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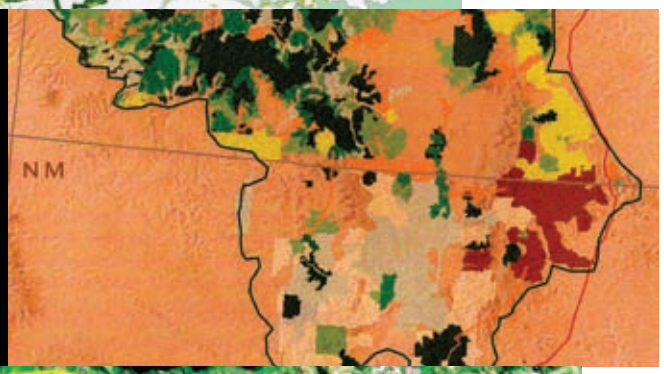
REVIEW OF EXPERIENCE WITH ECOLOGICAL NETWORKS, CORRIDORS AND BUFFER ZONES



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REVIEW OF EXPERIENCE WITH ECOLOGICAL NETWORKS, CORRIDORS AND BUFFER ZONES

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FOREWORD

The unprecedented increase in the human use of natural resources over the last century has adversely affected ecosystems, leading to their fragmentation and loss of biological diversity. Protected areas that remain as isolated units, surrounded by a radically altered habitat, almost always face serious viability problems over the long term.

The importance of strengthening ecological coherence and resilience as necessary conditions for both biodiversity conservation and sustainable development has been echoed in conservation and development fora for some time. One of the actions identified by the Plan of Implementation of the World Summit on Sustainable Development as necessary to achieve the 2010 biodiversity target is to "promote the development of national and regional ecological networks and corridors". The CBD programme of work on protected areas emphasizes the importance of establishing protected areas in a mosaic of land and water habitats to facilitate maintenance of ecological processes. Goal 1.2 of the programme of work specifically calls for integrating protected areas into broader land- and seascapes and sectors to maintain the structural and functional viability of ecosystems. Specific activities of the programme of work refer to "linking habitats", such as buffer zones around protected areas (where human use is allowed to the extent that it does not undermine the integrity of protected areas), biological corridors and ecological stepping stones.

The concept of the ecological network becomes important here. Ecological networks provide an operational model for conserving biological diversity while reconciling the conflicting demand of natural resource use. Ecological networks connect ecosystems and populations of species that are threatened by fragmented habitats, facilitating genetic exchange between different populations and thus increasing the chances of survival of threatened species. The ecological network concept also provides a tool for ecological design and physical planning that facilitates interaction with other types of land use.

A large number of ecological networks have been developed around the world. However, a thorough and systematic compilation of information on ecological networks and their contribution to conservation and the sustainable use of biological diversity and sustainable development was, until now, not available. Against this background, the Secretariat of the Convention on Biological Diversity has undertaken this initiative. This review document contains detailed information on the development and implementation of ecological networks in each of the five UN regions. The examples and case studies provide a wealth of information on ecological networks. The study also focuses on lessons learned and on the suitability of ecological networks for biodiversity conservation, sustainable use and poverty alleviation, and on their contribution to the 2010 target.

I hope this review will provide a better understanding of ecological networks and assist protected-area managers and policy-makers in governments, NGOs and communities to develop ecological networks when planning and implementing protected areas and to achieve the twin objectives of biodiversity conservation and sustainable development.

I thank the authors for undertaking such an exhaustive review and presenting the information clearly and succinctly. I am also grateful to the Government of Netherlands for providing financial resources.

Dr. Ahmed Djoghlaf
Executive Secretary
Convention on Biological Diversity

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Graham Bennett
Jo Mulongoy

CONTENTS

1. INTRODUCTION

At their meeting in Kuala Lumpur in February 2004, the Seventh Conference of the Parties to the Convention on Biological Diversity adopted through decision VII/28 a detailed programme of work on protected areas. The overall purpose of the programme of work is "to support the establishment and maintenance by 2010 for terrestrial and by 2012 for marine areas of comprehensive, effectively managed and ecologically representative national and regional systems of protected areas that collectively, *inter alia*, through a global network, contribute to achieving the three objectives of the Convention and the 2010 target to significantly reduce the current rate of biodiversity loss at the global, regional, national and sub-national levels and contribute to poverty reduction and the pursuit of sustainable development".

The first of the four substantive programme elements in the programme of work concerns direct actions for planning, selecting, establishing, strengthening and managing protected-area systems and sites — in other words, what protected areas need to conserve, where and how. Five specific goals are established:

1.1 To establish and strengthen national and regional systems of protected areas integrated into a global network as a contribution to globally agreed goals.

1.2 To integrate protected areas into broader land- and seascapes and sectors so as to maintain ecological structure and function.

1.3 To establish and strengthen regional networks, transboundary protected areas and collaboration between neighbouring protected areas across national boundaries.

1.4 To substantially improve site-based protected area planning and management.

1.5 To prevent and mitigate the negative impacts of key threats to protected areas.

Each goal is elaborated into a specific target to be used as a tangible indicator of the achievement of that goal. A series of suggested activities of the Parties and supporting activities of the Executive Secretary are then listed as steps to be taken in moving towards the target.

Decision VII/28 also established a follow-up mechanism in order to support and review the implementation of the programme of work, namely an Open-Ended Working Group on Protected Areas. One of the tasks of the Working Group is to contribute to the further development of tool kits for the identification, designation, management, monitoring and evaluation of national and regional systems of protected areas, including ecological networks, ecological corridors and buffer zones. In order to develop these tool kits in relation to goals 1.2 and 1.3, the CBD Secretariat identified a need for a review of experience in developing ecological networks, corridors and buffer zones. This document constitutes that review.

SUBJECT AND SCOPE OF THE REVIEW

The requirements for the review were, first, to prepare case studies illustrating experience in each of the five UN regions on the development of ecological networks, corridors and buffer zones and, second, to draw conclusions on their suitability for biodiversity conservation, sustainable use and poverty alleviation, as appropriate, and their contribution to the 2010 biodiversity target. The scope of the review is therefore exceptionally broad: not only is it global in its coverage, it also covers a wide range of conservation measures that range from a single ecoduct to intercontinental, interconnected networks of protected areas. Of the thousands of programmes and projects that fall within the scope of the review, only a small proportion can be assessed in detail. The conclusions are therefore based on both the experiences illustrated by the case studies and relevant literature.

However, before discussing global experience, it is necessary to clarify the concepts that are the subject of the review: that is, ecological networks, corridors and buffer zones.

Ecological Networks

The ecological network is a model that has developed over the past 30 years with the broad aim of maintaining the integrity of environmental processes. In Central and Eastern Europe, several national ecological-network programmes were developed in the 1980s inspired by the polarized-landscape theory of the Russian geographer Boris Rodoman. Based on this theory, the "eco-stabilizing" approach proposed that the landscape should be zoned in such a way that intensively used areas are balanced by natural zones that function as a coherent, self-regulating whole. The resulting programmes not only developed the first ecological networks but also integrated biodiversity conservation into broad environmental management plans, approximating what would now be described as national sustainable development strategies.

In most other regions the ecological-network model evolved out of developments in ecological theory, primarily MacArthur and Wilson's equilibrium theory of island biogeography and metapopulation theory. The most important insight that followed from these theories was that habitat fragmentation increases the vulnerability of species populations by reducing the area of habitat available to local populations and limiting opportunities for dispersal, migration and genetic exchange. Interest therefore grew in developing conservation approaches that promoted ecological coherence at the landscape scale. During the 1990s, local regional and national programmes that aimed to integrate protected areas into more extensive linked networks were developed in many countries in Western Europe, North America, Latin America, Australia and Asia.

Although the way in which the model is elaborated and applied reflects certain conceptual and methodological variants and is subject to local and regional circumstances, the approaches that are usually classified as ecological networks share two generic goals, namely (1) maintaining the functioning of ecosystems as a means of facilitating the conservation of species and habitats and (2) promoting the sustainable use of natural resources in order to reduce the impacts of human activities on biodiversity and/or to increase the biodiversity value of managed landscapes (Bennett and Wit, 2001).

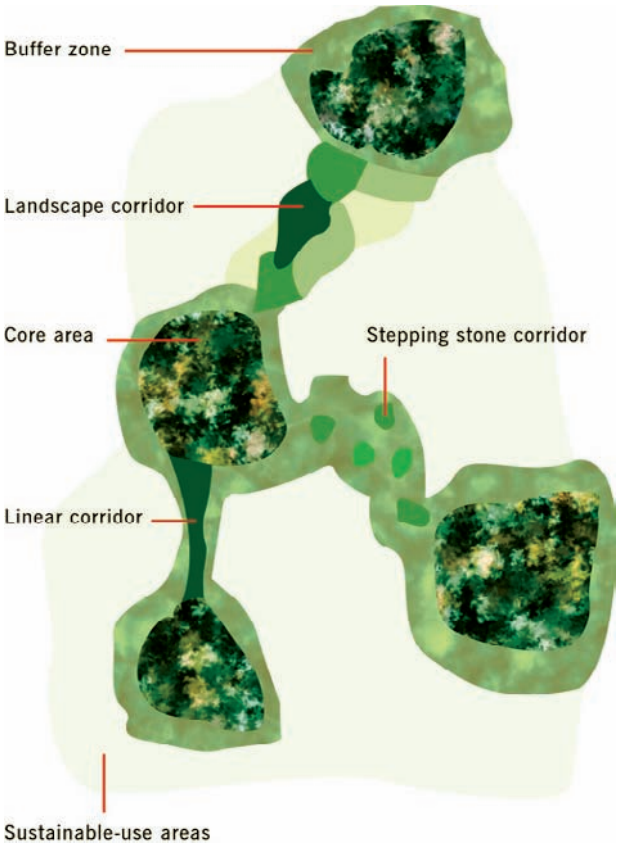
In achieving these goals, a number of elements can be discerned which together characterize all ecological networks. These are:

- a focus on conserving biodiversity at the landscape, ecosystem or regional scale
- an emphasis on maintaining or strengthening ecological coherence, primarily through providing for connectivity
- ensuring that critical areas are buffered from the effects of potentially damaging external activities
- restoring degraded ecosystems where appropriate
- promoting the sustainable use of natural resources in areas of importance to biodiversity conservation

Ecological networks also share a common understanding of how this model should be applied on the ground, namely through the allocation of specific functions to different areas depending on their ecological value and their natural-resource potential (Bennett, 2004). These functions are reflected in a coherent system of areal components:

- CORE AREAS, where the conservation of biodiversity takes primary importance, even if the area is not legally protected
- CORRIDORS, which serve to maintain vital ecological or environmental connections by maintaining physical (though

Figure 1.1. Diagrammatic representation of the spatial configuration of an ecological network



not necessarily linear) linkages between the core areas

- BUFFER ZONES, which protect the network from potentially damaging external influences and which are essentially transitional areas characterized by compatible land uses
- SUSTAINABLE-USE AREAS, where opportunities are exploited within the landscape mozaic for the sustainable use of natural resources together with maintenance of most ecosystem services

A diagrammatic representation of this spatial arrangement is shown in Figure 1.1.

One feature of ecological-network programmes that can lead to some confusion is the variation in terminology. The term "ecological network" gained favour in Europe in the early 1990s and has been used in the most important international mechanisms in recent years, including IUCN's World Conservation Congresses, the World Summit on Sustainable Development's Plan of Implementation and the CBD Conferences of the Parties, including the programme of work on protected areas. In regional and national settings, however, different terms are used to describe the model. These include "territorial system of ecological stability", "reserve network", "bioregional planning", "ecoregion-based conservation",

"connectivity conservation areas" and various language-specific variants, but also "corridor". As a result, it is not always obvious from the title of a programme or project whether the approach reflects the ecological-network model.

Further information on the origins of the approaches and the conceptual, methodological and terminological variations is provided in the regional case studies.

Corridors

Corridors — in the sense of functional linkages between sites — are essentially devices to maintain or restore a degree of coherence in fragmented ecosystems. In principle, linking isolated patches of habitat can help increase the viability of local species populations in several ways:

- by allowing individual animals access to a larger area of habitat — for example, to forage, to facilitate the dispersal of juveniles or to encourage the recolonization of "empty" habitat patches
- by facilitating seasonal migration
- by permitting genetic exchange with other local populations of the same species (although this generally requires only very occasional contact)
- by offering opportunities for individuals to move away from a habitat that is degrading or from an area that is under threat (which may become increasingly important if climate change proves to have a serious impact on ecosystems)
- by securing the integrity of physical environmental processes that are vital to the requirements of certain species (such as periodic flooding)

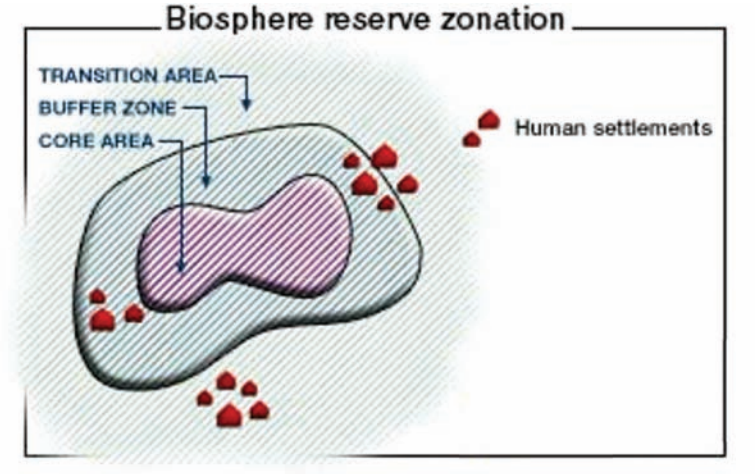
Corridors vary enormously in scale: from a tunnel to allow amphibians to pass under a road to intercontinental flyways for migrating birds. They also take many different forms. In general, three broad kinds of landscape corridor can be distinguished:

- a linear corridor (such as a hedgerow, forest strip or river)
- "stepping stones", that is, an array of small patches of habitat that individuals use during movement for shelter, feeding and resting
- various forms of interlinked landscape matrices that allow individuals to survive during movement between habitat patches

Corridors have been the subject of growing interest for about 20 years and are increasingly being included in biodiversity conservation programmes around the world. Their practical conservation value has nevertheless been the subject of fierce debate (see, for example, Dawson, 1994; Rosenberg *et al.*, 1997; Beier and Noss, 1998). Bienen (2002) draws attention to conservation corridors and the spread of infectious disease. Fortunately, a better understanding of the potential value of corridors in particular situations is now developing as a result of the growing body of data generated by carefully designed experiments and project experience (see, for example, Tewksbury *et al.*, 2002; Bennett, 2004).

As is the case with ecological networks, however, the terminology used to describe corridors requires some clarification. The term "corridor" is used to describe many different kinds of measures, including landscape linkages (both linear and non-linear), recreational routes (also known as greenways) and entire ecological networks. Other terms are therefore becoming more prominent in the conservation literature, such as "linkage" in relation to corridors and "permeability" to indicate the general principle of maintaining or enhancing ecological coherence across a landscape. "Connectivity" is also widely used as a general term. In this review, the term "corridor" will be retained in most instances to connote a

Figure 1.2. The Biosphere Reserve zoning system (UNESCO).



UNESCO

human-managed connection since it is used by the Conference of Parties. The term "linkage" is used to signify a naturally existing connection that is the focus of conservation action.

Buffer Zones

In contrast to ecological networks and corridors, the concept of a buffer zone is generally far less controversial. The prime purpose of a buffer zone is to insulate areas where biodiversity conservation is the primary objective from potentially damaging external influences, and particularly from those caused by inappropriate forms of land use. In principle, this function therefore permits a range of sustainable human activities.

The concept of a buffer zone was first proposed in the 1930s, but it rose to prominence as a conservation instrument in the 1970s when it became an integral part of the management approach in UNESCO's Man and Biosphere Programme (UNESCO, 1974; 1995). In fact, UNESCO introduced the Biosphere Reserve concept with a two-tier hierarchy for buffering protected areas: a "buffer zone" where land use is restricted to activities that are compatible with the protection of the core area, and a "transition area" where appropriate economic activities are permitted and where sustainable resource management practices can be developed, which today are often called "sustainable-use areas" or "zones of cooperation" (see Figure 1.2.).

But although the concept of a buffer zone may be straightforward, its design and its functioning in practice raise many challenges. Adequately understanding the interaction between human activities and species populations and the resulting dynamics is a complex issue; determining appropriate land uses is therefore far from easy. Buffer zones may perform a corridor function or in themselves harbour valuable biodiversity, such as species populations that are dependent on certain traditional forms of agriculture. Decisions to restrict human activities in buffer zones will also impose costs on the landowners and users, raising the question of compensation. Land-use management is therefore a critical factor in the degree to which buffer zones can in practice prove to be effective as a conservation instrument. Biosphere Reserves has shown that the buffer zone may be designated less for its defensive " buffering" function and more as a less

strictly protected type of area which can link up protected core areas and thus ensure connectivity within a large transition area. This is particularly relevant in cultural landscapes, in which the buffer zone may have a defined conservation function of its own (UNESCO, 2005)

Other Issues

The Breadth of the Review

As the foregoing discussion on ecological networks, corridors and buffer zones suggests, the task of identifying programmes and projects that fall within the scope of this review is confronted with a substantial grey area. Due to information shortcomings, it is not always readily apparent whether the conservation model that is applied by specific initiatives can be regarded as an ecological network. This particularly applies to many of the large-scale "ecoregion" programmes which have not yet progressed to the stage of preparing a plan that specifies how biodiversity conservation and sustainable use will be achieved on the ground. For example, many of these initiatives adopt a management approach that is closer to the Biosphere Reserve model than that of the ecological network — that is to say, the sites that are the subject of conservation action are relatively large, integral areas within which zoning distinguishes between biodiversity conservation, buffer zones and sustainable forms of land use; no explicit measures are taken to enhance connectivity between sites. However, in the interests of presenting as complete a review as possible, both ecoregion initiatives and Biosphere Reserves are included among the programmes that are covered by the review since to a significant extent their management approach overlaps that of the ecological-network model.

Although the network model was originally developed for application in terrrestrial ecosystems, interest has grown in recent years in considering to what extent the same principles might usefully be applied to marine ecosystems that are under pressure from human activities such as oil and gas exploitation, fishing and coastal development. At the oceanic scale, the homogeneous nature of the marine environment is clearly less suited to the structural principles of the ecological network than terrestrial landscapes. However, there are several specific kinds of marine systems that offer comparable challenges to terrestrial ecosystems:

- MARINE LINKAGES (such as sea straits that are used by certain species during migration, for dispersal or to move between spawning and feeding grounds)
- SEA-RIVER LINKAGES (that is, ecosystems that are formed by the interaction between a river and the sea, such as those used by migratory fish)
- COASTAL SYSTEMS (where land and sea constitute an interacting system, such as where turtles and seals depend on littoral shallows or the presence of a coastline)
- LOCATION-SPECIFIC MARINE BREEDING GROUNDS

Nevertheless, because of the special factors that affect marine conservation, this review is limited to terrestrial, freshwater and coastal ecosystems.

The Ecosystem Approach

A conservation model that is closely related to the ecological network is the ecosystem approach. The ecosystem approach can be regarded as a strategy for the management of land, water and living resources that promotes biodiversity conservation and sustainable use in an equitable way. At the heart of the approach is the awareness that, without the effective management of ecosystems, there can be no economic development that generates sustainable human and social welfare; equally, without the full engagement of diverse sectors in the economy and society in the management of ecosystems, there can be

no effective biodiversity conservation. In that sense, the ecosystem approach is a framework for holistic decision-making and action. In 2000 the Conference of the Parties identified the ecosystem approach as the primary framework for the implementation of the Convention on Biological Diversity and recommended the application of its principles.

The ecosystem approach is the application of 12 principles and five points of operational guidance (see box). These show a high level of correspondence with the characteristics of the ecological-network model: both focus on maintaining ecosystem functions in the long term and securing the sustainable use of land. The way in which the two models have evolved has nevertheless resulted in certain differences in emphasis and application. Ecological networks emerged in the main as national or regional responses to the challenges of biodiversity conservation and sustainable development, in many cases with little knowledge of comparable approaches elsewhere. As a result, ecological networks display a variety of methodological approaches and management philosophies. But despite this diversity they have arrived — often independently — at a common

The Ecosystem Approach

Principles

1. The objectives of management of land, water and living resources are a matter of societal choice.
2. Management should be decentralized to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:
   a) Reduce those market distortions that adversely affect biological diversity;
   b) Align incentives to promote biodiversity conservation and sustainable use;
   c) Internalize costs and benefits in the given ecosystem to the extent feasible.
5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
6. Ecosystems must be managed within the limits of their functioning.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management must recognize that change is inevitable.
10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Points of operational guidance

1. Focus on the relationships and processes within ecosystems.
2. Enhance benefit-sharing.
3. Use adaptive management practices.
4. Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to the lowest level, as appropriate.
5. Ensure intersectoral cooperation.

Taken from Smith and Maltby (2003).

model of how the two objectives can best be achieved. By contrast, the ecosystem approach was developed in the 1990s through a broad-based, globally organized process. It therefore operates through generally applicable principles which allow scope for elaboration to take account of local and regional circumstances. It also gives greater emphasis to the application of common management principles. A series of case studies that have been carried out in recent years illustrate how this process operates in practice (see Smith and Maltby, 2003; Shepherd, 2004). These examples demonstrate that in practice the application of the ecosystem approach leads to a wide range of solutions on the ground which in many cases arrive at a form of management that is comparable to an ecological network. This has also been found with the Biosphere Reserve concept, which has been proposed by UNESCO MAB as the "embodiment" of the ecosystem approach (UNESCO, 2000). Some countries, such as Argentina, are now establishing new Biosphere Reserves with the explicit purpose of implementing the ecosystem approach.

Protected Areas and Ecological Networks

In practice, land tenure and management in ecological networks vary widely. Some of this land may include protected areas which commonly form all or a large part of the core areas. Moreover, protected areas themselves vary widely with regard to type, objectives and human use (see box). Clearly, for governments and communal or private entities, legally established protected areas are the most secure form of tenure available for ensuring management longevity of the respective areas. Protected areas are typically managed to achieve conservation outcomes, but there may be variation in the amount of management for other parts of ecological networks. Protected areas can therefore play a special role in maintaining the ecological integrity of ecological networks. Indeed, some protected areas may themselves function as ecological networks. For example, the Australian Great Barrier Reef Marine Park, a protected area that falls predominantly in IUCN's Category VI and which is of continental scale, functions as a very large ecological network between more secure Category Ia and Category II protected areas within the reef system. Other interconnected protected areas, such as parts of the Rocky Mountains in the USA and Canada (Glacier National Park—Waterton National Park and Banff National Park—Jasper National Park) and the Kruger National Park of South Africa, also form large ecological networks. Conversely, because ecological networks can minimise fragmentation, retain opportunities for the movement of wildlife and promote nature-friendly land use, they also have a role in supporting the long-term viability of protected areas.

STRUCTURE OF THE REVIEW

The structure of the review of experience follows the UN regional classification. That is to say, it is organized around five regions:

- Asia and the Pacific
- Africa
- Central and Eastern Europe
- Latin America and the Caribbean
- Western Europe and Others Group

The order in which the regions are discussed reflects the chronology of the development and application of the ecological-network model. Thus, the first region covered by the review is Central and Eastern Europe, where the ecological network was originally conceived.

The experience of each region is presented through an introduction on the development of ecological networks, an overview of the known programmes (including brief descriptions of two to five examples), the presentation of two case studies, and a concluding section that highlights the main characteristics of the programmes. The examples and the case studies have been

IUCN Categories of Protected Areas

CATEGORY Ia	Strict Nature Reserve: protected area managed mainly for science.
Definition	Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.
CATEGORY Ib	Wilderness Area: protected area managed mainly for wilderness protection.
Definition	Large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.
CATEGORY II	National Park: protected area managed mainly for ecosystem protection and recreation.
Definition	Natural area of land and/or sea, designated to: (a) protect the ecological integrity of one or more ecosystems for present and future generations (b) exclude exploitation or occupation inimical to the purposes of designation of the area (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.
CATEGORY III	Natural Monument: protected area managed mainly for conservation of specific natural features.
Definition	Area containing one, or more, specific natural or natural/cultural feature which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.
CATEGORY IV	Habitat/Species Management Area: protected area managed mainly for conservation through management intervention.
Definition	Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.
CATEGORY V	Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation.
Definition	Area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.
CATEGORY VI	Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems.
Definition	Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

selected to cover as wide a range of programmes as possible. They therefore illustrate comprehensive ecological-network programmes at the one extreme through to individual corridors and buffer zones at the other. But they also vary with respect to geographical scale, implementing phase, whether a government or an NGO was the initiating organization and also the degree of success in achieving their objectives.

In order to simplify the presentation of specific types of programme, agreements under the Bonn Convention on the Conservation of Migratory Species of Wild Animals are grouped together under Western countries (where the majority are located). Flyway agreements are discussed under Asia and the Pacific, since a substantial proportion is found in that region. All information presented is based, as far as possible, on original sources.

2. CENTRAL AND EASTERN EUROPE

Programmes to develop and establish ecological networks were pioneered in Central and Eastern Europe in the 1980s (Külvick, 2002). The first initiative to establish what is now recognized as an ecological network was the Estonian Network of Ecologically Compensating Areas. This programme, which originated as a concept in the mid-1970s and was elaborated into a national proposal in 1983, was based to a large extent on the polarized-landscape theory of the Russian geographer Boris Rodoman (Rodoman, 1974). At around the same time several other countries in the region developed proposals that were also based on the landscape-stabilization approach, most notably Lithuania and former Czechoslovakia. All these programmes were characterized by an integrated approach to land-use zoning and environmental management within a strong national development-planning system.

The programmes continued to be elaborated throughout the 1980s. However, the revolutionary political changes that overtook Central and Eastern Europe at the end of the decade had significant impacts on the government institutions and administrative systems of all the countries in the region. The changes were accompanied by a period of economic decline and restructuring, with the result that the further development and implementation of the ecological-network programmes was subordinated to more pressing political priorities.

An impulse that reinvigorated the work on ecological networks in the region arrived in 1995 with the adoption of the Pan-European Biological and Landscape Diversity Strategy. This international agreement includes the commitment to establish a Pan-European Ecological Network. Although the model underlying the Pan-European Ecological Network owes more to the principles of landscape ecology than to the theory of landscape stabilization, the programme to develop and implement an ecological network from the Atlantic to the Pacific provided enough impetus to persuade countries in Central and Eastern Europe to revive their ecological-network programmes or develop new national schemes. However, in line with the pan-European approach, in most cases the current programmes feature a greater focus on biodiversity conservation than on integrated environmental planning.

OVERVIEW OF THE PROGRAMMES

Ecological networks in Central and Eastern Europe are being developed in three main ways: through the collaborative framework of the Pan-European Biological and Landscape Diversity Strategy, through national or (in Russia) regional government programmes and through various NGO projects.

The Pan-European Ecological Network is the most ambitious international ecological-network programme. In 1995 52 Eurasian countries endorsed the Pan-European Biological and Landscape Diversity Strategy. The agreement operates to a large extent as a coordinating framework within which national actions are being taken to conserve biological and landscape diversity in the period to 2015. However, the Strategy included a range of ambitious actions that went beyond existing international agreements and national policies. The most significant of these was the establishment of the Pan-European Ecological Network (see box).

With regard to government-driven programmes, national ecological networks are under development in 11 countries in Central and Eastern Europe, as follows:

- Czech Republic: Territorial System of Ecological Stability
- Belarus: National Ecological Network
- Estonia: Green Network (see case study 1)
- Hungary: National Ecological Network
- Latvia: Ecological Network
- Lithuania: Ecological Network (see box)

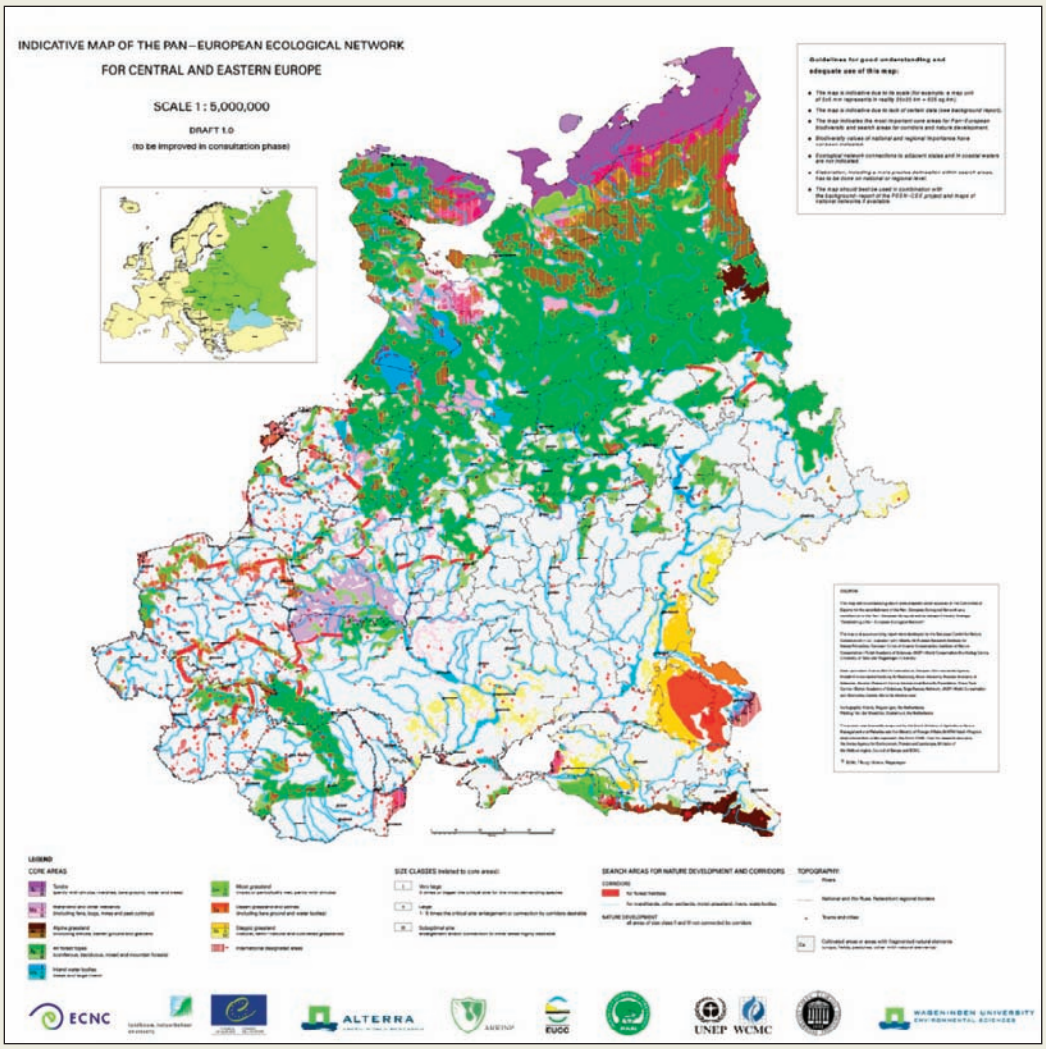
Eurasia: The Pan-European Ecological Network in Central and Eastern Europe

The aim of the Pan-European Ecological Network is to ensure:

- the conservation of the characteristic ecosystems and the natural habitats and landscapes of European importance across their traditional ranges;
- the sustainable use of semi-natural habitats and cultural landscapes of European importance;
- the maintenance of viable populations of species of European importance across their traditional ranges;
- the maintenance of the environmental processes on which these ecosystems, habitats, species and landscapes depend.

These objectives are to be achieved through the establishment of an ecological network that will be built up from three functionally complementary components: core areas that provide the optimum achievable quantity and quality of environmental space, corridors to ensure appropriate interconnectivity between the core areas, and buffer zones to protect the core areas and corridors from potentially damaging external influences.

Many Eurasian countries, particularly in Central and Eastern Europe, were already developing national ecological network programmes when the Strategy was finalized, and many others have initiated comparable programmes since 1995. However, in order to strengthen the international coordination of these programmes, a supranational programme was initiated in 1999 with the aim of configuring the main lines of the network for Central and Eastern Europe. The resulting map, prepared by the European Centre for Nature Conservation (European Centre for Nature Conservation, 2002), indicates core areas of pan-European importance and broad areas within which associated corridors or stepping stones could be located.

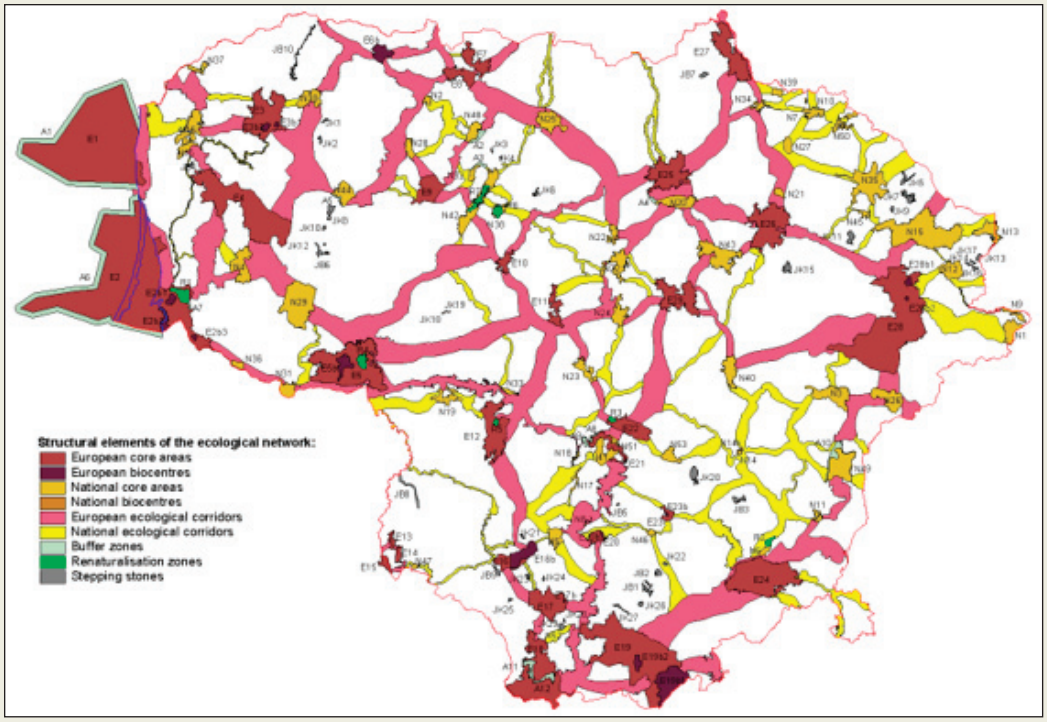


Lithuania: The Ecological Network

The first proposal for an ecological network in Lithuania was developed in the early 1980s as the Nature Frame (Sepp and Kaasik, 2002). During the period up to 1993 the concept was elaborated at the national level and then for all 44 districts. The Nature Frame follows Central European practice in providing a broad planning framework for land management. In environmental terms the approach aims to integrate the management of three systems: watersheds, biodiversity and landscape linkages (both ecological and physical). About 60 percent of Lithuanian territory falls within the Nature Frame, which has legal status through the Environmental Protection Act (1992) and the Protected Areas Act (1993).

Substantial adaptations have been made in recent years to ensure closer correspondence with the approach adopted by the Pan-European Ecological Network and also to facilitate implemention of the EU's representative system of protected areas, Natura 2000, and the Bern Convention. For example, the European importance of species populations, habitats and corridors was added as a design criterion, analyses of indicator species, species communities and habitats were given greater emphasis in determining the configuration of the network, and a clear functional distinction is now made between core areas, buffer zones, restoration areas, corridors and stepping stones. Accordingly, the term "ecological network" is usually used to describe the current programme.

An IUCN project has tested implementation of the ecological network through a pilot project in the Klaipėda district on the Baltic coast; 35 percent of the district falls within the network.



Institute of Geography/IUCN — The World Conservation Union

- Moldova: National Ecological Network (see case study 2)
- Romania: National Network
- Russian Federation: Ruseconet
- Slovakia: Territorial System of Ecological Stability
- Ukraine: National Ecological Network.

In addition, in Russia a large number of regional ecological networks are being developed (with the main responsible organizations in brackets):

- Heart of Russia — Central Russian Plain (Ministry of Natural Resources of the Russian Federation, Biodiversity Conservation Center, WWF Russia)

- Natural Ecological Frame of Moscow Oblast (Biodiversity Conservation Center)
- Natural Complex of Moscow City (Department of Nature Use and Environmental Protection of Moscow City Government, Institute of the General Plan of the Moscow City)
- System of Reserved Natural Lands of Ryazan Oblast (Biodiversity Conservation Center, Esenin Ryazan State Pedagogical University)
- Natural Ecological Frame of Ryazan City (Biodiversity Conservation Center, Esenin Ryazan State Pedagogical University)
- System of Protected Natural Areas of Bryansk, Kaluga and Orel Oblasts (WWF Russia, Orel State University, Kovyl Centre)
- Ecological Network of Orel Oblast (Orel Oblast Branch of the Federal Supervisory Natural Resources Management Service, Orel State University, Kovyl Centre, WWF Russia
- Ecological Network of the Volga-Viatka Region (Biodiversity Conservation Center)
- Ecological Network of the Nizhniy Novgorod Oblast (Federal Supervisory Natural Resources Management Service, Inspection in Povolzhie Federal District, Nizhniy Novgorod Branch of the Russian Bird Conservation Union)
- Ecological Network of Chuvash Republic (Ministry of Nature Use of Chuvash Republic, Prisursky State Nature Reserve, the Institute of Urbanistic)
- Volga-Ural Econet (the Volga-Ural ECONET Assistance Centre)
- Ecological Network of the Southern Ural (WWF Russia, the Volga-Ural ECONET Assistance Centre)
- System of Protected Natural Areas of the Republic of Bashkortostan (Ministry of Natural Resources of the Republic of Bashkortostan, the Volga-Ural ECONET Assistance Centre, WWF Russia)
- Landscape and Ecological Network of Orenbourg Oblast (the Steppe Institute of the Ural Branch of the Russian Academy of Sciences)
- Ecological Network of the Lower Volga Region (Biodiversity Conservation Center)
- Caucasus Econet (WWF Russia)
- Ecological Network of Altai-Sayan Ecoregion (WWF Russia)
- Ecological Network of Baikal Lake Basin (Institute of Geography of the Siberian Branch of the Russian Academy of Sciences)
- Ecological Network of Goloustnaya River Basin (Administration of Irkutsk Oblast, Baikalo-Lensky State Natural Reserve)
- Ecological Network of Khilok River Basin (Institute of Natural Resources of the Siberian Branch of the Russian Academy of Sciences)
- Sacred Earth Network — the Republican System of Specially Protected Natural Areas (Ministry of Nature Conservation of the Republic of Sakha-Yakutia, WWF Russia)
- Ecological Network of the Russian Far East (WWF Russia) — see box

Of the NGO projects that involve the development of ecological networks, WWF is most active through its ecoregion conservation programme. Ecoregion programmes that were underway at the time of writing include the following terrestrial and coastal regions:

- European-Mediterranean montane mixed forests (the Alps, the Carpathians and the Dinaric Alps)

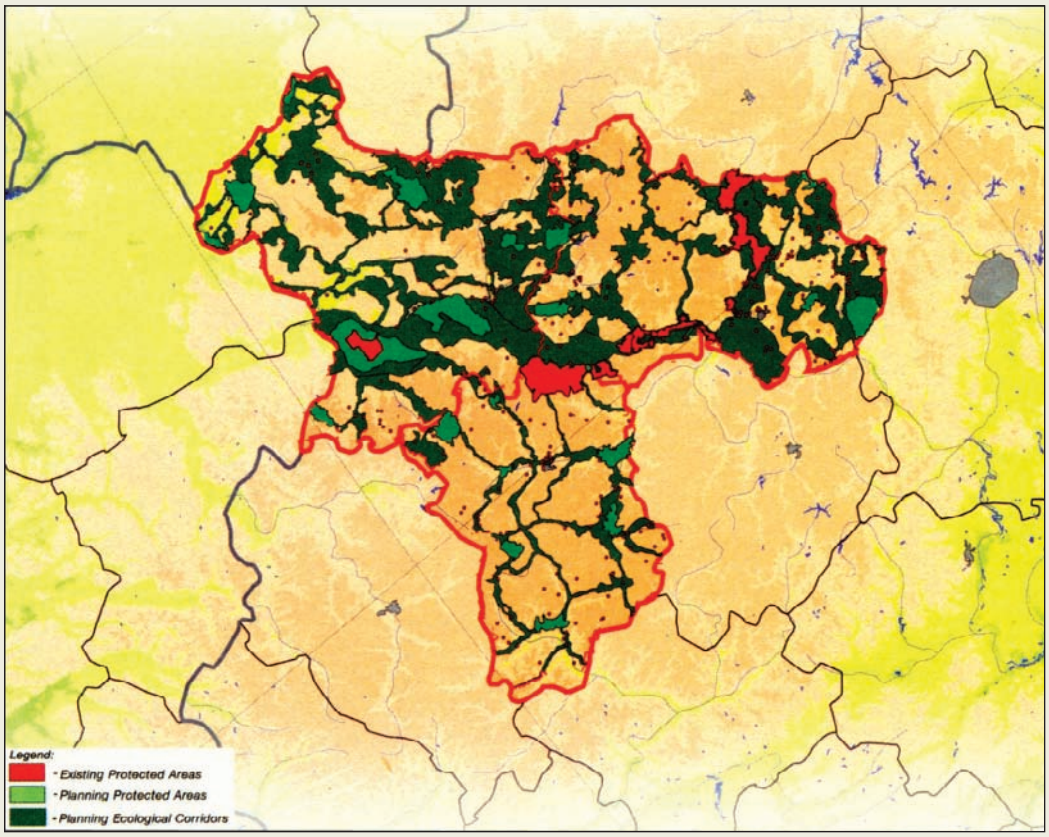
Russia: The Central European Forest-Steppe Ecoregion

Following the preparation of its Global 200 Programme, which identified 233 priority ecoregions, WWF initiated a large number of projects with the aim of conserving biodiversity in these regions. The approach to be applied to this task is known as "Ecoregion-Based Conservation" (ERBC) and corresponds in many respects to the ecological-network model and the ecosystem approach, though with a major emphasis on process management. ERBC aims to achieve four fundamental conservation goals:

- representation of all distinct natural communities
- maintenance of ecological and evolutionary processes
- maintenance of viable populations of species
- resiliency in the face of large-scale periodic disturbances and long-term change

An example of ERBC is the forest-steppe ecosystem in Central European Russia, which is part of the East-European broadleaf forest and forest-steppe ecoregion. Covering 90,000 square kilometres at the confluence of the Volga, Dnepr and Don river basins, the area is primarily broadleaved forest with some southern taiga and a small area of steppe. A large proportion of the region is devoted to agriculture.

The WWF project began in 1998 and includes an inventory of the region's natural potential, field verification studies, ecological-network planning, model projects and developing proposals for new legislation. This resulted in the adoption of the regional Law on a System of Protected Nature Areas in 2002, which laid down the framework for allocating competences and also for planning, establishing, managing and protecting ecological networks.



Worldwide Fund for Nature

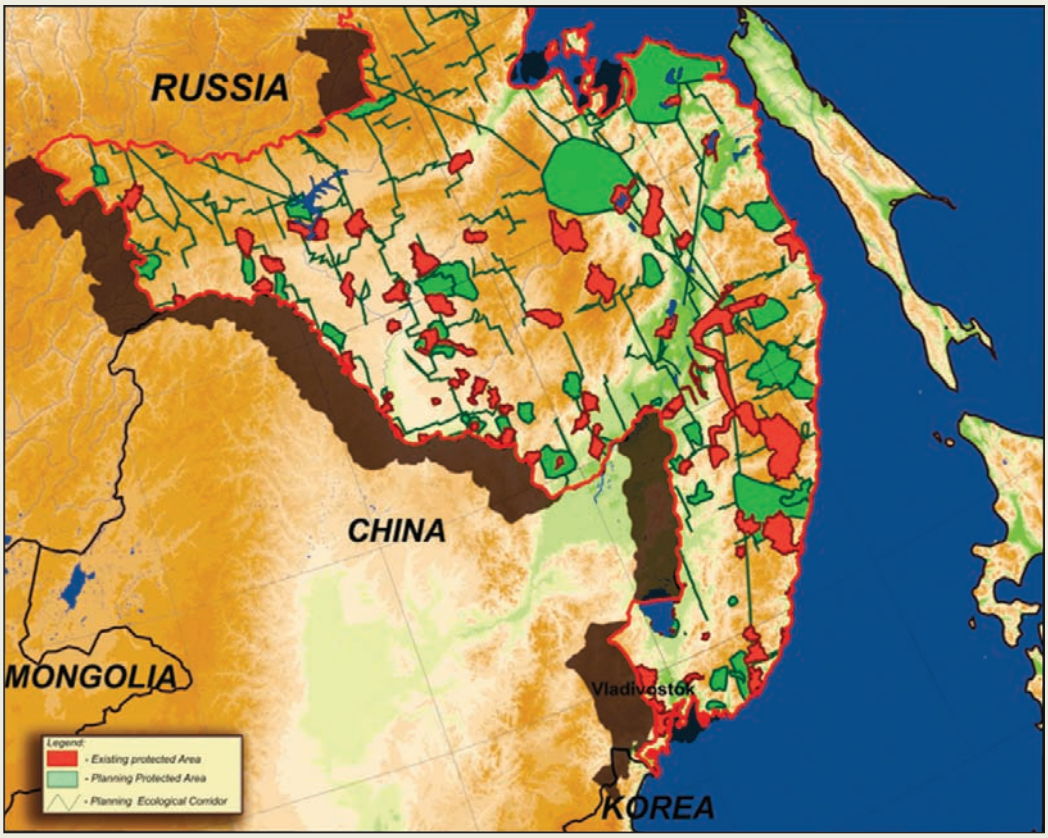
Russia: Ecological Network of the Russian Far East

Located on Russia's Pacific rim, the Ecological Network of the Russian Far East covers over 1.3 million square kilometres. The striking variation in landscapes and microclimates has produced a high level of biological diversity in the region's prairies, mixed broadleaf forests, moraines, alpine tundra, intricate coastline and over 60,000 lakes. These temperate forests are among the richest in the world, and endemism is exceptionally high.

WWF initiated a biodiversity conservation project for the region in 1998, applying its Ecoregion-Based Conservation approach. Cooperating with experts and representatives from the Far East Academy of Sciences, government research institutes, the provincial administrations, environmental NGOs and international consultancies, biodiversity and socio-economic assessments were prepared. A biodiversity vision was then drawn up to establish qualitative long-term conservation objectives for the region in collaboration with the main stakeholders.

Based on this work, a Conservation Action Plan was prepared in 2003 with measures organized around three action tracks: conserving biodiversity, strengthening institutions and management procedures, and creating a sustainable economy in the region. The finalization and implementation of the plan is supervised by the Ecoregional Council for Sustainable Nature Use, with participation by representatives of federal and provincial governments, scientists and NGOs. Although it was unrealistic to secure unanimous agreement on all the recommendations in the Conservation Action Plan, most of the recommendations enjoyed broad endorsement from the stakeholders.

A provisional ecological network has been developed and is currently under consideration by the Council. The network is to be established primarily to conserve biodiversity and promote sustainable development in the forest and wetland areas. It is projected to be fully implemented by 2020, with the main areas being under protection or appropriate management by 2010.



Worldwide Fund for Nature

- Caucasus-Anatolian Hyrcanian temperate forests
- Mediterranean forests, woodlands and scrub (southwest Iberia and the northwest Morocco lowlands, the Baetic-Atlas mountains and the Italian Peninsula)
- East-European broadleaf forest and forest-steppe
- the Russian Far East (temperate forests and rivers and streams)
- Altai Sayan montane forests

In addition, WWF is carrying out two large-scale non-ecoregion programmes in Central and Eastern Europe:

- woodlands and the Danube River delta
- the middle-Asian montane steppe

Examples of WWF ecoregion projects that involve the development of an ecological network include the Central European forest-steppe ecoregion (see box), the Ecological Network of the Russian Far East (see box) and the Southern Ural Mountains (Shestakov and Krever, 2003).

IUCN has also promoted and supported the development of ecological networks in Central and Eastern Europe. The IUCN Office for Central Europe took the initiative to develop a common regional approach (Liro, 1998) and to prepare proposals for national ecological networks in Poland (Liro *et al.*, 1995) and the Ukraine (Vakarenko, 1999).

Finally, it can be noted that UNESCO's Man and Biosphere Programme includes 88 biosphere reserves in Central and Eastern Europe, including four transboundary reserves.

CASE STUDY 1
ESTONIA: THE GREEN NETWORK

Estonia must be credited as the first country to develop the ecological network concept and to elaborate the model into a comprehensive plan and implementation programme. Today, despite the disruptions caused by the revolutionary changes of the early 1990s, plans for implementing the network at county level throughout Estonia are now vitually complete.

In comparison with Europe as a whole, biodiversity in Estonia is still rich. For example, 71 different forest types and almost 700 species of meadow flora have been identified. Moreover, many species that are threatened at the continental or global scale are still relatively abundant. These include the wolf, the lynx, the otter, the beaver, the black stork, the corncrake, the lesser-spotted eagle and the crane. The main reasons for the high level of habitat and species diversity are the long-standing traditional forms of land-use combined with the multiple environmental gradients that characterize the region, such as the long, relatively undisturbed coastline, the high soil differentiation, the varied topography and the diverse water regimes.

During the period under Soviet rule from 1940 to 1991, Estonia remained relatively underdeveloped in economic terms. This low level of economic development combined with the low population density allowed an extensive system of protected areas to be built up and maintained. However, important changes in the organization of agricultural practices were effected which resulted in the replacement of much of the traditional small-scale rural mozaic with large fields and extensive forests. In addition, a large number of wetlands were drained for conversion to agricultural land, although many of these areas were later abandoned.

The origins of the first proposal to develop an Estonian ecological network date back to the 1970s (Sepp and Kaasik, 2002). In 1983 this proposal was finalized as a plan to establish a "Network of Ecologically Compensating Areas", a national scheme that aimed to achieve far broader goals than biodiversity conservation. Indeed, in modern terminology this plan would be described as a national sustainable development strategy. Nine strategic objectives were explicitly identified:

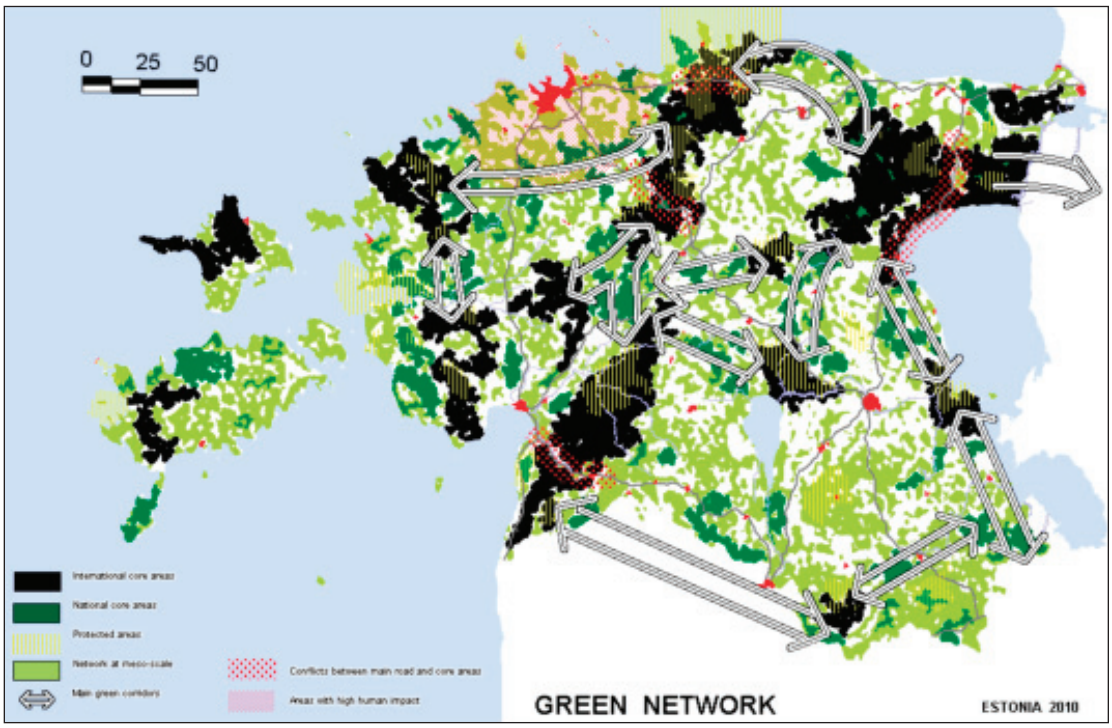
- providing refuges for wildlife
- facilitating the migration of species
- buffering undesirable impacts
- efficiently ordering human settlements
- providing opportunities for recreation
- reducing pollution
- promoting the conservation of energy and materials
- promoting recycling

In Estonia's vision, the ecological-network concept is regarded as a means to integrate land use with landscape functions in a model that can be incorporated into regional and national planning processes. From its inception, therefore, the Estonian ecological network has been developed as a spatial-planning tool for the purpose of balancing and integrating land uses.

With the broad framework established, the approach was elaborated using data on geology, climate, soils, hydrology, forests and land uses. Simultaneously, a methodology for applying the approach at the local level was developed, using districts in northwestern and northeastern Estonia, the Tallinn region, Hiiumaa and the Saaremma islands, with the intention of using the results in the development-planning process.

However, the independence of Estonia in 1991 and the initiation of political and institutional reforms marked the start of a long period of severe economic difficulties, particularly in the public sector. One of the results of this transitional phase was that agriculture came under severe economic pressure, and this in turn is threatening many valuable semi-natural habitats that have been managed through traditional agricultural practices. Forest habitats are also coming under increasing pressure: almost half of Estonia's forests are now privately owned but ef-

Figure 2.1. The Estonian Green Network

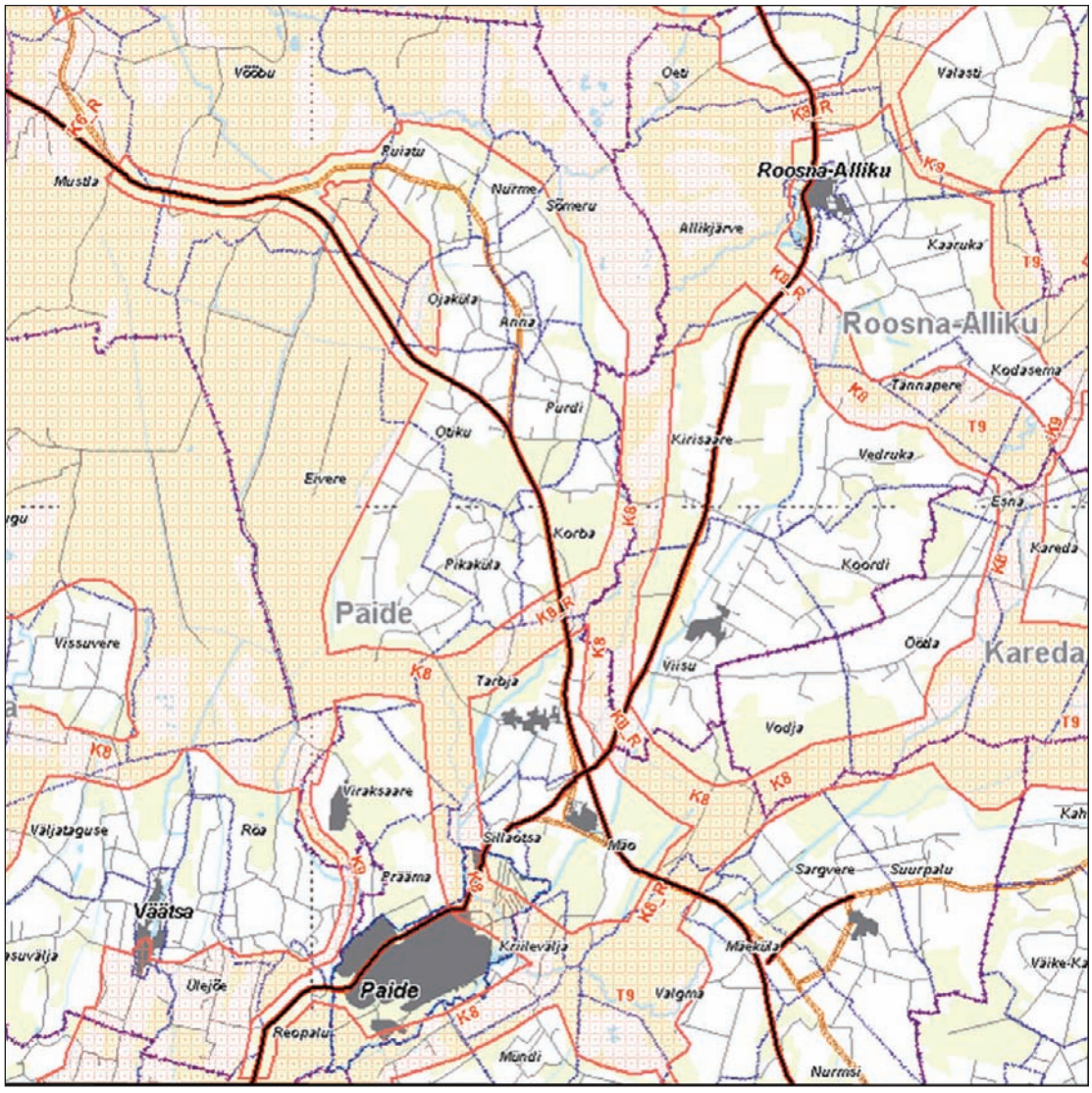


Estonian Ministry of Environment

fective regulatory regimes to promote sustainable forms of forestry management are still lacking.

A new implementing framework for the Network of Ecologically Compensating Areas was established through the reform of Estonian political institions and legislation. Through these reforms, the network has been incorporated into new spatial planning and environmental legislation: the 1995 Sustainable Development Act, the 1994 Protection of Natural Features Act and the 1995 Planning and Building Act, which required all 15 counties to prepare a map of the ecological network for their territory. In addition, the network has been the subject of policy papers such as the *National Environmental Strategy* (which includes an indicative map), the *Environmental*

Figure 2.2. Part of the Green Network as delineated in Järva County



Action Plan and *Estonia — Vision 2010*. The National Agri-Environmental Programme further provides for the development of ecological networks at the local level as a way of supporting extensive farming practices. Since 1995, the development of the Pan-European Ecological Network — with the active participation of Estonia — has further stimulated the process, as has an IUCN project to support the further elaboration, integration and implementation of the ecological networks in the three Baltic countries. These influences have led to the development of a revised concept that focuses primarily on biodiversity conservation: the Green Network.

As currently delineated, the Estonian Green Network covers about 50 percent of the country's territory and is structured to achieve a variety of objectives:

- to shape the spatial structure of natural areas in order to meet ecological, environmental, economic and social goals
- to establish a fully functioning network of protected areas that are an integral part of a complete system with natural areas
- to protect valuable natural habitats and to preserve the migration routes of wild animals and valuable landscapes
- to mitigate human impacts on biodiversity and promote sustainable development
- to promote biodiversity-friendly management, lifestyles and recreation by ensuring access to natural areas
- to promote biodiversity conservation outside protected areas
- to use spatial planning as a means to minimize conflicts between different sectors
- to guide human settlement and land use
- to maintain the natural environment's self-regulatory capacity
- to promote international cooperation

Identifying and delineating the network's national-scale core areas was carried out mainly on the basis of the size of the natural areas and their conservation value. Of these core areas, 12 are considered to be of international importance, each covering at least 100 square kilometres. Other core areas are at least 15 square kilometres in extent.

Under the national legislation, each county is required to prepare a map of the Green Network at a scale of 1:50,000 as a framework for defining the conditions that are necessary to ensure sustainable development in the region. The process through which this is achieved involves local public hearings. In Järva County, for example, the map delineates four levels of core area — varying from one or two kilometres to up to 50 kilometres across — and interconnecting corridors. These corridors are configured on the basis of data indicating the needs of species for dispersal and migration and the existence of natural linkages, including stepping stones in the landscape. Account is also taken of the 1995 Protection of Marine and Freshwater Coasts, Shores and Banks Act, which provides for corridors and buffer zones in relation to surface water.

The network that is delineated in each county plan lays down the conditions that will apply to the regulation of land use in the development-planning process. This is particularly concerned with reducing conflicts between different land-use demands within the network, with the appropriate intensity of land uses and with how serious conflicts of interest — such as between a road and a wildlife linkage — should be resolved in a structural way. The specific measures adopted in the final plan for Järva County were approved by the national government in 2003, with the result that the plan now has the force of law.

CASE STUDY 2
MOLDOVA: THE NATIONAL ECOLOGICAL NETWORK

Moldova has a well-established system of protected areas. However, these sites have historically been identified on the basis of national conservation priorities. It was only with the ratification of the Ramsar Convention in 1999 that for the first time international criteria were formally applied in delineating and managing valuable habitats. At the same time, Moldova's endorsement of the Pan-European Biological and Landscape Diversity Strategy in 1995 brought with it the commitment to contribute to the establishment of the Pan-European Ecological Network.

Prior to these developments, however, some scientific work had already been carried out that was closely related to the ecological-network approach. On the one hand, the "biocoenotic-oases" model had been developed in the late 1980s with the aim of optimizing the conservation value of a matrix of natural habitats and agricultural land. More or less simultaneously, an approach comparable to the polarized-landscape model was developed — the "ecological framework" — and elaborated in the 1991 Territorial Complex Scheme for Nature Protection. Building on this work, the development of a national ecological network that would also form the Moldavian part of the Pan-European Ecological Network was undertaken by the BIOTICA Ecological Society with the support of the National Ecological Fund of the Republic of Moldova (Andreev *et al.*, 2001). Established in 1993, the BIOTICA Ecological Society is an NGO dedicated to advancing biodiversity conservation and environmental law and policy.

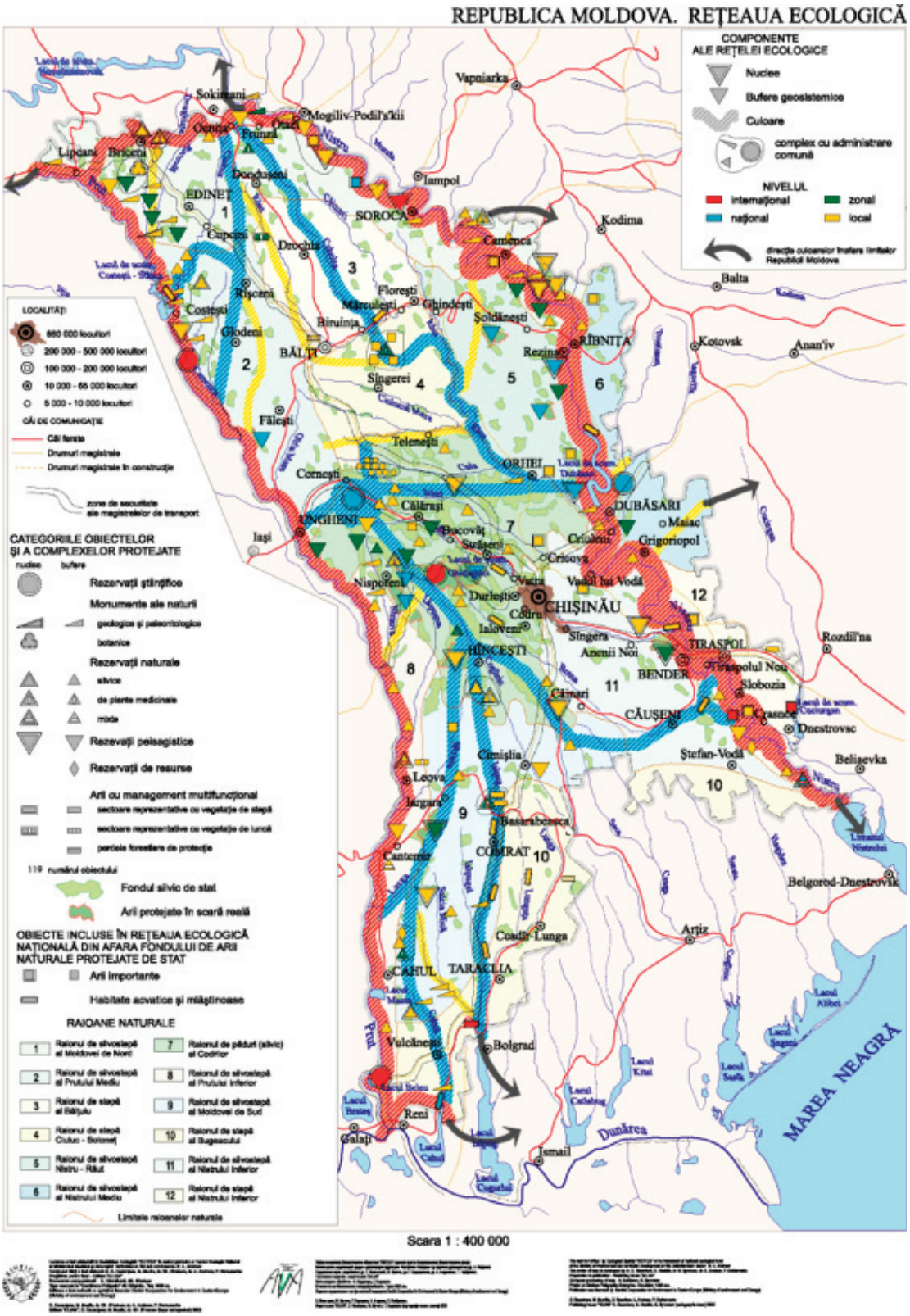
Developing the proposal for the National Ecological Network involved two main challenges. In the first place, data on species, habitats and land use had to be reassessed and expanded in order to be able to apply the ecological-network model. In addition the legislative framework, which had always been structured to secure conservation on publicly owned sites, had to be reframed in order to support conservation across the wider landscape and in combination with other land uses.

As applied in Moldova, the ecological-network model is understood to consist of "a totality of natural habitats that are interconnected physically and functionally through populations of species and ecosystems, natural and historic landscapes, and natural and cultural monuments which inherently belong to landscapes". In functional terms, the network is intended the achieve the following objectives:

- maintaining ecosystems, habitats, species and landscapes at the national, regional and global scale;
- maintaining and restoring the integrity of, and the connections between, core areas;
- protecting and enhancing natural resources within ecological systems;
- improving the stability of agricultural ecosystems, including, where appropriate, their restoration;
- stabilizing the effects of climate change;
- maintaining and improving the recreational value of national ecosystems;
- stimulating tourism, especially eco-tourism;
- encouraging public involvement in nature conservation;
- developing a system of biological monitoring.

In line with the approach adopted by the Pan-European Ecological Network, the Moldavian network comprises core areas, biological corridors, restoration areas and buffer zones. These elements were identified and delineated with reference to 12 natural zones, mainly steppe and forest-steppe habitats. An interesting feature of the network proposal is that the use of genetically modified organisms is prohibited in a three kilometre-wide zone surrounding the network.

Figure 2.3. The Moldavian National Ecological Network



The design of the Moldavian National Ecological Network has currently progressed to the stage of a strategic proposal. Elaborating this broad framework into a detailed, implementable proposal requires an array of further actions, including the following:

- developing an operational checklist of threatened ecosystems
- elaborating the ecological network at the scale of natural zones and also at the local level
- updating the national Red List
- developing a scientific methodology for weighing species richness and diversity
- developing methodological guidelines for environmentally appropriate land use
- identifying critically degraded areas that require urgent conservation action
- adopting policy instruments for designating restoration areas.

A special challenge concerns the reform of Moldova's legislation in order to establish a legal, policy and administrative framework and set of instruments that are suited to the particular characteristics of the ecological-network approach to biodiversity conservation and sustainable use. The most important needs are:

- extending regulations for designating and managing land in the interests of biodiversity conservation and the sustainable use of private land
- introducing a broader range of instruments to promote appropriate forms of land use and management
- introducing the possibility of compulsory purchase of land for conservation purposes.

A bill to introduce the most important amendments to the existing legislation is currently before the Moldavian parliament.

CONCLUSIONS

As the region where the development of ecological networks was pioneered, the experience of Central and Eastern Europe in elaborating the model into detailed proposals and implementation programmes is instructive. The most striking aspect of this experience is the long period that has elapsed between the original proposals and implementation on the ground, which even in the most advanced country — Estonia — will take many more years. However, as the examples show, there are good reasons why the implementation process has proven to be so protracted.

Of course, as pioneers of ecological-network programmes, countries such as Estonia, Lithuania and Czechoslovakia could not draw on experience elsewhere as a guide to how to translate a model of environmental management into reality: no blueprints were available as reference material, scarce resources had to be allocated, novel scientific and methodological issues had to be resolved, other stakeholders had to be convinced of the approach, pilot projects had to be carried out and an implementation programme had to be devised.

A further complication followed from the characteristics of the particular ecological-network model that was developed in Central and Eastern Europe. The key feature of the landscape-stabilization concept is its integrated approach to environmental management. To a large extent this model strives to achieve what subsequently became known as sustainable development. It therefore requires far broader, complex and structural measures than those that focus primarily on the conservation and sustainable use of priority habitats.

It is also important to note that all the early ecological-network initiatives were developed through government programmes. Moreover, given the prevailing dominance of planned economies and powerful state institutions during the period when the networks were first developed,

their implementation inferred the adoption of a wide range of legislative and planning measures. Such processes are necessarily time-consuming.

However, this process was disrupted by the revolutionary political changes that took place across the entire region at the end of the 1980s. Not only did the changes lead to a radically different institutional and economic architecture in most countries in the region, they were accompanied by economic decline and a drastic fall in the resources available to the public sector. Under these circumstances, the continued development of ecological networks was given a low priority. It was only after the agreement in 1995 to develop and establish the Pan-European Ecological Network that the existing programmes were revived, albeit with a greater focus on biodiversity conservation at the expense of the broader sustainable-development framework. However, to this day resources and weakened government institutions remain severely limiting factors.

Interestingly, whereas one international agreement — the Pan-European Biological and Landscape Diversity Strategy — stimulated the further development of ecological networks in Central and Eastern Europe, another — the EU's representative system of protected areas known as Natura 2000 — obliged those countries in the region that applied for membership in the EU to focus their limited biodiversity-conservation resources on adapting their protected-area systems to comply with the new requirements. Although Natura 2000 marks without doubt the most important advance in protecting valuable sites and species populations in Europe, it has also obliged EU member states and candidate countries, given their scarce resources, to direct their policies and a substantial proportion of their biodiversity-conservation funds to ensuring its implementation rather than developing broader, more integrated approaches to biodiversity conservation and environmental management.

These many obstacles have combined to ensure that none of the early ecological-network programmes has yet been fully implemented. Nevertheless, it is significant that progress in developing ecological networks in Central and Eastern Europe is continuing, notably in the Baltic countries. Most important, in addition to the networks that were under development in the 1980s, several new programmes have been initiated by governments within the framework of the Pan-European Ecological Network. Moreover, in Russia WWF has launched a series of regional ecoregion-conservation projects that use the ecological-network model as a strategic framework for conservation action. The fact that an NGO is now an important driver in establishing ecological networks in the region is a significant development, although it is clear that the task of managing the associated stakeholder processes is proving to be a major challenge in each project.

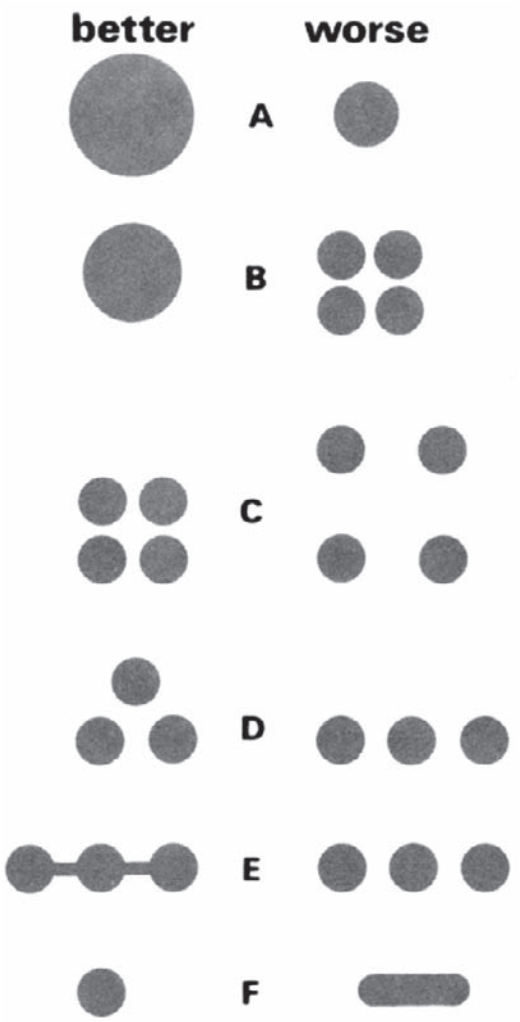
3. WESTERN EUROPE AND OTHER COUNTRIES

In contrast to Central and Eastern Europe, the stimulus that led to the ecological-network model in Western countries came primarily from developments in ecological theory. In 1967 Robert H. MacArthur and Edward O. Wilson published their equilibrium theory of island biogeography (MacArthur and Wilson, 1967). MacArthur and Wilson concluded that the number of species that can be found on an island is determined by the balance between the rate at which new species colonize the island and the rate at which species become extinct. Thus, islands closer to the mainland will harbour greater numbers of species than remote islands because they are more accessible and therefore subject to higher rates of immigration. Further, larger islands contain larger populations of species than smaller islands, and these populations are therefore less vulnerable to extinction. Equilibrium theory therefore predicts that, other things being equal, larger islands that are closer to the mainland will contain more species.

The significance of island biogeography for biodiversity conservation was augmented in the early 1970s with the introduction of the concept of metapopulations (see, for example, Gilpin and Hanski, 1991). According to this concept, species do not exist as stable, homogenous populations, but rather are dynamic entities that are distributed unevenly across landscapes in habitats of varying quality. Local populations are vulnerable to extinction, but as long as individuals from other local populations can recolonize the empty habitat, the metapopulation can continue to survive. These insights led in turn to the inference that habitat fragmentation increases the vulnerability of species populations by reducing the area of habitat available to local populations and limiting opportunities for dispersal, migration and genetic exchange.

The realization that island biogeography and the concept of metapopulations offered important lessons for biodiversity conservation was given practical form in the mid-1970s when Jared Diamond and others proposed general rules for the configuration of nature reserves (Diamond, 1975). In simple terms, these rules stated that nature reserves should be as large as possible, as round as possible (in order to reduce damaging edge effects), as close as possible to each other, and as far as possible connected with each other. The impact of these rules was increased when the principles were included in IUCN's World Conservation Strategy (IUCN, 1980; see Figure 3.1).

Figure 3.1. Jared Diamond's rules for the design of nature reserves



Following these developments, interest grew in Western countries in developing conservation approaches that promoted ecological coherence at the landscape scale. In Western Europe, the concept of wildlife corridors was introduced into regional planning in Denmark, and in 1990 the Dutch government adopted a plan for a national ecological network. From 1995 the agreement to establish the Pan-European Ecological Network stimulated many new national programmes. In the US, various independent proposals to establish linkages between protected areas were published in the 1980s, and in 1991 the Wildlands Project was launched with the goal of securing an interconnected system of protected areas across North America that can ensure the survival of all native species in the context of fully functioning ecosystems. In Australia, the value of maintaining corridors in fragmented habitats became quite widely recognized in the 1980s, such as in the 1989 code of practice that regulated logging in Victoria. More recently the broad-based, nationwide WildCountry Project has been launched. The result is that, as in Central and Eastern Europe, ecological-network programmes can be found in a substantial proportion of Western countries.

Although virtually all the ecological-network programmes in Western countries are framed within biodiversity conservation objectives rather than broader environmental management strategies, there is a sharp distinction between Western Europe and North America with regard to the context within which the networks are being developed. Thus, virtually all the programmes in Western Europe are being developed and implemented primarily through government policy processes. Only a small number — primarily WWF's ecoregion projects — are driven by NGOs, although even these initiatives aim to achieve a significant part of their objectives through policy measures. In North America, by contrast, the approach is almost the exact opposite: virtually all the ecological-network programmes have been initiated by and are being managed by NGOs. These programmes aim to achieve their objectives primarily through broad stakeholder processes and private action, relying to an important extent on citizen support. Australian experience lies more or less between these two extremes, with both regional government measures and NGO programmes.

OVERVIEW OF THE PROGRAMMES

Western Europe

In Western Europe six countries have initiated nationwide ecological-network programmes:

- Netherlands (see box)
- Denmark: through county-level plans although implementation has been patchy, and recently through an initiative for a national Nature Network by the Danish Society for Nature Conservation
- Switzerland: the National Ecological Network
- Germany: through state-level ecological networks under the Federal Nature Conservation Act 2002, and expert recommendations for the implementation of ecological networks (Burkhardt *et al.* 2003; 2004)
- Italy: the National Ecological Network (although the network is currently in a preliminary phase, research being limited to vertebrate species — see box)

There are, however, a larger number of regional programmes. These include the following:

- United Kingdom: the Forest Habitat Network in Scotland and the Cheshire ECOnetwork
- Belgium: the Flemish and Walloon Ecological Networks
- Germany: ecological networks in Schleswig-Holstein, Rhineland-Palatinate and Bavaria

The Netherlands: The National Ecological Network

The Dutch government decided in 1990, following a multi-year research programme, to develop a National Ecological Network that could provide the long-term basis for ecological sustainability throughout the country. Given the scale of the initiative, establishing the network is a long-term enterprise, with full implementation scheduled for 2018.

The National Ecological Network as originally adopted in 1990 was an "oversized" indicative map of core areas, nature development areas and corridors. It is the task of the 12 provinces to delineate the precise boundaries of the network. This will be done using 132 habitat and landscape types for which minimum aggregate total areas have been fixed at the national level. The final network is intended to cover about 730,000 hectares, or 17.5 percent of the Dutch countryside.

Ministry of Agriculture, Nature and Food Quality

The realization of the ecological network requires cooperation between a wide range of stakeholders: national, provincial and local governments, protected-area managers, water authorities, farmers, foresters, other land owners and business. Three forms of land management are being applied in order to create the ecological network: protected areas of national or international importance, privately owned areas managed for nature conservation purposes (often agricultural land) and nature development areas. In addition to government regulations and local development plans, financial instruments such as subsidies and payments through voluntary agreements with land owners play an important role in securing implemention.

An example of how the ecological network is being implemented is the restoration of a corridor known as the Renkumse Poort. The aim of the Renkumse Poort project is to restore three ecological linkages that connect the raised wooded area known as the Veluwe in the central part of the Netherlands with the Rhine River to the south. Restoring the linkages will increase the habitat available to local populations of wild boar, red deer, small mammals, reptiles and amphibians. However, several obstacles will need to be overcome, such as two motorways and a railway. An industrial complex in the Renkum brook valley has already been demolished and the site is being restored to natural wet grassland.

The Renkum brook valley before restoration

After restoration

Dutch Ministry of Agriculture, Nature and Food Quality/Pandion Arnhem

Italy: Ren, The National Ecological Network

In 1999 the Italian Ministry of Environment and Territorial Protection approved a document outling the general guidelines for the National Ecological Network (REN), the definition of its structure and its main objectives. The Ministry contracted the Department of Animal and Human Biology of La Sapienza University to carry out the first phase of a programme to develop the network. This programme was started in 2000 and has three main aims:

- to outline the distribution patterns of all 431 Italian vertebrate species
- to determine whether the protected-area system corresponds with these distribution patterns
- to determine which actions would improve the effectiveness of the protected-area system and the conservation of these species

Data on species distribution and habitat suitability were combined to produce a map that shows the degree of suitability for increasing numbers of vertebrate species. This map is intended to form the basis for the design of the ecological network. In general, it is concluded that mountain areas, especially the Alps and the Appenines, will be most suitable as core areas for all vertebrate species.

Italian Ministry of Environment/University of Rome "La Sapienza"/Institute of Applied Ecology

- Italy: the planeco Project in the Central Appenines
- France/Spain: the Cantabric-Pyrenees-Alps Great Mountain Corridor, an initiative of the Spanish Territory and Landscape Foundation
- Spain: RENPA, the Andalusian ecological network (see case study 4)

At the international level in Europe, three ecological networks are under development: the Pan-European Ecological Network (see Central and Eastern Europe for more information), the Transnational Ecological Network (TEN, a cooperative project between regional governments in the United Kingdom, the Netherlands, Germany and Denmark that is focusing on wetlands and aquatic ecosystems) and the Green Belt (intended to stretch along the entire border region of the former Iron Curtain — see box).

It can also be noted that the principle of connectivity is included in the EU's most important biodiversity conservation legislation, the 1979 Birds Directive and the 1992 Habitats Directive. These directives provide for the establishment of a representative system of legally protected areas throughout the EU known as Natura 2000. Natura 2000 now consists of about 20,000 sites covering approximately 17 percent of the EU's territory. The number of sites and their total area is still increasing. Although Natura 2000 was conceived as a system of protected areas, the value of connectivity is recognized in the Habitats Directive. Article 10 provides that "Member States shall endeavour, where they consider it necessary … with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species. As is clear from the text, the decision to take such measures lies at the discretion of each country. Where the achievement or maintenance of "favourable conservation status" is only possible by improving connectivity, this can be regarded as a binding obligation. Additional legal references to coherence and/or networks can be found in the Preamble, Articles 1, 2, 3, 4(4) and 6(4) and in Annex III Stage 2 of the Habitat Directive. In the Birds Directive, the Preamble and Article 4(3) require a "coherent whole" of the network of protected sites. In practice, although the sites designated under the Birds and Habitats Directives form a sturdy basis for an EU-wide ecological network, few corridors have been established as a formal part of Natura 2000. Discussions on the implementation of Article 10 are, however, underway with a view to using corridors as a means of strengthening the conservation status of Natura 2000 sites.

With regard to related initiatives, WWF is carrying out the following terrestrial ecoregion projects in Western Europe:

- the Alps
- the Dinaric Alps (Croatia/Bosnia-Herzegovina/Serbia)
- Mediterranean forests, woodlands and scrub (southwest Iberia and the northwesten Morocco Lowlands, the Baetic-Atlas Mountains, the Italian Peninsula and the South Thyrrenian Sea)

A large-scale non-ecoregion project is also underway in the Fenno-Scandian Alpine tundra and taiga of northern Europe.

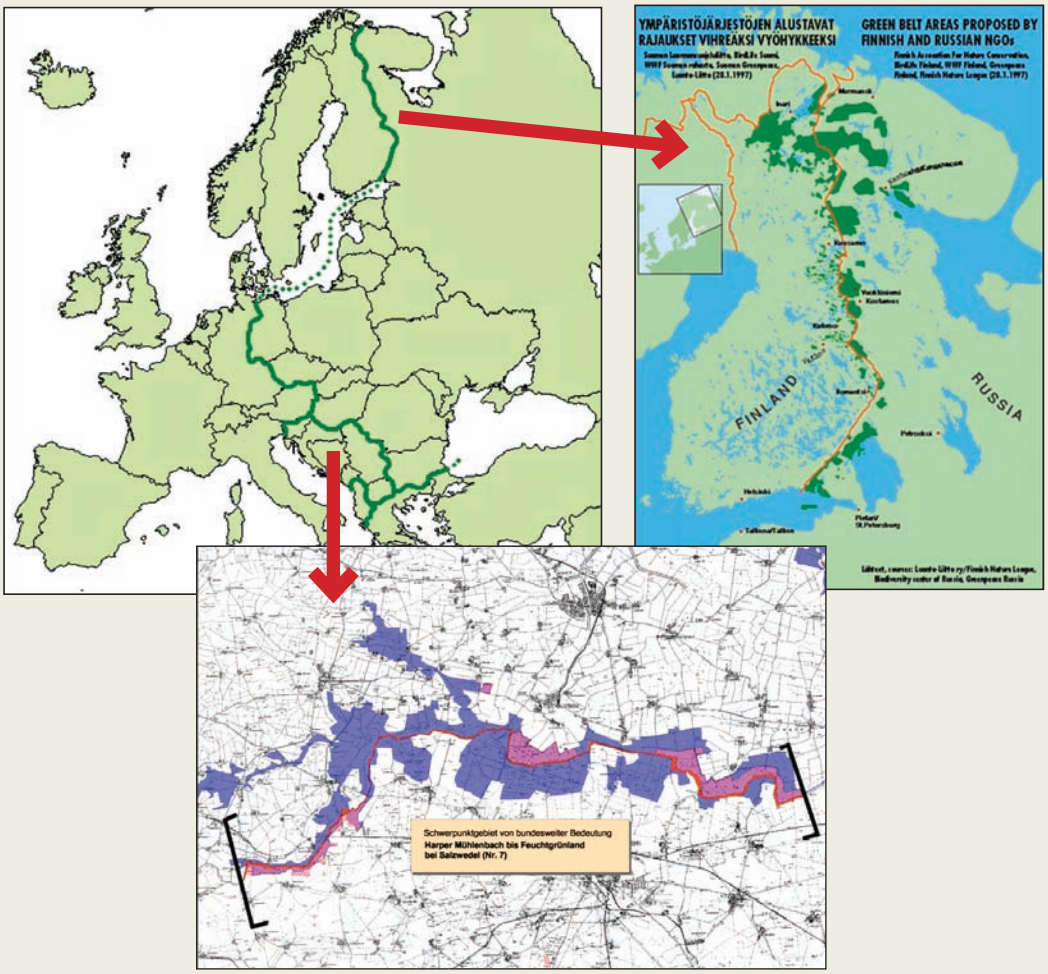
The Former Iron Curtain: The Green Belt

The aim of the Green Belt programme is to maintain and enhance the biodiversity value of the relatively undisturbed strip of land that bordered the former Iron Curtain. This strip runs in two sections divided by the Baltic Sea from the border between Norway and Russia at the northern tip of Europe to the coasts of the Adriatic Sea and the Black Sea in the south.

Launched in 2004 by the German Federal Agency for Nature Conservation (BfN) and IUCN, the corridor is to be created through joint projects along the Green Belt with the support of the respective countries and other partners. The structure of the corridor will differ depending on the circumstances in each region. In some areas the Green Belt will be a continuous strip of land constituting part of existing or new protected areas; in other areas it will be established by linking transfrontier protected areas and protecting other priority transfrontier habitats. Examples of how the Green Belt can be configured have been developed for the northern section along the Finnish-Russian border and for part of the former border between West and East Germany.

A conference of the Green Belt countries, held in September 2004, adopted a work programme with three components:

- direct actions for the establishment of the Green Belt
- participation and the institutional structure of the Green Belt
- enabling activities



IUCN — The World Conservation Union/German Federal Agency for Nature Conservation/Finnish Association for Nature Conservation/BirdLife Finland/WWF Finland/Greenpeace Finland/Finnish Nature League

North America

In North America the principal ecological-network driver is the Wildlands Project. Launched in 1991, the initiative aims to protect and restore the natural heritage of North America through the establishment of a connected system of "wildlands", that is "reserve networks" comprising core areas, corridors and buffer zones (Noss, 1992). This is to be achieved through:

- conserving a representative system of native ecosystems;
- maintaining viable populations of all native species in their natural habitats;
- maintaining ecological and evolutionary processes;
- ensuring adequate resilience of ecosystems and species.

The Wildlands Project operates by promoting the ecological-network concept, advancing methodologies and providing support to regional and local initiatives. This support comprises scientific research, conservation-planning methodologies and promoting partnerships with grassroots and national conservation organizations, government agencies, indigenous peoples, private landowners, naturalists, scientists and conservationists (see, for example, Soulé and Terborough, 1999). The following Wildlands projects have progressed to the preparation of a complete plan:

- Heart of the West Wildlands Network Design, located in the Rocky Mountains and developed in collaboration with several other NGOs, including the Wild Utah Project and the Biodiversity Conservation Alliance;
- Southern Rockies Wildlands Network Design, developed in cooperation with the Southern Rockies Ecosystem Project and the Denver Zoo (see box);
- New Mexico Highlands Wildlands Network Design, located at the juncture of the Rocky Mountains, the Great Plains, the Chihuahuan Desert and the Great Basin;
- Sky Islands Wildlands Network Design, covering parts of Arizona and New Mexico (in collaboration with Naturalia, a Mexican NGO, work is underway to extend the network into Sonora and Chihuahua as the Northern Sierra Madre Wildlands Network Design — see below);
- Southern Appalachian Conservation Plan;
- Oregon Coast Range Conservation Plan, completed in the early 1990s and covering a relatively small area.

Several more Wildlands initiatives are working to prepare a plan:

- Yellowstone to Yukon Conservation Initiative (Y2Y), extending along 3,200 kilometres of the northern Rocky Mountains from Wyoming to the Arctic Circle and initiated in collaboration with the Canadian Parks and Wilderness Society (although the project has since become an independent entity) — see also Tabor and Locke (2004)
- Northern Sierra Madre Wildlands Network Design, a project launched in collaboration with the Mexican NGO Naturalia
- Grand Canyon, an initiative still in an early phase
- Colorado Plateau, again an initiative that is in an early phase
- Northern Appalachians Wildlands Network Design, an initiative launched by a coalition of US and Canadian partners covering the New England states, the Adirondack Mountains of New York, Nova Scotia, parts of Newfoundland, Ontario and Quebec.

- Oceans of Grass Wildlands Network, focusing on the plains of Alberta, Saskatchewan, Montana, Wyoming and North and South Dakota
- Florida Conservation 2000, an initative that has been taken over and revised by the Florida Nature Conservancy and the state of Florida

The work of the Wildlands Project focuses primarily on North America's "megalinkages", the continental-scale linkages that run north-south and east-west. Within each megalinkage, initiatives are taken to develop a cluster of ecological networks. For example, in the Spine of the Continent megalinkage running north to south from Alaska through the Rocky Mountains to Central America, six contiguous networks are under development: Yellowstone to Yukon, Heart of the West, the Southern Rockies, the New Mexico Highlands, the Sky Islands and the Northern Sierra Madre.

In addition to the work by the Wildlands Project, several other regional ecological-network initiatives are underway in North America. These include the following:

- Conception Coast Project (California): the initiative covers a relatively small region and is still in an early phase.
- Southern California Coastal Sage Scrub Natural Community Conservation Plan (California): the initiative again covers a relatively small region with an emphasis on strengthening connectivity.
- Klamath-Siskiyou Bioregional Conservation Plan (California and Oregon): the proposal covers a relatively small region and the descriptive phase has been completed.
- Ecosystem Recovery Project (Minnesota): this initiative is still in an early phase.
- Corridors of Life (Montana): carried out by the NGO American Wildlands, the initiative is primarily focusing on connectivity planning and implementation and is located within the Y2Y region.
- Southeastern Wildlands Project (Florida).
- Bioreserve Network (Southern Appalachians): a plan has been prepared (which is also the South Appalachian Biosphere Reserve, SAMAB).
- Regional Reserve Network (British Columbia): plans have been prepared by the NGO Round River Conservation Studies for the Great Bear Rainforest and the coastal forest and mountains (in collaboration with the Transboundary Watershed Alliance, the Nature Conservancy of Alaska and the Nature Conservancy of Canada).

With regard to WWF initiatives, the following terrestrial ecoregion projects are being carried out in North America:

- the Northern High Plains
- the South Florida ecosystem
- the Klamath-Siskiyou coniferous forests
- southeastern rivers and streams

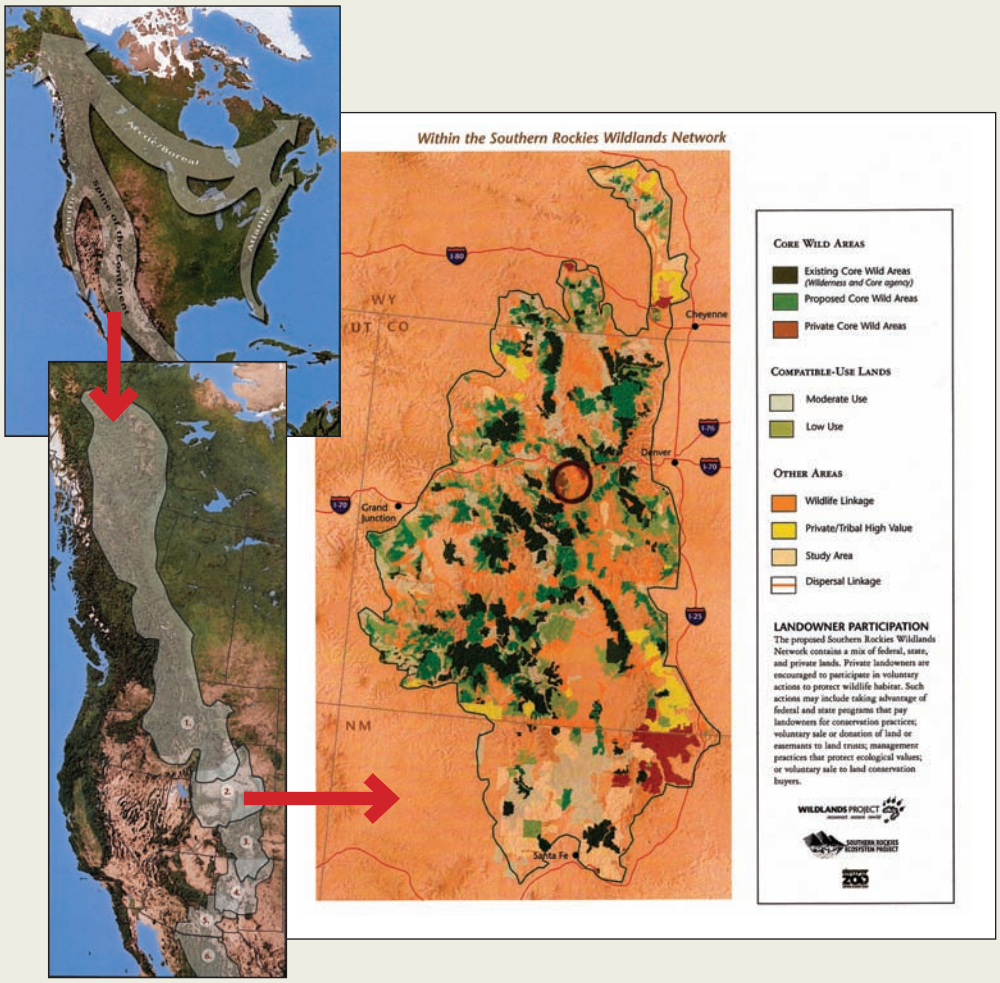
A further 10 to 15 NGO ecological-network initiatives in the US have failed to progress beyond the original proposal for lack of funding, a problem that has become exacerbated for many US NGOs in recent years.

The United States: The Southern Rockies Wildlands Network

The Southern Rockies Wildlands Network is one of a series of six contiguous ecological networks that the Wildlands Project is developing along the Rocky Mountains. From alpine tundra to ponderosa pine forests and sagebrush grasslands, over 500 vertebrate species find their home in the Southern Rockies. A rich variety of plants and invertebrate species can also be found within its borders. Over 270 butterfly species and 5,200 moth species make the Southern Rockies the second leading hotspot in North America for the insect order Lepidoptera. One of the biggest threats to the region's biodiversity is the exceptionally high population growth rate and the accompanying residential development. Scattered, low-density development is fragmenting habitat, particularly in many mountain valleys and foothill forests.

A proposal for an ecological network has been prepared based on the principal design elements of large core areas, functional connectivity, keystone species and processes, ecological restoration, ecosystem representation, conserving special elements and focal species planning. The preparatory work was carried out by the Southern Rockies Ecosystem Project in collaboration with the Denver Zoo, with assistance from the Wildlands Project and support from 23 environmental organizations and private foundations.

The Southern Rockies Wildlands Network encompasses federal, state and private land and is built up primarily from core wild areas, compatible-use areas and linkages. Establishing the network will require a mix of actions: government policy, private partnerships, public support and cooperation with tribes and pueblos. The current proposal includes an indicative programme of actions, but securing the necessary commitment from the wide range of stakeholders will clearly be a major challenge (Miller *et al.*, 2003).



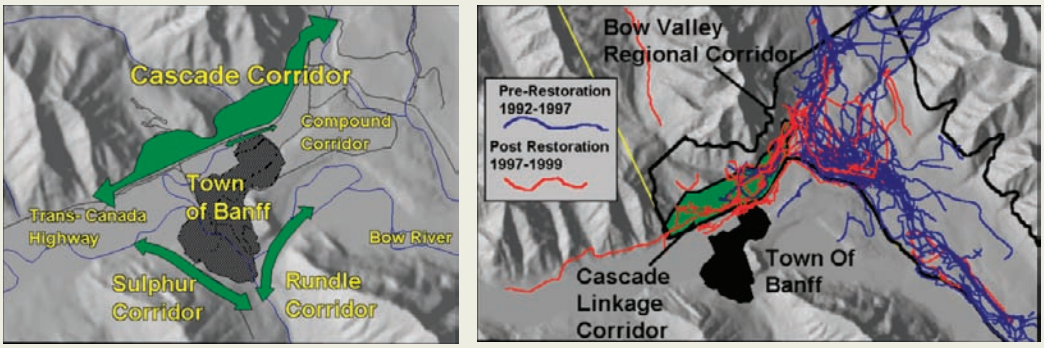
The Wildlands Project/Southern Rockies Ecosystem Project/Denver Zoo

Canada: The Bow Valley Wolf Corridor

The Rocky Mountains are North America's last remaining intact mountain ecoregion. However, local extinctions and endangered species are causing serious and increasing concern. Among the most striking of the species under threat is the wolf. In the central Canadian Rockies, the rugged nature of the terrain forces wolves to confine their movements to low-lying valley bottoms. Rivers and passes therefore function as natural linkages. This can clearly be seen in the Bow River Valley in Alberta's Banff National Park, a linkage that offers the highest-quality habitat for wolves in the central Canadian Rockies and permits the movement of wolf packs between Canada and the US. In recent years, increasing development has severely disrupted the opportunities for wolves to move through the valley.

The Cascade Corridor, one of three routes around the town of Banff that are available to wolves, offers the greatest potential for movement. Wolves made little use of the route before 1997 because of the moderate-to-high level of human intrusion in the linkage, which included a hotel, ski access road, buffalo paddock, barns, horse corrals, an airport and a military training facility. Because of the regional importance of the linkage in facilitating the movement of wolves, however, Parks Canada agreed to take action to reduce the intensity of human activities. As a result, in 1997 the buffalo paddock and several barns and horse corrals were removed, and the airstrip was closed to all air traffic except emergency landings. The actions also reduced associated recreational activities and vehicle use in the linkage.

Following these actions, monitoring showed that the relative movement of wolves through the Cascade Corridor increased sevenfold in the period 1997–1999 compared with the period 1993–1997, an increase substantially greater than had been hypothesized. Moreover, not only was the intensity of movement through the Cascade Corridor far greater, the improved connectivity seemed to allow the Cascade wolf pack to expand its range: the home range of the pack increased in extent to include four more valleys, expanding from 607 to 1,847 square kilometres (Duke *et al.*, 2001; Duke, 2001).



Danah Duke

Australia

Programmes designed to retain and promote landscape connectivity in Australia date back to the 1980s (several examples are described in Bennett, 1998). In the main, these programmes were directed at repairing the disruption caused to specific habitats or local species populations by fragmentation of tracts of land that have single or only a few owners, which in most cases is public land (Bennett and Lowe, 2002). To date it has proved more difficult to expand these initiatives from local projects to regional-scale networks in the heavily cleared agricultural environments where biodiversity remains primarily as relicts and fragments. In 2000, however, a nationwide initiative, WildCountry (see case study 3), was launched by the Wilderness Society Australia in

partnership with government authorities, NGOs, business and private landowners. The aim of the proposal is to halt the continuing degradation of the continent's biotic diversity through a science-based vision that integrates existing conservation programmes into a coherent, interconnected system of core areas and promotes the appropriate management of other land and aquatic systems. The general approach and methodology that is being applied by the Wilderness Society is based largely on that developed by the Wildlands Project in North America.

An example of a large-scale ecological network that is being built on existing protected areas is the Australian Alps and the Great Escarpment of Eastern Australia corridor system. In 1996 a South East Forests National Park for Southeastern New South Wales was established on public land. The decision also designated a conservation corridor that interconnects protected areas for over 150 km along the Great Escarpment. An initiative has been taken to extend the corridor to over 600 km. The potential outcome is an continuous conservation corridor along the Great Escarpment from the Victorian border to central New South Wales (Pulsford *et al.*, 2004).

Finally, a bioregional-planning project has been launched in the Fitzgerald River National Park in Western Australia (Watson, 2005), and WWF is carrying out an ecoregion project in the southwestern forests and scrub region.

Other International Programmes

Actions to protect the transboundary linkages used by migratory species is the special focus of the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention). Under the Convention, a series of agreements and memoranda of understanding have been adopted by range states with the aim of conserving threatened migratory species or those with an unfavourable conservation status, including their habitats. Four agreements concerning the conservation of terrestrial or coastal species and birds have been adopted to date (which are grouped together here since a substantial proportion of the range states are Western countries):

- European bats (48 European range states)
- seals in the Wadden Sea (three range states)
- African-Eurasian migratory waterbirds (117 range states in Africa, Europe, Canada, Central Asia and the Middle East)
- albatrosses and petrels (25 range states in the Southern Hemisphere, including European, African, Asian and South American countries)

In addition, memoranda of understanding have been concluded with the respective range states with the aim of conserving the following species:

- the Siberian crane (12 range states, primarily in Asia)
- the slender-billed curlew (30 range states in Southern and Eastern Europe, Northern Africa and the Middle East)
- marine turtles of the Atlantic coast of Africa (26 range states along the Atlantic coast of Africa
- marine turtles of the Indian Ocean and Southeast Asia (41 range states around the Indian Ocean and Southeast Asia and adjacent seas)
- the middle-European population of the great bustard (17 range states in Central and Eastern Europe)
- the Bukhara deer (four range states in Central Asia)
- the aquatic warbler (14 range states in Europe and Africa)

UNESCO's Man and Biosphere programme has designated 155 sites in Western and other

countries as biosphere reserves, including one transboundary reserve.

CASE STUDY 3
AUSTRALIA: WILDCOUNTRY

Australia is home to a remarkably diverse and unique natural heritage. However, over the past two centuries more native species have been lost here than in any other country. Today over 1,500 species are threatened with extinction, and Australia has the greatest number of threatened reptile and amphibian species. Despite this decline, the country remains one of the world's richest centres of biodiversity. For example, more endemic animal species can be found in Australia than in any other country.

In response to these challenges, WildCountry is using landscape ecology to improve understanding of the large-scale ecological connections that still remain in place across huge areas of the continent and which will form the basis of the conservation approach. Seven categories of ecological phenomena have been identified that require landscape connectivity and are crucial to biodiversity conservation (Soulé *et al.*, 2004; Mackey *et al.*, 2005):

- Highly interactive species. A priority is to maintain the dispersal and migration of these species, such as water birds, pollinators and animal dispersers of seeds and fungal spores.
- Long-distance biological movement. For example, 30 to 60 percent of Australian woodland and open-forest birds are non-residents, and their persistence in a region may depend on seasonal migration or episodic movement that is related to highly irregular precipitation patterns.
- Local and regional disturbance events. Disturbance may be a natural process (such as foraging by feral carnivores) or caused by human activities (such as logging). Maintaining connectivity will facilitate the continuation of natural disturbance events and permit escape from human-induced disturbances.
- Climate change. Although the regional impact of climate change is difficult to predict, it seems likely that climatically driven biome changes cannot be accommodated by small or isolated protected areas. This infers the need for large, contiguous areas that allow movement and flows at the regional scale.
- Hydroecology. The scarcity of water over much of Australia makes it a critical natural resource. The interruption of catchment processes can therefore have catastrophic effects on regional and continental ecological phenomena.
- Coastal-zone fluxes. The concentration of human populations along Australia's coastline, combined with the sensitivity of many coastal systems such as estuaries and coral reefs, is imposing considerable pressure on ecological and behavioural processes.
- Spatially dependent evolutionary processes. These processes can require the movement of organisms over long distances. Examples include new genetic variants that evolve through range expansion and, in the longer term, speciation.

These considerations have led WildCountry to shape a conservation approach that aims to integrate the needs of nature with the demands of human use by strengthening ecological processes and environmental flows. The programme's focus is therefore on maintaining and restoring ecological connections in the landscape. Specifically, the management approach will apply the following principles:

- networks of core areas will build upon the criteria of comprehensiveness, adequacy and representativeness
- biodiversity conservation assessment and planning should aim for the maintenance and restoration of large-scale ecological and evolutionary processes over the entire landscape
- the network should be buffered from sources of disturbance and incorporate where appropriate complementary land uses and management
- degraded landscapes must be restored, particularly in the intensive land-use areas
- long-term ecological connectivity will be facilitated, which will remain an ongoing research and development challenge.

The WildCountry programme is currently working in five regions: northern Australia, Cape York Peninsula, the Gondwana Link, the Western Wilderness and western Victoria. The Gondwana Link is a good example of the approach. Southwestern Australia is regarded as one of the world's top 25 biodiversity hotspots. However, as a result of agricultural expansion two thirds of the vegetation has been cleared, leaving less than 10 percent of the original bushland. The removal of deep-rooted vegetation has left the resulting agricultural land very fragile; moreover, over 30 percent of the agricultural land is threatened by salinity. It is now widely recognized that 30 to 40 percent of this area needs to be covered by perennial woody vegetation if it is to remain stable.

The five largest areas of high biodiversity value in the region are along the south coast, where about six million hectares of public land were saved from the spread of agriculture in the early 1980s. Together, these areas form the last remaining link between the wet forests in the continent's southwestern tip through to the dry inland. This connection provided a vital opportunity for fauna species to move between seasonal

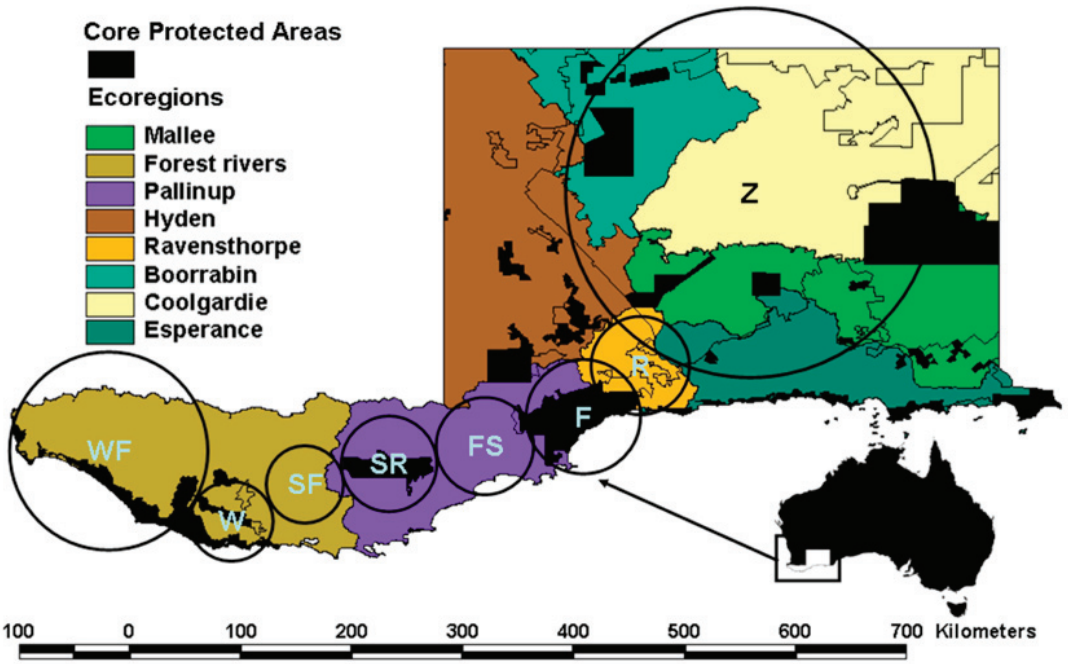
Figure 3.2. The five WildCountry projects

WildCountry

feeding areas, offering critical nectar and pollen during the dry late-summer and early-autumn period. However, the farmed areas form barriers to this movement with the result that population levels of many species have dropped across the entire "wheatbelt".

Five NGOs — the Australian Bush Heritage Fund, the Fitzgerald Biosphere Group, the Friends of the Fitzgerald River National Park, Greening Australia and the Wilderness Society — are cooperating within the WildCountry framework to partially restore this vital pattern of movement into and across south-coast plant communities. By doing so, resilience to climate change will also be improved, since current predictions are for a warming of the southwest region over the next 50 years with a significant decline in winter rainfall. To achieve this goal, it is proposed to remove areas least suited to agriculture from production (which are already economically marginal or unviable) and to develop and demonstrate the potential for other land-use options that have commercial value, such as sandalwood growing, dry-country forestry (that is, bush poles and brush fencing) and bush foods. One of the first actions is a cooperative project with the state

Figure 3.3. The Gondwana Link proposal



GONDWANA LINK CORE NATURAL AREAS
W - Walpole Wilderness; SR- Stirling Range NP; F- Fitzgerald NP; Z- Goldfields Woodlands
GONDWANA LINK RESTORATION AREAS
WF- Southern (Wet) Forests; SF- Stirlings to Forest; FS- Fitzgerald-Stirling;
R- Ravensthorpe Connection;

WildCountry/Australian Bush Heritage Fund/Fitzgerald Biosphere Group/Friends of the Fitzgerald River National Park/Greening Australia/Wilderness Society

government to secure the Walpole Wilderness Area — over 200,000 hectares of forest where the Gondwana Link corridor meets the wetter forest areas.

CASE STUDY 4
SPAIN: THE GUADIAMAR GREEN CORRIDOR

On 25 April 1998 the retaining dam of the lagoon containing tailings from the Aznalcóllar pyrite mine in Andalusia failed, releasing about six million cubic metres of toxic sludge into the Agrio and Guadiamar River Basin. Significant flooding occurred along the Guadiamar River and the spill threatened the nearby Doñana marshes — world famous as a World Heritage Site, a Ramsar Site, a Biosphere Reserve and an Important Bird Area. Fortunately the national park was not directly affected, but the aquatic fauna of the Guadiamar River were almost totally exterminated and sludge deposits of up to three metres thick were left along 40 kilometres of the watercourse.

Soon after the disaster, the regional government of Andalusia approved a proposal to mitigate the impacts and restore the river ecosystem. A year later, in June 1999, the Strategy for the Guadiamar Green Corridor was established at a specially organized international seminar

(Secretaría General Técnica, 2000). Interestingly, the goal of the strategy was not only to remedy the damage caused by the spill but also to restore the Guadiamar River as an ecological connection between the Sierra Morena mountains and ecosystems along the Atlantic coast. The Guadiamar Green Corridor will also form part of the Andalusian ecological network (RENPA), which is currently under development and aims to build the areas designated as EU Natura 2000 sites into an interconnected network (Vázquez, 2003).

The Guadiamar River is one of the few rivers in Andalusia that still retains its natural Mediterranean regime of high winter and low summer flows. Serious fragmentation of the Guadiamar basin dates back many decades. However, the process has accelerated in recent years, primarily as a result of the increasing predominance of arable farming at the expense of old olive groves. An important consequence of this process was that the former intricate land-use matrix became transformed into a far simpler and homogeneous landscape. In addition, industrial and housing developments have caused serious fragmentation in the central and lower parts of the river basin.

Recreating the regional ecological function of the river basin requires both direct restoration of the areas directly affected by the spill and actions to increase connectivity at local and regional scales. Five specific measures are being undertaken with the aim of achieving these objectives (Arenas Cabello, 2003; see also Figure 3.5):

1. Improving connectivity. The priority is to reconnect the northern part of the Green Corridor and the Sierra Morena mountains. Monitoring studies of small mammals show relatively limited movement in this area. Restoration works are directed mainly at reforestation and the replacement of eucalyptus stands with indigenous tree species.

Figure 3.4. Schematic representation of the main linkages in the Guadiamar river basin

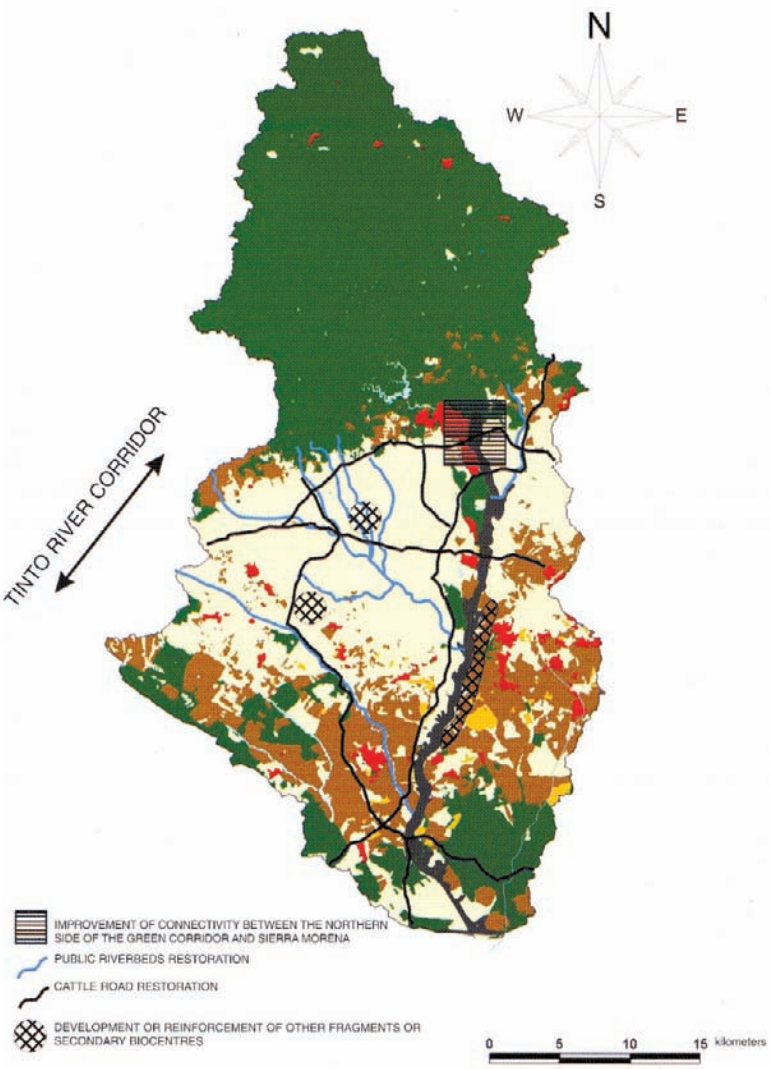
Andalusian Ministry of Environment

2. Restoring streams. The linking role of the smaller rivers is especially important in the central area of the basin. In addition, priority will be given to the headwaters of the Guadiamar River and the two western tributaries, the Alcarayón and the Agrio. Attention is also being given to the Tinto River to the west because of its important ecological relationship with the Guadiamar River.

3. Restoring drovers' roads. An extensive network of of drovers' roads has existed in Spain for centuries, enabling livestock to be moved seasonally both north–south and between low- and high-lying ground. These tracks have come to provide an important semi-natural corridor function, particularly with regard to the dispersal of herbaceous species.

4. Improving connectivity across the transport infrastructure. Several roads and railways have created barriers to the movement of species, particularly the A49 motorway and the Seville-Huelva railway. The construction of ecoducts and other measures to increase their permeability to ecological flows is under consideration.

Figure 3.5. The Green Corridor plan



Andalusian Ministry of Environment

5. Restoring or creating "stepping stones". Many areas of land that are under public ownership or protected as part of the region's cultural heritage offer the potential to be developed as resting and feeding places.

In order to support the formulation of effective measures, a special research programme was established as part of the action plan. This Green Corridor Research Programme (PICOVER) is multidisciplinary in structure and aims to apply the principles of the ecosystem approach through its four main themes: remedying and monitoring the contamination, the design of the Green Corridor, ecosystem restoration and integrating natural and human systems (Arenas *et al.*, 2003).

The integration of natural and human systems is an explicit element of the Green Corridor strategy. This is not only of significance in relation to the need to promote new employment opportunities following the closure of the mines and the loss of 500 jobs, but also to assist in the overall restructuring of the region's economy. Priority here is being given to developing sustainable forms of agriculture (which was seriously affected by the disaster) and promoting recreational and tourist activities. Use is being made of the funding made available through the EU Agri-Environment Regulation and the Community Aid Scheme for Forestry Measures.

The administrative framework within which the measures are being taken is provided through the designation of the Green Corridor as a Protected Landscape under national legislation. Much of the land directly affected by the spill, amounting to about 5,000 hectares, was also taken into public ownership. Funding for developing the Guadiamar Green Corridor programme and implementing the various actions is being provided by four main sources: the national government, the Andalusian regional government, the regional water authority and the administration of the Doñana National Park.

Monitoring shows that important progress has been made in restoring the Guadiamar ecosystem, although the results achieved are very variable. Recovery of fish and amphibians has been generally good. The otter has also recovered well, being present along the entire length of the river, as have some wetland bird populations in the northern part of the basin. Other mammals, such as the badger, the genet and the mongoose, have yet to return to the northern part of the basin in any numbers since they depend on the recovery of vegetation. The wild cat remains limited to the outer margins of the Green Corridor. Moreover it is clear that, given the scale of the pollution disaster and the structural degradation of the ecosystem over many years, full restoration of the basin's ecology will require a long-term commitment and continuing action.

CONCLUSIONS

The large number of ecological networks that are being developed in Western countries share a number of common features and some striking differences. Most obvious is the primary focus on biodiversity conservation rather than the broader goal of sustainable development which characterized the early ecological networks in Central and Eastern Europe. To be sure, securing biodiversity conservation through an ecological network leads to a broad range of accompanying measures which have the aim of reducing impacts on biodiversity, removing ecological barriers and promoting compatible forms of land use. Nevertheless, it is biodiversity conservation that lies at the heart of virtually all ecological networks in Western countries.

However, other factors combine to lead to markedly different approaches between Western Europe on the one hand and North America and Australia on the other. First, in contrast to Western Europe, large areas of wilderness still

exist on both other continents. As a result, wilderness areas are a prime focus for ecological networks in North America and Australia. In North America, the priority accorded to wilderness areas is strengthened by concern to conserve the continent's remaining populations of wide-ranging carnivores. In Western Europe, the most valuable areas in terms of biodiversity are relatively small sites (which, in general, already enjoy a high level of protection) and semi-natural landscapes that have been formed over a period of many centuries through extensive forms of land use: grasslands, field mozaics and coppices, for example. Devising ways of maintaining the traditional forms of management in these areas is a major challenge in Europe.

Another striking distinction between Western Europe and the other two continents is the organizational framework within which ecological networks are being developed. In Western Europe, the traditionally prominent role of government in nature conservation and spatial planning is reflected in the fact that virtually all ecological networks are policy driven. Even where NGOs are taking a pro-active role in initiating ecological-network programmes, they invariably aim to secure action in large part through new government policies. By contrast, in North America and Australia the most important initiatives are driven by NGOs that aim to achieve their goals through broad-based stakeholder processes. At the regional level, where the implementing projects are being undertaken, this includes collaboration with government authorities where possible in order to secure the necessary action in conservation policy and public land management. Nevertheless, it is clear that, to date, the realization of ecological networks in Western Europe has benefited where governments have embraced the model and have used legislative and other policy instruments to secure action on the ground.

It should be noted, however, that one significant advantage of the NGO-driven processes in North America and Australia is that the initiatives can de directed at the ecosystem or ecoregion scale within a continental context rather than being limited to administrative boundaries. In practice this is invariably the case in both North America and Australia, whereas in Western Europe the relatively small size of most countries often prevents the national and regional ecological-network programmes from extending management measures across entire ecosystems. The Pan-European Ecological Networks certainly aims to work in this way, but it is being implemented through national government action and relies on voluntary cooperation. The EU's Natura 2000 scheme, although building an EU-wide representative system of protected areas, has not yet provided for a significant level of ecological coherence. Interestingly enough, some countries have tried to attain this coherence through the Biosphere Reserve concept, with Natura 2000 sites designated as core areas within the larger-scale Biosphere Reserve. Examples include the Gran Cantabrica Biosphere Reserve, which covers the mountain range in northern Spain, and also some existing and planned bioshere reserves in Europe.

4. ASIA AND THE PACIFIC

The principles that underly ecological networks first generated broad interest in Asia during the mid-1990s when developments in Western countries attracted the attention of biodiversity conservation experts in South Korea and Japan. In South Korea, the government published a proposal for the nationwide Countryside Green Network Plan in 1995. In the same year the Ecosystem Conservation Society – Japan organized "The Ecological Network Symposium" in Tokyo in order to present the model to a Japanese audience, an initiative that led to the approach being included in several areas of government policy from 1996. Inspired by developments in Western countries, these programmes adopted a comparable approach.

In recent years, international NGOs have also become active in the region, initiating an increasing number of ecological-network programmes and corridors. WWF has launched a large number of landscape-scale and ecoregion projects in cooperation with governments and international donors. Conservation International is also active through programmes in Cambodia, China, Indonesia, Melanesia and the Philippines. A wide variety of corridors have also been developed in several Asian countries, for example to help conserve flagship species such as the Asian elephant and the giant panda.

OVERVIEW OF THE PROGRAMMES

South Korea's Countryside Green Network Plan was first proposed in a government report in 1995 (Ministry of Environment, 1995) and subsequently included in the country's National Biodiversity Strategy of 1997. The document — a presentation of the ecological-network concept rather than a detailed plan — set out the principles to be applied in developing the ecological network, including explicit reference to Jared Diamond's indicative recommendations for the design of nature reserves, the Biosphere Reserve management approach and a range of foreign examples. The Countryside Green Network Plan foresees the establishment of a national ecological network with a special focus on conserving and restoring the ecosystems associated with South Korea's five major mountain ranges. Interestingly, it is proposed to extend the concept to urban regions. Following the publication of the original concept, the Countryside Green Network has been incorporated into the Revised Nature Conservation Act and the Basic Guideline of Nature Conservation. Since then, work has continued on a proposal to establish the Ecological Network of the Korean Penisula and the Capital Region. A number of local projects have also been carried out, particularly the establishment of corridors and the construction of ecoducts across major highways.

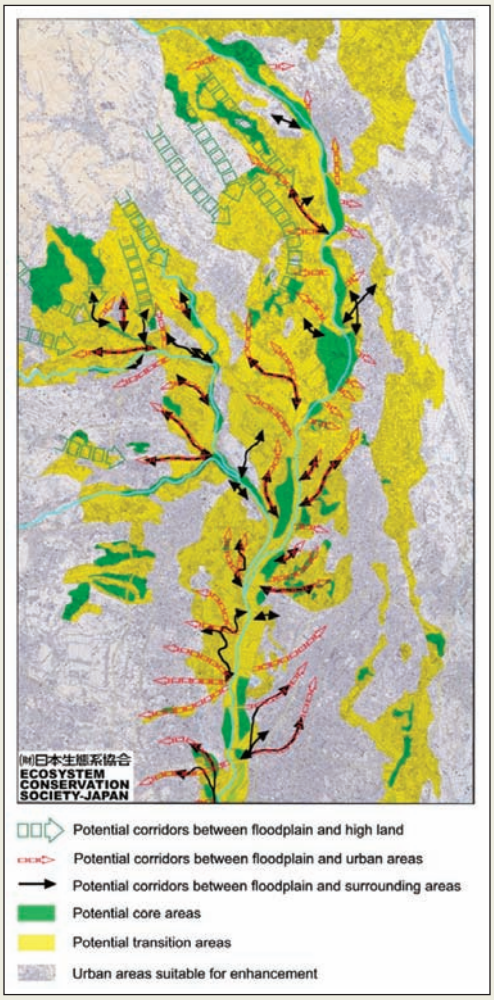
In Japan a growing number of initiatives to develop ecological networks have been taken in recent years at municipal, prefectural, regional and national levels (see box). For example, in 1996 the government decided that, as part of the Third National Land-Use Plan, it would "make efforts to network ecosystems in order to conserve biological diversity", and in the Fifth Comprehensive National Development Plan – Grand Design for the 21st Century that was adopted in March 1998, the commitment was made to develop a "national-scale ecological network". Further, the New National Biodiversity Strategy of 2002 included the objective "to develop networks of fine quality ecosystems with protected areas as their cores". Currently the Ministry of Land Use, Infrastructure and Transport, the Ministry of Environment, the Ministry of Agriculture and the Forestry Agency are cooperating in developing the national plan for a Japanese ecological network.

Other than South Korea and Japan, the main initiator of landscape-scale conservation programmes that incorporate ecological-network principles is WWF through the organization's ecoregion programmes. A large number of terrestrial programmes are underway in Asia and the Pacific, as follows:

- Annamites range moist forests
- Eastern Himalayas
- Lower Mekong dry forests
- Borneo lowland and montane forests
- New Caledonian dry forests
- Western Ghats
- Yangtze basin
- southwestern Australian forests and scrub
- Indus delta
- Transfly savannas (Forest of New Guinea)
- Mekong River

Although the WWF projects take on a variety of forms, several explicitly apply the ecological-network model, such as the Terai Arc Landscape in Nepal and India (see case study 6). Other WWF landscape-scale projects outside the organization's ecoregion programme include the following:

Japan: The Arakawa River Ecological Network



One example of an ecological network in Japan is the Arakawa River Ecological Network. The Arakawa River flows through lowlands in the Tokyo metropolitan area and the Saitama Prefecture. However, due to the pressure of human activities, including flood-control works, the stream flow has changed substantially from its natural state, and the river basin habitat has degraded.

A regional restoration programme that was developed by the national government identified key areas for conservation. This programme included the Arakawa River Biotope Project — with an area of 50 hectares, the largest nature restoration project ever carried out in Japan — and Mitsumata Numa Swamp Biotope Project. However, these projects only targeted a part of the river, with the result that the restored habitats continued to be adversely affected by degraded upstream sections of the river, for example through the reduced levels of aggradation.

At the initiative of the Ecosystem Conservation Society – Japan, a comprehensive programme to restore the Arakawa River was developed together with a wide range of stakeholders. The Arakawa River Ecological Network Plan has the main objective of re-establishing ecological continuity between the upper and lower reaches of the river. This is to be secured through enhancing the natural flows of water, nutrients, sand and gravel, and also by restoring ecological connectivity. This will involve establishing corridors between woodlands and other upland habitats in the upper reaches of the river.

Ecosystem Conservation Society – Japan

- the peninsular Malaysia lowland and montane forests
- the Kayah Karen/Tenasserim moist forests (Malaysia and Thailand)
- the Sumatran Islands lowland and montane forests
- Nansei Shoto (Japan)
- the Sunderbans mangroves (India)
- the Tibetan plateau steppe

Conservation International is also active in developing ecological networks in the region. This NGO has established the Commonwealth Scientific and Industrial Research Organization in order to focus scientific analysis on island biodiversity and ecological networks ("conservation corridors"), particularly on the island of New Guinea. In the northwest part of the Philippines, Conservation International has initiated the Sierra Madre Biodiversity Corridor. The project's aim is to protect and manage the biological resources of the Sierra Madre mountain range by developing the whole Sierra Madre mountain range into an ecological network. Proposed measures include the strengthening of existing protected and community-based forest management. A comparable initiative is being taken by the Philippine Eagle Conservation Program Foundation in association with other partners in the southern Philippines in order to establish the Eastern Mindanao Corridor. A prime goal of the initiative is to conserve the habitat of the Philippine Eagle, the second-largest and rarest eagle in the world.

On Sumatra, Conservation International is working with local communities and local government representatives to establish the Batang Gadis National Park as an integral part of the Northern Sumatra Conservation Corridor that Conservation International, other local organizations, communities and governmental representatives are working to create with support from the Critical Ecosystem Partnership Fund.

In the same part of Sumatra, a four-year project managed by Fauna and Flora International is underway to conserve globally important biodiversity in the forests of northern Aceh by using internationally important Asian elephant populations as flagships and indicators. Managed by a team of local staff, the project has two main objectives:

- to conserve biologically rich forest ecosystems in northern Aceh, focusing on the lowland forests that are important wildlife linkages, especially for elephants
- to maintain linkages between the well-protected Gunung Leuser ecosystem and the northern Aceh forests

Elephant migration routes are the focus of several programmes. An important strategic framework for these initiatives is the Asian Elephant Action Plan that was drawn up by IUCN's Species Survival Commission in 1990 (Santiapillai and Jackson, 1990). For example, in Cambodia the Southern Cardamom mountain range is home to one of the last seven remaining elephant corridors in Southeast Asia. However, relatively large numbers of elephants and tigers have been killed in recent years and 100 to 300 hectares of tropical forest are being cleared each month. In response to these threats, WildAid is developing the South West Elephant Corridor which combines ranger patrolling, community outreach and wildlife monitoring to stop wildlife poaching and illegal logging along the migration route and also to help develop income alternatives for surrounding communities.

In 2003 WWF, the UN Development Programme and the government of Bhutan agreed to protect and manage a "Green Corridor" through the Himalayan country in a US$ 1.8-million project. The corridor is intended to ensure the long-term conservation of the country's forest and mountain ecosystems that are home to the endangered Bengal tiger and other species

that are threatened by overgrazing, poaching, illegal trading, deforestation and destructive agricultural practices. It also aims to provide ecologically friendly development opportunities through alternative energy sources, improved health services and cottage industries, such as cheese-making, honey production and non-timber forest products (see also Sherpa *et al.*, 2004).

In Vietnam, the government-supported Central Truong Son Biodiversity Conservation Initiative has been developed as a pilot project with the strategic goal to ensure effective conservation across the Greater Truong Son Ecoregion — the ecological unit that covers most of northern and eastern Vietnam (Ministry of Agriculture and Rural Development, 2004). The project has the objective of establishing an integrated mosaic of complementary land-use and development practices to protect, manage and restore natural resources and biodiversity in the Truong Son region while also contributing to institutional development, good governance and raised standards of living for local communities. The programme will be implemented in three phases:

- 2003–2010: creating the foundations for a sustainable landscape
- 2011–2015: expanding the priority landscapes
- 2016–2020: making the connections

The project includes the conservation of vital ecological linkages, such as the Green Corridor area between Bach Ma National Park and Phong Dien Nature Reserve (which is the focus of a joint Vietnamese government/GEF/WWF/Netherlands Development Organization project) and a tiger corridor funded by the US National Fish and Wildlife Foundation.

A large number of corridor projects are also underway in China (see case study 5). These include several corridors intended to reconnect the increasingly fragmented habitat of the giant panda, such as in the Qinling Mountains where WWF and the Shaaxi Forestry Department have initiated a collaborative project. The corridor will comprise five components: Houzhenzi in Zhouzhi County, Dashuping in the Taibai Bureau, Erlangba in Taibai County, Jiuchihe in Yangxian County and Canziping in the Ningxi Bureau. The intention is to designate the linkages, improve the management of the existing forests, reforest other areas, introduce fire-prevention measures, construct ecoducts and promote appropriate forms of economic development in the local communities.

Flyways constitute a specific type of linkage. Migratory birds depend on widely separated areas for their survival. Measures designed to conserve these networks of sites focus on the breeding grounds, overwintering areas and, for the species that migrate over longer distances, feeding and resting places en route. In most cases these measures require international cooperation. Globally, about 25 flyway agreements have been concluded (including the agreements under the Bonn Convention — see also Western Europe and Other Countries). About half of these flyways can be found in the Asia and Pacific region (see Table 4.1). Some of the agreements date from the first half of the twentieth century (Boere and Rubec, 2002). For example, in 1916 Canada and the United States signed a bilateral Convention on the Conservation of Migratory Birds.

In Taiwan, the feasibility of establishing a corridor in the central mountain region has been assessed (Kuo, 2002). Finally, it can be noted that UNESCO's Man and Biosphere Programme includes 94 Biosphere Reserves in 21 countries in the Asia and Pacific region.

CASE STUDY 5
CHINA: CORRIDORS IN YUNNAN PROVINCE

Yunnan province lies in the south of China, bordering Myanmar, Laos and Vietnam. The region is mountainous, which results in a range of climatic zones varying from temperate through subtropical to tropical. Biodiversity in the province is exceptionally rich. For example, 1,638 vertebrate species, over 10,000 insect species and over 17,000 higher plant species have been recorded, equivalent to about 60 percent of the species diversity in China. Cultural diversity is also exceptionally high, with 26 ethnic groups.

As a result of high population densities and a rapidly growing economy, this rich biodiversity is coming under increasing pressure. Yunnan provincial government has therefore designated a large number of new protected areas, the total number increasing from 92 to 168 between 1998 and 2004. However, potential conflicts between biodiversity conservation and local communities have led to most of these areas being limited

Table 4.1. International flyway agreements

- Asian-Pacific Waterbird Conservation Strategy
- Asia-Pacific Migratory Crane Action Plan and North-East Asian Crane Site Network
- Central Asian-Indian Flyway Programme
- East Asian-Australasian Shorebird Reserve Network
- China-Australia Migratory Birds Agreement
- Japan-Australia Migratory Birds Agreement
- Japan-Russia Migratory Birds Agreement
- Japan-USA Migratory Birds Agreement
- Republic of Korea-Russia Migratory Birds Agreement
- Democratic People's Republic of Korea-Russia Migratory Birds Agreement
- American-Pacific Flyway Programme
- Convention Between the Government of the United States of America and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction, and Their Environment
- USA-Russia Migratory Birds Agreement
- Convention between the United States of America and Great Britain (acting for Canada) for the Protection of Migratory Species
- Convention between the United States of America and the Union of Soviet Socialist Republics Concerning the Conservation of Migratory Birds and Their Environment
- Convention Between the United States of America and the United Mexican States for the Protection of Migratory Birds and Game Animals
- Convention between Canada and the United States on the Conservation of Migratory Birds
- North American Waterfowl Management Plan
- Migratory Birds Convention
- Western Hemisphere Shorebird Reserve Network
- Bonn Convention: Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)
- Bonn Convention: Agreement on the Conservation of Albatrosses and Petrels
- Bonn Convention: Memorandum of Understanding concerning Conservation Measures for the Slender-Billed Curlew (*Numensius tenuirostris*)
- Bonn Convention: Memorandum of Understanding concerning Conservation Measures for the Siberian Crane (*Grus leucogeranus*)
- Bonn Convention: Memorandum of Understanding concerning Conservation Measures for the Aquatic Warbler (*Acrocephalus paludicola*)
- Bonn Convention: Memorandum of Understanding on the Conservation and Management of the Middle-European Population of the Great Bustard (*Otis tarda*)

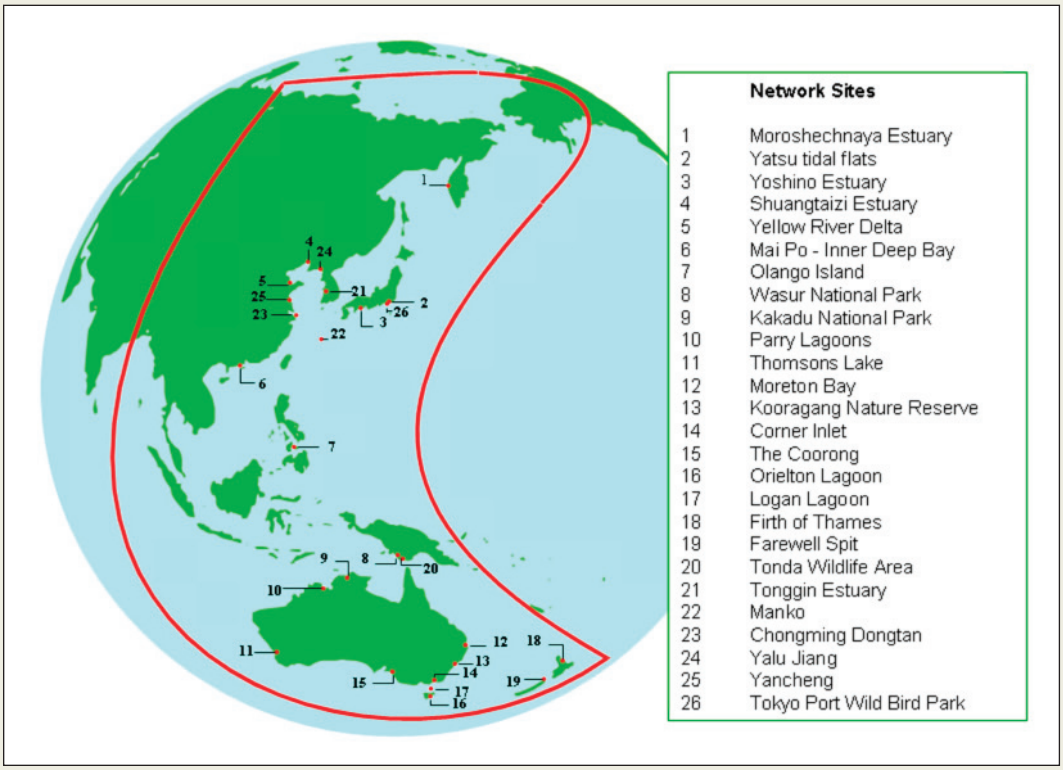
to former state forests. Moreover, administrative boundaries play an important role in the configuration of the nature reserves since local governments are responsible for proposing protected areas.

Given the need to strengthen the conservation of Yunnan's biodiversity, a project was launched in 1998 to formulate protected-area management plans and promote sustainable community development in the province's tropical and subtropical forest zones. Funded

The East Asian–Australasian Shorebird Site Network

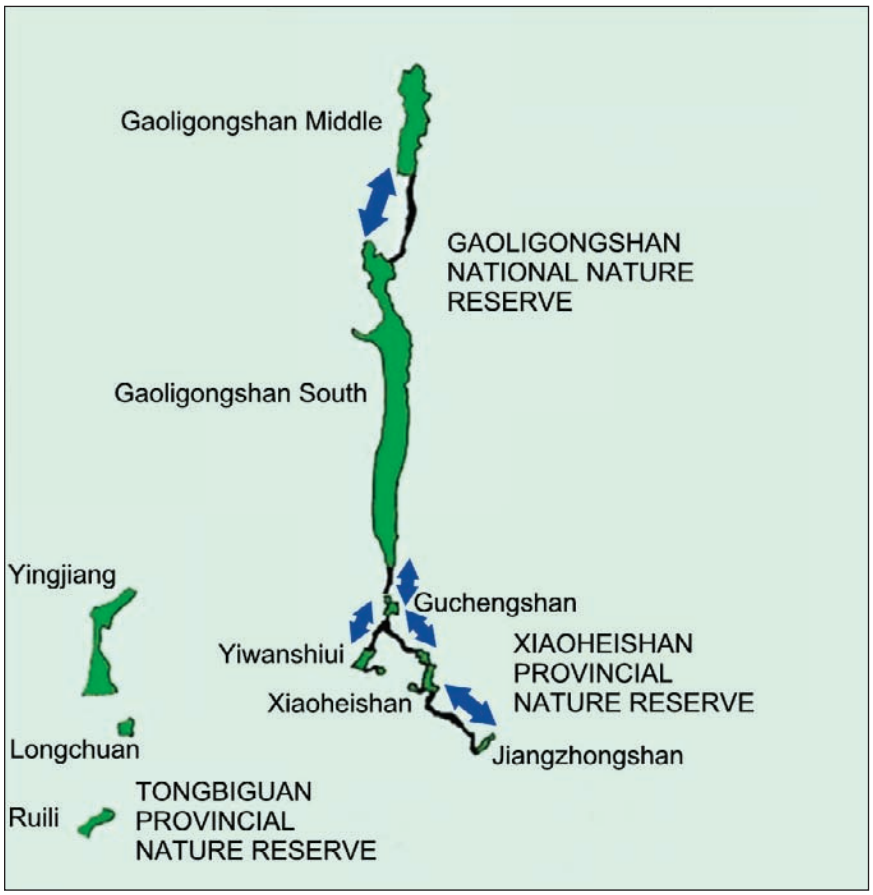
Launched in 1996, the East Asian–Australasian Shorebird Site Network aims to secure the long-term conservation of migratory shorebirds in the East Asian–Australasian Flyway through the recognition and appropriate management of a network of internationally important sites. It is estimated that over 400 such sites exist in the flyway. The flyway is used by over 65 populations of migratory shorebirds, including 11 species of special conservation concern and two endangered species (the spoon-billed sandpiper and the spotted greenshank).

The network, which is coordinated by Wetlands International–Oceania, currently includes 29 designated sites in nine countries: Russia, South Korea, Japan, China, the Philippines, Indonesia, Papua New Guinea, Australia and New Zealand. As a voluntary collaborative framework, some consideration was given to regional geo-political considerations in deciding how to define national involvement along the eastern margin of the flyway. The Action Plan for the Conservation of Migratory Shorebirds in Asia Pacific was agreed in 1999 and an international advisory group meets once a year to review implementation of the plan. Core funding is provided by the Australian Government.



East Asian–Australasian Shorebird Site Network

Figure 4.1. The locations of the corridors linking the nature reserves in Yunnan province



Forest Conservation and Community Development Project

jointly by the Chinese and Dutch governments, the Forest Conservation and Community Development Project focused on six nature reserves: Caiyanghe, Nuozhadu, Wuliangshan, Tongbiguan, Gaoligongshan and Xiaoheishan (Weimin and Busstra, 2004).

The latter two protected areas lie in close proximity to each other in western Yunnan. Gaoligongshan National Nature Reserve was established in 1983; with an aggregate area of 4,000 square kilometres it is the largest protected area in Yunnan province. In 1992 WWF recognized the reserve as a Grade A protected area of global importance, and in 1997 part of the protected area was listed as a Biosphere Reserve. The reserve comprises three separate sites that harbour 10 different grassland, scrub and forest vegetation types. About 5,000 species of vascular plants and 200 animal species have been identified, including takin (*Burdocas taxicolor*), gibbons, the red panda and the clouded leopard. Because Gaoligongshan extends across the boundary between Nujiang prefecture and Baoshan city it is managed jointly by two agencies, one in each district. About 360,000 people live in the Biosphere Reserve, including over 20 ethnic

groups. Economic development is relatively low, and the local communities therefore depend to an important extent on the natural resources of the forest.

Xiaoheishan Provincial Nature Reserve lies just to the south of Gaoligongshan. The reserve consists of four separate sites covering 16,000 hectares and is characterized by tropical evergreen and temperate forest. Wild rice and tree ferns can be found in the reserve. An important ecological feature of Xiaoheishan is that it acts as a linkage between Tongbiguan and Gaoligongshan reserves. The local population of almost 80,000 is very poor, and the economic potential of the area is low: agriculture, livestock breeding and non-timber forest products remain the most important sources of subsistence.

The management plans for Gaoligongshan and Xiaoheishan reserves recognize three categories of area: a central core area with a high level of protection, a surrounding "experimental zone" (equivalent to a buffer zone) and an outer "adjacent area" (a transitional area that is also intended to have a buffering function). Moreover, because of the ecological relationship between the separate sites, the project is supporting the development of corridors between and within the two nature reserves.

The corridor linking the central and southern parts of the Gaoligongshan nature reserve is intended to ensure continued movement of temperate and subtropical species between the two sites. Gaoligongshan South was formally linked with the Guchengshan site in the Xiaoheishan nature reserve in 2001 when a corridor was designated by Tengchong County and Longyang District as a county-level protected area. The main purpose of the corridor is to maintain a continuum of the vertically diverse habitats that characterize Gaoligongshan and Xiaoheishan.

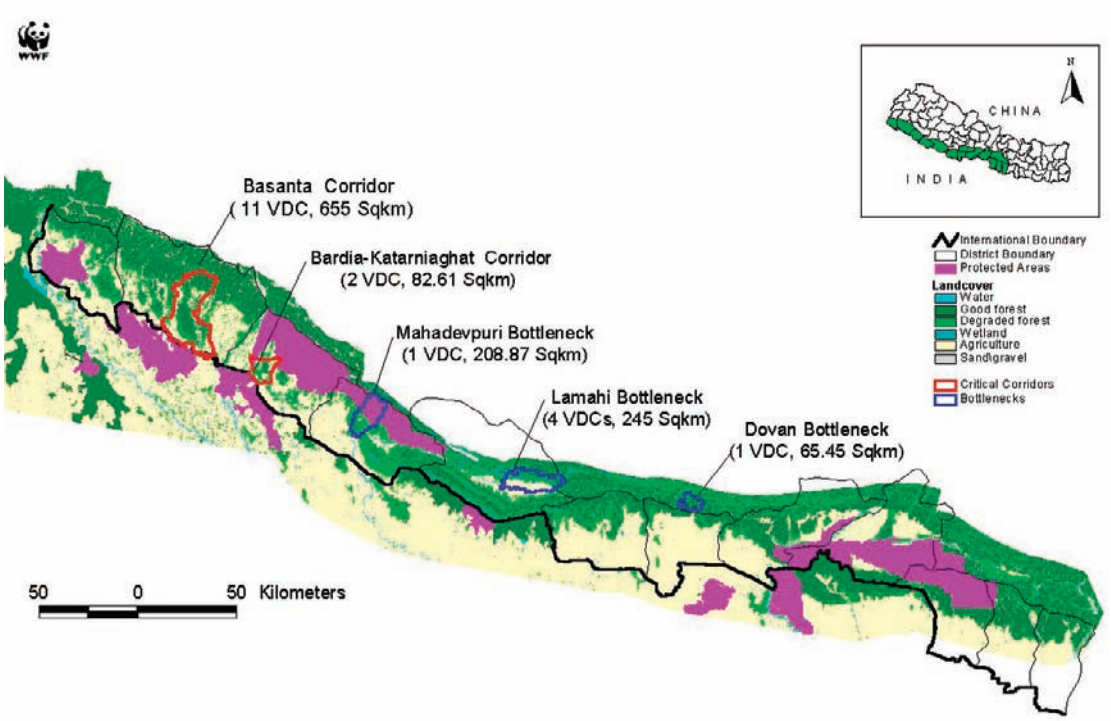
Within the Xiaoheishan Nature Reserve, the Forest Conservation and Community Development Project funded the preparation of a corridor development plan that aims to link all four sites. The proposal, which encompasses 11,550 hectares, is currently under consideration by the county government. Priority will be given in the first instance to linking Guchengshan with the Xiaoheishan and Yiwanshui sites as part of a current reforestation programme that is intended to expand the mixed-forest habitat that characterizes the nature reserve. A particular concern is the limited area of habitat currently available to the 30 mammal species in Xiaoheishan.

A further extension of the corridors to link Xiaoheishan Nature reserve with Tongbiguan Nature Reserve is under consideration, and Tongbiguan itself may be expanded. However, for such a corridor to be functionally viable, an ecological restoration programme will first have to be carried out. An important obstacle to realizing these plans is that part of the forest in the Tongbiguan area is community owned, which limits the scope for introducing new forms of management. Further research is also necessary in order to ensure that the projected corridors will meet the needs of local species populations.

CASE STUDY 6
NEPAL: THE TERAI ARC LANDSCAPE

Nepal is home to some of the world's most striking landscapes and valuable biological diversity. Seven of the world's 10 highest mountains are to be found in the country, including Mount Everest, and the five major geomorphological zones host diverse vegetation communities. Dense tropical monsoon Sal forests and exceptionally tall grasslands predominate in the Terai zone, while in the Siwaliks, Chirpine forests characterize the west and central regions up to about 1,600 metres, being replaced by *Schima-Castanopsis* forests up to 2,000 metres. In the east, broadleaf hill forests are found across the entire sub-tropical zone. The temperate zone between 2,000 and 3,000 metres is forested with evergreen oak in west Nepal and *Quercus semecarpifolia*, *Q. lamellosa* and *Q. glauca* in central and east Nepal. At higher altitudes, the

Figure 4.2. The Terai Arc Landscape



Worldwide Fund for Nature

oak gives way to forests with blue pine and, in the east, rhododendron. Fir and birch take over up to 4,000 metres, with rhododendrons at the tree line in the west and central regions and sub-tropical mixed conifer forests with a fir upper treeline zone in the east. Above the tree line a narrow zone of juniper and rhododendron scrub can be found, merging into alpine shrub and meadows at higher altitudes. In all, forest covers about 35 percent of the country's territory, but there are also extensive wetlands and river systems that contribute up to 40 percent of the total flow of the River Ganges.

This remarkable landscape harbours a rich diversity of flora and fauna. More than 6,500 higher plant species have been identified — 133 of which are endangered — and 157 mammal species, 28 of which are endangered, including the Indian rhinoceros, the Asian elephant, the royal Bengal tiger, the snow leopard, the red panda and the blue sheep. Other fauna include 858 bird species, 127 reptile species, 51 amphibian species, 182 fish species and 643 butterfly species.

Nepal is also one of the least developed countries in the world. With less than 20 percent of the working population employed in industry or trade and services, average income is only about US$ 200 per annum. At the same time, Nepal's population of over 25 million is growing steadily. Most Nepalese are Hindu, but there are substantial minorities of Buddhists and Muslims. These religious groupings harbour considerable cultural diversity and about 20 languages are spoken in the country. Almost half of the population lives in the Terai zone, a belt of land along the foothills of the Himalayas about 35 kilometres wide that stretches across southern Nepal and into India, Bhutan and Bangladesh. The relations between

the Nepalese and Indian parts of the Terai are strong, and there is considerable transboundary employment. However, about 20 percent of the Nepalese Terai population has no safe drinking water supplies and 80 percent has no access to health care. Nearly half the children in Nepal are underweight and average life expectancy is relatively low at about 60 years for both men and women.

As a result of the exceptionally high human pressure, environmental impacts in the Terai region are causing serious problems. The vegetation has become greatly degraded by deforestation and fuel-wood collection. About a third of all the forests have been cleared, with losses continuing at about four percent a year. Surface waters are polluted by untreated waste water, and irrigation and hydro-electric projects are threatening the ecological integrity of the river basins still further. Poaching, which in the current political climate is difficult to control, is a major threat to endangered species such as the rhinoceros, the tiger and the elephant.

It is in response to these pressures that WWF initiated the Terai Arc Landscape programme. The Terai Arc is included in WWF's 25 Focal Ecoregions as part of the Global 200 list. It is also a priority area of the Save the Tiger Fund. Operational since 2001 as a merger of two existing projects — the Bardiya Integrated Conservation Project and the Western Terai Tiger, Rhino and Elephant Conservation Complex — the initiative became a joint programme of Nepal's Department of National Parks and Wildlife Conservation, the Department of Forests, WWF's Nepal Programme, local communities and NGOs. However, although built on two existing conservation projects, the Terai Arc Landscape has established far broader goals. These were formulated on the basis of a Root Causes Analysis Workshop that identified the main causes of environmental degradation and loss of biodiversity in the Terai. Expertise and local knowledge was provided by the Forestry Department and the National Parks and Wildlife Conservation Department, WWF, Resources Himalaya and other NGOs, such as the Wildlife Conservation Society.

Working within the framework of a long-term sustainable-development and conservation vision for the region, the programme aims, within 10 years, to strengthen the existing protected areas, conserve the remaining forests, restore degraded forests, establish community forests, introduce effective management practices in the buffer zones, create corridors between critical protected areas and introduce appropriate management practices in buffer zones. The programme as a whole is formalized through agreements with the Nepalese government which establish a legal basis for the various activities, and it is supported through funds provided by WWF, with US$ 6 million being available for the first 10-year phase.

Four protected areas exist in the Nepalese part of the region — two as wildlife reserves and two as national parks, one being a World Heritage site. However, it is clear that, with their restricted extent and the current human pressures, these protected areas are inadequate in themselves to secure the ecological integrity of the region, particularly in relation to the populations of wide-ranging species. The Terai Arc Landscape has therefore focused on five priority areas: three sites where serious barriers to ecological continuity exist, Mahadevpuri, Lamahi and Dovan, and two corridors, Basanta and Bardia-Katarniaghat.

Additional corridors between seven protected areas in the adjacent Indian Terai are under development, as are linkages with protected areas across the border with India, such as the three-kilometre Khata corridor across the lowland savannah and grassland habitats between the Royal Bardiya National Park in Nepal and Katarniyaghat Wildlife Reserve in India. This linkage was identified as a critical area for restoration in 2000, and restoration work commenced in 2001. The corridor consists of areas of good

forest, degraded forest and agriculture, and it is adjoined by 11 community forests. Around 300 families live in the surrounding area. Nepal's Department of National Parks and Wildlife Conservation estimates that about 40 breeding tigers survive in the neighbouring Royal Bardia National Park. Recent monitoring and reports from local villagers have confirmed that tigers and elephants use the corridor, particularly during the rainy season when the flooded tributaries of the Karnali River waterlog the forests across the Nepal-India border.

These projects are being supported by education courses for 275 local livestock herders and awareness-raising programmes that are being developed by 39 newly established "ecoclubs". To meet the increasing demand for tree seedlings, 13 multi-purpose tree nurseries have been established that together have an annual production capacity of 330,000 seedlings. In order to expand the distribution of the Nepalese rhinoceros population, 64 animals were relocated from Royal Chitwan National Park to the Royal Bardiya National Park and four to Royal Shuklaphanta Wildlife Reserve. Illicit hunting is being discouraged by 17 units that are stationed in the protected areas, while three new anti-poaching units are discouraging poaching in the corridors — the first community-based anti-poaching initiatives in Nepal.

The implementation of the Terai Arc programme is being secured through projects that focus on sustainable community development, awareness-raising and capacity-building. Support on the ground is being facilitated through the establishment of a field office in the Royal Bardiya National Park that plans, implements and monitors all the field activities in the four protected areas. Starting in August 2002, the Forestry Office of Palpa District handed over five community forests to local communities in Dovan. In addition, 26 community forest user groups were registered at the district forestry offices along the corridors and in the bottlenecks. Four community forest coordination centres were formed in Basanta, Katarnia, Lamahi and Dovan to promote the participation of local people in the conservation activities and to assist collaboration with the community forest-user groups. These actions have contributed to the mobilization and institutional embedment of the local communities.

A total of 536 hectares of degraded land were restored in the first year of the programme. In addition, a management plan and a tourism plan were drawn up for the Royal Bardiya National Park, both of which have since been endorsed by the Nepalese government. Cooperation with local communities enabled the District Forest Office to relocate over 10,000 families who had encroached onto forest areas in the Basanta corridor (although such programmes inevitably cause local tensions and require careful management if they are to secure the cooperation of both the people who are to be relocated and the population in the area to which they are moved). Support to the community-forest user groups in the Khata corridor and the Lamahi bottleneck also enabled the construction of 17 livestock pens that discourage uncontrolled cattle grazing in the corridors.

Institutional measures that support the Terai Arc programme include the adoption of a National Environment Policy and Action Plan (that includes ecological guidelines) and the National Biodiversity Action Plan. In addition, the buffer-zone concept was incorporated into the National Parks and Wildlife Conservation Act, and the Buffer-Zone Development Council was established. The Council is entitled to receive 50 percent of national park revenues for financing buffer-zone development projects. As a result all four protected areas are now buttressed by buffer zones. Community forests also enjoy a formal status under Nepalese law.

The challenges involved in securing sustainable natural resource exploitation and biodiversity conservation in a poor, culturally

diverse and politically unstable country such as Nepal are enormous. Given the lack of institutional capacity, progress in the coming years will depend largely on external funding and on the ability to work closely with local communities and demonstrate that sustainable development and biodiversity conservation deliver tangible benefits in the short term while still offering a long-term perspective. In this respect, the Terai Arc Landscape programme has already shown that it can achieve important results.

CONCLUSIONS

Despite the high level of poverty and political and institutional problems in many Asian and Pacific countries, a relatively large number of ecological networks and corridors are under development in the region. These range from local corridor projects to national ecological-network programmes. Flagship species such as the Asian elephant, the giant panda and the tiger are an important focus for many of the corridor projects. To date, however, the extensive application of the ecological-network model has not yet led to a structured region-wide exchange of information and experience as has occurred in Europe and in North America.

Notably, despite the extensive application of the model, only two ecological-network programmes — in South Korea and Japan — are the product of national-government policy processes. Both of these schemes share several key characteristics: they are national in scope, their development is proving to involve a protracted process and implementation to date has been limited to a series of pilot and local projects. They nevertheless represent an important strategic development for the long-term direction in which biodiversity conservation policy in South Korea and Japan is heading.

The most important driving force for establishing ecological networks and corridors in most Asian and Pacific countries is therefore coming primarily from the NGO community in cooperation with international donors and research institutes. WWF and Conservation International are particularly active in promoting the approach across the region. Also, in collaboration with a range of international financial institutions, foreign donors, private foundations and the respective governments, they play an important role in funding the early phases of many of the initiatives.

The scope of many of these programmes is necessarily bounded by the need to achieve results in regions with weak institutional mechanisms. Another notable feature of many of the initiatives, particularly in the poorer countries, is the incorporation of community-development objectives into the programmes with the aim of providing sustainable economic opportunities that go hand in hand with biodiversity conservation. Programmes such as the Terai Arc Landscape are providing valuable lessons in this respect.

5. LATIN AMERICA AND THE CARIBBEAN

The ecological-network model was introduced to Latin America through the Mesoamerican Biological Corridor in the mid-1990s. The idea for the network was conceived by the US-based Caribbean Conservation Corporation and the Wildlife Conservation Society as a means to re-establish a natural corridor in Central America for the Florida panther under the name Paseo Pantera (Path of the Panther). Funds to support the development of the concept were provided by the US Agency for International Development (USAID), and in 1997 the proposal was formally adopted by the heads of state of the eight countries, becoming the Mesoamerican Biological Corridor (see box).

In South America the first large-scale ecological network programme to be initiated was the Vilcabamba–Amboró Conservation Corridor (see box), which grew out of a 1998 proposal to establish a transboundary Biosphere Reserve between Peru and Bolivia. Since then, a remarkably large number of ecological-network initiatives have been launched. US NGOs such as Conservation International and the World Resources Institute have been active in promoting the approach and a wide range of international donors are working with national and local governments and other stakeholders to support the programmes.

OVERVIEW OF THE PROGRAMMES

In the Latin American context, the relatively recent development of ecological networks has not yet led to a common understanding of the approach. Different terms are also used to describe the various initiatives, although the generic name "corridor" is preferred following the example of the Mesoamerican Biological Corridor. Variations include biological corridor (*corredor biológico*, such as Bremen–Barbas in Colombia), ecological corridor (*corredor ecológico*, such as Llanganates–Sangay in Ecuador), biodiversity corridor (*corredor biodiversidad*, such as Central da Mata Atlántica in Brazil), conservation corridor (*corredor conservación*, such as Patagonia in Argentina and Chile) and biogeographical corridor (*corredor biogeográfico*, such as Madidi–Pilón Lajas–Manuripi–Tambopata–Candamo–Bahuaja Sonene in Bolivia and Peru).

Four key elements are shared by the initiatives in the region that fall within the scope of this review:

- integrating protected areas into a broader management approach
- promoting functional connectivity
- a primary focus on biodiversity conservation
- using land-use planning as a means to realize the goals

On the basis of these defining characteristics, a recent inventory identified a total of 82 ecological-network initiatives in South America (Cracco and Guerrero, 2004; see also Table 5.1). In relation to specific countries, the highest number of programmes are underway in Brazil and Colombia.

The inventory also collected information on 68 of these programmes (see Table 5.2). Both governments and NGOs are active in launching the

Table 5.1. Number of ecological-network and corridor initiatives in South American countries

COUNTRY	NUMBER
Argentina	7
Bolivia	3
Brazil	14
Colombia	17
Chile	3
Ecuador	9
Paraguay	3
Venezuela	8
Transboundary	18
Total	**82**

Adapted from Cracco and Guerro, 2004

Central America: The Mesoamerican Biological Corridor

Although covering only one half percent of the world's land surface, Mesoamerica is home to about seven percent of the planet's terrestrial biodiversity. This biological wealth is the result not only of Mesoamerica's particular environmental characteristics but also of its strategic position as a land bridge connecting the biotas of the two American continents. About 30 ecoregions have been identified, an exceptionally large number for such a small landmass.

The plan for establishing the Mesoamerican Biological Corridor distinguishes four kinds of zones: core areas, buffer zones, corridors and multiple-use areas. Together these zones cover 208,000 square kilometres, or 27 percent of Mesoamerican territory. Within this area can be found 26 indigenous groups and all the major Maya sites, such as Tikal, Chichén Itza and Copán. More detailed ecological-network maps are being developed at the national level.

The basis of the Corridor's core areas are the region's 368 protected areas, 18 of which are larger than 100,000 hectares. Together they protect nearly 11 percent of Mesoamerica's land area. Building on this foundation, projects in the buffer zones, corridors and multiple-use areas encourage land users to test and adopt management practices that are both biodiversity-friendly and economically viable, using incentives such as environmental service payments. Many local projects are working to secure sustainable development and biodiversity conservation on the ground. For example, the 1,500-strong Small Farmers' Association of Talamanca in Costa Rica is now producing 20 percent of the world's organic cocoa.

An evaluation of the Corridor by the World Resources Institute in 2001 was broadly positive (Miller *et al.*, 2001) but identified a number of issues that the programme needs to address if it is to achieve its objectives, such as reconciling stakeholder interests and addressing property rights and land-tenure issues. The evaluation nevertheless concluded that the initiative had built a strong foundation through actively solliciting the support of a wide range of stakeholders and actors. Its involvement of local groups — farmers, organizations of indigenous peoples, municipalities and local companies — offers the main key to the initiative's success (Inter-American Development Bank and World Bank, 2001).

CCAD/PNUD/GEF/SICA/GTZ/World Bank

Peru and Bolivia: The Vilcabamba–Amboró Conservation Corridor

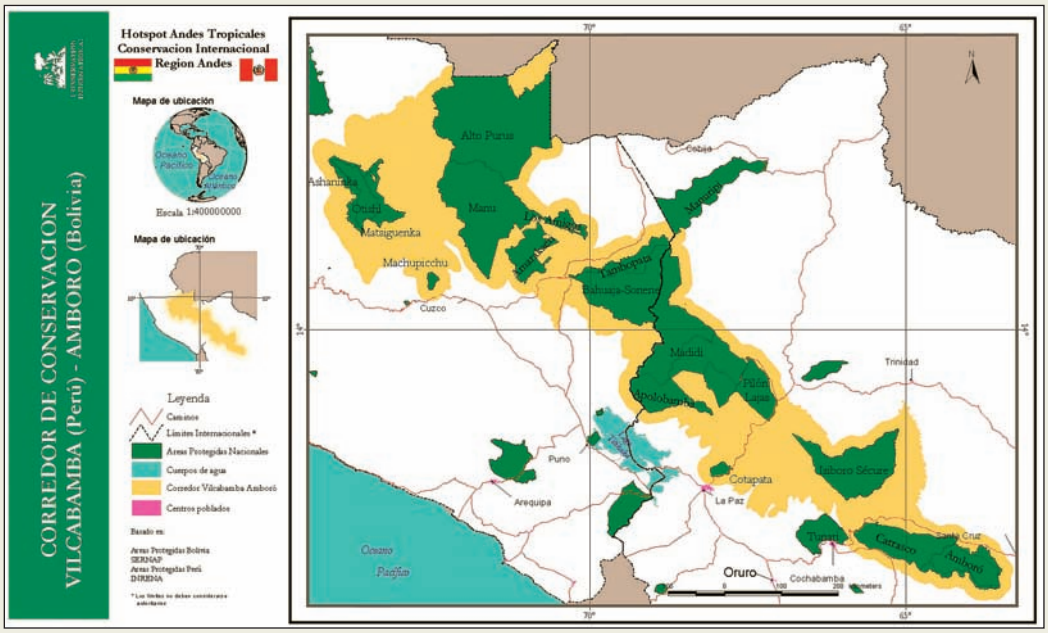
The Vilcabamba–Amboro ecosystem extends from the Vilcabamba mountain range in south-central Peru southeast to Amboró National Park in central Bolivia. The ecosystem is located within the tropical Andes hotspot, and the vegetation follows a gradient from tropical moist forests through cloud-forest formations to alpine grassland and scrubland. Other vegetation types, such as the unique dry *Polylepis* forests, are found at higher elevations. Species diversity is exceptional, with more than 6,000 plant species and more than 3,500 vertebrates. For example, in the 17,000 square-kilometre Manu National Park, over a thousand species of birds have been identified and in the Tambopata reserve approximately 1,200 species of butterfly (Critical Ecosystem Partnership Fund, 2000).

About 40 different ethnic groups can be found in the region, including some indigenous groups that reject the encroachment of modern civilization. Although population density is relatively low, human pressure is having a significant impact on the biodiversity. Direct threats include oil and gas exploitation, gold mining, uncontrolled logging, dam construction, road construction and the associated colonization. The fact that many protected areas are underfunded only increases their vulnerability.

In 1998, the Organization of American States funded a proposal that involved the creation of a trans-boundary Biosphere Reserve. The proposal incorporated corridors and buffer zones into its configuration and complemented a similar idea that was being developed by Conservation International. These developments evolved into a more ambitious ecological network called the Vilcabamba–Amboró Conservation Corridor, which is built up around large protected-area complexes composed of protected areas, multiple-use areas and indigenous peoples' reserves.

The programme now encompasses 18 protected areas, which are the core areas of a developing ecological network. Three of the areas are also indigenous reserves, and a series of Inca and pre-Inca archaeological sites are located in the network, including the world-famous Machu Picchu. The next phase in the programme is the preparation of detailed action plans.

The majority of the funding for developing the Vilcabamba–Amboró Conservation Corridor comes from a range of international donors. These include, in addition to Conservation International, WWF, USAID and the Critical Ecosystem Partnership Fund (a joint initiative of Conservation International, the Global Environment Facility, the government of Japan, the MacArthur Foundation and the World Bank).



Conservation International

initiatives. Although biodiversity conservation was the original object of all these programmes, an increasing number of the newer initiatives, such as Ecoaméricas, are following the example of the Mesoamerican Biological Corridor and embracing broader sustainable development objectives.

WWF is also very active in Latin America and is currently developing the following terrestrial and coastal ecoregion programmes:

- Chihuahuan deserts and springs (Mexico)
- Galapagos Islands
- Northern Andean montane forests (Colombia)
- southwestern Amazonian moist forest (Brazil/Bolivia/Peru)
- Atlantic forests (Argentina/Paraguay/Brazil)
- Valdivian temperate forests (Chile)
- Amazon River and floodplain (Brazil/Peru)
- Choco-Darien (Colombia)
- Llanos (Venezuela/Colombia)
- Pantanal (Brazil/Bolivia)

In addition, a non-ecoregion project to conserve the Guianan moist forests in Surinam is underway.

UNESCO's Man and Biosphere Programme includes 75 biosphere reserves in the region, including two in French overseas territories: Atoll de Taiaro (currently under revision to become the Tuamotu Biosphere Reserve) and Archipel de la Guadeloupe (see box). For an example, see the discussion of the La Amistad Binational Biosphere Reserve in Costa Rica and Panama in Ramirez Umana (2004).

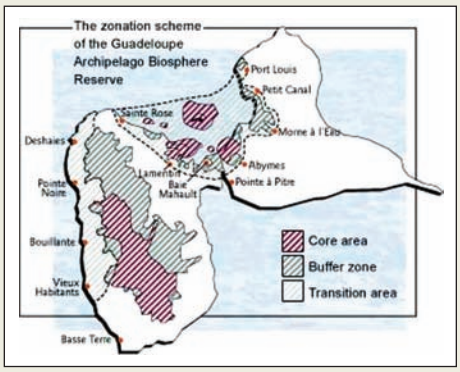
Guadeloupe: Archipel de la Guadeloupe Biosphere Reserve

Situated on Guadeloupe Island in the Caribbean Sea, this Biosphere Reserve comprises two geographically separate sites:

- Basse-Terre, a tropical humid forest located in the west of the island, which is uninhabited and home to over 300 species of trees and shrubs.
- Grand-Cul-de-Sac Marin, a bay of 15,000 hectares between Basse-Terre and Grande-Terre which includes coral reefs, mud flats, a sea-grass bed and mangrove forests, freshwater swamps forests and marshes. The lagoon provides a habitat for turtles, giant sponges, soft corals, urchins and fish. The mangrove hosts many sedentary and migratory birds (pelicans, terns, moorhens, ducks, herons and kingfishers). Parts of the reserve also comprise a Ramsar site.

The transition areas of the Biosphere Reserve include numerous small towns and villages with many tourist facilities. About 225,500 inhabitants live permanently in the reserve and each year about 20,000 tourists visit the marine part of the area. Threats to the reserve include hurricanes, tourism, anchorage on coral reefs, deforestation and water pollution.

Following designation as a Biosphere Reserve in 1992, a management plan was adopted in 1998 with the objectives of maintaining biodiversity and good water quality. The zonation into core areas, buffer zones and transition zones is a good example of the Biosphere Reserve management approach.



UNESCO

Table 5.2. Ecological-network and corridor programmes in South American countries

ARGENTINA

Iniciativa Corredor de Humedales del Litoral Fluvial de la Argentina
Proyecto de Biodiversidad Costera Patagónica
Corredor de conservación del Cóndor Andino
Corredor de Interconexión entre los Parques Nacionales, Parques Provinciales y Áreas Protegidas en la Región Triprovincial
Corredor Biológico de Humedales del Centro-Oeste Argentino
Corredor Ecorregional Norandino Patagónico
Diseño de una Estrategia Regional de Corredores de Conservación en el Gran Chaco Argentino

BOLIVIA

Corredor Amboró–Madidi
Corredor Amboró–Tariquía
Corredor Chiquitano–Iténez–Mamoré

BRAZIL

Corredor da Biodiversidade do Amapá
Corredor de Biodiversidad Central da Mata Atlántica
Corredor Centro-Amazónico o Central da Amazonía (CCA)
Corredor do Descobrimento
Corredor Norte-Amazónico
Corredor Oeste-Amazónico
Corredor Sul-Amazónico
Corredor Ecológico Cerrado–Pantanal
Corredor da Serra do Mar o Corredor Sul da Mata Atlántica
Corredor do Ecótono Sul-Amazónico (Amazonía Cerrado)
Corredor Ecológico Araguaia–Bananal
Corredor Ecológico do Cerrado
Corredor Ecológico Jalapão–Mangabeiras
Corredor JICA

CHILE

Corredor Nevados de Chillán–Laguna de la Laja
Corredor entre la cordillera de los Andes y la Cordillera de la Costa

Colombia

Corredor Biológico Guácharos–Puracé
Corredor Biológico Bremen–Barbas
Corredor Guantiva–La Rusia–Iguaque de Bosques Altoandinos de Roble o Iguaque–Guanentá o Guantiva–Iguaque
Corredor Transandino–Amazónico
Corredor Páramo de Bordoncillo–Cerro Patascoy–Laguna de la Cocha
Corredor Biológico de la Cordillera Central
Corredor Dagua–Calima–Paraguas
Corredor de Naya
Corredor Costero del manglar Proyecto Biopacífico
Corredor Amazonía Colombiana
Corredor Ecológico Abierto
Corredor Costero Urabá–Alto Sinú
Corredor Laguna de Fuquene y Laguna Palacio

ECUADOR

Corredor Chocó–Andino
Corredor Ecológico Llanganates–Sangay

PARAGUAY

Corredores de conservación en la Reserva de Biósfera del Bosque Mbaracayú y áreas de influencia
Corredores ecológicos y culturales en el valle central de la cuenca del Plata y valles interconexos

VENEZUELA

Corredor en el Caribe entre Curaçao, Bonaire, Aves y Los Roques
Corredor Biológico de la Sierra de Portuguesa
Biocorredor Ramal de Calderas
Corredor Canaima–Alto Orinoco (part of the Guyana Shield proposal)
Corredor Nacional Fulquena
Corredor Papero
Corredor Caparo
Corredor Pueblos del Sur

TRANSBOUNDARY INITIATIVES

Corredor Tariquía–Baritú o Corredor Regional de los Yungas (Argentina/Bolivia)
Corredores Guaporé–Itenez (Bolivia/Brazil)
Corredor Vilcabamba–Amboró (Perú/Bolivia)
Corredor Cóndor Kutukú (Perú/Ecuador)
Corredor Chocó–Manabí (Ecuador/Colombia
Corredor verde de Misiones (Paraguay/Brazil/Argentina)
Corredor Trinacional del bosque Atlántico del Alto Paraná (Brazil/Argentina/Paraguay)
Propuesta de Corredor Biológico para el Huemul *Hippocamelus bisulcus* (Argentina/Chile)
Corredores de Conservación en la Patagonia (Argentina/Chile)
Corredor Chaqueño (Argentina/Bolivia/Paraguay)
Corredor Nor-Andino o Andes del Norte (Venezuela/Colombia)
Andean Bear Biological Corridor (Venezuela/Colombia/Peru)
Área de manejo coordinado o Corredor Altoandino o Humedales Altoandinos (Chile/Bolivia/Argentina)
Cielos de América (Argentina/Bolivia)
Proyecto Cooperación entre Reservas de Biosfera Costeras (Uruguay/Argentina/Brazil)
Corredor Biogeográfico Madidi–Pilón Lajas–Manuripi–Tambopata–Candamo–Bahuaja Sonene (Bolivia/Perú)
Corredor Ecológico (Perú/Brazil)
Corredor Marino de Conservación del Pacífico Este Tropical Oriental (Colombia/Ecuador/Panama/Costa Rica)
Iniciativa de Conservación Escudo Caura–Guyana/the Guiana Shield (Venezuela/Guyana/ Surinam/French Guiana/Brazil/Colombia)
Corredor Ecológico de las Américas: Ecoaméricas

Adapted from Cracco and Guerro, 2004. Note: the inventory does not include initiatives in Central America such as the Mesoamerican Biological Corridor

CASE STUDY 7
CORRIDORS IN THE BARBAS–BREMEN–CESTILLAL REGION

It has been claimed that the Tropical Andes is the most biologically diverse ecoregion in the world. However, this ecoregion is losing its biodiversity as a result of habitat change and fragmentation (Laurance and Bierregaard, 1997; Renjifo, 1999; Kattan and Murcia, 2003). With over 30 million people living in the Colombian Andes system, human activities are impacting more than 70 percent of the region's natural ecosystems (Etter, 1998; Etter and Van Wyngaarden, 2000).

The Central mountain range is the most deforested region in Colombia, with only 10 percent of the original forest cover remaining. Of these remnants, less than three percent are protected. Almost all of the fragments are to be found in the upper reaches of the mountain range (Arango *et al.*, 2003). Habitat loss and fragmentation in the mountains (and also the rest of the Colombian Andes) is more widespread and serious in lower and medium elevations (1,500–2,500 metres). It is in these areas where biodiversity is richest (Fjedsa and Krabbe, 1990; Renjifo *et al.*, 1997). In the sub-Andes, with only seven percent of the land area, 54 percent of the threatened bird species of the country are found (Renjifo *et al.*, 2002). In the past, these zones were entirely covered by different forest types. Today, pastures for livestock, coffee plantations, exotic tree plantations and urban areas are the dominant elements of the landscape. Nonetheless, the rural parts of the region still host a rich biodiversity, including a large number of threatened species and those with a restricted distribution range.

Important patches of forest habitat still exist in some parts of the mountains. These remnants are of high priority for the conservation of threatened and endemic species, especially since the areas are the only remaining available habitat. However, because these forest remnants are highly fragmented, a conservation strategy that is restricted to their protection cannot guarantee the long-term survival of the species.

The subregion of the Central Andes Western Watershed covers over eight million hectares. The Flora and Fauna Sanctuary Otún–Quimbaya, with an area of just 580 hectares, is the only reserve within the national protected-areas system that harbours sub-Andean forests in the mountain chain (Arango *et al.*, 2003). This sanctuary, together with its neighbouring local and regional protected areas (Ucumarí and Campoalegre) protects the only sub-Andean forest in the subregion.

An area where relatively large remnants of sub-Andean forests still exist is the Rio Barbas canyon and its surroundings. This canyon contains a 790-hectare block of forest, which historically was protected because of its steep topography. Located one kilometre south of the Rio Barbas canyon is the Bremen Forest Reserve, which was established in the early 1970s in order to protect the watersheds. Bremen contains 336 hectares of native forests and 411 hectares of exotic conifer plantations. Since the 1990s, the Quindío Regional Corporation (CRQ), the reserve's owner, began removing conifer plantations and restoring the native forest through natural regeneration. In the near future this reserve will encompass 747 hectares of natural forest and will be the only sub-Andean protected forest in the Quindío region. A second large forest remnant is found along the Cestillal canyon towards the northern section of the canyon, containing 296 hectares of forest.

Bremen, Barbas and Cestillal together cover 1,833 hectares. Although this area is small, the reserve is the most important protected area in its altitudinal range of the Central Andes Western Watershed, since only 0.38 percent of the original forest still exists in the sub-ecoregion at this altitude in Barbas and Bremen (1,500–2,100 metres). Barbas–Bremen–Cestillal has high topographic complexity, which creates a variety of microhabitats with diverse species assemblages.

A biodiversity survey of the area covering ants, trees, shrubs and birds found 95 species of ants belonging to 36 genera. Of these, six are newly discovered species and two were registered for the first time in Colombia. The survey also found 409 species of trees and shrubs. These include 22 species that at the national level are threatened, some being endemic to Colombia. It is known that 199 species of birds — the best-studied group — are found in the area. Of these, four species are threatened at the global level: *Penelope perspicax*, *Grallaria alleni*, *Chlorochrysa nitidissima* and *Dacnis hartlaubi* (Renjifo *et al.*, 2002). Four other species with restricted ranges have populations in Barbas, 20 species of birds found in Barbas are not present in Bremen and 16 species found in Bremen are not found in Barbas.

The Barbas and Bremen watersheds provide a good source of quality water for about 175,000 people in eight municipalities and also a large number of businesses, coffee plantations and two tourist theme parks. Because of its landscapes, Quindío department is the second most important tourist destination in Colombia, after the Caribbean coast.

Recent studies have demonstrated that Bremen has lost around 20 percent of its bird species due to its prolonged isolation from other areas of similar habitat (Renjifo 1999). In Barbas, however, the majority of the species populations that have disappeared from Bremen can still be found. The establishment of a corridor reconnecting the forest blocks could therefore facilitate the recolonization of these species in Bremen.

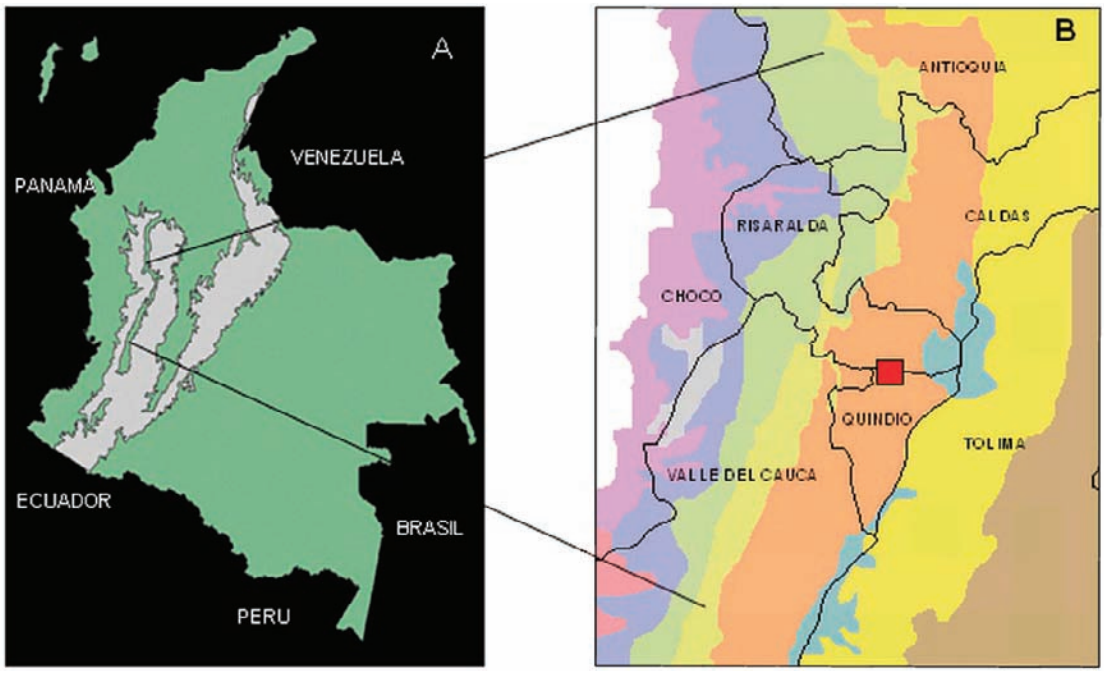
The proposal to strengthen connectivity in the region was initiated by the Instituto Humboldt as part of the larger GEF/Netherlands Embassy/Colombian government project Conservation and Sustainable Use of Biodiversity in the Colombian Andes. The ecological-network proposal was elaborated in 1999 in collaboration with local and regional environmental authorities, and its implementation commenced in mid-2001. Socio-economic studies concluded that local people have a high level of environmental awareness and are keen to be involved in conservation efforts. The establishment of corridors would also contribute to the scenic value of the landscape.

The goal of the project is to establish forests between the Bremen Natural Reserve, the Barbas river canyon and the Cestillal canyon in order to connect these areas, both physically and functionally. The measures involved in establishing the corridors will include:

- obtaining baseline data on existing biological and socio-economic conditions (completed)
- developing a communication strategy to strengthen the level of participation by local communities in the project (ongoing since 2003)
- economic analyses to determine the viability of economic and institutional incentives that would help secure the project's objectives (ongoing since 2003)
- concluding agreements to reduce the intensity of agricultural systems on private land that could then function as a corridor (ongoing since 2003)
- land acquisition
- reforestation with native trees in order to attract fauna, and constructing fences in order to prevent forest damage by livestock (ongoing since 2003)
- establishing landscape elements, such as hedgerows and windbreaks, that will improve connectivity (ongoing since 2003)
- establishing a fauna tunnel under the main highway
- monitoring focal species and vegetation cover in relation to connectivity

Potential sites for corridors between Barbas, Bremen and Cestillal have been identified on

Figure 5.1. The location of Barbas–Bremen–Cestillal



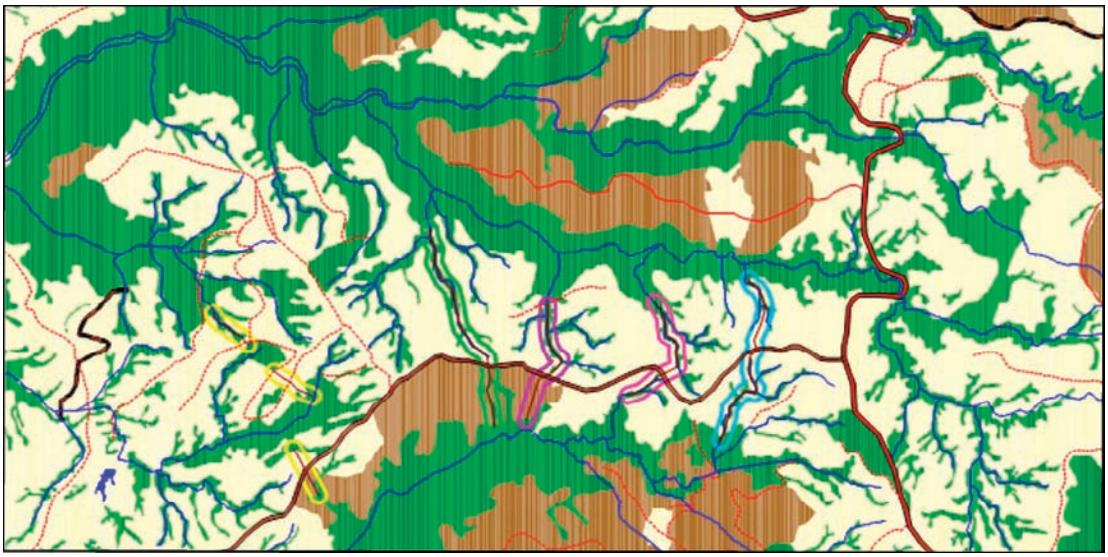
Diana Patricia Ramírez

the basis of studies, aerial photographs and data from the land registry. One potential scenario is to establish five corridors of about 100 metres wide in order to connect Bremen and Barbas forests, with two other corridors of the same width connecting Barbas and Cestillal. Another scenario is to establish a single corridor 500 meters wide connecting Barbas and Bremen and a second corridor of the same width connecting Barbas and Cestillal. The latter scenario offers certain advantages because it would be easier to establish and monitor and it would also have a shorter boundary length, thereby reducing edge effects. However, the final result will be strongly influenced by the results of negotiations with the landowners (although 100 metres is regarded as the minimum acceptable width).

The physical establishment of the corridors started in 2003 and is progressing well. The majority of the actions can be undertaken with the participation of local people. However, the establishment of larger corridors will require the acquisition of land and taking valuable agricultural land out of production.

The primary actors in the project are private landowners, the municipal government of Filandia, the regional autonomous corporations, two logging companies and local communities. Other parties include neighbouring municipalities that benefit from the protection of the forests within the project area (through measures that serve to protect the watershed, for example) and local environmental NGOs. All the main actors have responded positively to the project, in some cases becoming active and committed supporters. One municipality is providing initial financing for land acquisition and the establishment of corridors. Bilateral agreements with municipalities that support the project are a source of additional funds that can be directed to the protection of the watershed. This reflects the well-established tradition of collaboration

Figure 5.2. The proposed locations of the corridors in Barbas–Bremen–Cestillal (delineated in yellow, green, red and blue)



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between municipalities and private landowners in promoting measures such as reforestation programmes and hedgerows.

CASE STUDY 8
BRAZIL: THE ATLANTIC FOREST CENTRAL CORRIDOR

The Atlantic Forest biome originally extended across 1.3 million square kilometres — about 15 percent of Brazilian territory — but today less than 100,000 square kilometres remain. The biome is divided into two main ecoregions: the coastal Atlantic Forest and the interior Atlantic Forest. Both run from sea level up to 1,800 metres, which results in an exceptionally high degree of biological and landscape diversity. Approximately 20,000 species of vascular plants can be found — of which 6,000 are considered endemic — and about 1,300 species of vertebrates (not including fish), of which over 500 are endemic. This species richness places the biome as the sixth most important hotspot in the world. At the same time the forest serves the crucial functions of regulating water run-off and thereby preventing soil erosion.

A substantial part of the Atlantic Forest has been lost in recent times: between 1990 and 1995, for example, more than 500,000 hectares were deforested, largely through housing development and the expansion of arable and livestock farming, but also industrial activities. As a result much of the remaining area of Atlantic Forest is severely fragmented.

It was in these circumstances that a first proposal for the Atlantic Forest Central Corridor was developed by the Brazilian Ministry of Environment in 1998. The ecological network is located on the Atlantic coast in the states of Espiritu Santo and Bahia, extending for more than 1,200 kilometres from north to south and covering a total area of 86,000 square kilometres. This tract of land is biologically diverse: it is one of the main centres of endemism in the Atlantic Forest and supports several species threatened with extinction. A study in a private reserve

Figure 5.3. The location of the Atlantic Forest

near Ilheus, Bahia, found 454 tree species in just a single hectare of forest — the highest known diversity of tree species in the world.

Within the Atlantic Forest Central Corridor, the total area under protection (including federal, state, municipal, privately owned and indigenous sites) represents just five percent of its total area. At the southern extreme of Bahia, one of the two most important blocks of the Corridor includes four national parks. However, protected-area management faces serious challenges. Human pressure on the sites is high and in most of the surrounding areas land use is not sustainable. The most serious threats include hunting, forest fires, uncontrolled tourism, illegal land occupation and palmetto cutting. Moreover, within the protected areas about 95 percent of the land is privately owned. A particular conservation challenge in the states of Espiritu Santo and Bahia is that the average size of the core areas is only 3,200 hectares, which is too small to provide sufficient habitat for many of the species populations. In Espiritu Santo, for example, of the 372,862 hectares of native forest only 72,263 hectares are formally protected (equivalent to three percent of the total area of the state forests).

The general objective of the Atlantic Forest Central Corridor is to improve the effective conservation of the Atlantic Forest's biodiversity. This is to be secured through establishing an ecological network in combination with a participatory socio-environmental management programme. Six specific types of measures are under development:

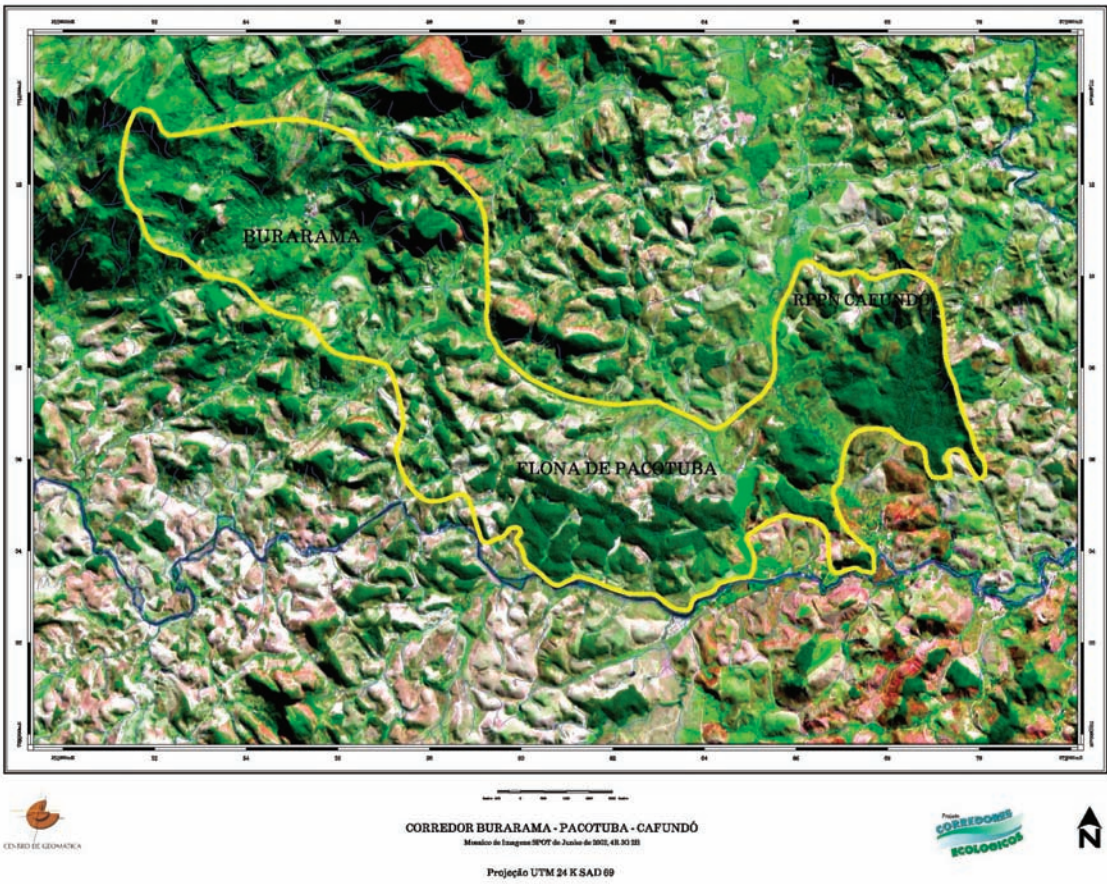
- formulating alternative strategies aimed at maintaining and/or increasing forest ecosystem connectivity
- developing and implementing innovative and replicable models for biodiversity conservation on private land
- developing technical, economic, legal and institutional tools to help secure the integrity of the ecosystems and promote the restoration of ecosystems in priority areas
- strengthening cooperative biodiversity conservation actions between public agencies, the private sector and civil society
- developing and promoting the adoption of incentives that encourage sustainable use in private and public economic sectors
- promoting the integration of conservation strategies and economic development policies

The organizational structure of the project involves four main elements: a General Coordination Unit (which manages the relations between the implementing agencies), the Management Committees (which monitor and evaluate project implementation), the State Coordination Units (which provide operational support to the implementing agencies and the Management Committees) and local parties (including civil organizations, the private sector, municipalities and other stakeholders).

Implementation of the programme commenced in 2002. The initial phase involves the development of a management plan that specifies the strategies, actions and resources for its implementation. The most important provisions are:

- developing a working proposal at the bioregional scale for the conservation of the entire area of the ecological network
- specifying processes and tools that ensure the sustainability of the areas to be conserved
- providing for the sustainable use of natural resources through socio-economic development strategies outside the protected areas
- indicating productive activities that are appropriate for biodiversity conserva-

Figure 5.4. The proposed Burarama–Pacotuba–Cafundó corridor within the Atlantic Forest Corridor



tion and restoration, and also developing alternative forms of natural-resource exploitation

- developing an environmental, social, economic and institutional information system that is integrated into a GIS, together with management procedures that allow the periodic updating of the data
- establishing a monitoring system that generates the information necessary to devise appropriate management measures
- establishing priority areas for the establishment of corridors

The development of the management plan was carried out in several phases. These included:

- preparatory phase: GIS and mapping work, database management, etc.
- evaluation phase: thematic analysis of sectoral issues, assessment of the political, administrative and socio-environmental structure, land-use trends and analysis of the negative impacts in relation to the individual corridors

Table 5.3. Typology of existing ecological network approaches in South America

Biological Corridor	Ecological Corridor	Conservation Corridor	Sustainable-Development Corridor
Promotes genetic exchange Focus on conserving priority species Linear structure Linear connectivity Physical connection between habitat fragments Facilitates movement of species Involves large-scale land planning	Reflects ecosystem vision Physical and functional connectivity Incorporates principles of landscape ecology Involves large-scale land planning Strengthens ecological processes Incorporates sustainable use and conservation objectives	Involvement of stakeholders Incorporates sustainable use Greater geographical scale Provides for connectivity between both protected and non-protected areas at the regional scale Incorporates both ecological and social objectives into corridor design	Integration of political, social and environmental aspects Active involvement of political and economic stakeholders Connectivity also aims to produce economic benefits Emphasis in sustainable production Linkages take full account of ecosystem, infrastructure and broader policy objectives

Adapted from Cracco and Guerro, 2004

- formulation of alternative strategies: developing conservation scenarios for the network, involving landscape modelling, selecting and prioritizing conservation areas and developing the main elements of the action plan
- final proposal: developing the general proposal for the implementation of the corridor, including the social and institutional validation of the final management plan

Specific management plans for three priority areas within the ecological network are currently being developed. The plans, which involve a more detailed analysis of ecosystem functioning, will define strategies for site management within the broader framework of the programme's objectives. This project area lies within the Mata Atlantica Biosphere Reserve, established by the Brazilian authorities under the UNESCO MAB Programme in 1992 and covering some 29.4 million hectares.

CONCLUSIONS

Although the ecological-network model was introduced to Latin America just 10 years ago, a remarkably large number of programmes are now underway. Indeed, at least one programme is underway in every Latin America country.

A recent review of ecological networks in South America assessed the characteristics of the various programmes and developed a typology that distinguishes between four different approaches to the ecological-network model (which in Latin America is referred to as "corridor"): "biological corridor", "ecological corridor", "conservation corridor" and "sustainable-development corridor" (see Table 5.3). Although it was clear that the typology reflects a continuum of approaches rather than four distinct models, the classification illustrates some important features of how ecological networks are developing across the continent.

To an important extent the typology also reflects a temporal evolution of ecological-network thinking in South America. Most of the early

networks focus predominantly on biodiversity conservation at the landscape scale. However, as a result of the realization that the involvement of a wide range of stakeholders facilitates the achievement of biodiversity conservation objectives and promotes community support, more recent initiatives are building broader sustainable-development objectives into their development. The different approaches also reflect the context of a particular initiative: whether, for example, it is to be established in a sparsely populated region, such as Vilcabamba–Amboró, or a more highly developed area, such as parts of Mesoamerica.

In addition to differences between approaches, the typology highlights a number of interesting common features. Thus, apart from the obvious elements of ecosystem management, connectivity and building on existing protected areas, it is notable that even the "ecological corridors" and the "conservation corridors" take account of broader sustainable development objectives in their programmes. Moreover, the use of land-use planning as a key instrument to establish the ecological networks is a striking feature, particularly given the relatively weak institutional structures in many regions and the unusually large scale of many of the initiatives (although the expert and financial support provided by international donors to many of the programmes is helping to strengthen institutional capacity). Most programmes are also actively promoting the involvement of stakeholders in their development and implementation.

Major challenges nevertheless remain for these programmes. Most initiatives, being relatively recent, have not yet progressed to an advanced phase of implementation, although valuable experience has been gained through a wide range of local projects. Nevertheless, it is on the ground that the most serious obstacles will be met, such as the illegal exploitation of natural resources (which characterizes many regions in Latin America), property rights and land-tenure conflicts, the exceptionally high ethnic diversity in many areas, and ensuring that measures directed at promoting sustainable development also provide economic benefits to local communities in the short term.

6. AFRICA

Protected areas in much of Africa date back to the colonial period. For example, in southern and eastern Africa, the British occupied present-day South Africa, Lesotho, Swaziland, Botswana, Zimbabwe, Zambia, Malawi, Tanzania and Kenya. Namibia was occupied by Germany but was later annexed to South Africa before gaining national independence. Angola and Mozambique were under Portuguese rule until they gained national independence in the mid-1970s.

The land tenure systems in most of these territories were such that prime productive land was reserved for the settlers while native populations were confined to densely populated, marginal lands of very low productivity. Later, the colonial governments — partly responding to international calls to set up special conservation areas and partly to arrest the rapid depletion of wildlife caused by commercial hunting — began to set up national parks, game reserves and other protected areas. In many cases, however, natives were seen as poachers, and game rangers were trained to keep them out of these "protected areas". Native populations therefore felt doubly expropriated — having lost both their traditional agricultural lands and their rights and access to exploiting wildlife (Murphree, 1990). Not surprisingly, very few protected areas have been created in the post-independence era.

Thus, the sites that were formally protected for conservation reasons were those that were least habitable by the colonists, although that does not mean that there was no human occupation of the areas: many of them were occupied by native populations who, in some cases, had to be moved to make way for the protected areas. However, population growth, with its concomitant demand for land coupled with advances in agricultural techniques and improved disease control, has led to steadily greater human pressure on the protected areas. As a result, many of the protected areas have increasingly become islands of nature where the boundaries have become more sharply defined.

Over the past twenty years African conservationists have started to question the efficacy of strict protected-area boundaries. This concern comes from the fact that many species are mobile and freely move into and out of protected areas. In fact, some of the protected areas tend to confine some wildlife species into areas smaller than their preferred ranges. Intrusive human activities, such as the erection of fences to separate wildlife from livestock for reasons of disease control, have also cut across the established migration routes of some species. These and other factors have led to a growing realization of the need to extend conservation efforts into territories outside protected areas and to allow linkages between and within protected areas.

A further impetus for the development of ecological networks is the emergence over the past 10 to 15 years of the concept of transboundary natural-resources management (see, for example, Van der Linde *et al.*, 2001). This arose in part from the challenge posed by the existence of a protected area in one country abutting a non-conservation area in the adjacent country, but also from a desire to link protected areas across territorial borders.

These landscape approaches, as opposed to site-specific management measures, are proving to be important drivers in the growing interest in the ecological-network model in Africa.

OVERVIEW OF THE PROGRAMMES

The restoration or establishment of corridors that allow large game species to move between protected areas has a long history in Africa. For example, in 1926 the Kibale Forest Game Corridor was established in Uganda (see box). However, human pressure on the land combined with poor management ensured that many of these corridors failed to maintain the conditions that were necessary to provide connectivity.

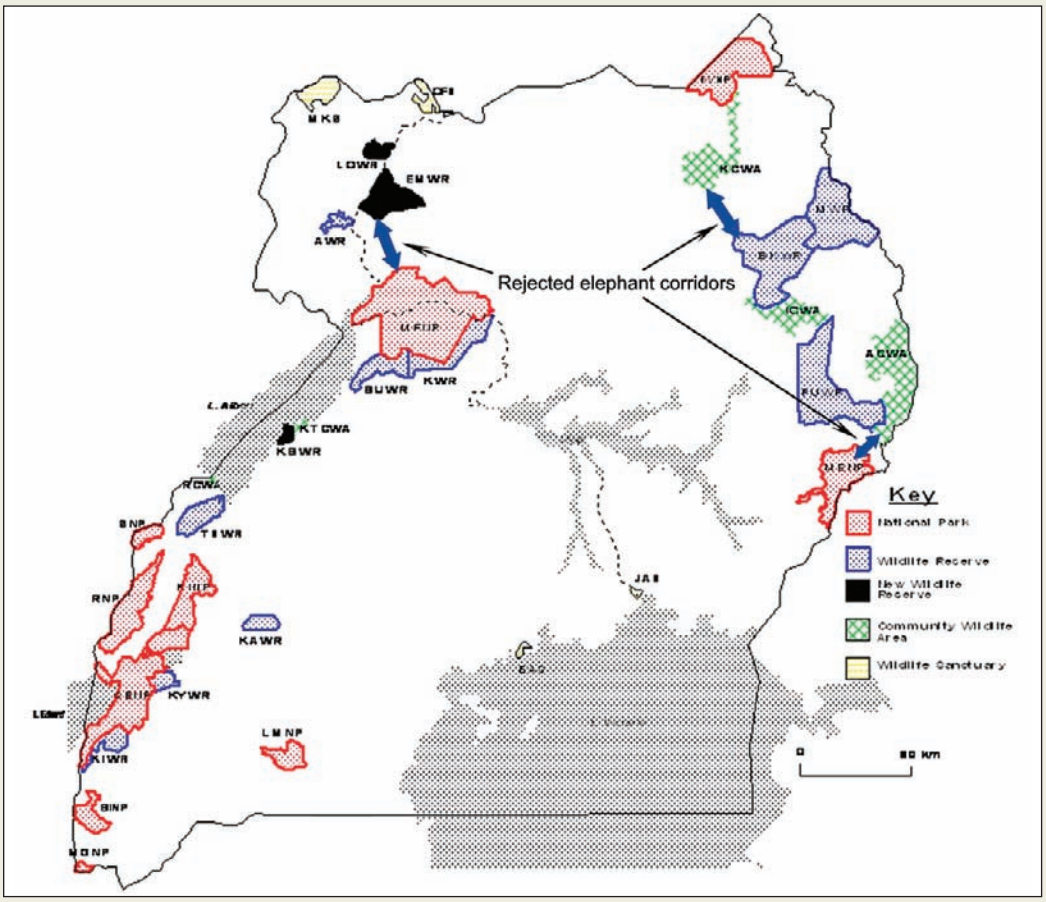
Some protected areas remain linked with their surrounding landscapes. For example, the

Uganda: Conflicts in Elephant Migration Corridors

Biodiversity conservation in Uganda faces tremendous challenges: financial resources are extremely limited, institutional capacity is low and human pressure on natural resources is high. In practice this often leads to local resistance to establishing new protected areas and to the encroachment of existing sites.

For example, the Kibale Forest Game Corridor in the southwest of Uganda was established in 1926 to allow large game mammals to move between the Kibale Forest and the Queen Elizabeth National Park. However, the corridor was poorly managed and by 1990 had lost almost all its special biodiversity value due to encroachment by 40,000 settlers and the clearing of most of the natural forest and elephant grass for cultivation. Monitoring showed that in 1991 the corridor was no longer used by elephants, Uganda kob, waterbuck or buffalo. Moreover, the number of elephants in the Kibale Forest and the Queen Elizabeth National Park had declined from 3,000 in 1973 to 500 by 1989 and their migration patterns had also changed. To rectify this situation, the Ugandan government evicted 30,000 settlers from the corridor in 1992 and a year later designated the corridor and the Kibale Forest as a national park.

Although the designation of such sites enhances their protection, the root causes of human–biodiversity conflicts often remain and continue to hinder conservation measures. For example, in three areas elsewhere in Uganda where there is a need to maintain or restore landscape linkages for elephants, proposals for new corridors have been rejected by the local communities due to the need of the expanding populations for access to land.



Environment Consultants Ltd.

Sapo National Park, which was created in 1983, was Liberia's first fully protected area. It covers an area of 107,300 hectares, consisting of lowland rainforest, swampy areas, dryland and riparian forests, and it represents the foremost intact forest ecosystem in Liberia. The park nevertheless remains reasonably connected by forested corridors to several other forest areas to the north, west and southeast, extending into Côte d'Ivoire.

Other programmes have focused on improving the management of land around protected areas, with the aim of strengthening their biodiversity value and also serving as buffer zones. These programmes include the Administrative Management Design for Game Management Areas in Zambia, Wildlife Management Areas in Botswana and the Communal Areas Management Programme for Indigenous Resources in Zimbabwe. Essentially, these programmes aim to mobilize and empower communities living close to protected areas by giving them access rights to wildlife and rights to controlled utilization of wildlife. The communities make decisions on hunting quotas, setting up tourist facilities and joint-venture business enterprises with the private sector. Economic benefits from the wildlife resources are intended to go directly to the communities who decide themselves on how best to share the benefits. UNESCO's Man and Biosphere Programme has applied this broader management approach to 87 Biosphere Reserves including two transboundary biospere reserves (the "W" region of Benin, Burkina Faso and Niger, and the Senegal delta between Mauritania and Senegal) in 39 African countries, the first reserve dating from 1976.

Linking existing protected areas and extending conservation management to surrounding areas through transboundary natural-resources management has led to the establishment of a number of transnational parks. Examples include the Kgalagadi Transfontier Park between Botswana and South Africa and the Great Limpopo Transfrontier Park shared by Mozambique, South Africa and Zimbabwe. The proposed Kavango-Zambezi Transfrontier Conservation Area will span parts of Angola, Botswana, Namibia, Zambia and Zimbabwe. The project, a collaborative effort between Conservation International, wildlife organizations, government agencies, NGOs and several donors, represents the largest contiguous wilderness, wetland and wildlife area in southern Africa. The initiative aims to restore wildlife migration routes and relieve unsustainable pressures on habitats and communities. Although transboundary natural-resources management is normally understood to bridge international boundaries, the approach is also apparent within countries where the management of natural resources may transcend other jurisdictional boundaries, such as district or provincial boundaries where similar issues to national borders arise.

Most recently, WWF's ecoregion programmes are applying the ecological-network model in a more consistent way to some large areas in Africa. The current terrestrial programmes in Africa include the following:

- East African coastal forests
- Madagascar dry/spiny forests
- western Congo basin moist forests, where five projects are being carried out (see box)
- Guinean moist forests
- Miombo (Central and Eastern Miombo woodlands and Zambezian woodlands and savannas)

WWF is also managing the following large-scale non-ecoregion programmes in Africa:

- Fynbos (South Africa)
- Rift Valley lakes
- Niger river basin
- northeast Congo basin moist forests/ central Congo basin moist forests
- Albertine Rift montane forests (Kenya)

Cameroon–Gabon–Congo: The Tri-Dom Ecological Network

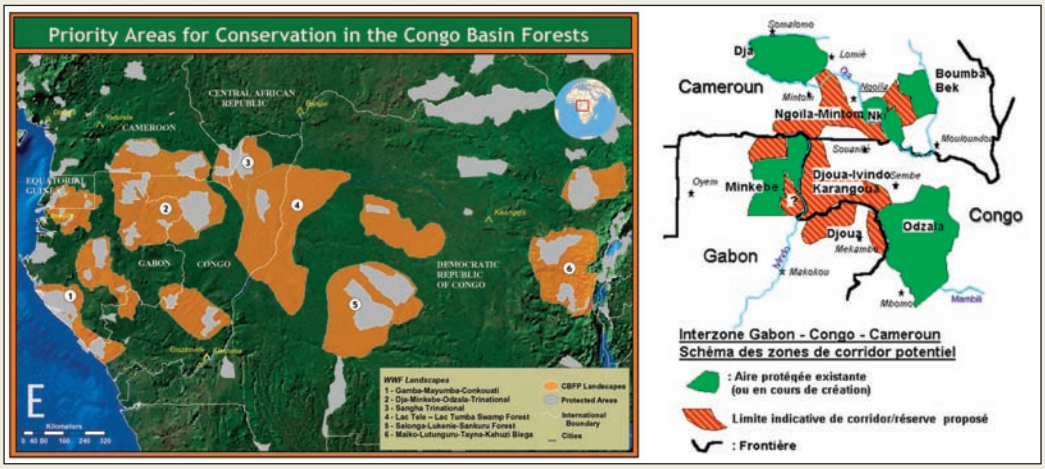
The moist forests of the Congo basin are part of WWF's Global 200 ecoregions (Kamdem Toham *et al.*, 2001 and 2003). WWF is implementing five projects in this region: TNS, TRIDOM, Gamba, Salonga and Lac Tumba-Lac Tele. TRIDOM is one of the most advanced projects.

The interzone rainforest around the junction of Cameroon, Gabon and Congo harbours one of the largest tracts of primary tropical rainforest in Africa, with an area of 141,400 square kilometres. It is also host to biodiversity of global importance. This includes the world's largest remaining populations of forest elephants, lowland gorillas, chimpanzees and forest buffalo. However, the rainforest is seriously threatened by human and economic activities, particularly hunting — a large and growing market exists for meat in the surrounding urban centres — and logging, which fragments the forest and increases the opportunities for hunting still further.

The indigenous population comprises BaAka and BaKola pygmies. These peoples were formerly hunter-gatherers but are now becoming increasingly settled, both through their own choice and because of government policies. There are also a number of Bantu tribes with whom the pygmies have a complex, largely interdependent social relationship. Currently, almost 25 percent of the forest lies within several protected areas. However, in all three countries severe limitations in institutional capacity are impeding effective management.

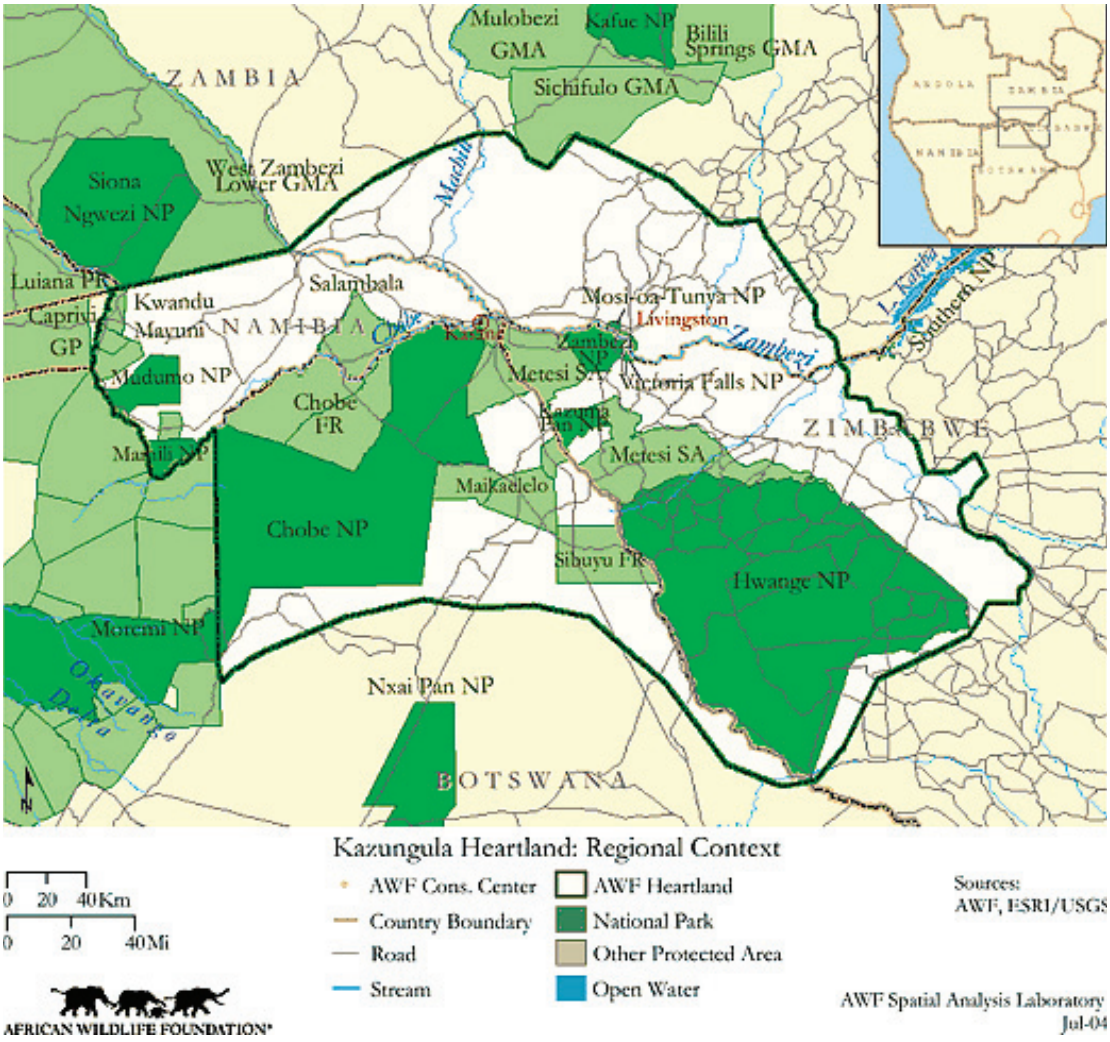
In the mid-1990s, these problems persuaded several conservation NGOs to launch an initiative to establish an ecological network across the region that can provide the framework for effective, long-term management. The discussions resulted in March 1999 in the adoption by the three governments of the Yaoundé Declaration, which established a framework for strengthening biodiversity conservation and the sustainable use of the forest's resources through a broad stakeholder process. The focal points of the Global Environment Facility in the three countries have endorsed the project and a tri-lateral coordination unit is being established to facilitate cooperation. WWF and ECOFAC have been requested by the three governments to provide expert assistance in formulating and implementing the programme with financing through the Global Environment Facility and bilateral donors.

The Declaration's objectives will be realized through an ecological network that is to be established over a period of 10 years. The plans provide for the establishment of a physical network of 40,000 square kilometres in extent together with a complementary management strategy that will apply to a total of 130,000 square kilometres. The immediate priority for action will be the areas that lie between the existing protected areas of Ngoïla-Mintom (Cameroon), Ivindo-Karangoua-Djoua (Congo) and the Djoua (Gabon) which have a rich fauna, a sparse human population and a relatively low potential for logging. These circumstances offer a good opportunity for establishing corridors between critical unprotected sites and the existing protected areas. A second priority concerns the forest access roads that are under construction, since their presence will result in intensified hunting pressures. The creation of buffer zones and the strengthening of the land-use planning system will therefore take a prominent role in the network development strategy.



Worldwide Fund for Nature

Figure 6.1. The Four Corners Transboundary Natural-Resources Management Area



African Wildlife Foundation

Other relevant initiatives include the Cape Floristic region in South Africa (Sandwith *et al.*, 2004), the Maloti-Drakensberg Transfrontier Conservation and Development Project in Lesotho and South Africa (Zunckel *et al.*, 2004) and the Albertine Rift Region in Uganda, Rwanda, Burundi, Tanzania, the Democratic Republic of Congo and Zambia (Plumptre, 2004).

CASE STUDY 9
BOTSWANA, NAMIBIA, ZAMBIA AND ZIMBABWE: THE FOUR CORNERS TRANSBOUNDARY NATURAL-RESOURCES MANAGEMENT AREA (THE KAZUNGULA HEARTLANDS PROJECT)

The Four Corners Transboundary Natural-Resources Management Area stretches across 220,000 square kilometres at the junction of Botswana, Namibia, Zambia and Zimbabwe. About half the area is formally protected: the Chobe National Park and Moremi Game Reserve in Botswana, the Mudumo, Mamili and Bwabwata National Parks in Namibia, Kafue, Mosi-oa-Tinya and Sioma Ngwezi in Zambia and the Hwange and Zambezi National Parks in Zimbabwe. Several protected forest sites in Botswana and Zimbabwe also fall within the Management Area. The land outside the protected areas is used for various forms of arable and animal husbandry, but several projects aimed at enhancing community-based natural-resources management with a primary focus on ecotourism are underway.

The Four Corners project started in 2000 and is being implemented by the African Wildlife Foundation with funding from the USAID Regional Office for Southern Africa. Four objectives have been defined:

- to improve landscape management and the management of specific sites
- to develop or improve conservation business ventures and partnerships
- to support policy and the institutional environment in the Management Area
- to disseminate widely information on the Management Area

In order to achieve these objectives a number of activities have been planned, such as:

- the identification and mapping of game corridors where game species move between protected areas (which include corridors linking Hwange National Park in Zimbabwe with Chobe National Park in Botswana and Zambezi National Park in Zimbabwe)
- standardizing fishery monitoring methods
- regulating commercial river activities in the riparian states
- encouraging all the traditional chiefs within the Management Area to sign a memorandum of understanding on collaboration in the management of natural resources
- developing general land-use management plans within parts of the Management Area
- promoting community/private-sector joint-venture partnerships as conservation business ventures

USAID provided financial support for the the first three-year phase of the projec, but funding to continue the work is being provided by the European Union. The current activities by the African Wildlife Foundation are focusing on a limited number of priority areas within the Management Area, known collectively as the Kazungula Heartlands. The main conservation targets in these sites, which cover a total of 8,900 square kilometres, are as follows:

- Systems:
  - river systems
  - wildlife migration corridors, particularly for elephants
  - woodland/grassland mosaics
- Communities:
  - wetlands
  - representative woodlands: teak, mopane and acacia
- Species assemblages:
  - flood-plain and semi-aquatic antelope (red lechwe, puku and water buck)

    - predator/prey interactions: lions with ungulates, livestock and people
    - cheetahs
    - birds of prey
    - giraffe/impala interactions with woodlands
- Species:
    - native fish (bream, tigerfish)
    - declining or threatened species (tsessebe, rhino, wild dog, Chobe bush buck, sitatunga, lion, leopard, cheetah, puku, sable and roan antelopes)
    - medicinal plants, endemic plants

At the end of the initial phase of this project the following achievements had been secured:

- all chiefs in the Management Area had signed a memorandum of understanding to collaborate on natural-resource management
- three wildlife corridors had been identified, two of which had been mapped
- an inventory of ecological monitoring systems had been developed
- standardized fisheries monitoring methods had been piloted
- aquatic biodiversity surveys had been conducted for the Upper Zambezi during low- and high-water periods
- a large carnivore-research programme had been established
- Conservation International had awarded a grant for research on the status of elephant populations
- a general land-use management plan had been developed for the Chobe Enclave
- a process to develop an agreement between Zambia and Zimbabwe to regulate commercial river activities on the Zambezi had been initiated
- a survey of wattled cranes had been undertaken in the Okavango delta
- a working group comprising directors of wildlife from the Four Corners states had been established

CASE STUDY 10
KENYA: THE WILDLIFE CONSERVATION LEASE PROGRAMME

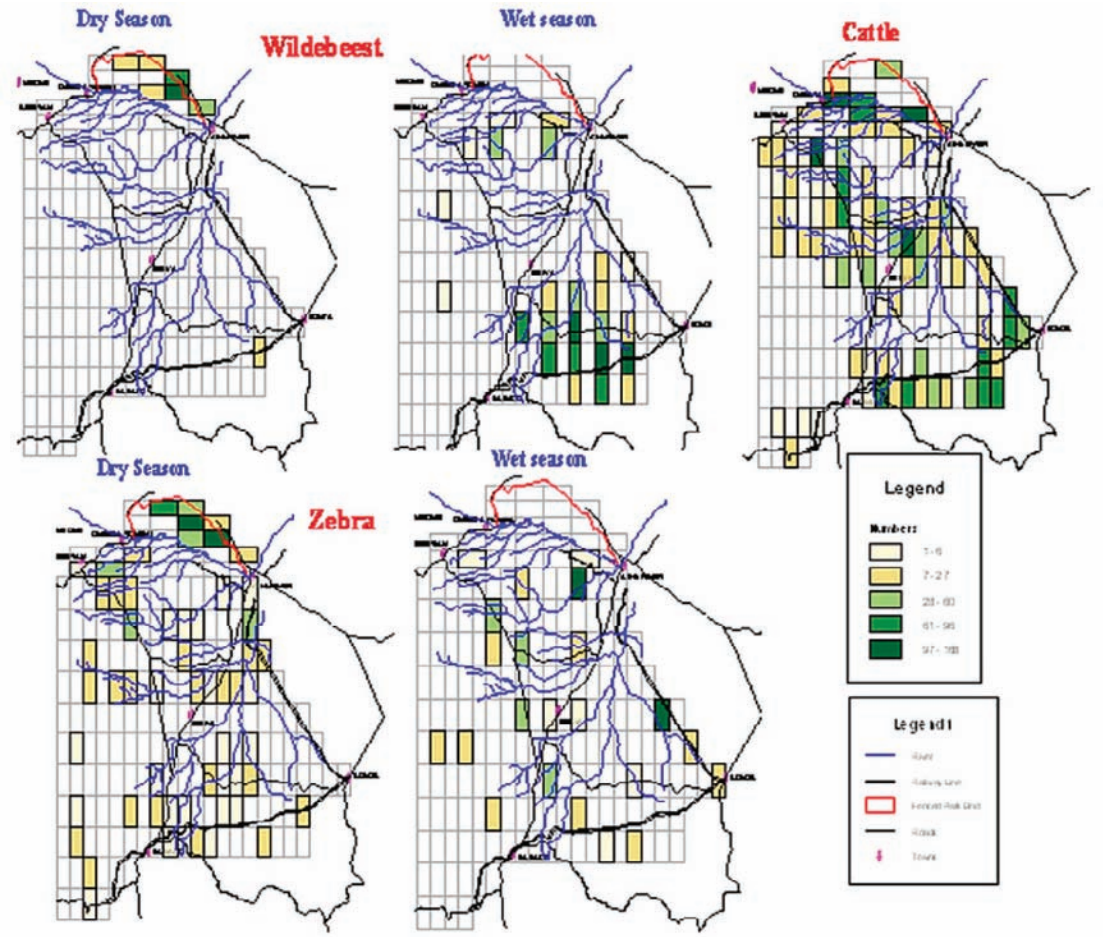
Nairobi Park is home to a wide range of mammals, including lions, zebra, wildebeest, impala, giraffe, various types of buck and antelope. During the dry season both zebra and wildebeest are concentrated in the park. With the onset of the wet season, the animals migrate southwards to the wildebeest calving zones in Amboseli National Park, a distance of about 200 kilometres. These migrations are crucial to the survival of the populations of zebra and wildebeest in the park (Gichohi, 2002; see also Figure 6.2).

Twenty years ago, the area between Nairobi Park in the north and Amboseli National Park in the south was not heavily used by humans. This has now changed, however, and an increasing proportion of the land is now farmed (see Figure 6.3).

Most of the land through which the zebra and wildebeest travel is privately owned by the Masaai, who are cattle farmers. However, as the zebra and the wildebeest migrate they are followed by predators — lions, cheetahs and leopards — and it is not unusual for these predators to kill Masaai livestock. The annual migrations are therefore viewed very negatively by the Masaai. The need to manage this conflict persuaded the Kenya Wild Service, the African Wildlife Foundation and other partners to initiate the Wildlife Conservation Lease Programme.

The programme covers an area of 2,500 square kilometres that extends from the Nairobi National Park through the migratory routes to the wildebeest calving zones in the south. Its goal is to change the attitudes of the Masaai livestock owners to the predators so that they accept that the migrating herds can continue to pass

Figure 6.2. Wildlife and livestock movements in the Athi-Kapiti

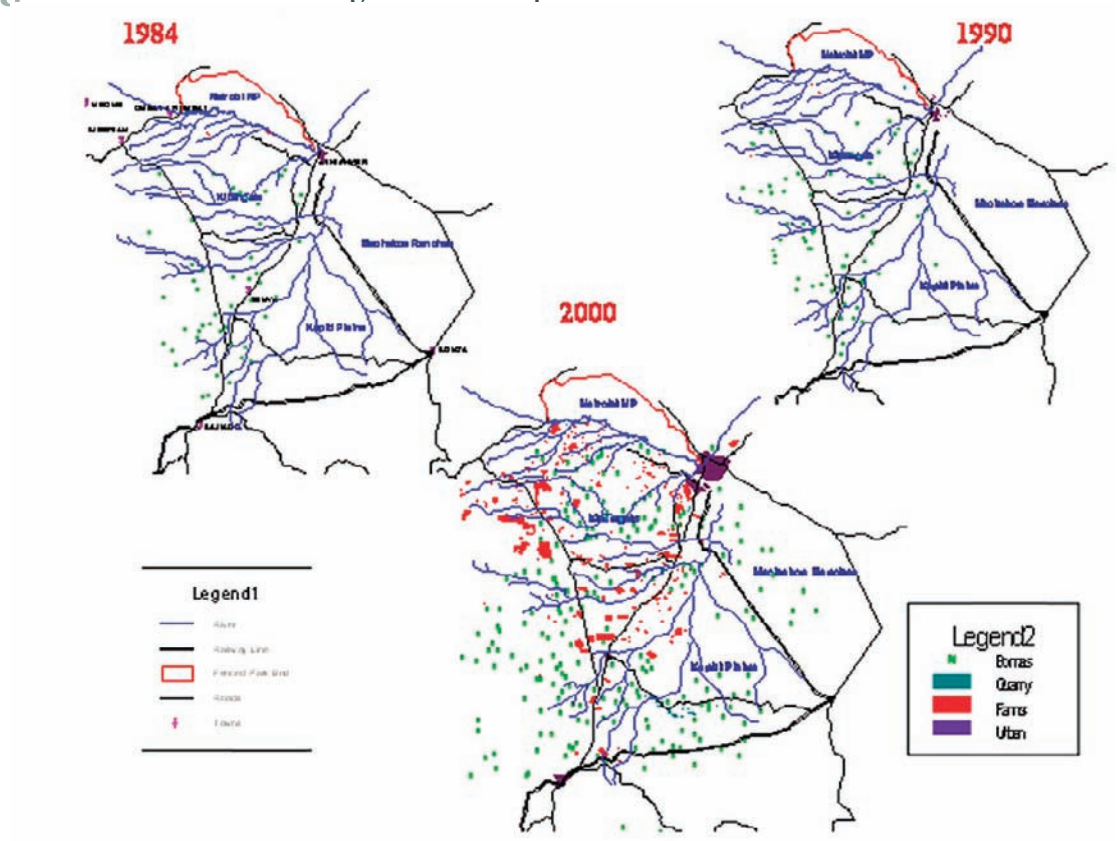


Gichohi, 2002

through their lands. This is to be achieved primarily through financial incentives. Landowners who join the programme receive compensation for any livestock lost to predators. Participants also receive a fixed annual payment whether or not they lose livestock. In return the landowners are expected to permit the movement of wildlife through their lands.

The Wildlife Conservation Lease Programme started in March 2000. Initially just two families participated in the scheme, but by October 2004 120 families had joined the project and many more were on the waiting list. The area of land that was covered by the programme increased from 87 hectares in 2000 to over 8,400 hectares in 2004. The current annual payment to landowners who "give away" land for wildlife is equivalent to US$ 10 per hectare. On average, participating landowners receive US $400 to 800 per year that is paid in three instalments. Cash compensation for livestock lost to predators is about US$ 30 per animal. These payments are financed through funds that are raised by the project team from donations. Partners that have donated funds to the project include Friends of the Nairobi National Park, the Wildlife Trust, the International Fund

Figure 6.3. Land-use changes in Athi-Kapiti



Gichohi, 2002

for Animal Welfare and the Wildlife Foundation. The project managers have also set up an endowment fund from which it hopes to continue to fund the project.

The long-term feasibility of the programme depends on the stability and sustainability of the endowment fund. However, Nairobi National Park, which receives about 24,000 foreign visitors each month, raises about US$ 720,000 per month through the entry fee for these tourists of US$ 30. There is therefore considerable potential for raising funds, although according to an official from the Kenya Wildlife Service this income goes to the national treasury.

CONCLUSIONS

The challenge of maintaining landscape-scale ecological processes in the face of human pressures was probably recognized in Africa before any other continent. For many decades, however, it was associated solely with the conspicuous issue of long-distance movements by game species. This was not only an issue of importance to a very limited group, the actions taken to conserve these species and to protect valuable areas also served to exacerbate the divisions between settlers and native populations — both economically and geographically. In these circumstances, proposals to establish protected areas that prevent access to natural resources or to take conservation action on land that provides only a marginal livelihood

to large numbers of natives inevitably came to be associated with colonial methods that disadvantaged local populations still further.

Perhaps more than on any other continent, the support of local comunities for landscape-scale conservation is a crucial issue in Africa, whereby the promise of sustainable livelihoods becomes the central challenge. In most African countries, especially in southern Africa, land in rural areas is either communally owned or state-owned, or both. The number of "beneficiaries" from schemes such as wildlife corridors is usually so large that the individual benefit is very small. There is also an increasing perception that governments and conservation agencies are focusing more on wild nature than on human needs. Setting aside land for corridors can therefore be perceived as a loss of land for agriculture.

Given this historical legacy and the severe lack of resources, it is not surprising that relatively few ecological-network initiatives, corridors and buffer zones have been developed or that, where programmes exist, their implementation has been impeded by intractable problems. Thus, corridors for game species often conflict with the subsistence needs of local populations, and transboundary conservation management programmes can be perceived as weakening the nation state and empowering communities across national or local government boundaries. This raises fundamental issues on the nature of borders. Should natural-resource management objectives determine where boundaries should be drawn? What is the status of national borders, which were imposed by colonists who have since relinquished power but are now promoting new boundaries in the form of protected areas and ecological networks?

At the same time, large areas are confronted with the over-exploitation of timber which, in addition to its impacts on biodiversity, both reduces the natural resources available to local populations and increases access to the remaining areas of forest, thereby increasing opportunities for illegal hunting. Dealing with these kinds of problems is a major task for large-scale conservation programmes, especially those modelled on ecological-network principles.

7. MEETING THE CHALLENGE

If one overriding conclusion can be drawn from this global review of experience, it is that programmes that aim to conserve biodiversity at the landscape, ecosystem or ecoregion scale through interconnected and buffered systems of protected areas are moving into the mainstream of conservation practice. Moreover, based on the number of such programmes that have been initiated around the world in recent years, it would be fair to conclude that the increasingly broad application of the ecological network represents one of the most significant strategic developments in conservation planning over the past decade. A few simple figures are sufficient to demonstrate the magnitude of the shift: this review, although describing only a proportion of the initiatives that are currently underway, nevertheless traced about 200 ecological networks, corridors and comparable projects, plus 26 flyways, 482 Biosphere Reserves in 102 countries and 11 Bonn Convention agreements to conserve populations of migratory species. Bearing in mind that ecological networks and corridors only began to generate broad interest in the mid-1990s, this is a remarkable development.

In fact, the changes that we are witnessing are more fundamental than simply the scale and the configuration of the territories that are managed for conservation purposes: they extend to the management objectives, competences, techniques and skills that are applied, the perceptions that underly the programmes, the involvement of local communities and the sources of funding. Ecological networks are above all a manifestation of an array of new insights into how conservation needs can effectively be addressed. Indeed, when viewed in a broader context these changes amount to a paradigm shift in protected-areas planning, as Phillips (2003) has elegantly demonstrated (see Table 7.1; see also Crofts, 2004).

Table 7.1. The changing paradigm of protected areas

	AS IT WAS **Protected Areas Were:**	**AS IT IS BECOMING** **Protected Areas Are:**
Objectives	• Set aside for conservation • Established mainly for spectacular wildlife and scenic protection • Managed mainly for visitors and tourists • Valued as wilderness • About protection	• Run also with social and economic objectives • Often set up for scientific, economic and cultural reasons • Managed with local people more in mind • Valued for the cultural importance of "wilderness" • Also about restoration and rehabilitation
Governance	• Run by central government	• Run by many partners
Local people	• Planned and managed against people • Managed without regard to local opinions	• Run with, for, and in some cases by local people • Managed to meet the needs of local people
Wider context	• Developed separately • Managed as "islands"	• Planned as part of national, regional and international systems • Developed as "networks" (strictly protected areas, buffered and linked by green corridors)
Perceptions	• Viewed primarily as a national asset • Viewed only as a national concern	• Viewed also as a community asset • Viewed also as an international concern
Management techniques	• Managed reactively within short timescale • Managed in a technocratic way	• Managed adaptively with long-term perspective • Managed with political considerations
Finance	• Paid for by taxpayer	• Paid for by many sources
Management skills	• Managed by scientists and natural resource experts • Expert led	• Managed by multi-skilled individuals • Drawing on local knowledge

taken from Phillips, 2003

MAIN CHARACTERISTICS OF THE PROGRAMMES

Shared Body of Conservation Goals

The programmes that are described in this review were selected on the basis of a shared body of conservation goals, management principles and a functional configuration. That is to say, in general:

- they aim to conserve biodiversity by maintaining the functioning of ecosystems and promoting the sustainable use of natural resources
- they secure these goals by working at the landscape, ecosystem or ecoregion scale, strengthening ecological coherence, minimizing the effects of potentially damaging external activities, restoring degraded ecosystems and promoting complementarity between land uses and biodiversity conservation
- they apply a spatial model comprising core areas, corridors, buffer zones and sustainable-use areas

In addition to these initiatives, two other types of programme are also included because of their close relationship to the ecological-network model: Biosphere Reserves and agreements under the Bonn Convention on the Conservation of Migratory Species of Wild Animals. Launched in 1970, UNESCO's Man and Biosphere Programme introduced the management hierarchy of core areas, buffer zones and transition areas into international conservation practice, thereby establishing a significant precursor to the ecological network. With 482 Biosphere Reserves designated in 102 countries, the programme has had a major impact on protected-areas management. The Bonn Convention, adopted in 1979, marked the first international recognition of the generic importance of maintaining ecological linkages for migratory species (although several bilateral and multilateral flyway agreements preceded the convention). A total of 13 species-specific agreements and memoranda of understanding covering 89 countries have since been adopted.

Wide Variation in Terminology

One aspect of the programmes that is the source of some confusion is the wide variation in terminology. As was noted in the introduction, programmes that apply the ecological-network model use a variety of terms to describe the approach. The examples discussed in this review carry the English or equivalent names of "ecological network", "green network", "reserve network", "wildlands network", "interwoven biotope system", "territorial system of ecological stability", "corridor", "biological corridor", "ecological corridor", "biodiversity corridor", "conservation corridor", "biogeographical corridor", "sustainable-development corridor", "green corridor", "ecoregion plan", "transboundary natural-resources management area" and "transfrontier conservation area". Still other names are undoubtedly used for programmes that have not been reviewed. Conservation programmes that apply the principles of the ecosystem approach can also in many cases be regarded as ecological networks (which include to some extent many freshwater management programmes with a comparable approach). Complicating the terminology issue further, not all programmes that use some of the names listed — such a proportion of WWF's ecoregion programmes and certain transboundary natural resources management area in Africa — can be regarded as ecological networks (although most of those that do not correspond to the model adopt an approach comparable to that found in Biosphere Reserves).

This variation in terminology may cause confusion, but it also demonstrates that the ecological-network model is a product of parallel evolution. A regional pattern in terminology can nevertheless be discerned: across Europe and in

international governmental organizations, the term "ecological network" is now generally used, in North America "reserve network" is preferred, while in South America and much of Asia many programmes are known as "ecological corridors". In Africa a generally accepted term has yet to evolve.

Wide Variation in Scale

As the many examples of ecological networks show, the programmes may share certain generic features, but the way in which the model is being applied varies in some important respects. The most obvious variable is geographical scale. Ecological-network programmes vary in scale from projects designed to conserve or re-establish linkages for specific local species populations (such as corridors for the giant panda in China or ecoducts for deer in the Netherlands) through regional programmes (such as North America's Wildlands Project, many of the programmes in Latin America and WWF's ecoregion projects) to continental strategies in the form of the Pan-European Ecological Network and Australia's WildCountry. However, although the geographical scale of these programmes varies enormously, most share a focus on ecosystems (the forest-steppe ecosystem of Central European Russia or the Guadiamar river basin in Spain), on larger ecoregions (such as the link between the wet forests in Australia's southwest tip through to the dry inland, North America's "megalinkages" or the mountain systems between the Amazon and the Orinovo rivers in northeastern South America) or on metapopulations (carnivores in Italy or elephants in Africa and Asia). Even the smaller-scale projects, although limited in terms of geographical scope, are usually framed within a broader ecological context. However, geopolitical boundaries often determine the practical scope of a programme. This is particularly the case in the government-driven programmes, such as the national ecological networks in Europe and the Green Belt.

Ecological Networks Initiated by Both Governments and NGOs

In this respect it is interesting to note that ecological networks are initiated not only by governments but also by NGOs, and large numbers of both types of programmes are underway. Some regional patterns are nevertheless discernible in the role taken by governmental and non-governmental organizations. In Europe the majority of ecological-network programmes have been initiated by national or, in a few instances such as in Andalusia (Spain), Cheshire (UK) and Russia, by regional governments. The only NGO programmes are a relatively small number of WWF ecoregion projects. In North America, by contrast, virtually all the ongoing programmes have been initiated by NGOs, in most cases within the framework of the continental Wildlands Project. In Australia, the nationwide WildCountry programme is also an NGO initiative, although the programme is being implemented in collaboration with government bodies. In Latin America most initiatives have come from NGOs, Conservation International being the primary driver; in many cases, however, the programmes are being developed in close cooperation with regional and national governments, such as the Mesoamerican Biological Corridor. In Asia NGOs are again the most important initiators, with both WWF and Conservation International playing an active role, but also some smaller NGOs that focus on specific areas, such as the Philippine Eagle Conservation Program Foundation.

BIODIVERSITY CONSERVATION

It is clear from this broad experience that considerable work still needs to be done before it can be demonstrated with confidence to what extent the potential biodiversity-conservation value of ecological networks is realized on the ground and across a wide range of conditions. Most programmes are clearly in too early a phase for

firm conclusions to be drawn in a generic sense, while those networks that are in a more advanced stage of implementation are almost invariably to be found in the more developed countries; they therefore represent a limited sample of the conditions in which ecological networks are being applied. Nevertheless, encouraging results have been secured by many of the programmes that have progressed to the implementation phase. These results are of sufficient substance and significance to justify some initial conclusions on progress to date.

Focus on Conditions Necessary for Long-Term Conservation

The first lesson that can be drawn is that the programmes are explicitly attempting to establish and maintain the environmental conditions that are necessary to secure the long-term conservation of biodiversity rather than limiting themselves to the *in-situ* protection of valuable sites or threatened species populations. This involves, in the main, safeguarding assemblages of habitat large enough and of sufficient quality to support species populations, providing, where necessary, opportunities for movement between these reserves, buffering the network from potentially damaging human activities and promoting sustainable forms of land use in the contiguous landscapes.

That this model applies to species that require access to very large areas or need to migrate across a landscape is obvious. However, a debate on the general effectiveness of this approach in conserving a substantial proportion of biodiversity has been underway for many years. For many species, extensive linked and buffered systems of core areas are not immediately essential to their survival. Most plant species, for example, do not critically depend on physical linkages with other habitat patches in the short term. Even for many of these species, however, other factors become important for their long-term viability, such as the survival of a full complement of species within an ecosystem, the opportunity to move away from an existing area that comes under threat, and the occurrence of periodic natural disturbances that may require some form of linkage, such as flooding. Moreover, the island-biogeography finding that the risk of extinction decreases as habitat size increases still holds for a large number of species.

It can also be noted that protected areas offer extensive experience that is both relevant and valuable to an assessment of ecologial networks. For example, large predators have become re-established in certain protected areas as a result of improved connectivity and increased size of the areas, such as in the European Alps, the Northern Rocky Mountains and the Apennines. This restores a needed trophic level to the ecosystems, giving more control of meso-predators and herbivores that can cause and have caused damage to both animal and plant components.

The Key Biodiversity-Conservation Challenges for Ecological Networks

If it is accepted that these factors are indeed crucial to the conservation of biodiversity in the long term, then the challenge for ecological networks is to demonstrate: (a) that the programmes are succeeding in establishing the conditions on the ground, (b) that the viability of species populations and communities is thereby improved in practice and (c) that human communities have access to sustainable livelihoods.

In assessing the degree to which current programmes are meeting these challenges, certain factors should be taken into account. First, the many examples of ecological networks that are described in this review represent two classes of network design that operate at different levels and with different degrees of specificity. The first group is a strategic configuration — the initial phase in virtually all the examples — that is based on a broad understanding of ecosystem

processes, the needs of the species populations, the threats that need to be resolved and the opportunities for sustainable forms of land use. The second group comprises precisely delineated configurations with broad stakeholder-oriented action plans that are being implemented on the ground. Most of the examples reviewed, having been initiated in the past few years, clearly fall into the first group: that is, they are still at the stage of a strategic programme. Many of these initiatives are in the process of being elaborated into more detailed implementation programmes or a series of local projects but have not yet led to action on the ground. Examples include the Guiana Shield in South America, the Far East Ecoregion in Russia and WildCountry in Australia.

In terms of assessing the value of the ecological-network approach, the more interesting examples are those where implementing actions have already been taken. Although no ecological-network programmes are at a sufficiently advanced stage of implementation to be able to draw conclusions on their overall effectiveness — which in any case will only be possible many years after their implementation when the measures have had full opportunity to take effect — some valuable lessons can be drawn from specific implementing actions and the research-and-development process.

The Potential Added Value of Ecological Networks

In terms of biodiversity conservation, ecological networks have the potential to offer added value over more traditional approaches in three main ways:

- by directly relating conservation actions to ecosystem processes
- by linking sites together to create coherent assemblages of habitat patches
- by extending biodiversity conservation into the wider landscape through compatible forms of land use

The examples discussed in this review present a wide range of experience in how these three aspects are given form and effect. As noted above, most programmes take one or more ecosystems or the larger ecoregion as their operational framework. This requires the programmes to address three major challenges: (a) to understand how the respective ecosystems function, (b) to devise conservation measures that are effective in maintaining ecosystem processes and (c) to secure and coordinate actions over large areas, which may involve devising appropriate mechanisms to facilitate cooperation between a large number of stakeholders.

These are clearly enormously complex tasks, and few programmes have advanced to the stage where it can be demonstrated that all three challenges have been met. With regard to understanding how ecosystems function, most programmes are based on a combination of habitat and species mapping (often using GIS) and an assessment of threats. Examples that are currently in this phase include Moldova's National Ecological Network, the Italian National Ecological Network, the Four Corners Transboundary Natural-Resources Management Area in Southern Africa, the Vilcabamba–Amboró Conservation Corridor in Peru and Bolivia and many of WWF's ecoregion programmes (which commence with a biodiversity and socio-economic "reconnaissance"), such as the Central European Forest-Steppe Ecoregion. In these and many similar examples an indicative configuration of the projected ecological network has also been formulated.

Only when programmes move beyond this initial phase — which usually takes some years — is it feasible to undertake more detailed analyses which can then form the basis of an elaborated proposal that takes account of the interests of a broad array of stakeholders. In some cases, an incremental approach is adopted for financial or political reasons or in order to elaborate certain parts of the network through pilot projects. A common feature of these programmes

is the objective to conserve a representative array of habitats. Examples include the Southern Rockies Wildlands Network in the US, some of the giant panda corridors in China, the Atlantic Forest Central Corridor in Brazil and Biosphere Reserves such as Las Yungas (Argentina), Rhon (Germany), Kruger to Canyons (South Africa) and Gran Cantabrica (Spain).

Very few ecological-network programmes have progressed to the stage where implementation on the ground has made substantial progress. Examples include the Mesoamerican Biological Corridor, the Estonian Green Network, the Dutch National Ecological Network and the Terai Arc Landscape. However, it will be many years before even these ecological networks can be considered "established", and measures to continue strengthening the quality of the networks will be necessary beyond that.

Lessons To Date

The fact that few ecological networks have reached an advanced stage of implementation — or that the measures that have been implemented on the ground have not yet been functional for a long enough period to be able to demonstrate that they have improved the viability of the respective species populations — prevents a comprehensive scientific assessment of the value of the programmes. That is not to say, however, that no lessons can be drawn from the experience to date on their likely long-term effectiveness.

Based on Scientific Assessments

First, it is worth noting that the ecological networks that have reached the implementation phase are all based on comprehensive scientific assessments of the needs of the habitats and species in relation to the threats to which they are exposed. These assessments — such as those for the Southern Rockies Wildlands Network, the Estonian Green Network, the Barbas–Bremen–

Summarized Checklist for Wildlands Network Designs

1. Scientists and other experts are intimately involved throughout the planning process, from the initial formulation of goals and hypotheses to the completion of the design and, in some cases, its implementation.
2. The methodology is rigorous and systematic, within the constraints imposed by broad-scale conservation planning, and seeks to address the stated goals and questions.
3. Methodology includes the three tracks of special elements, representation and focal-species analysis. In addition, existing or potential threats to biodiversity are addressed.
4. Methodology is well documented and replicable; studies could be repeated by others.
5. Interpretation and application of results are congruent with principles (i.e., empirical generalizations) of conservation biology, demonstrate a good command of relevant literature and theory, and apply the precautionary principle.
6. The project is thoroughly peer reviewed. In addition, the wildlands network design is available to the public for review. Review comments are thoughtfully considered and addressed.
7. At least some of the results are publishable in reputable, peer-reviewed journals, as well as other outlets.
8. The entire process, from developing research methods through implementation, is iterative and adaptive. There is no "final plan"; rather, the wildlands network design is continually refined and improved with feedback from research, monitoring, peer review and practice.

Taken from Noss (2003).

Cestillal programme and many of the WWF ecoregion projects — offer convincing evidence of the justification for applying the ecological-network model. The checklist developed by the Wildlands Project gives an indication of the concern for scientific rigour in developing the plans (see box).

Increasing Evidence of the Value of Corridors

A further source of evidence on the effect of ecological networks is the experience that has been generated through corridor projects. Over the past decades, a substantial literature on connectivity has been generated and many projects have produced measurable results. Good examples are the Bow Valley corridor in Canada and various elephant corridors in Africa and Asia. Although the concept of corridors has generated a lively debate over many years, evidence from the increasing number of projects shows that appropriately designed corridors generally meet the expectations of how they will function in practice. Moreover, most of the documented examples of corridors suggest that establishing or maintaining the linkage was the most cost-effective means of achieving the conservation objective. Indeed, in many cases the corridor was demonstrably the only feasible and practicable option to achieve the objective, while in other cases alternative courses of action — such as enlarging a protected area — would have involved intractable problems. A good illustration of this latter point was the proposal to enlarge the Bialowieza National Park, harbouring a remaining tract of the primeval European Forest, which met considerable opposition from local communities. A compromise situation was attained by enlarging the Bialowieza Biosphere Reserve to allow a multiple land use approach with different degrees of protection combined with sustainable use and optimum connectivity (MAB Poland, 2005).

It is important to emphasize in this respect that connectivity is essential not only for certain species, it is fundamental to many ecosystem processes. Aquatic ecosystems are the most obvious example. Inland water systems are probably the most fragmented of all ecosystems, yet they depend for their functioning on physical connections between their upper and lower catchments, including temporal fluxes such as flooding. Disrupting these flows can impact the entire ecosystem. Maintaining the integrity of aquatic systems — for example where sites are designated under the Ramsar Convention — therefore involves management approaches that are complementary to the ecological-network approach, as the extensive experience with river-basin management demonstrates (see, for example, Ramsar Convention Secretariat, 2004).

The role of large predators can also be crucial in many ecosystems. By creating conditions for the return or maintenance of large predators (often by migration through connectivity or by providing a larger "protected" home range), we can restore or conserve ecosystem elements whose presence helps to control meso-predators or herbivores that damage the ecosystems, such as overbrowsing by deer or the loss of songbirds to both meso-predators and the absence of understory cover.

Climate Change

An issue that is attracting growing attention is the question of whether ecological networks offer a potentially useful conservation strategy for responding to climate change. The ecological consequences of climate change are the subject of an increasing number of studies (see, for example, Watson *et al.*, 1998; Thomas *et al.*, 2004). It is projected that certain ecosystems are particularly vulnerable to climate change. These include mangrove forests, boreal and tropical montane cloud forests, coastal marshes, alpine and arctic ecosystems, wetlands overlying permafrost and coral reefs. Further, monitoring studies of ecosystems and migratory species are identifying changes that seem to be linked to rising temperatures,

such as different migratory patterns for certain bird species. However, to what degree ecological networks can assist in ameliorating the impacts of climate change remains an open question. Corridors may offer populations of animal species opportunities to move away from threatened habitats, but vegetation communities cannot shift so readily and many ecosystems are inextricably linked to geomorphological features, such as mountain ranges and estuaries. IUCN's World Commission on Protected Areas nevertheless recommends that three strategies for adapting protected areas to global change are to link isolated core areas by corridors, surround core areas with buffer zones, and surround clusters of core areas, corridors and buffer zones with "biodiversity-friendly" land uses (World Commission on Protected Areas, 2003).

Retaining Coherence in Intact Ecosystems

Another feature of the examples in this review is that the majority of ecological networks which are in an advanced stage of implementation are in developed countries where, in most cases, ecosystems have become highly fragmented. In these circumstances, the network approach is being applied to an important extent in order to restore ecological coherence. The Guadiamar Green Corridor in Spain and WildCountry in Australia are good examples of this approach. However, as some of the examples show, the ecological network is also being applied in order to retain the coherence of large ecosystems or ecoregions which are still relatively intact but are coming under increasing pressure — often through a combination of development and underdevelopment — such as the Far East Ecoregion and the Vilcabamba—Amboró Conservation Corridor. In these cases the goal of the network is to guide the region's development strategy so that conflicts with ecosystem processes and valuable concentrations of biodiversity are as far as possible avoided. It is clear that most of these programmes will require considerable further development if they are to be able to take on such a role. However, if they can succeed in this ambition their potential conservation value would be enormous.

Successful International Cooperation

A final observation on the characteristics of ecological networks in relation to the conservation of biodiversity concerns the issue of international cooperation. A large number of the programmes discussed in this review are being developed across the borders of two or more countries. Rivers are a common focus of transboundary management efforts. Working at the international scale is an inevitable consequence of focusing action on ecosystem processes. That, however, introduces further complications into an already complex process. Yet in very few of the transboundary programmes does the international dimension seem to be a significant barrier to progress (although for practical reasons many of the implementing projects in these cases are limited to one of the countries involved in the programme). What these examples demonstrate is that operational methods are being found within which fruitful international cooperation on biodiversity conservation can be realized.

SUSTAINABLE USE

All Programmes Promote Sustainable Use

The integration of biodiversity conservation and sustainable use is one of the defining features of ecological networks. Thus, all the programmes covered by this review promote an array of land-use functions which can range from strictly protected areas (equivalent to IUCN's Category Ia Strict Nature Reserve or Category Ib Wilderness Area) through to multiple-use areas in which the landscape has an important productive role. In virtually all cases this hierarchy of functions is based on an integral assessment of conservation priorities and socio-economic needs.

Inevitably, the scope of the assessment and the rigour with which it is carried out vary considerably from programme to programme, depending on the resources available or the working scale. A large number of programmes have nevertheless developed comprehensive guidelines and plans for the sustainable use of biodiversity. Thus, the older national ecological-network programmes in Central Europe were based on an approach that would now be called sustainable development and involved detailed elaboration at the local level through the comprehensive planning systems in those countries (although, due to the political disruptions of the 1990s, not all the programmes have progressed to that stage).

As the examples demonstrate, the variety of complementary land uses that are being promoted is extremely wide. These include support for extensive farming practices (Estonian Green Network), the sustainable harvesting of non-timber forest products and the cultivation of organic cocoa (Mesoamerican Biological Corridor), ecotourism and developing sustainable forestry in indigenous territories (Vilcabamba—Amboró Conservation Corridor), the establishment of tree nurseries (Terai Arc Landscape), promoting sandalwood growing, dry-country forestry and bush foods (Gondwana Link), developing recreational opportunities (Heart of the West Wildlands Network) and supporting livestock farming in corridors used by predatory species (Kenyan Wildlife Conservation Lease Programme).

Given the recent initiation of many of the programmes and the lengthy implementation process, it is clearly too early to be able to demonstrate to what extent each particular type of land use will prove in practice to be compatible with environmental sustainability in the long term and how the various instruments will operate in practice. Moreover, some of the projects cannot strictly be regarded as economically sustainable since they currently depend for their viability on a degree of external funding, whether from governments or donors.

Instruments and Methodologies to Promote Sustainable Use

Most government-driven programmes use the spatial-planning system — but also a range of other instruments such as financial incentives — to promote the sustainable use of biodiversity. Support for extensive forms of traditional farming in Europe is a common feature, such as in the Andalusian ecological network. Purchase of land by government agencies or privately funded nature conservation organizations in order to ensure that appropriate forms of management are applied — which can include sustainable uses such as forestry and recreation — is also common, such as in the Dutch National Ecological Network. A diverse range of other instruments are also applied by the programmes. These include legal protection, spatial planning, land reform, the establishment of community forests, buying up logging concessions, compensating livestock losses, organizing smallholders into producer associations, forest certification, conducting awareness-raising campaigns and education programmes, offering training courses, strengthening institutional capacity, and negotiating voluntary agreements, environmental service payments and conservation easements with land owners.

The NGOs that operate at the continental or international scale have developed more-or-less standard methodologies that encompass sustainable use. For example, WWF's Annamites Conservation Plan, that extends across Vietnam, Lao and Cambodia and which is used as a model for some other ecoregion projects, sets out 10 priority programmes for conservation action in the region which explicitly integrate sustainable use into the plan. Similarly, the Wildlands Project in North America has developed a common approach to preparing plans that includes sustainable use. For example, the Southern Rockies Wildlands Network distinguishes between four kinds of compatible-use lands: low-use lands,

moderate-use lands, transportation lands and private lands (see box).

THE KEY SUSTAINABLE-USE CHALLENGES

Management Resources and Integrative Approach

Several other major challenges also need to be overcome if these programmes are to secure sustainable use on the ground. Developing a comprehensive and coherent proposal that is appropriate to its setting and can meet strategic objectives requires a substantial investment in management resources and the adoption of an integrative approach: a complex array of data need to be collected and assessed, long-term funders have to be attracted, local communities should be fully involved, and all relevant stakeholders have to be brought together and their commitment secured. Certainly, by no means all the programmes have yet found workable and effective solutions in practice. However, many of the programmes are becoming increasingly sophisticated in their approach to implementation. Many WWF ecoregion programmes, for example, include monitoring and evaluation plans which assess progress through indicators and the achievement of quantitative targets.

Need for Political Stability

The long-term process that characterizes the development and implementation of an ecological

Two Examples of Sustainable-use Planning

The 10 priority programmes for conservation action in WWF's Annamites Conservation Plan are:

- protecting priority river basins
- an effective protected-area network
- three major landscape-scale initiatives
- creating a constituency for conservation
- understanding the Annamites
- building the capacity for success
- controlling unsustainable harvesting
- promoting good infrastructure development
- people, land and resources.

The Southern Rockies Wildlands Network Vision proposes the following uses in "low-use compatible-use lands":

- Primitive recreation, including mountain bike and vehicle use on designated dirt roads only, with no vehicle use off-road. Mountain bikes may be allowed on designated trails.
- Low impact, small, developed camp grounds accessible by vehicle, and some dispersed camping areas.
- Hunting and fishing, in so far as these are compatible with the full range of biological diversity.
- Ecologically sensitive and predator-friendly livestock grazing, except in riparian areas or other highly sensitive areas.
- Limited low-intensity silviculture, such as light selective cutting of previously logged forest followed by road obliteration and closure, and restoration thinning. Cutting of large trees should be prohibited and the goal should be to restore old-growth conditions and natural fire regimes.
- Limited habitat manipulation for focal plant and animal species.
- Restorative management, including those measures listed for Wilderness Areas, but without wilderness restrictions.
- No road construction, vehicle use or resource extraction in roadless areas of 400 hectares or larger.

network also has important implications for the necessary degree of political stability. At the basic level this concerns the robustness of government and basic political institutions. But at a higher level it is also important that a particular vision of conservation and economic development be shared across the political spectrum and by successive governments. These types of programme are therefore facing major challenges in politically unstable countries and regions with weak institutional structures.

Involving Stakeholders

A particularly difficult issue that confronts all the initiatives is how to ensure that dominant stakeholders can be persuaded to become fully involved in the programmes and committed to achieving their goals. The examples suggest that it is in the more developed countries, where institutions are stronger and where stakeholders are more accustomed to working within these kinds of processes, that progress to date has been most successful. Moreover, because the programmes are generally applied at the landscape or regional level, involve a long-term process, operate across an array of administrative units and embrace an exceptionally large number and wide range of stakeholders, the development and realization of an ecological network place high demands on the institutional framework and on process management. It is worth noting, however, that many of the programmes are supported and managed by organizations with substantial resources and extensive experience of implementing biodiversity conservation programmes in cooperation with other stakeholders. In fact in many ways large, internationally active organizations such as WWF and Conservation International are better equipped for this task than many local and regional governments since they are well-funded, have developed sophisticated assessment methodologies and also possess management resources that benefit from many years of experience.

POVERTY ALLEVIATION

Given the exceptionally wide range of circumstances in which ecological networks are being developed — from advanced industrialized countries to some of the poorest regions in the world — contributing to the alleviation of poverty is a concern of only a proportion of the initiatives. The information available on these programmes shows that they are predicated on the goal of establishing the conditions for sustainable livelihoods in combination with biodiversity conservation.

Poverty Alleviation Challenges and Responses

It is clear that many of the programmes are confronted with intractable problems that are closely related to extreme poverty. Many core areas, corridors and buffer zones, for example, are under high pressure from poor communities, such as in southern China where the buffer zones are densely populated and the protected forests have traditionally been an important source of non-timber forest products. In the Congo Basin, local hunters are threatening the rainforest ecosystem, encouraged by the large market for dried meat in the surrounding urban centres and the increasing number of access roads that are constructed by commercial logging companies. Corridors used by large mammals in southern Africa are a source of conflict with local populations who depend on the land for their subsistence.

The examples give many illustrations of measures designed to achieve these conditions. For instance, the Four Corners Transboundary Natural-Resources Management Area in southern Africa is supporting the establishment of conservation business ventures that will generate income for local communities; the Green Corridor project in Bhutan is supporting new cottage industries such as cheese-making and honey production; the Forest Conservation and Community Development Project in southern

China is supporting a large number of poverty-alleviation measures such as improved drinking-water supplies, the construction of biogas pits and training in agricultural techniques; the Terai Arc Landscape has provided education courses for local livestock herders; and the Mesoamerican Biological Corridor is promoting the cultivation of organic cocoa.

Short-Term Versus Long-Term Priorities

The urgency of the poverty challenge has raised concerns that ecological networks encourage too large a share of the available resources to be directed at the realization of long-term conservation objectives at the cost of urgent poverty-alleviation and biodiversity-protection measures. However, an interesting consequence of the broad-based, integrative process that characterizes ecological networks is that it seems in practice to be offering an increasingly attractive vehicle to donors for channelling development aid. Thus, many of the examples suggest that the initiatives are attracting a higher level of funding from a broader range of sources and over a longer period than would have been the case if the programmes had been limited to isolated conservation or development projects. The programmes in Vilcabamba—Amboró, Mesoamerica and the Congo Basin are good examples of this phenomenon. The value of such initiatives seems to be that they articulate politically necessary sustainability objectives within a coherent programme, while still offering opportunities for supporting clearly defined complementary actions at the local level.

The question of to what extent this additional funding represents an increase in the total funds that are being made available for biodiversity conservation and sustainable development rather than a reallocation of existing financial support cannot be answered by this review. However, there are strong indications that this is the case in some of the examples, such as the Mesoamerican Biological Corridor and the Kenyan Wildlife Conservation Lease Programme. Moreover, in underdeveloped regions or countries in transition, the examples indicate that an ecological network can work pro-actively to shape the policy agenda towards an integrated approach to securing conservation and development as, for example, in Vietnam's Greater Truong Son Ecoregion and, potentially, Russia's Far East Ecoregion.

MEETING THE 2010 TARGET

One of the most significant political commitments of recent years has been the international consensus to achieve a significant reduction in the current rate of loss of biodiversity by 2010 or even halt the loss altogether by that year. Specifically, in June 2001 the EU Heads of State committed themselves to halt the loss of biodiversity by 2010, an objective that was reaffirmed in March 2005. In April 2002 the Parties to the Convention on Biological Diversity adopted a Strategic Plan that includes the target of achieving by 2010 a significant reduction in the current rate of biodiversity loss. In September 2002 the UN World Summit on Sustainable Development endorsed the achievement by 2010 of a significant reduction in the current rate of loss of biodiversity. Finally, in May 2003 at the Fifth Environment for Europe Ministerial Conference, over 50 Eurasian states reiterated the objective to halt the loss of biodiversity at all levels by the year 2010.

It is clear, given the rate at which biodiversity is being lost on all continents and the imminence of the 2010 deadline, that these commitments infer a substantial upgrading of conservation measures, a stronger focus on sustainability across a wide range of policy sectors and a marked improvement in the effectiveness with which actions are implemented on the ground. Meeting the 2010 target will therefore require not only specific biodiversity-conservation measures but also structural changes in how natural resources are exploited.

In that perspective, the management model that underlies ecological networks has much to offer: it not only aims to conserve specific sites and species populations, it has the goal of ensuring the maintenance of ecosystem functions and promoting the sustainable use of natural resources. In other words, it aims to establish and maintain the conditions that are necessary for the long-term conservation of biodiversity and to do so at the landscape, the ecosystem or even the ecoregion scale. The 2010 target — significantly reducing the current rate of, or even halting the loss of biodiversity — is therefore intrinsic to the model.

However, as the examples demonstrate, achieving this goal within a few years is beyond the capability of most of the current programmes, if only because of the scale at which they are being implemented and the recent commencement of most initiatives. To be sure, important progress in halting the decline in biodiversity has been achieved in limited areas and the sustainability of land use has been improved: examples that have produced tangible results are the Terai Arc Landscape and Canada's Bow Valley Corridor. But even the older programmes which are in an advanced phase have not yet progressed to the point where the measures have been fully implemented on the ground across their geographical range, although a small number which are well advanced — Estonia and the Netherlands are good examples — have succeeded in contributing to a significant reduction in the rate of biodiversity loss in recent years. Ecological networks, if they secure their goals, will certainly make an important contribution to achieving the 2010 target. In most cases, however, given the implementation timescales involved, this will only be achieved some years after 2010.

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