exploit diverse resources
rarity	A seldom—occurring event either in absolute number of individuals or in space
refugia	Habitats that have allowed the persistence of species or communities because of the stability of favorable environmental conditions over time
regionally outstanding	A biological distinctiveness category
relatively intact	A conservation status category indicating the least possible disruption of ecosystem processes; natural communities are relatively intact with species and ecosystem processes occurring within their natural ranges of variation

relatively stable	A conservation status category between the categories of Vulnerable and Relatively Intact and in which extensive areas of intact habitat remain but in which local species declines and disruptions of ecological processes have occurred
relictual taxa	A species or group of organisms largely characteristic of a past environment or ancient biota
representation	The protection of the full range of biodiversity of a given biogeographic unit within a system of protected areas
restoration	Management of a habitat that is disturbed, degraded or both that recovers to its original state
riparian	Referring to the interface between freshwater streams and lakes and the terrestrial landscape
savanna	A habitat largely dominated by grasslands but with woodland and gallery forest elements
sclerophyll	Type of vegetation characterized by hard, leathery, evergreen foliage that is specially adapted to prevent moisture loss; generally characteristic of regions with Mediterranean climates
sclerophyllous	Relating to sclerophyll
semiaquatic	Living partly in or adjacent to water
seral	Relating to the stages of successive ecological communities that a natural community experiences after a disturbance event
shrub steppe	Shrub and grass habitats in cooler environments
shrublands	Habitats dominated by various species of shrubs, often with many grass and forb elements
silviculture	The management of forest trees, usually to enhance timber production
sinkholes	Depressions or cavities that are created by dissolution of limestone bedrock or collapse of caves; typically found in karst landscapes
source pool	A habitat that provides individuals or propagules that disperse to and colonize adjacent or neighboring habitats
species	The basic unit of biological classification consisting of a population or series of populations of closely related and similar organisms

species richness A simple measure of species diversity calculated as the total number of species in a habitat or community

spring A natural discharge of water as leakage or overflow from an aquifer through a natural opening in the soil or rock onto the land surface or into a body of water

steppe Arid land with xerophilous vegetation; usually found in regions with extreme temperature range and scarce soils

stream A general term for a body of flowing water; often used to describe a midsized tributary (as opposed to a river or creek)

subspecies Subdivision of a species; usually defined as a population or series of populations occupying a discrete range and differing genetically from other geographical races of the same species

subtropical An area in which the mean annual temperature ranges from 13°-20° C

taiga Subarctic habitat type consisting of moist coniferous forest, dominated by spruce and fir, that begins where tundra ends

taxon (pl. taxa) A general term for any taxonomic category (e.g., a species, genus, family, or order)

temperate An area in which the mean annual temperature ranges from 10°-13° C

terrestrial Living on land

tributary A stream or river that flows into a larger stream, river, or lake, feeding it water

umbrella species A species whose effective conservation will benefit many other species and habitats, often, because of their large area requirements or sensitivity to disturbance

ungulate A member of the group of mammals with hoofs most are herbivorous

vagile Able to be transported or to move actively from one place to another

vascular plant A plant that possesses a specialized vascular system for supplying its tissues with water and nutrients from the roots and with food from the leaves

vulnerable A conservation status category that is characterized by good probability of persistence of remaining intact habitat (assuming adequate protection) but also characterized by loss of some sensitive or exploited species

xeric	Describes dryland or desert areas
xerophilous	Thriving in or tolerant of xeric climates
zoogeography	The study of the distributions of animals