On Defying Nature's End: The Case for Landscape-Scale Conservation

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Introduction

TODAY, SOME OF THE EARTH'S LAST REMAINING BIODIVERSITY "HOTSPOTS" appear headed for a cataclysm due to widespread loss of native habitat, particularly in the species-rich tropics (Myers et al. 2000). Even where forests still remain, in many areas inadequate protection has resulted in the elimination of most medium- and large-bodied wildlife species, resulting in the so-called "empty forest syndrome" (Redford 1992). It has become clear that humans have the power to eliminate a broad spectrum of species, not just large game, and to destroy entire biological communities.

Fortunately, scientists studying these changes have now accumulated enough information to provide strong predictions of what can be expected if we do not intervene. Recent analyses suggest that in the next five years, for example, Mesoamerica (Mexico to Panama) is likely to lose 10% of its remaining natural vegetation, with the resulting extinction of at least 22 species of vertebrates and 93 species of plants (Brooks et al. 2002). Even the major tropical wilderness areas (MTWAs) (Myers et al. 2000; Mittermeier et al., in press)—which, unlike the hotspots, still retain 70% or more of their native vegetation cover—are rapidly changing with the advancement of agriculture frontiers. Anticipated loss of habitat in these areas will result in a far greater number of species at risk of extinction (Pimm and Raven 2000).

Awareness of this impending crisis gives us early warning that if we do not act, it will soon be too late; the question is what actions are necessary. The challenges faced by conservationists in the past offer some important lessons. Parks and reserves, despite widespread pressure, have shown themselves to be the only areas where the full complement of biodiversity persists in contexts of serious threats. On the other hand, ecological and economic dynamics have also made it clear that the *status quo* approach to conservation, highly site-specific and largely reactive, is barely holding the line in a sort of environmental "trench warfare," and is not adequate to protect biodiversity in the long run. Despite increased conservation efforts, many critical areas are still lost each year.

If we are to avert a massive crisis, there is an urgent need to both drastically increase the scale of conservation work, and, equally important, to adjust our strategies to address large-scale ecological, social, and economic realities. This article describes some of the principal results arising from a broad portfolio of scientific investigation conducted by the Center for Applied Biodiversity Science (CABS) at Conservation International (CI). Since its creation in 1999, CABS has functioned as a strategic research unit closely linked to CI's needs in the field. The strategy presented here, like those also under development by many conservation organizations on a worldwide scale, begins with the need for strict definition of biodiversity conservation priorities, followed by focused action at both site and regional scales, seeking to achieve concrete, measurable, and time-bound conservation outcomes. This article also examines working at the landscape scale to successfully integrate biodiversity conservation with sustainable development.

Where to work: setting biological priorities

The world is far too big and resources too limited for conservationists to be active everywhere. Setting priorities for investment and action is therefore vital. Biodiversity loss is arguably the only major global environmental problem that is truly irreversible, and facing this challenge requires immediate and targeted action.

If we are to minimize loss of biodiversity, as measured at the level of species, identifying areas with concentrations of endemic (restricted-range) plants and animals becomes paramount. A number of regions stand out globally as centers of terrestrial species richness and endemism. A pioneering approach to identifying these regions is represented by the global biodiversity hotspots, areas featuring exceptional concentrations of endemic species, and experiencing exceptionally rapid loss of habitat. Myers (1988, 1990) was the first to highlight the extreme value of these few terrestrial habitats that account for a significant portion of Earth's biodiversity represented by endemic species.

A recent re-analysis of this framework (Mittermeier et al. 1998, 1999; Myers et al. 2000) defined 25 hotspots (Figure 1), currently covering only 1.4% of the land surface of the Earth, which provide the only remaining habitat for an estimated 44% of all species of vascular plants and 35% of all of mammals, birds, reptiles, and amphibians. All of the hotspots have already lost more than 70% of their original vegetation. Many species in the hotspots are also extremely vulnerable, with diminished populations, highly fragmented habitat, and pressures from numerous sources. Since 1800, close to 80% of all bird species that have gone extinct were lost from the biodiversity hotspots (Myers et al. 2000).

A complementary approach to priority setting is to select regions that are exceptionally species-rich, but still largely intact. These regions offer the opportunity to protect large, relatively pristine areas and intact faunal assemblages, a strategy that may prove vital in the long term. The biological importance of the three MTWAs (Figure 1) has been recognized by a range of groups for over a decade. Covering only 4.8% of the Earth's land surface, they provide the only habitat for over 14% of the world's vascular plant species, and for over 7% of all non-fish vertebrate species (Mittermeier et al., in press). A re-analysis of important wilderness areas, considering 37 regions in a range of ecosystems, is being finalized at the time of writing, and suggests that at least two new wilderness areas should be considered highest priority for conservation (Mittermeier et al., in press).

Cumulatively, the hotspots and the three MTWAs contain, *as endemics*, almost

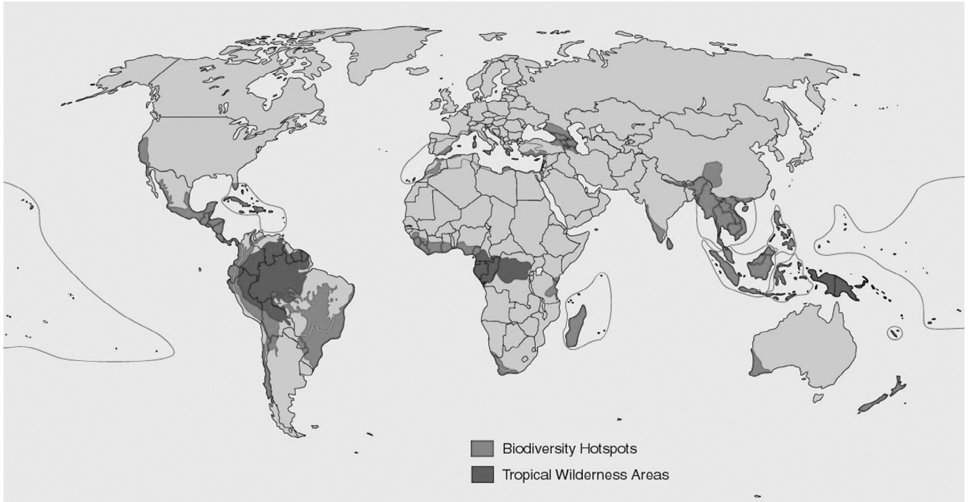


Figure 1. Global biodiversity hotspots and major tropical wilderness areas (adapted from Myers et al. 2000).

59% of the world's vascular plants, and just over 42% of the world's non-fish vertebrates in just over 6% of the land surface. With the addition of the two new high-biodiversity wilderness areas, the hotspots and wilderness areas contain an even greater share of the world's biodiversity. Focusing on these two types of areas, representing extremes of extinction threat and intact functioning ecosystems, offers an unparalleled opportunity to save great numbers of species by concentrating conservation activities in a geographically restricted area.

The identification of a global priority agenda is a critical first step in achieving much-needed consensus on priority areas. To a large extent, the results of different approaches to setting priorities at a global scale, led by different conservation organizations, are beginning to converge (Fonseca et al. 2000; see Figure 2). Moving to finer scales, where specific regions and sites can be selected for action, represents the next challenge, one which can only be accomplished with detailed, spatially explicit, species-level data. Progress is being made on this front as well: a number of research groups and organizations are collaborating in compiling such data and making them available to the global conservation community (Brooks et al. 2001). These data make it possible for the first time to identify with precision where we need to work to protect specific species.

Site conservation tools

Species conservation objectives are made more manageable by defining geographical focus areas. But once we decide *where* to work, the challenge becomes *how* to do effective conservation there. In this section, we discuss conservation tools for protecting specific areas. We review evidence on the effectiveness of protected areas and draw conclusions for what strategies are likely to be most effective in the future. We also present *conservation corridors* as a means to combine site conservation tools into an integrated strategy at a scale sufficient to address ecological and economic needs.

Beginning with the model of Yellowstone National Park in the United States, the creation of protected areas to restrict direct use of biological resources became the predominant strategy to ensure the persistence of representative samples of native habitat and their associated biodiversity in many parts of the world. Other forms of protected areas, such as game reserves or national forests, also sought to prohibit public use of specific resources (in these cases, large game species and timber, respectively). In the last two decades, however, protection by means of reserves, or activities traditionally associated with parks, such as border demarcation and enforcement, have been criticized as both inappropriate and ineffective in many cases (Wilshusen et al. 2002; Ghmire and Pimbert 1997; Brown and Wyckoff-Baird 1995; IUCN et al. 1991). Furthermore, the often-stated goal of placing 10% of national territory in protected areas has come to be viewed by many groups as a limit to the acceptable amount of protection, rather than an important short-term objective (Soulé and Sanjayan 1998; Schwartzman et al. 2000).

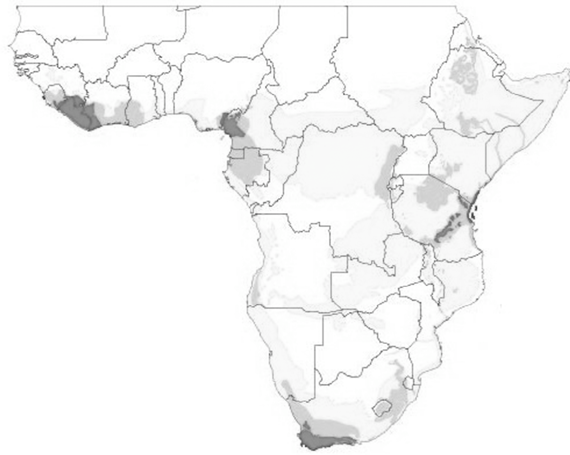


Figure 2. Overlay of conservation priority regions in Sub-Saharan Africa identified using different priority-setting approaches (biodiversity hotspots, World Wildlife Fund's Global 200 most important ecoregions, and Birdlife International's endemic bird areas). Darkest shading indicates intersection for all three approaches, and medium shading indicates intersection for two (from Fonseca et al. 2000).

These criticisms have combined with the appealing possibility of jointly promoting conservation and development, to bring about a major change in conservation strategies. A large portion of conservation effort is now dedicated to promoting, frequently as a direct substitute for parks, the rather vague concept of "sustainable development" (IUCN et al. 1991). Instead of seeking to separate areas for conservation from areas for resource use, sustainable development attempts to integrate them in the same place by promoting types and intensities of use that are profitable but compatible with conservation goals. This strategy is based on an appealing premise: successful sustainable development-based conservation projects should create a win–win situation in which relevant stakeholders benefit from, and therefore try to promote, conservation. Sustainable development can therefore ideally create a situation in which pressure on natural resources decreases, constituencies for conservation increase, and effective conservation becomes possible in a range of difficult contexts.

What does recent experience tell us about these strategies? In regard to parks, there is evidence of both successful areas as well as those that have become heavily degraded. It is also clear that, in many cases, park management is far from ideal. Studies detail a myriad of problems such as Ghana's "empty" forests (Oates 1999), oil spills in parks in Ecuador (van Schaik et al. 1997) and illegal logging and clearing of Indonesia's parks (EIA/Telepak 1999). In a review of rainforest parks across the tropics, van Schaik et al. (1997, 64) write: "Protected nature reserves are in a state of crisis. A number of tropical parks have already been degraded almost beyond redemption; others face severe threats of many kinds with little capacity to resist. The final bulwark erected to shield tropical nature from extinction is collapsing." They go on to detail numerous cases of degradation from causes such as illegal hunting, grazing, logging, and land clearing. More fundamentally, there is a widespread perception that traditional parks cannot protect the resources within their borders against ever-increasing human pressures.

In contrast, ample evidence suggests that protected areas have had a significant impact even with relatively low levels of investment. In large areas across Latin America that are completely cleared, parks often stand out as the only remaining natural habitat (Dourojeanni 1999). Even highly degraded parks often harbor the last remaining species in otherwise devastated ecosystems (van Schaik et al. 1997). A growing body of literature from various disciplines offers convincing support for parks. Statistical analyses have found strong protective effects of parks in Belize and Mexico (Chomitz and Gray 1996; Deininger and Minten 1997). A study in Costa Rica, using satellite imagery, similarly found that while the country as a whole lost approximately 10% of its remaining forest between 1987 and 1997, national parks lost only 0.4% (CCT/CIEDES 1998). A regional study in Costa Rica found similar trends over a twenty-year period starting in 1975 (Sanchez-Azofeifa et al. 1999).

A study of 22 tropical countries (Bruner et al. 2001) attempted to quantify effectiveness in parks under high levels of threat. They used a sample of 93 parks to assess effectiveness by both calculating land clearing over time and comparing the condition of parks with the condition of their surroundings. They found that 83% of the parks in the sample experienced no net clearing since they were established (median age 21 years), and that a full 40% permitted the regeneration of native vegetation on land that was cleared at the time of park establishment. Only 17% had a net loss of native vegetation to land clearing. In comparing parks with their surroundings, although they found instances of serious degradation, most often from hunting, overall the parks were in significantly better condition than their surrounding areas for all impacts tested (land clearing, logging, hunting, grazing, and fire). These findings suggest that the perception that parks cannot resist high levels of pressure is inaccurate, and that on the contrary, with relatively modest support, parks can be highly effective.

Finally, challenging some common claims, the rate of creation of new protected areas has not slowed in recent years (WCPA 1999), demonstrating that opportunities still exist, and may even be expanding, to create and support more protected areas in key ecosystems around the world. A wealth of data from countries such as Brazil (Ayres et al. 1997) and India (Kutti and Kothari 2001) indicate a burst of creation of additional parks and reserves during the last decade.

What about the track record of sustainable development? A look at the effects on biodiversity conservation of a range of sustainable development projects suggests that the reality has not lived up to original expectations. For instance, despite years of effort and hundreds of millions of dollars spent to support sustainable forest management (SFM), there is still very little natural forest in the tropics actually under SFM. As of 2001, the Forest Stewardship Council (FSC) had certified only 2 million hectares of natural forest in the tropics (FSC 2001). In broader terms, the International Tropical Timber Organization (ITTO) notes that "while policy successes have been many and awareness ... of the need for sustainable forest management is growing, the review of progress (Poore and Chiew 2000) reports far less evidence of the implementation of good management in the forest itself" (ITTO 2002).

Related limitations also exist for conserving areas via forestry as well as other types of sustainable development projects, such as sustainable harvest and marketing of non-timber forest products, development of non-destructive means of income generation (e.g., bee-keeping), and organic or low-impact agriculture. Frequently, some of the most important of these limitations are inadequate market value or difficulty in marketing many forest products, and limited markets for green agricultural products. These factors make it difficult in many cases for sustainably harvested forest resources to generate sufficient income to compete with land conversion, and also mean that the majority of agricultural production will not be able to take advantage of the demand for green products (Hardner and Rice 2002; Dourojeanni 1999).

Finally, even where projects succeed in creating profitable enterprises, conservation has largely been promoted only as an indirect by-product of development activities. Abundant literature suggests that the result of this strategy has been that most sustainable development projects have failed to shift people's behaviors towards helping to conserve biodiversity (Robinson 1993; Kramer and van Schaik 1997; Southgate 1998; Simpson 1995). Indeed, reviews of integrated conservation and development programs (ICDPs) have found that sustainable development as a stand-alone conservation strategy has been widely unsuccessful (Wells et al. 1999; Terborgh 1999; CIFOR et al. 1999).

These limitations suggest that substituting sustainable use schemes for protected areas is unlikely to result in effective species conservation, and that support for protected areas should be the top priority for conservation funds. On the other hand, ensuring that production supports conservation goals in key areas, and that conservation and development are mutually reinforcing, remains a fundamental goal: well-designed development-based conservation projects have an important role to play supporting protected areas in this context. Among other important needs, these projects can provide connectivity across fragmented landscapes, as well as local benefits and increased support for conservation.

The limits of site-based action: bringing conservation to the landscape scale

Where does this leave us? If parks can work for species conservation and there are serious limitations to sustainable development as a substitute, then it appears that conservation must come primarily from setting resources aside from human use, while enabling a supporting role for sustainable use projects. Still, many critical biodiversity areas are located in regions where economic development needs are a reality, and park creation may not be a viable option due to population, social, or political pressures. Even where parks exist, many are too small to maintain ecological processes and allow for global change dynamics. In particular, changes driven by human-induced global warming may cause such serious shifts in habitat locations that protected areas that do not contain an altitudinal gradient may lose all suitable habitat for the species they are designed to protect (Peters and Lovejoy 1992; Hannah et al. 2002). Finally, with millions of people living in poverty, highly indebted governments, massive and growing levels of consumption in developed countries, and with world population expected to increase by another 3 billion in the next 50 years (United Nations 1998), development needs and pressures on protected areas are only expected to increase (see Figure 3). In this context , the aim of reconciling poverty alleviation with conservation objectives seems largely unattainable at the site scale, particularly when dealing with small and fragmented parks.

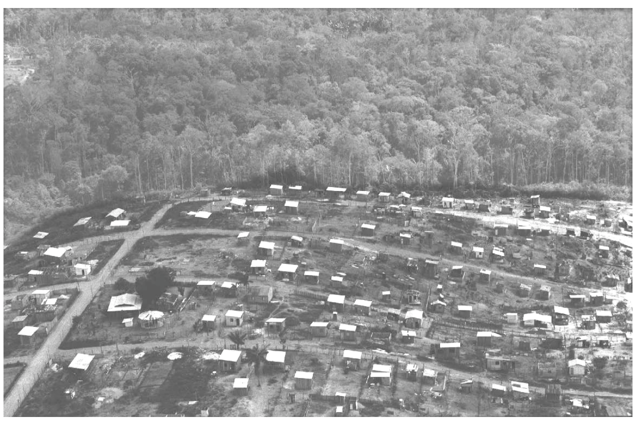


Figure 3. Hard edge around the Adolpho Ducke Forest Reserve, Manaus, Brazil. Photograph taken in 2000. *Photo courtesy of the authors*

To face these challenges, we must find a way to implement conservation strategies that address development needs, but still put effective conservation tools in place at a scale commensurate with ecological processes. A key issue in finding the solution to this challenge is *scale.*

Traditionally, conservationists have focused only on individual pieces of the landscape. We believe that past efforts to combine conservation and development objectives in this context have often failed because the planning and implementation scales were geographically so limited that they placed conservation and development goals in direct competition with each other, resulting in frequent conflict and mutual loss. In reality, biologically important landscapes are often highly varied, with a wide range of actors, ecosystem types, and economic activities. Embracing all land uses by broadening the focus of conservation planning to the landscape level greatly increases opportunities to coordinate and promote conservation and development goals together, addressing both ecological and economic dynamics.

We call conservation planning units at this scale *landscape-level biodiversity corridors*, a concept first articulated in the connection with a major project designed to stimulate the creation of additional protected areas in the Brazilian Amazon and the Atlantic forest, financed by the Brazilian government and the World Bank's Pilot Project to Conserve the Brazilian Rain Forest (Ayres et al. 1997). Landscape corridors are distinct from biological corridors in that their purpose is not simply to permit demographic and genetic flow of animal and plant populations. A landscape corridor is a biologically and strategically defined sub-regional space selected as an unit for large-scale conservation planning and implementation purposes, in which conservation action can be reconciled with inevitable economic development, in this case freed from the constraints of competing land use claims over very small-sized areas. Within landscape corridors, planners can seek to place critical biodiversity areas under strict protection, important areas can be allocated to economic development, and others with mixed goals with can also be defined. A landscape corridor therefore comprises a network of parks, reserves, and other areas of less-intensive use whose management is integrated into the landscape matrix to ensure the survival of the largest possible spectrum of species, while avoiding direct conflict with unavoidable economic development needs.

Using landscape-level corridors as planning units can accomplish what planning at the scale of individual parks and buffer zones cannot: the optimum allocation of resources to conserve biodiversity at the least economic cost to society. Furthermore, planning at this scale enables conservation planning to address long-term trends and changes in ecological and economic dynamics. Large landscape-level corridors can even go a step further in designing mosaics that are mutually beneficial to both conservation and development goals (e.g., protected areas to conserve watersheds and tourism resources, and compatible development to promote species movement between protected areas or to provide important buffers).

Corridor planning in Brazil's Atlantic forest serves as a useful example of how the corridor strategy can work in practice. The Atlantic forest is among the top five "hottest" hotspots in the world. With only 7.5% of its original forest cover remaining, it is home to 11,000 endemic plant species, and is among the top areas in the world in numbers of arboreal plants, reaching 454 species in a single hectare (Thomas et al. 1998). The area is also densely populated by over 60% of the entire Brazilian human population. Only 2.7% of original forest is in protected areas, far too little to conserve its vast diversity of species.

Because the Atlantic forest is highly fragmented, populations of plants and animals are highly vulnerable and isolated. The few parks and reserves that existed up to the mid-1990s were being progressively encroached and opportunities for the expansion of the reserve network were perceived as diminishing, if not altogether vanished. In this context, site-by-site conservation was not a viable strategy for long-term species protection. For species to persist, it was necessary to maintain and restore connectivity across the landscape. In the heavily populated context of the Atlantic forest, this required both core zones of protection and mosaics of multiple land uses in a managed landscape to allow populations to move among proximate, intact forest blocks (Ayres et al. 1997), while at the same time addressing existing socioeconomic needs. Thus, in order to design a functional mosaic of land uses (see Figure 4), corridor planning took account of a number of major socioeconomic and biological factors, including (1) land ownership and major uses, (2) location of remaining forest, (3) location of key species, (4) location of current and proposed roads, and (5) land values.

Priority actions under the corridor plan were, first, to consolidate existing pro-

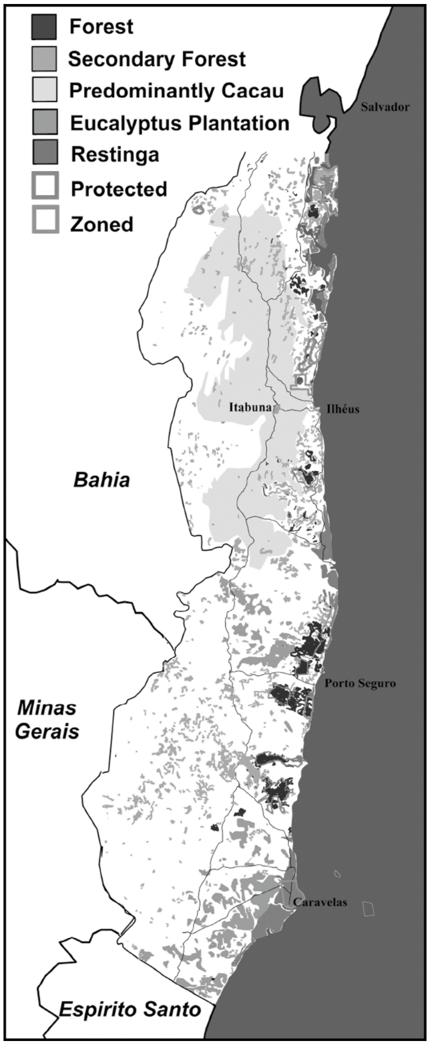


Figure 4. Southern Bahia portion of the central Atlantic forest corridor, indicating major land uses, remaining forests, and protected areas.

tected areas and create new ones, to form critical corridor nuclei. These nuclei also needed to be supported by links across private properties by providing economic incentives for key private landowners to shift to compatible land uses. In the case of the Atlantic forest, these uses included shade cocoa and the creation of private reserves. The final corridor design, spanning over 50,000 sq km, includes conservation nuclei and linkages as well as areas for both high- and low-intensity economic activities, creating a plan that is increasingly being met with broad public approval (CABS, 2000; Figure 5). A multi-stakeholder management committee to oversee the implementation of corridor-scale activities is now operational, orienting the investment of financial resources from the World Bank and the Brazilian government.

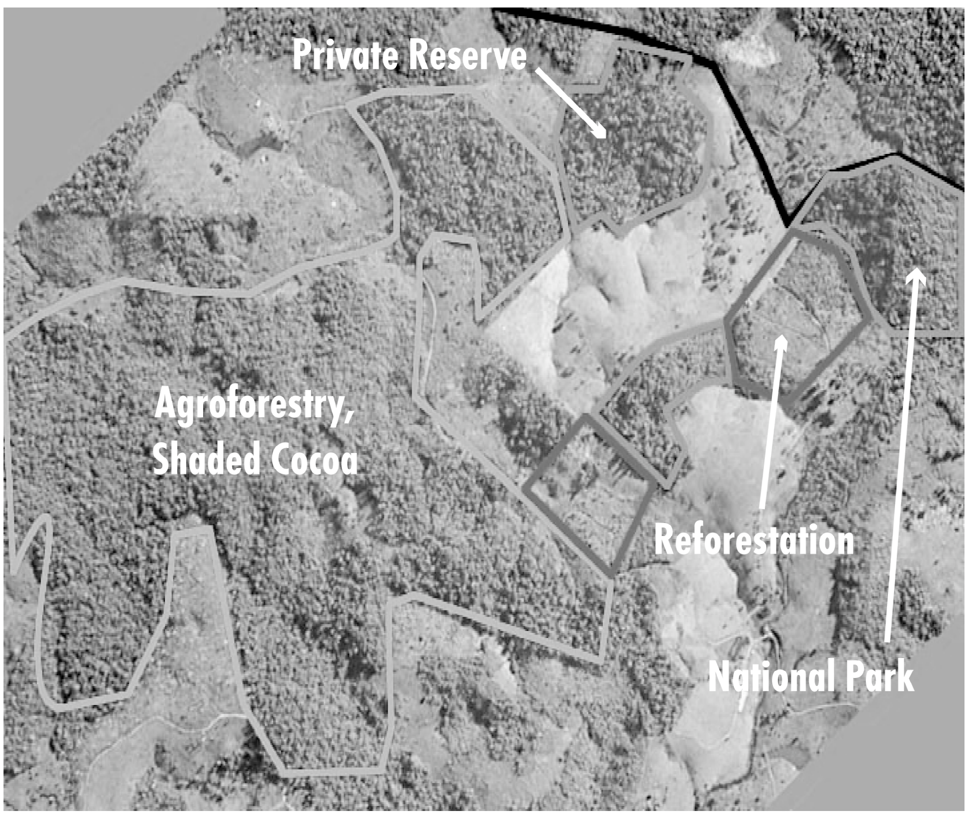
Several important lessons can be drawn from work in the Atlantic forest and other corridor projects to date. First, the value of biodiversity (both market and non-market) is often not recognized in local economies; planning at a regional scale can provide a format for ensuring that these values are considered. Second, there are always trade-offs in conservation planning. Given limited funding and competing interests, conservation of some areas will need to take priority over others. Finally, corridors, like all conservation strategies, are no "silver bullet": they simply increase the scope for cooperation and grant some breathing room to promote both conservation and development objectives without attempting to put them both in the same place. Experience suggests that there will be winners and losers in almost every possible outcome, even those that are optimal for society as a whole. What corridors offer is an opportunity to more effectively design combinations of site conservation tools and integrate them with development plans.

Defying Nature's End: a practical plan of action

As part of a major effort to transform these ideas into a concrete plan of action, in August 2000 over 50 scientists and 17 private-sector representatives met in California at a conference entitled "Defying Nature's End: A Practical Agenda for Saving Life on the Planet." The objective was to pull together current scientific thinking to develop a plan for the fundamental components of a conservation strategy to save the most threatened portion of global biodiversity (Pimm et al. 2001; www.defyingnaturesend.org). The conference concluded that acting rapidly and strategically in key places in the tropics, particularly targeting the protection of habitat in the global biodiversity hotspots and the MTWAs, could have a major impact in stemming many looming extinction events (see Pimm and Raven 2000; Brooks et al. 2002).

For the hotspots, the agenda calls for a focus on 60% of the remaining intact habitat by improving management of 800,000 sq km of existing protected areas and by bringing an additional 400,000 sq km of land under protection. For the wilderness areas, the agenda is to focus on 55% of the remaining intact habitat to more than double the area under park protection, in addition to improving management of existing protected areas and indigenous reserves. In contrast to the hotspots, a significant portion of remaining natural habitat in wilderness areas is under indigenous control. For instance, over 24% of the Brazilian Amazon has been demarcated for indigenous tribes (Ricardo 2001). Some tribes, like the Kayapo of Southern Para, are doing a remarkable job in resisting encroachment from agriculture and cattle ranching, but

Figure 5. Hypothetical land uses in a portion of a conservation or biodiversity corridor in the Brazilian Atlantic forest.



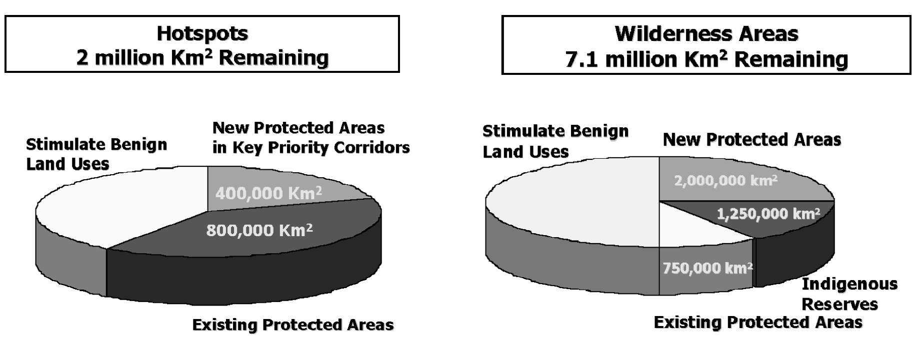
over time these efforts alone may not suffice. If resources can be secured so that these lands are better managed in perpetuity and incorporate biodiversity objectives that can be pursued by indigenous peoples themselves, the wilderness areas agenda will be greatly strengthened. Finally, in both hotspots and wilderness areas, direct protection must be complemented by additional investments to bring more compatible land use schemes to critical parts of the remainder of the landscape matrix (Figure 6).

Participants at Defying Nature's End also estimated the cost of implementing the direct protection components of this strategy. These included placing additional land under protection via land acquisition or compensation, long-term management of new protected areas, and improving management in existing protected areas. Data used for these estimates included published figures (e.g., James et al. 1999a), and unpublished data on the cost of acquisition, compensation, and management in specific sites. For the hotspots, needs were estimated at US$24 billion above current expenditure ($6 billion of private investment leveraging an additional $18 billion). For the wilderness areas, needs were estimated at US$4 billion above current expenditure ($1 billion leveraging $3 billion). Taken together, an estimated one-time investment of US$28 billion could take the world a long way towards conserving biodiversity (Pimm et al. 2001).

Conclusions

Over the course of the last few years conservation biologists, conservation economists, landscape planners and conservation practitioners are arriving at the general consensus that several of Earth's most altered ecosystems are headed for major catastrophes, the most noticeable consequence being a massive loss of species. Nonetheless, the analyses conducted at the Defying Nature's End Conference were optimistic: participants concluded that avoiding major extinctions in key areas is possible if we act urgently and at a scale commensurate with threats and ecological needs. Furthermore, the necessary actions are affordable—if funds are well spent, protecting a significant portion of Earth's biodiversity is within reach (also see James et

Figure 6. A plan of action for the hotspots and major tropical wilderness areas.



al. 1999b).

The strategy emerging from Defying Nature's End for meeting this challenge was straightforward. Based on the conclusion that protected areas are the most effective tool we have to protect biodiversity at the site level, parks and reserves were proposed as the centerpiece of a conservation strategy. This will mean that the priority use of conservation funds should be to bring more area under protection, and improve management of existing protected areas. Because working at the protected area scale is necessary but insufficient, conservation planning must also be increased in scale. Corridor-level planning offers a context in which conservation and development goals can both be effectively promoted, and become mutually reinforcing. In this context, there is an important supporting role for low-impact agricultural production, sustainable development projects, and new tools such as conservation concessions. Participants concluded that if we scale-up conservation activities along these lines, focused on the most critical areas, we still have a real opportunity to save much of the Earth's biodiversity.

Acknowledgments

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