Conservation Biology

Diversity

Conservation in the Anthropocene

TIM CARO,*‡ JACK DARWIN,* TAVIS FORRESTER,* CYNTHIA LEDOUX-BLOOM,† AND CAITLIN WELLS*

*Department of Wildlife, Fish and Conservation Biology, University of California, Davis, CA 95616, U.S.A.
†Department of Animal Science, University of California, Davis, CA 95616, U.S.A.

It has become commonplace to remark that humans are now the dominant environmental force on the Earth. The indications are strong and diverse. They range from paleontologists reaching a consensus that humans contributed to megafaunal extinctions on at least two continents, North America and Australia (Barnosky et al. 2004); recognition that formerly intact marine ecosystems have changed enormously (Jackson et al. 2001); suggestions that climate has changed sufficiently that no ecosystem is immune from alterations in species composition (Lavergne et al. 2010); remarks that pollution is widespread even in Antarctica (van den Brink et al. 2011); and arguments that human predation on mammals is pernicious (Collins & Kays 2011) and the principal driver of changes in phenotypic traits of exploited species in many areas (Darimont et al. 2009). Some scientists use geographic data to show that human activities affect almost every terrestrial system (e.g., the human footprint [Sanderson et al. 2002]). Indeed, the current epoch is now being referred to as the Anthropocene (Crutzen & Stoermer 2000), which has led geologists to formally debate stratigraphic evidence for this new phenomenon (Zalasiewicz et al. 2011) and to argue over not if but when it began (Ruddiman 2003). With the catchword *Anthropocene* in ascendancy, one might easily come away with the impression that nowhere on Earth is natural, in one of the word's specific meanings of ecosystems being untouched by humans (Karieva et al. 2007), and indeed it is common to hear the phrase *humans have altered everything*.

Although we agree that humans are a dominant species and have affected natural systems at a global scale, we suggest that humans may have less influence at smaller extents of specific regions and even ecosystems. We fear that the concept of pervasive human-caused change may cultivate hopelessness in those dedicated to conservation and may even be an impetus for accelerated changes in land use motivated by profit.

Airborne and waterborne chemicals, lowered water pH, rising temperatures, increasing rates of extinctions, habitat fragmentation and loss, non-native invasive species, and new diseases have not yet altered key aspects of every ecosystem. There are still ecosystems that are sufficiently intact to retain key ecological functions and species (Table 1), and it is vital to identify and protect them now. We define intact ecosystems as those in which the majority of native species are still present in abundances at which they play the same functional roles as they did before extensive human settlement or use, where pollution has not affected nutrient flows to any great degree, and where human density is low. This definition is similar to Mittermeier et al.'s (2003) definition of *wilderness areas*, but it does not specify the size of the area. Ecosystems where human influence is relatively mild in terms of exploitation, pollution, and climate change include newly discovered ecosystems (e.g., Brandt et al. 2007; Laybourn-Parry & Pearce 2007); large, relatively intact areas with low human densities (Mittermeier et al. 2003); newly discovered areas of high species diversity or places with no recent history of human activity (e.g., Wilson 1981; Thing et al. 1987; Brito et al. 2009); areas with very low human population densities at both large and small extents (e.g., Sandin et al. 2008; Stokes et al. 2010; van Heist et al. 2010); and places of still extraordinarily high species diversity (e.g., Garcia & Mba 1997; Myers et al. 2000; Herrmann et al. 2005) (Table 1).

We recognize that humans have had at least marginal influence on most if not all of the world's biomes, but there are several reasons to doubt that humans have altered everything (a phrase that is generously interpreted as including nutrient flows and species composition

‡ *tmcaro@ucdavis.edu*
Paper submitted June 04, 2011; revised manuscript accepted July 18, 2011.

Conservation Biology, Volume **, No. *, ***–***

DOI: 10.1111/j.1523-1739.2011.01752.x

Table 1. Examples of relatively intact ecosystems.

Type of ecosystem	*Location*
Unexploited by humans	Lake Vostok and other lakes under Antarctic ice sheets
	Southern Ocean deep sea
Wilderness areas	North America
	Rocky Mountains
	Alaskan Pacific northwest temperate rainforest
	Southwestern deserts
	South America
	Amazonia
	Chaco
	Patagonia
	Pantanal
	Africa
	Congo Forest
	Miombo-Mopane woodland
	Asia
	central Asian deserts
	boreal forest
Ecoregions with virtually no human presence	Central Greenland
	Antarctica
	high-elevation Himalayas
	central Sahara
Smaller sites little influenced by human activity	waters around the Line Islands in western Pacific
	Foja Mountains, Papua
	Ndoki-Likouala, central Africa
Sites of extraordinary species richness	Rupununi, Guyana
	Province Nord, New Caledonia
	Monte Alen region, Equatorial Guinea
	Cameroon Mountains, Congo
	edaphic grasslands

and interactions). First, the human footprint—a compilation of human population density, land-cover and land-use change, human accessibility via roads, rivers, or coastlines, and electrical power infrastructure (Sanderson et al. 2002)—shows large gaps at equatorial (central Africa), subtropical (central Australia, Sahara), temperate (Himalayas), and palearctic (Russia and Canada) latitudes. Second, increases in global temperature, touted as now affecting everything from patterns of migration, plant phenology, and laying dates of birds to species' range expansions (Hannah 2010), have occurred principally in northern and southern latitudes and at high elevations. It is acknowledged that temperature increases, at least, will be smallest in the lowland tropics, where most of the world's species occur. Third, species diversity, apex predators, intact food webs, functioning ecosystems, and nutrient cycles may be little affected by humans in areas inhabited by people living at low densities (e.g., Mittermeier et al. 2003).

We believe that there are four reasons to acknowledge that some areas of the globe are still intact. First, if nothing is believed to be intact, it allows humans to think that species invasions are inevitable and not problematic and may open the floodgates to human manipulation of species assemblages. For example, if species composition in northern temperate ecosystems now is a mélange of species formerly found at lower latitudes, then it may be fair to argue that it is better to construct new ecosystems through assisted migration in order to conserve species as climate changes (Thomas 2011) or to initiate Pleistocene rewilding programs to reconstruct former functioning ecosystems or reinstate past evolutionary drivers (Donlan et al. 2006). Although the ideas of assisted migration and Pleistocene rewilding are debated (Caro 2007; Ricciardi & Simberloff 2009), they seem more acceptable if one believes that everything has already been anthropogenically altered.

Second, planning and setting goals for conservation action usually require relatively intact areas that serve as baselines for comparisons and to set targets (Karr & Dudley 1981). Without spatial comparisons it is difficult to understand how ecosystems have changed or to frame management goals. If there are no contemporary intact benchmarks for comparative purposes, one must rely on incomplete data and memories of past ecosystems, which are known to change over time (i.e., shifting baseline syndrome; Sáenz-Arroyo et al. 2005; McClenachan 2009). Although restoring poorly functioning ecosystems is a conservation goal, protecting nearly intact ecosystems also is a fundamental conservation priority.

Third, if no ecosystem is intact, governments can more easily argue, and societies concur, that land use ranging

from subsistence farming to extensive resource extraction is acceptable because the environment has already been degraded. Dam building in major rivers, oil exploration in western Amazonia or the Arctic National Wildlife Refuge, and construction of housing developments become more tolerable in an irrevocably modified world. Especially worrying to us is the ongoing change in conservation agenda from identifying and protecting sites of high conservation priority to conserving "working landscapes" with extensive human influence.

Fourth, if the idea that Earth is already spoiled further permeates the general mindset, monetary contributions to and efforts for conservation may seem futile to the general public, whose support is vital to conservation. Already a doom-and-gloom discipline, conservation science may want to obviate this pessimism by focusing on the reality that not every place in the world has been severely affected by anthropogenic activities and that these places can serve as models for the structure of and interactions within natural communities.

While accepting humans' enormous effect on the planet, we see a crucial need to identify remaining intact ecosystems at local extents, to protect them, and to remind the public of them. We need to do this for scientific reasons so that baselines for determining, for example, extent of pollution and declines in ecosystem function (e.g., Sandin et al. 2008) are preserved. We need to do this for practical reasons so that goals for restoration projects have a basis in reality. We need to do this for public relations reasons, to reiterate that natural ecosystems exist and to engage society in conservation. And, we need to do this for ethical reasons; we have a duty to future generations to enhance their quality of life by providing them with the opportunity to observe the wonders of nature. We acknowledge that this is the goal of many conservation organizations, but we are concerned that the increasing adoption of the concept of the Anthropocene will undermine both conservation and restoration objectives.

Acknowledgments

We thank E. Fleishman, P. Sherman, and three reviewers for helpful comments.

Literature Cited

Barnosky, A. D., P. L. Koch, R. S. Feranec, S. L. Wing, and A. B. Shabel. 2004. Assessing the causes of late Pleistocene extinctions on the continents. Science **306:**70–75.

Brandt, A., et al. 2007. First insights into the biodiversity and biogeography of the Southern Ocean deep sea. Nature **447:**307–311.

Brito, J. C., A. L. Acosta, F. Álvares, and F. Cuzin. 2009. Biogeography and conservation of taxa from remote regions: an application of ecological-niche based models and GIS to North-African canids. Biological Conservation **142:**3020–3029.

Caro, T. 2007. The Pleistocene re-wilding gambit. Trends in Ecology & Evolution **22:**281–283.

Collins, C., and R. Kays. 2011. Causes of mortality in North American populations of large and medium-sized mammals. Animal Conservation DOI:10.1111/j.1469-1795.2011.00458.x

Crutzen, P. J., and E. F. Stoermer. 2000. The 'Anthropocene.' Global Change Newsletter **41:**17–18.

Darimont, C. T., S. M. Carlson, M. T. Kinnison, P. C. Paquet, T. E. Reimchen, and C. C. Wilmers. 2009. Human predators outpace other agents of trait change in the wild. Proceedings of the National Academy of Sciences **106:**952–954.

Donlan, C. J., et al. 2006. Pleistocene rewilding: an optimistic agenda for twenty-first century conservation. The American Naturalist **168:**660–681.

Garcia, J. E., and J. Mba. 1997. Distribution, status and conservation of primates in Monte Alen National Park, equatorial Guinea. Oryx **31:**67–76.

Hannah, L. J. 2010. Climate change biology. Elsevier, Burlington, Massachusetts.

Herrmann, H. W., W. Bohme, O. Euskirchen, P. A. Herrmann, and A. Schmitz. 2005. African biodiversity hotspots: the reptiles of Mt Nlonako, Cameroon. Revue Suisse de Zoologie **112:**1045–1069.

Jackson, J. B. C., et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science **293:**629–638.

Kareiva, P., S. Watts, R. McDonald, and T. Boucher. 2007. Domesticated nature: shaping landscapes and ecosystems for human welfare. Science **316:**1866–1869.

Karr, J. R., and D. R. Dudley. 1981. Ecological perspectives on water quality goals. Environmental Management **5**:55–68.

Lavergne, S., N. Mouquet, W. Thuiller, and O. Ronce. 2010. Biodiversity and climate change: integrating evolutionary and ecological responses of species and communities. Annual Review of Ecology, Evolution, and Systematics **41:**321–350.

Laybourn-Parry, J., and D. A. Pearce. 2007. The biodiversity and ecology of Antarctic lakes: models for evolution. Philosophical Transactions of the Royal Society B **362:**2273–2289.

McClenachan, L. 2009. Documenting loss of large trophy fish from the Florida Keys with historical photographs. Conservation Biology **23:**636–643.

Mittermeier, R. A., C. G. Mittermeier, T. M. Brooks, J. D. Pilgrim, W. R. Konstant, G. A. B. da Fonseca, and C. Kormos. 2003. Wilderness and biodiversity conservation. Proceedings of the National Academy of Sciences **100:**10309–10313.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature **403:**853–858.

Ricciardi, A., and D. Simberloff. 2009. Assisted colonization is not a viable conservation strategy. Trends in Ecology & Evolution **24:**248–253.

Ruddiman, W. F. 2003. The anthropogenic greenhouse era began thousands of years ago. Climatic Change **61:**261–293.

Sáenz-Arroyo, A., C. M. Roberts, J. Torre, M. Carino-Olvera, and R. R. Enríquez-Andrade. 2005. Rapidly shifting environmental baselines among fishers of the Gulf of California. Proceedings of the Royal Society B **272:**1957–1962.

Sanderson, E. W., M. Jaiteh, M. A. Levy, K. H. Redford, A. V. Wannebo, and G. Woolmer. 2002. The human footprint and the last of the wild. BioScience **52:**891–904.

Sandin, S. A., et al. 2008. Baselines and degradation of coral reefs in the Northern Line Islands. Public Library of Science ONE **3** DOI:10.1371/journal.pone.0001548.

Stokes, E. J., et al. 2010. Monitoring great ape and elephant abundance at large spatial scales: measuring effectiveness of a conservation landscape. Public Library of Science ONE **5:**DOI:10.1371/journal.pone.0010294.

Thing, H., D. R. Klein, K. Jingfors, and S. Holt. 1987. Ecology of muskoxen in Jameson Land, northeast Greenland. Holarctic Ecology **10:**95–103.

Thomas, C. D. 2011. Translocation of species, climate change, and the end of trying to recreate past ecological communities. Trends in Ecology & Evolution **26:**216–221.

van den Brink, N. W., M. J. Riddle, M. van den Huevel-Greve, and J. A. van Franeker. 2011. Contrasting time trends of organic contaminants in Antarctic pelagic and benthic food webs. Marine Pollution Bulletin **62:**128–132.

van Heist, M., D. Sheil, I. Rachmann, P. Gusbager, C. O. Raweyai and H. S. M. Yoteni. 2010. The forests and related vegetation of Kwerba, on the Foja foothills, Mamberamo, Papua (Indonesia New Guinea). Blumea **55:**153–161.

Wilson, P. 1981. Ecology and habitat utilization of blue sheep (*Pseudois nayaur*) in Nepal. Biological Conservation **21:**55–74.

Zalasiewicz, J., et al. 2011. Stratigraphy of the Anthropocene. Philosophical Transactions of the Royal Society A **369:**1036–1055.