EarthTrends Featured Topic:

Protecting Ecosystems on a Changing Planet

Author: Jessica Forrest
Date Written: July 2003

A thick blanket of clouds shrouds the higher reaches of the Tilarán Mountain Range of Costa Rica, protecting the vast community of plants and animals that inhabit its steep slopes. Over time, mists have swept up the Caribbean side of these mountains with a rhythm guided by global climatic phenomena (Pounds et al. 1999, Still et al. 1999). During the dry season in particular, these mists are critical to the survival of many reptiles, butterflies, and other species that inhabit the forest (Haber 2001, Pounds 2003a, Pounds 2003b).

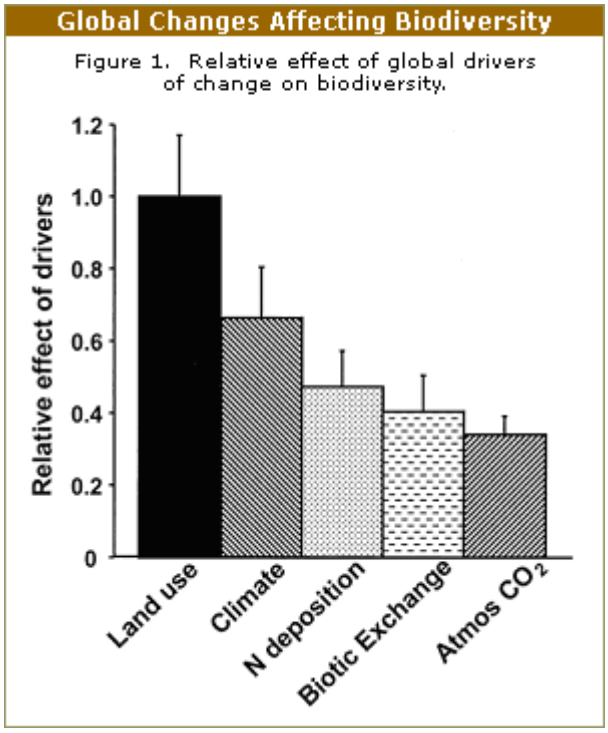
Although the Monteverde Reserve was established to protect this unique place, recent evidence suggests that all is not well here. In response to global warming trends, the mists do not bring water to the area as frequently as they used to, and the base of the clouds has shifted upslope (Pounds et al. 1999, Still et al. 1999). This shift in the cloud cycle has resulted in catastrophes that range from population crashes of 20 species of frogs and toads (Pounds et al. 1999) to the complete disappearance of the golden toad in 1989, a species that was previously found only in the cloud forest of the Monteverde Reserve (McCarty 2001, Pounds 2003b). The birds of Monteverde have also been affected by recent shifts in cloud patterns: at least 15 species of birds that previously lived only at lower elevations, such as Keel-billed toucans, have moved upslope to compete for food and other resources with other birds such as resplendent quetzals that historically inhabited the cloud forest (Pounds et al. 1999).

Evidence that climate change is already taking its toll on plant and animal communities, regardless of the presence of protected area boundaries, is unfortunately not limited to the mountains of Costa Rica. In North America, the entire range of the arctic fox is shifting northward (Hersteinsson and MacDonald 1992), while butterflies in Europe are also heading north in search of cooler temperatures (Parmesan et al. 1999). In Southeast Asia, warmer ocean waters during El Niño years have caused coral reefs to bleach and die, impacting both marine biodiversity and fisheries (Reaser et al. 2000).

And in South Africa, rising temperatures and reduced precipitation have already led to local extinctions of some rare species in a group of plants known as succulents (Midgley 2003). These plants are adapted to hot, dry weather conditions and store water in their leaves. If climate predictions for South Africa are correct, however, the entire succulent karoo biome that hosts these plants is expected to shift southward, and drastically reduce in size as it approaches the southern tip of Africa (National Botanical Institute 2003).

Global Change and Ecosystems

These stories of plants and wildlife already adversely affected by climate change at the local level are grim, and warn of further changes to come if global temperature continues to rise. Global climate change, however, is only one in a set of ongoing global changes that have implications for all life on Earth. Global changes other than warming include habitat loss and fragmentation, introductions of non-native—often invasive—species to ecosystems, sea level rise, nitrogen deposition from industrial and agricultural pollution sources, and increasing concentrations of atmospheric carbon dioxide (Miller 2003, Sala 2000). Because they are global in nature, these factors both link



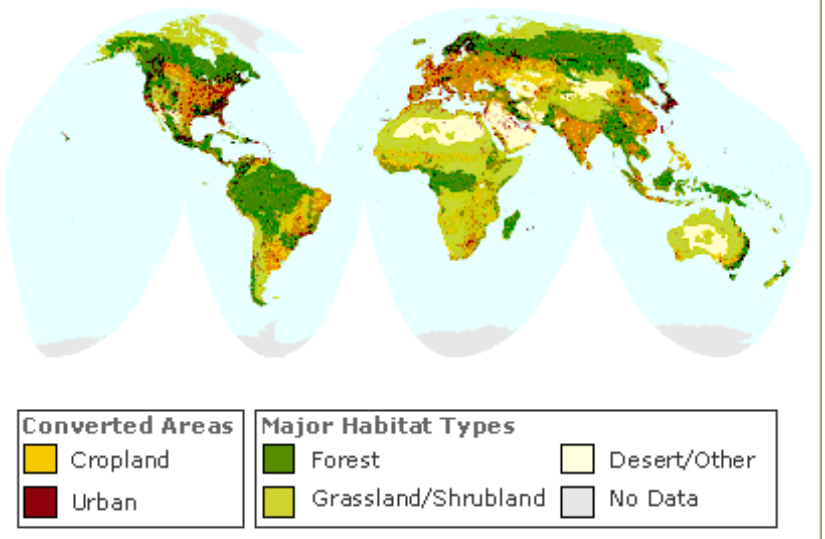
and affect protected areas efforts worldwide.

Global change factors are unified by the fact that their causes- whether economic, political, or social- extend beyond the local level. Among others, major root causes of global ecosystem changes include growing population, intensified land use, and changing systems of governance. Since ecosystems provide services to people—including flood control, water filtration, and local climate control (WRI 2000)--in addition to providing habitat for plants and animals, global change has inevitable consequences for both humans and wildlife.

Of the five primary global change drivers, land use change will be the primary driver of change to biodiversity—the delicate balance of plants, wildlife, and microbes—in the 21st century (Sala et al 2000). This prediction is consistent with past trends (Vitousek et al. 1997, Pimm and Raven 2000). Habitat destruction acts like a cookie-cutter, stamping out species caught in its path. Worldwide, humans have already converted approximately 29 percent of land area—almost 3.8 billion hectares—to agriculture and urban or built-up areas (WRI 2000). Habitat fragmentation is even more pervasive than habitat loss, and results in pieces of original habitat that are too small to maintain populations of some species (Meffe and Carroll 1997, p.148; Miller 2003). While Figure 1 shows a graph comparing the relative impact of the five drivers of global change on biodiversity, Figure 2 shows a map of areas of the world converted to croplands and urban areas.

Converted Areas Span the Globe

Figure 2: Global Map of Converted Areas



Source: Based on data from Global Land Cover Characteristics Database Version 1.2 (Loveland et al. 2000); NOAA-NGDC (1998); WWF (1999).

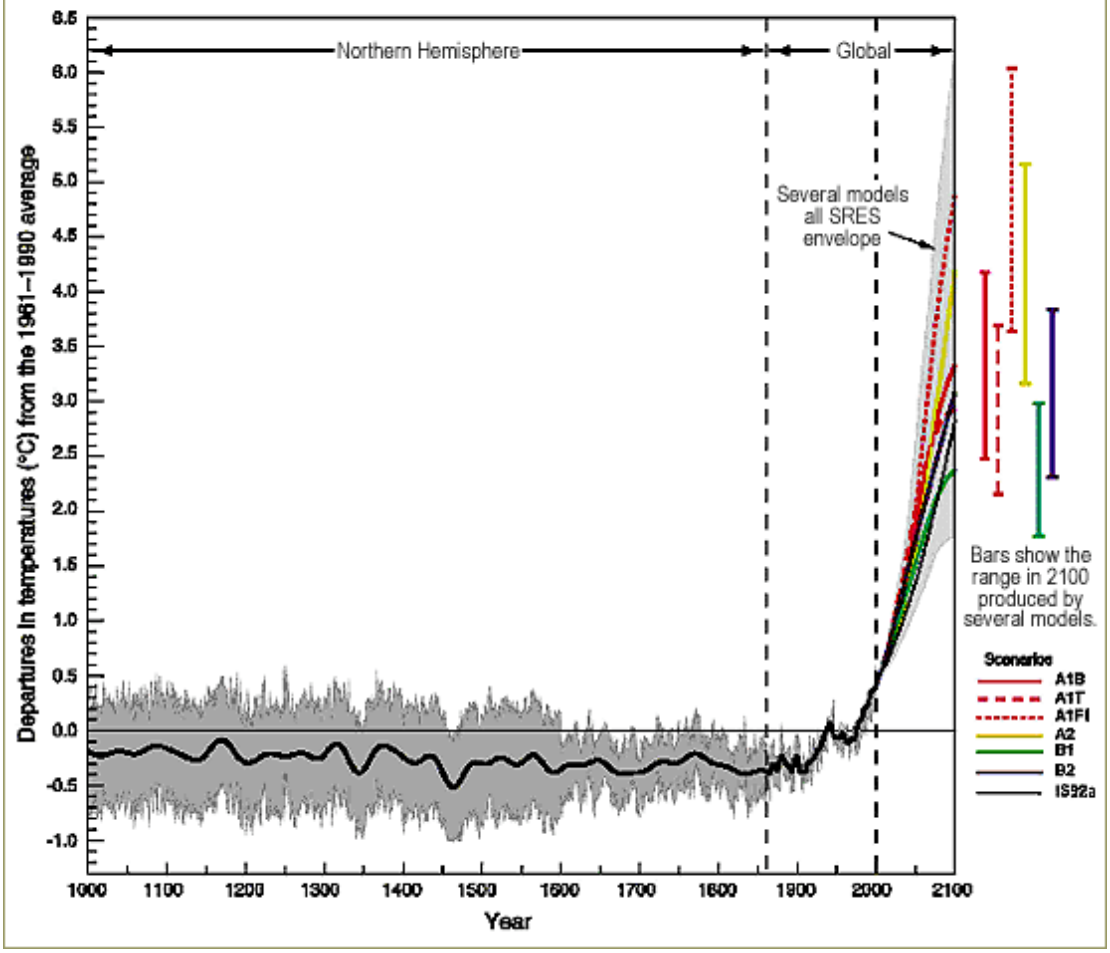
Early known victims of land use change in the U.S. include four species of birds that were eliminated when primary forests were cleared for agriculture by early settlers (Gibbs 2001). Human victims of land use change include the nearly 18,000 people who lost their lives when steep agricultural land that had been cleared from tropical forest failed to absorb the flood-waters of Hurricane Mitch in 1998 (DFID et al. 2002).

After land use change, climate change will be the second biggest factor to affect biodiversity in the 21st century (Sala et al. 2000). Already, global climate has increased by more than 0.6 ºC during the past 100 years (IPCC 2001), and is thought to be the direct result of anthropogenic activities such as fossil fuel burning and forest clearing (Levitus et al. 2001, IPCC 2001). In the context of geological history, this rate of change is unprecedented: the rate of global temperature increase over the past 100 years has been 20 times the average rate of increase since the end of the last ice age 18,000 years ago (Wilcott and Thomas 2001). Warming trends are expected to continue throughout the next century, and the planet is expected to be 1.4 to 5.8 ºC warmer in the year 2100 as compared with today (IPCC 2001). The increase in global temperature over the past 100 years has been accompanied by a global increase in precipitation of 5 to 10%, an increased frequency of extreme weather events such as hurricanes, and sea level rise. See Figure 3 for a graph of past and future climate trends.

Biotic change caused by invasive species is another example of global change that is affecting protected areas efforts worldwide. Invasive species often travel with people- such as in the ballast of ships or in cargo holds of airplanes. When these vehicles reach their destinations, alien species are released, wreaking havoc in their destination ecosystems, either by predating on, or competing with, native species. Invasive species have also intentionally been released into new ecosystems, with unintended consequences for local or regional ecosystems (WRI 2001).

A Coming Century of Warming Trends

Figure 3: Observed and Expected Change in Global Temperature



each country that is protected. Also see the *EarthTrends Protected Areas Data Table* (http://www.earthtrends.wri.org/datatables/index.cfm?theme=7) for a country-by-country comparison of number and area of protected areas.

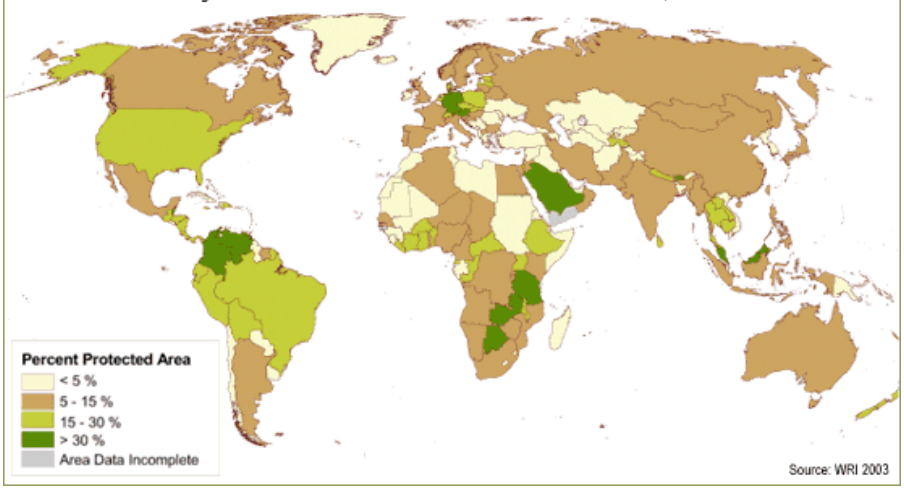
The accomplishment of this global effort is real, as protected areas are widely held to be the most effective means of conserving biodiversity (Green and Paine 1997, McNeely and Miller, 1984; Leader-Williams et al. 1990) and other valuable ecosystem services. In a world that is dynamic and changing, however, protected areas remain static. Although current protected area boundaries may be adequate to protect many species and ecosystems in the short term, it is becoming evident that current boundaries may be inadequate when faced with the unpredictable shifts associated with changing

Grappling with Global Change: Protecting the Planet in the Next Millennium

Despite the fact that that natural systems on this planet are undergoing un-naturally rapid amounts of change, people worldwide are making unprecedented strides to protect them. Representative of this effort is the fact that governments have established protected areas to manage threatened ecosystems and ecosystem services, protect species from extinction, and to maintain cultural diversity and resources. To date, more than 98,000 nature reserves, national and state parks, protected landscapes, and managed resource areas have been established to protect more than 10 percent of the earth's terrestrial surface. In addition, more than 3800 marine protected areas have been established to protect marine biodiversity and fisheries worldwide (UNEP-WCMC 2003). Figure 4 shows a global map of the percent of

Changing Habits: Establishing Protected Areas to Manage Threatened Ecosystems

Figure 4: Percent of Total Land Area that is Protected, 2003



climate and invasive species. These factors of global change produce new challenges for local protected area managers, who see the effects of global change increasingly on the land that they are charged to protect.

It is apparent that our dynamic planet will require more dynamic strategies for keeping protected areas healthy. There are certain ways that reserves can be designed to protect their biodiversity despite change, such as by making them large in area, span latitudinal (north-south) or elevation gradients, and use biological corridors to connect populations. In addition to designing parks for resiliency, adaptive management—constant assessment and revision of conservation strategies in the face of successes and failures—will be required in the face of ongoing global changes. Exchange ideas with other protected areas managers across country and even continents boundaries will also play an important role in helping local managers in different parts of the world combat these global challenges.

The Fifth World Parks Congress, which is being held in Durban, South Africa in September 2003, offers one opportunity for thousands of people involved in ecosystem protection, conservation, and local communities to come together to grapple with the enormous challenges of protecting ecosystems on a changing planet (WCPA 2003). But it is the follow-up activities to the Congress, which will involve many more than just its attendees that will determine how humans are able to better manage ecosystems so that they can anticipate and adapt to, or even slow and reverse, some of the current global changes that are affecting the Earth.

REFERENCES

Department for International Development, U.K. (DFID), Directorate General for Development, European Commission (EC), United Nations Development Programme (UNDP), and the World Bank (WB). 2002. *Linking Poverty Reduction and Environmental Management: Policy Challenges and Opportunities*. July 2002.

Gibbs, Wayt. "On the termination of species." *Scientific American.* New York. November 2001.

Green, M.J.B. and Paine, J. 1997. State of the World's Protected Areas at the end of the Twentieth Century. Paper presented at IUCN World Commission on Protected Areas Symposium on "protected Areas in the 21st Century: From Islands to Networks." Albany, Australia, 24-29 November 1997. World Conservation Monitoring Centre, Cambride, U.K.

Haber, W.A. 2001. Monteverde Natural History. Available at http://www.cs.umb.edu/efg/. Updated: 3 June 2001. Accessed August 2003.

Hersteinsson, P. and MacDonald, D.W. 1992. Interspecific competition and the geographical distribution of red and arctic foxes *Vulpes vulpes* and *Alopex lagopus.* Oikos 64: 505-515.

Hobbs, R.J. 2000. Land-use changes and invasions. Invasive Species in Changing World (Mooney, H.A. and Hobbs, R.J., eds). Washington, DC: Island Press.

Intergovernmental Panel on Climate Change (IPCC). 2001. Climate Change 2001: Synthesis Report for Policymakers. Internet Web site: http://www.ipcc.ch/pub/un/syreng/spm.pdf. Accessed on August 18, 2003.

Leader-Williams, N., Harrison, J., and Green, M.J.B. 1990. Designing protected areas to conserve natural resources. Science Progress 74: 189-204.

Levitus, S., Barnett, T., Pierce, D. and Schnur, R. 2001. Anthropogenic Warming of the Earth's Climate System. Science 292(5515) 267-270.

Loveland, T.R., Reed, B.C., J.F., Brown, J.F., Ohlen, D.O., Zhu, Z., Yang, L. Merchant. J. 2000. *Global Land Cover Characteristics Database (GLCCD) Version 2.0.* Available online at: http://edcdaac.usgs.gov/glcc/globdoc2_0.html.

McCarty, J.P. 2001. Ecological Consequences of Recent Climate Change. *Conservation Biology* 15(2) 320-331. April 2001.

McNeely and Miller. 1984. National Parks, Conservation and Development: The role of protected areas in sustaining society. Proceedings of the World Congress on National Parks held on 11-22 October 1982 in Bali, Indonesia. Smithsonian Institution Press, Washington, DC.

Meffe, G.K., Carroll, C.R., and contributors. 1997. Conservation Biology, 2nd ed. Sunderland, MA: Sinauer Associates, Inc.

Midgley, G. Direct quote. National Geographic Today, Article by Trivedi, B.P. August 4, 2003.

Miller, K. 2003. A Guide to: Securing Protected Areas in the Face of Global Change: Options and Guidelines. A Draft Report by the Ecosystems, Protected Areas, and People Project, International Union for the Conservation of Nature and Natural Resources World Commission on Protected Areas. August 2003.

Mooney, H.A. and Hobbs, R.J.. 2000. Invasive Species in Changing World (Mooney, H.A. and Hobbs, R.J., eds). Washington, DC: Island Press.

National Botanical Institute. 2003. Impacts of Climate Change on Plant Diversity in South Africa: Methods Details for Succulent Karoo Bioclimactic Modelling. Internet Web site: http://www.nbi.ac.za/climrep/10.htm . Accessed on August 5, 2003.

National Oceanic and Atmospheric Administration-National Geophysical Data Center (NOAA-NGDC). 1998. Stable Lights and Radiance Calibrated Lights of the World CD-ROM. Boulder, CO: NOAA-NGDC. On-line at: http://julius.ngdc.noaa.gov:8080/production/html/BIOMASS/night.html. (December 1998).

Parmesan, C, Ryrholm, N., Stefanescus, J., Hill, K., Thomas, C.D., Descimon, H., Huntley, B., Kaila, L., Killberg, J., Tammaru, T., Tennent, W.J., Thomas, J.A., and Warren, M. 1999. Poleward shifts in geographical ranges in butterfly species associated with regional warming. Nature 399: 579-583.

Pimm, S.L. and Raven, P. 2000. Extinction by Numbers. *Nature.* 403 (6772): 843-845 Feb 24 2000

Pounds, J.A., Fogden M.P.L., and Campbell, J.H. 1999. Biological response to climate change on a tropical mountain. Nature Vol 398 611-615. 15 April 1999.

Pounds, J.A. 2003a. How is climate change affecting the cloud forests of Costa Rica? Television presentation. Televation Trust for the Environment. Available at: http://tv.oneworld.net/tapestry?link=252#. Accessed August 2003.

Pounds, J.A. 2003b. What has happened to the golden toad? Television presentation. Televation Trust for the Environment. Available at: http://tv.oneworld.net/tapestry?link=252#. Accessed August 2003.

Reaser, J.K., Pomerance, R., Thomas, P.O. 2000. Coral bleaching and global climate change: Scientific findings and policy recommendations. Conservation biology 14(5) 1500-1511. Oct 2000.

Sala, O.E., Chapin III, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., and 14 others. 2000. Global Biodiversity Scenarios for the Year 2100. *Science* (287) March 10, 2000.

Still, C., Foster, P.N., Schneider, S.H. 1999. Simulating the effects of climate change on tropical montane cloud forests. Nature Vol 398 608-610. 15 April 1999.

Sutherst, R.W. 2000. Climate change and invasive species: a conceptual framework. Ch. 10 in Invasive Species in Changing World (Mooney, H.A. and Hobbs, R.J., eds). Washington, DC: Island Press.

World Resources Institute and Amy Wagener (WRI). 2001. Bioinvasions: Stemming the Tide of Exotic Species. Washington, D.C.: World Resources Institute. Available on-line at http://earthtrends.wri.org/pdf_library/features/bio_fea_invasives.pdf

World Wildlife Fund-US (WWF-US). 1999. Ecoregions database: Unpublished database. Washington, DC: WWF-US.

United Nations Environment Programme - World Conservation Monitoring Centre (UNEP-WCMC). 2003. World Database on Protected Areas (WDPA) Version 6. Compiled by the World Database on Protected Areas Consortium. Cambridge, U.K., August, 2003.

Vitousek, P.M., Mooney, H.A., Lubchenco, J., and Mellilo, J.M. 1997. Human domination of the Earth's ecosystems. *Science* 277: 494-499.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. *BioScience* 48:607-615.

Willcott, J. and Thomas, C. 2001. *Briefing Paper: Implications for Climate Change for Species Conservation*. International Union for the Conservation of Nature and Natural Resources (IUCN) Workshop. Gland, Switzerland. February 19-21, 2001.

World Commission on Protected Areas. 2003. World Congress on Protected Areas Web Portal. Internet Web site: http://www.iucn.org/themes/wcpa/wpc2003/. Accessed on August 18, 2003.

World Resources Institute (WRI) in collaboration with United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), and World Bank. 2000. *World Resources 2000–2001: People and Ecosystems: The Fraying Web of Life.* Washington, DC: WRI.