The Landscape Approach: Designing New Reserves for Protection of Biological and Cultural Diversity in Latin America

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One of the greatest challenges for Latin America and the Caribbean, the most biologically and culturally diverse region in the world, is to halt the loss of species caused by habitat destruction and land degradation. Up to now, setting aside protected natural areas is considered the most effective alternative to conserve biodiversity. Protected areas, however, are under increasing assault by agricultural, silvicultural, and industrial development that surround and isolate them, reducing their habitat quality at the landscape scale. Among the different types of protected areas that have been proposed, biosphere reserves stand out for their attempt to compatibilize social development and conservation. Their management is the most amenable to integration of natural and human disturbance, inclusion of traditional management techniques, and participation by social and economic sectors in the administration. Biosphere reserves have proliferated all over the world, and today there are 531 of them located in 105 countries, where they protect vast ecological and cultural diversity. Even though the design of biosphere reserves is based on the landscape concept, it has yet to take into account ecosystem scales, possible long-term effects of disturbances, and better integrate and give higher consideration to the knowledge and experience of numerous ethnic groups that live within them. However, doing so requires a transformation of the function of the core, buffer, and transition areas. The current design of biosphere reserves is centripetal because the main function of the buffer zone is to protect biodiversity in the core. We propose a centrifugal model, where biodiversity of the core spreads freely toward the area of greater human influence with the buffer zone functioning as a connector. This connectivity can promote land-use practices that are in alignment with both ecosystems functioning and biodiversity conservation in natural, semi-natural, urban and industrial landscapes.

INTRODUCTION

Establishing protected areas is the most widely used instrument for dealing with the decline of biodiversity associated with agricultural, urban, and industrial activity. In the last fifty years, biodiversity conservation has predominantly relied on protected areas, but recently there have been signs of burnout, due to insufficient wilderness area remaining for new reserves and the isolation and limited (or nonexistent) connection among existing protected areas. In general, the design of nature reserves disregards the biodiversity of surrounding agricultural and urban

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areas, and with respect to their management, it is often blind to the benefits of social participation, especially that of indigenous groups, in spite of their broad range of knowledge and long experience with the land.

The Latin American and Caribbean region, i.e., the Neotropics, harbor the greatest biological and cultural diversity in the world.[1] At the same time, this region suffers one of the highest deforestation rates, the latter being prompted by disordered land use resulting from the creation of extensive, short-term productive systems.[2] In the next one hundred years, terrestrial ecosystems of Latin America are expected to be transformed principally by changes in land use, as well as by significant climate change, increased nitrogen deposition, as well as decreases in the numbers of plant and animal species.[3] These changes will affect both ecosystem resilience and the sustainable flow of goods and services from ecosystems to society.[4]

Latin America is also bearing increased poverty and social marginalization, which are in consequence of the loss of natural resources and a decrease in the services provided by ecosystems.[5] For this reason, stopping the loss of biodiversity in Latin America can also help address questions of social and environmental justice.[6] Under such current conditions, the protection and conservation of biodiversity are of the highest priority.[7] In this essay, we propose a connectivity model for biosphere reserves as one that could improve the protection of the system in the long term; at the same time we point out that this model deserves further discussion for its successful application.

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[1] UNESCO (2008), http://portal.unesco.org/education/en/ev.php-URL_ID=18391&URL_DO=DO_TOPIC&URL_SECTION=201.html.

[2] V. M. Toledo, "Metabolismos Rurales: Hacia una Teoría Económico-Ecológica de la Apropiación de la Naturaleza," *Revista Iberoamericana de Economía Ecológica* 7 (2008): 1–26; R. Primack, R. Rozzi, P. Feinsinger, R. Dirzo, and F. Massardo, *Fundamentos de Conservación Biológica: Perspectivas Latinoamericanas,* 2d ed. (México City: Fondo de Cultura Económica, 2006).

[3] O. A. Sala, F. S. Chapin III, J. J. Armesto, E. Berlow, J. Blooomfield, R. Dirzo, E. Huber-Sanwald, L. F. Huenneke, R. B. Jackson, A. Kinzig, R. Leemans, D. M. Lodge, H. A, Money, M. Oesterheld, N. L. Poff, M. T. Skyes, B. H. Walker, M. Walker, and D. H. Wall, "Global Biodiversity Scenarios for the Year 2100," *Science* 287 (2000): 1770–74; J. J. Armesto, R. Rozzi, and J. Caspersen, "Past, Present, and Future Scenarios for Biological Diversity in South American Temperate Forests," *Biodiversity in a Changing Environment: Scenarios for the Twenty-First Century,* ed. F. S. Chapin, O. E. Sala, and E. Huber-Sannwald (New York: Springer Verlag, 2001), pp. 223–49.

[4] See Bengtsson, J., P. Angelstam, T. Elmqvist, U. Emanuelsson, C. Folke, M. Ihse, F. Moberg, and M. Nyström, "Reserves, Resilience, and Dynamic Landscapes," *Ambio* 32, no. 6 (2003): 389–96.

[5] The large-scale initiative of the Millennium Ecosystem Assessment (MA), carried out between 2001 and 2005 assessed the consequences of ecosystem change for human well-being and demonstrated a variety of linkages between ecosystems and human well-being. See R. Hassan, R. Scholes, and N. Ash, eds., *Ecosystems and Human Well-being: Current State and Trends,* vol. 1 (Washington D.C.: Island Press, 2005).

[6] V. M. Toledo, "La Diversidad Biológica de Latinoamérica: Un Patrimonio Amenazado," *Ambiente y Desarrollo* 4 (1988): 13–24; H. J. Geist and E. F. Lambin, "Proximate Causes and Underlying Driving Forces of Tropical Deforestation," *BioScience* 52, no. 2 (2002): 143–50.

[7] Ibid.

THE CAUSES OF DIMINISHING BIOLOGICAL AND CULTURAL DIVERSITY

The main factors responsible for the global loss of species are landscape changes and habitat fragmentation.[8] Their effects can be detected both on individual species and on landscape patterns, resulting in changing species assemblages.[9] The most obvious causes of landscape changes in Latin America are monocultures of crop and tree species, along with extensive and intensive cattle ranching. Both activities extract products and exploit ecosystem services in a non-renewable way.[10] In Latin America the relationship between humans and nature began at least 20,000 years ago, but a major change in predominant patterns of land use and natural resource management began with the arrival of Columbus to the New World.[11] Tropical crops, as well as small and large livestock, were introduced from other parts of the world. These introductions were tantamount to an invasion of exotic species and land use practices that were markedly different from traditional Amerindian practices. These changes unleashed the greatest environmental globalization that ever occurred; on a scale unlike any other since the massive transformations of the Pleistocene.

Today, Latin America plays a strategic role in the conservation of the world's biodiversity. Brazil, Colombia, Ecuador, Venezuela, Peru, and Mexico are six of the fourteen megadiversity countries, containing sixty to seventy percent of the world's biodiversity.[12] Biological diversity in Latin America overlaps with the highest indigenous cultural diversity. One of the main indicators of cultural diversity is the number of languages spoken in a given country or territory.[13] The links between language, culture and the environment suggest that biological, cultural and linguistic diversity should be considered together.[14] They form a systemic unit that contains and expresses a total "pool of ideas," nurtured over time through heritage,

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[8] Primack et al., *Fundamentos de Conservación Biológica.*

[9] J. Fischer, and D. B. Lindenmayer, "Landscape Modification and Habitat Fragmentation: A Synthesis," *Global Ecology and Biogeography* 16, no. 3 (2007): 265–80.

[10] L. Fahrig, "Effects of Habitat Fragmentation on Biodiversity," *Annual Review of Ecology, Evolution and Systematics* 34 (2003): 487–515.

[11] A. W. Crosby, "Globalization as Boon or Curse," *International History Review* 25, no. 2 (2003): 375–79; A. W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900–1900* (Cambridge and New York: Cambridge University Press, 1993).

[12] N. Myers, "Threatened Biotas: 'Hotspots' in Tropical Forests," *Environmentalist* 8 (1988): 1-20; N. Myers, "The Biodiversity Challenge: Expanded "Hotspot' Analysis," *Environmentalist* 10 (1991): 243–56; Víctor M. Toledo and Alicia Castillo, "La Ecología en Latinoamérica: Siete Tesis para una Ciencia Pertinente en una Región en Crisis," *Interciencia* 24, no. 3 (1999): 157–68.

[13] See http://www.cdi.gob.mx.

[14] See R. Rozzi, and A. Poole, "Biocultural and Linguistic Diversity," in J. B. Callicott and R. Frodeman, eds., *Encyclopedia of Environmental Ethics and Philosophy* (Farmington Hills, Mich.: Gale, Cengage Learning, 2008).

local traditions and customs communicated through local languages. The diversity of ideas derived from different languages and sustained by different cultures is as necessary as the diversity of species and ecosystems for the survival of humanity and all life in our planet.[15] The loss of languages is linked to the loss of irreplaceable knowledge about the environment.[16]

Today more than fifty-five percent of industrialized agriculture in Latin America is devoted to production of two introduced species: sugar cane (30.4 percent), and coffee (25.7 percent). Almost seventy percent of the cultivated land in the region is sown with crops that are non-native to the Americas: sugar cane, coffee, banana, rice, and wheat.[17] The gravest environmental consequence of this ecological globalization, occurred over the past five centuries, is that the centers of genetic diversity of these crop species are no longer their main production centers.[18] Concomitantly, the economic and production model most extensively used nowadays, includes a minimal part of the biological diversity and does not take into account the cultural diversity native to the continent.[19] Current production patterns are largely based on the simplification of landscapes and the exploitation of ecosystems without considering their natural rates of regeneration.[20]

PRISTINE, RURAL, AND INDUSTRIALIZED LANDSCAPES

During the twentieth century, in tropical America there was concern about preserving and conserving the diversity of landscapes, ecosystems, communities and species threatened by expanding agriculture, cattle raising, industry and urbanization. Since, then, reserves and national parks have been central to the preservation of species and natural areas.[21] The greatest efforts focused on setting aside pristine areas, ignoring the effect of both natural and anthropogenic disturbances.[22] This approach has managed to protect approximately 6.4 percent of the Earth's land; an insufficient sample of the biodiversity and ecosystems in the world. Furthermore, the availability of pristine areas declines daily due to land use changes.[23]

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[15] See http://portal.unesco.org/education/en/ev.php-URL_ID=18391&URL_DO=DO_TOPIC&URL_SECTION=201.html.

[16] Tove Skutnabb-Kangas, Luisa Maffi, and David Harmon, *Sharing a World of Difference: The Earth's Linguistic, Cultural, and Biological Diversity* (Venice: UNESCO Publishing, 2003).

[17] P. Bifani, *La Globalización: Otra Caja de Pandora?* (Granada: Universidad de Granada, 2002), p. 297.

[18] Ibid.

[19] Toledo, "La Diversidad Biológica"; and Geist and Lambin, "Proximate Causes."

[20] Ibid.

[21] Bengtsson et al., "Reserves, Resilience, and Dynamic Landscapes."

[22] Toledo, "La Diversidad Biológica"; and Geist and Lambin, "Proximate Causes."

[23] A. Gomez-Pompa and A. Kaus, "Taming the Wilderness Myth," *BioScience* 424 (1992): 271–79; Primack et al., *Fundamentos de Conservación Biológica.*

When we speak of landscapes, we need to differentiate the rural landscape from the industrial landscape.[24] The former implies uses that are adapted to the climate, soil conditions, and resilience of the regional ecosystems, while the latter is based on the exploitation of soil fertility and water, with the use of fertilizers and agrochemicals. The two landscape types require entirely different environmental scenarios. On rural landscapes, traditional management practices maintain the highest availability and mobility of species across the landscape mosaic, a mechanism that ecologist Janne Bengtsson referrs to as an internal ecological memory. There is an ecological memory that takes the form of the availability of species that are allowed to interact with the other components of the landscape.[25] Ecological memory has almost completely disappeared from industrial landscapes, which function mainly as a species sink, depending on the constant consumption of energy and resources that are not regenerated by the ecosystem.

Human society and nature are two forces that shape landscapes and ecosystems.[26] Historically, pristine and human-disturbed areas have coexisted, leaving an area where the original vegetation persists, in the form of fragments of varying shapes and sizes. The result is a mosaic of succesional stages of natural vegetation. This idea of the landscape formed by expanses of natural areas, crop fields, traditional husbandry, pasture management, and human settlements encompasses a broader biological and cultural diversity than pristine areas by themselves.[27] This landscape perspective offers important lessons about the conservation of species, ecological processes, and the resilience of ecosystems.

Landscape ecology offers new insights about processes that act on different spatial and temporal scales. This information can be useful to planners who are involved in optimizing the use of space or improving environmental conditions. While important advances have been made in the study and characterization of landscape patterns and change, landscape function is still poorly understood. Flows of biota, water, nutrients, and other materials across the landscape are determined, to a large extent, by landscape patterns, but an appreciation of the functional links between patterns and processes has been slow in coming. If landscape ecology is to make a useful contribution to land use and conservation issues, greater effort needs to be invested in understanding the functional aspects of landscapes.[28]

The focus on pristine areas for conservation ignores the biodiversity that occurs

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[24] G. Halffter, "Towards a Culture of Biodiversity Conservation," *Acta Zoológica Mexicana* 21, no. 2 (2005): 133–53.

[25] Bengtsson et al., "Reserves, Resilience, and Dynamic Landscapes."

[26] See A. Farina, "The Cultural Landscape as a Model for the Integration of Ecology and Economics," *BioScience* 50, no. 4 (2000): 313–20.

[27] See C. Mann, *1491: New Revelations of the Americas before Columbus* (New York: Alfred Knopf, 2005).

[28] See M. G. Turner, "Landscape Ecology in North America: Past, Present, and Future," *Ecology* 86 (2005): 1967–74.

outside protected areas. Agro-ecosystems found outside the conserved areas are a valuable resource, which should be considered for creating an alternative model of conservation and sustainable land use.[29] We should understand landscapes as a dynamic mosaic fashioned by sets of species that are temporally associated with successional stages of vegetation formations created by disturbance and abandonment of agricultural land. Landscapes change because of the dynamic interaction between natural and cultural forces. Cultural landscapes are the result of the successive reorganization of the land to better adapt to changing demands of society. Today, such changes are seen as a threat because they reduce biodiversity, coherence, and identity of the ecosystem. These aspects were not only characteristic of, but also enriched by the traditional cultural landscapes, which today are rapidly disappearing.

BIOSPHERE RESERVES: A LANDSCAPE APPROACH TO CONSERVATION

Protected natural areas fall into a broad range of categories. In general, they coincide in their goals, which are to prevent ecosystem degradation, conserve biodiversity, and develop harmony between bio-cultural diversity and sustainable development.[30] Of all the categories of protected natural areas, the biosphere reserve model conceived by UNESCO at the beginning of the 1970s stands out because it takes into account the structure and dynamics of regional landscapes, integrates the concept of ecosystem, and incorporates the presence of human settlements and productive activities.

The UNESCO biosphere reserve program is a very successful international agreement. This reserve model has proven to be versatile and adaptable to a variety of ecological, cultural, and social conditions. It has been accepted by many countries to protect their biodiversity; to date, 531 biosphere reserves have been created in 105 countries (fig. 1). In Ibero-America and the Caribbean, 143 biosphere reserves have been decreed in twenty-one countries, covering 255,147,598 hectares of land (fig. 2).

The biosphere reserve model has three zones. The first, the core zone, justifies the creation of the reserve; it is the best conserved, and contains most of the biodiversity. Around the core area is the buffer zone, which allows low impact activities, and has the function of protecting the core zone from high human impact. The buffer zone is externally surrounded by the transition zone, where land-use practices by local inhabitants are permitted, in ways that are amenable to biodiversity conservation goals (fig. 3a).This model acknowledges the presence of both the rural landscape in the buffer zone, as well as more intensive, sustainable industrial uses in the

[29] See J. F. Franklin, "Preserving Biodiversity: Species, Ecosystems or Landscapes," *Ecological Applications* 3, no. 2 (1993): 202–05.

[30] See B. S. Orlove, and S. B. Brush, "Anthropology and the Conservation of Biodiversity," *Annual Review of Anthropology* 25 (1996): 329–52.

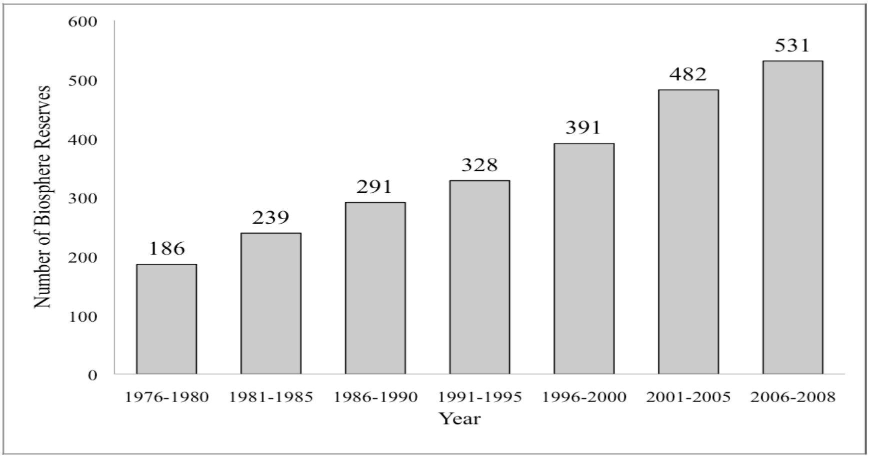

Figure 1. Number of reserves in the UNESCO World Network of Biosphere Reserves in five-year increments, since the creation of the Man and Biosphere Program.

transition zone. From the landscape perspective, the biosphere reserve is a visionary category of protected natural area that includes humans. To date, it is the only type of reserve that explicitly takes into account in its conservation strategy the biodiversity of the surrounding agro-ecosystems and urban areas.

At the Third World Biosphere Reserve Congress, held in February 2008 in Madrid, it was recognized that biosphere reserves have made a huge contribution to research, biodiversity inventories and conservation biology. Since their origin, biosphere reserves have been tightly linked to research institutions and thanks to this, some of the most important studies on biodiversity have been produced. However, studies have not fully examined the fact that the reserves fall short on the spatial and temporal scales of ecosystem dynamics.[31] Nor has the effect of large-scale disturbances on the structure and functioning of ecosystems and the landscape been considered. This lack of knowledge can produce ecological surprises and interfere with conservation goals.[32] An additional, critical shortcoming of the current application of the biosphere reserve model is that the relationship between biodiversity and indigenous populations settled in the reserve has been frequently overlooked. The geographic distribution of indigenous groups is related to the sites with the greatest biological diversity; this could be a consequence of the way in which biodiversity is used.[33] The type of land ownership, and traditional management practices of species and ecosystems have also been frequently disregarded. This disregard has

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[31] Bengtsson et al., "Reserves, Resilience, and Dynamic Landscapes."

[32] See R. T. Paine, M. J. Tegner, and E. A. Johnson, "Compounded Perturbations Yield Ecological Surprises," *Ecosystems* 1 (1998): 535–45.

[33] V. M. Toledo, "Biodiversity and Indigenous Peoples," in S. A. Levin, ed., *Encyclopedia of Biodiversity* (San Diego: Academic Press, 2001), pp. 330–40.

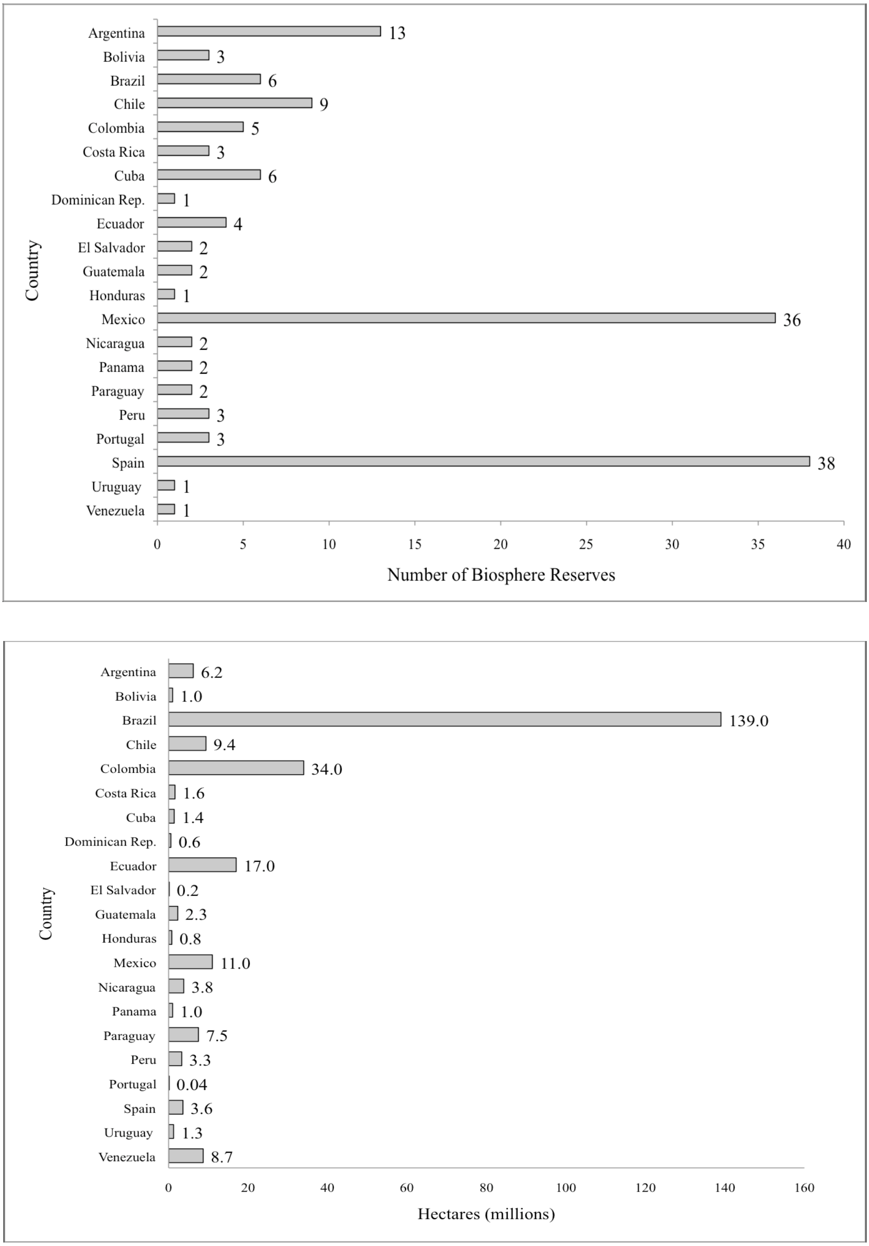

Figure 2. Biosphere Reserves in Ibero-America and the Caribbean: (a) number of IberoMAB-UNESCO biosphere reserves per country; (b) area protected by biosphere reserves per country.

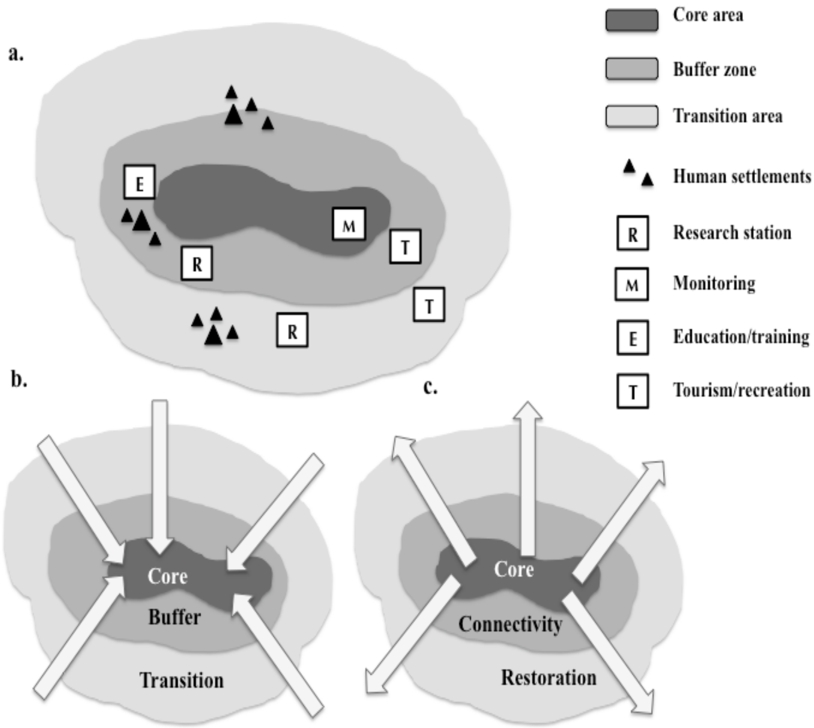

Figure 3. Biosphere Reserve Zoning Models. (a) Three essential, concentric zones: strictly protected core zones at the center (dark gray), surrounded by buffer zones admitting low impact human activities (medium gray), which are in turn surrounded by transition zones where more intensive development can take place (light gray). (b) Conventional centripetal model: the main function of buffer and transition zones is to protect the biodiversity found in the core area. (c) Centrifugal model: buffer and transition zones function as connectivity and restoration areas. This model facilitates the movement of native plants and animals from the strictly protected core zones into transition zones of the reserves, and even outside protected areas into anthropogenic landscapes. Figure 3c illustrates a model that has been analyzed for the management of Manantlan Biosphere Reserve in Mexico, where a forestry landscape restoration strategy is being implemented immediately outside the reserve. Management of native forests in the buffer zone, combined with restoration and reintroduction of tree native plant species, functions as a nurse crop for reintroducing a set of native species in the transition zone, and outside the biosphere reserve. These scarce tree species would otherwise not be available because they need native ecosystems in order to grow. Therefore, restoration is conducted for the protection and management of natural regrowth and active reintroduction of key species. An initial fast-growing nurse crop supplying commercially useful timbers or other goods can facilitate the subsequent establishment of more species-rich forests.

resulted in cultural erosion, the loss of experience and knowledge about landscape management. In addition, this omission has generated frictions between researchers, managers, large-scale producers and the local and federal authorities. As the area of land modified by agricultural, urban, and industrial activities continues to grow, and so does the disparity between the spatial scale of the protected areas and the scale of their ecosystem dynamics.[34]

RETHINKING BIOSPHERE RESERVES

Until now, biosphere reserves have had a limited effect on the regional scale, even though this was one of the main objectives of their creation. Practically all of the reserves in Ibero-America and the Caribbean are pressured by ecologically aggressive land-use practices in their immediate surroundings. As a result, biosphere reserves are being isolated and endangered.

At present, the transition zone of the biosphere reserves is the most critical. This situation is a consequence of their limited size, the absence of consideration for the type of land use outside the reserve, and the lack of capacity to communicate available knowledge and information about sustainable-use practices. Two additional disadvantages are that many reserves were created on marginal lands[35] and that they were conceived as static entities that stay essentially the same for centuries.[36] If this situation does not change, biosphere reserves will soon become ecological islands, degraded by human impact in their surroundings, and suffering from an ever-increasing edge effect. Increasing loss of species and clandestine extraction of flora and fauna are expressions of these effects.[37] The conservation strategy for natural areas implemented to date is not producing the results we had initially hoped for.

Disturbance produced by both natural forces and human activity is the motor of landscape heterogeneity and diversity. Disturbance is related to two relevant attributes of the landscape, its fragility and resilience.[38] If the dynamics of ecosystems and landscapes are to be taken into account, we must reconsider the way in which

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[34] S. T. A. Pickett and J. N. Thompson, "Patch Dynamics and the Design of Nature Reserves," *Biological Conservation* 13 (1978): 27–37; C. S. Holling, D. W. Schindler, B. W. Walker, and J. Roughgarden, "Biodiversity and the Functioning of Ecosystems: An Ecological Synthesis," in C. A. Perrings, K. G. Mäler, C. Folke, C. S. Holling, and B. O. Jansson, eds., *Biodiversity Loss: Economic and Ecological Issues* (Cambridge: Cambridge University Press, 1995), pp. 44–83; and P. M. Vitousek, H. A. Money, J. Lubchenco, and J. M. Melillo, "Human Domination of Earth Ecosystems," *Science* 277 (1997): 494–99.

[35] Gomez-Pompa and Kaus, "Taming the Wilderness Myth"; and Primack et al., *Fundamentos de Conservación Biológica.*

[36] J. Caldecott, *Designing Conservation Projects* (Cambridge: Cambridge University Press, 1996), p. 312.

[37] D. Janzen, "No Park is an Island," *Oikos* 41 (1983): 402–10.

[38] Farina, "The Cultural Landscape as a Model."

the reserves are designed and managed. Reserves should be part of a landscape mosaic increasingly controlled by human activities.[39]

The main purpose of the original landscape pattern for biosphere reserves is to conserve the biodiversity of the core area, like a sanctuary. The two surrounding zones (buffer and transition) protect the core area from the effect of land management in the surroundings. This model is centripetal in its character, as its main function is to isolate and to protect the core from the "negative effects" of regional land uses (fig. 3b).

We propose that the biosphere reserve model has the potential to adapt to the spatial scale of ecosystem processes and human interference. For this to happen, the landscape pattern for biosphere reserves should be reversed. Instead of isolating the core area, fluxes should be facilitated, and biodiversity should have free access to transition zones. Doing so requires changing the function of the buffer zone from that of protection to that of facilitating the movement of species toward the transition zone, thus, converting buffer zones into areas of ecological connectivity. This model of biosphere reserves then becomes centrifugal in character (fig. 3c).

Reversing the function of the buffer zone from one that mitigates the damaging effects of anthropogenic change in the surroundings to a zone in which the main function is facilitating the spread of biodiversity toward the area of influence and eventually to the surroundings of the reserve links the reserve with its local and regional environs. This reversal could restore the ecological connectivity of the landscape around the core area, and allow the reserve to become an integral part of the landscape. The self-regeneration capacity of the ecosystem would also be restored (fig. 3c).

The core—thought of as an untouchable area—needs to be reconceived as the most important repository of biodiversity capital of the biosphere reserve and its surroundings. This landscape perspective will allow us to proceed with environmental restoration at the scale of the ecosystem and to respond to both natural and human disturbances in a more proactive manner. Facilitating the movement of biodiversity from core to transition zones enhances the connectivity between zones with different degrees and types of human uses; i.e, an integrated landscape, one that is structured and functional, and which becomes a coherent sustainable ecosphere. Ultimately, the goal is to establish a sustainable balance between attractive, healthy, liveable, productive, and industrial landscapes for future generations.[40] More important than the conservation of intact areas is the conservation,

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[39] Bengtsson et al., "Reserves, Resilience, and Dynamic Landscapes."

[40] Z. Naveh, "Ecological and Cultural Landscape Restoration and the Cultural Evolution towards a Post-Industrial Symbiosis between Human Society and Nature," *Restoration Ecology* 6 (1998): 135–43; Z. Naveh, "What is Holistic Landscape Ecology? A Conceptual Introduction," *Landscape and Urban Planning* 50, no. 1–3 (2000): 7–26.

on a regional scale, of strategies of resource use that do not interrupt the ecological processes that maintain the resilience of the landscape.[41]

Biodiversity is crucial for recovering ecosystem function and, above all, its resilience. The most powerful instrument for conserving biodiversity is not a fence that isolates, but rather policies and reforms that turn conservation into a matter of both private and social concern.[42] We should focus our attention on active efforts to produce a truly integrated science, the development of sound landscape design principles and increased interaction with policy planners and managers.

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[41] B. Walker, "Conserving Biological Diversity through Ecosystem Resilience," *Conservation Biology* 9, no. 4 (1995): 747–52.

[42] C. Folke, C. S. Holling, and C. Perrings, "Biological Diversity, Ecosystems, and the Human Scale," *Ecological Applications* 6, no. 4 (1996): 1018–24.