Life on the Brink

Environmentalists Confront Overpopulation

2012

Edited by Philip Cafaro and Eileen Crist
The University of Georgia Press

CHAPTER 7

The Human Population Footprint on Global Biodiversity

JEFFREY MCKEE

THE TERM *footprint* has become a common expression for various types of human environmental impacts on both urban and natural environments. Architects refer to the *footprint* of a building, the *carbon footprint* was launched into the political domain, and the more general term *ecological footprint* is spreading from the academic world to the general public. What is often lacking is discussion of the *human population footprint*. To be sure, the general effects of human population growth are discussed in terms of urbanization and suburban sprawl, for example, but not so much in terms of environmental impact and, particularly, the effects of human population density on biological diversity. There is now a growing body of academic literature (reviewed by Luck 2007) establishing a scientific link between human population density and growth and increased extinction threats for plants and animals, yet this key footprint remains on the outskirts of conservation dialogue.

Contemporary trends among threatened species, as gauged by long-term paleontological data, confirm that Earth is experiencing its sixth mass extinction of plant and animal species (Barnosky et al. 2011). Although the causes of the current mass extinction are complex and mediated by human behavior, there is clearly a strong connection between the density of the human population and threats of further extinctions. Moreover, both human population and threatened species are growing in numbers.

Here I pursue the hypothesis that human population density alone is a key factor in threats of extinction to other animals. This is not to say that it is the only factor, for indeed human behavior and a host of other factors are important as well. But population density appears to be at the core of the matter. I further argue that without ending human population growth, the mass extinction we are experiencing will accelerate, despite the most noble conservation efforts. I conclude that all conservation strategies in which biologists and planners engage must continue, but that they should integrate the realities of the effects of human population density and growth.

MASS EXTINCTION IN PERSPECTIVE

The fossil record has revealed five mass extinctions in the past, including the one 65 million years ago in which most of the dinosaurs met their demise. With such knowledge from the fossil record, extinction rates can be gauged paleontologically. For example, in southern Africa, prior to 1.8 million years ago when the mammalian biodiversity deficit began, every 100,000 years would see the extinction of four large mammals, balanced out by the evolutionary origin of four large mammals (McKee 1995, 2001, 2003). But in the past 10,000 years alone, southern Africa has seen the extinction of at least sixteen mammal species, nine of which have gone extinct in historic times (Klein 2000). As this is typical of other places and time frames since the origins of humans and their ancestors, such an extinction rate increase warrants the claim of a sixth mass extinction in the world today.

Despite the African extinctions, Africa is often referred to as the "living Pleistocene" because large mammals such as elephant and rhino have persisted into the present, while their counterparts have gone extinct on other continents, largely at the hands of humans. One explanation for this persistence of African megafauna comes from our knowledge of hominin origins in Africa. Our prehuman ancestors there gradually moved into a hunting niche, so the likes of elephants, hippos, and rhinos had more time to adapt to the new predators. Elsewhere the arrival of skilled human (and prehuman) hunters had a more immediate and devastating effect.

On this basis it could be argued that once humans have had their initial impact, animals might adapt and survive alongside our growing human populations. But there are problems with this argument, for indeed there remain many threatened species, even in Africa. Although the rate of human population growth is steadily declining, our overall numbers are

still growing exponentially as the number of threatened species continues to climb. So we must look at both extinction rates and extinction threats as our population grows.

Extinction rates during historic times are difficult to gauge. Only a thousand or so species have been *recorded* as having gone extinct since 1600. Indeed, no good correlation has been found between known extinctions and human population densities (Luck 2007). But as wildlife populations dwindle in the wake of our expansion, one can infer that biodiversity is being diminished at genetic levels. As Darwin presciently noted, "rarity precedes extinction; and we know that this been the progress of events with those animals which have been exterminated, either locally or wholly, through man's agency" (1859, 319–320). So whereas we might not see species extinctions per se, we can measure with a wide gauge the effects of human population density on nonhuman species by looking at species *threatened* with extinction.

THREATENED SPECIES AND HUMAN POPULATION DENSITY

We must look at threatened species together with elements of the human enterprise, particularly human population density and growth. Taking a broad view of current ecological trends, McKee et al. (2004) analyzed data on threatened species per nation, comprising critically endangered, endangered, and vulnerable species of mammals and birds from the International Union for Conservation of Nature (IUCN) Red List (based on threats in 2000). Data from continental nations, excluding exceptionally small nations, were also compiled on human population densities and "species richness"—defined for the analyses as the number of known mammal and bird species per unit area. Using a stepwise multiple regression analysis, a mathematical model was discovered that explained 88 percent of the variability in current threats to mammal and bird species per country on the basis of just two variables: human population density and species richness. Clearly "species richness" is not the root cause of the threats—these diverse ecosystems persisted through climatic changes and ecosystem shifts over many thousands of years. That leaves the other variable in the equation, human population density, as the likely causal factor leading to global increases in threatened species. It appears that the greater concentration of species set the conditions for the human population impact to be more intense.

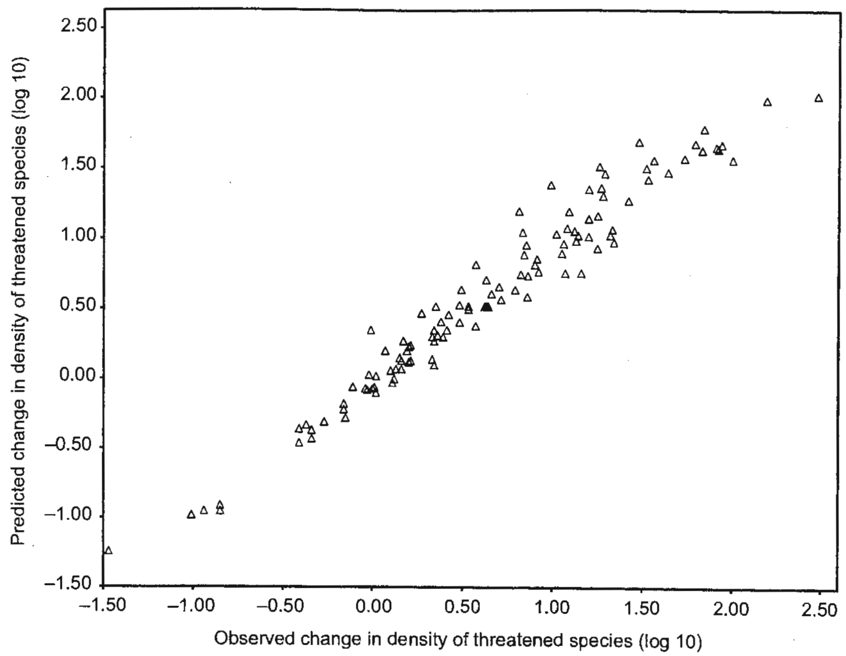

Figure 7.1
Correlation between predicted and observed changes in the density of threatened species per nation between 2000 and 2010

Has the trend continued? Predictions of extinction threats for mammal and bird species in 2010, on the basis of projections from the 2000 model, were strongly correlated with the observed data, with the model predicting 83.8 percent of species threat levels (McKee, Chambers, and Guseman forthcoming). On the other hand, this was somewhat expected, given the time span of just one decade, so it was worth looking at how *change* over the decade might relate to our observations. There we found that the model's predicted change in densities of threatened species had a 95.6 percent correlation with observed changes in human population density alone (figure 7.1).

In order to test how much of the change over one decade was attributable to human population growth as opposed to other potential factors, we used a stepwise multiple regression to find the most statistically significant variables accounting for the changes in species threat levels. Human population density change was the most statistically significant variable entered by the analysis, accounting for 96.4 percent of the change

(McKee, Chambers, and Guseman forthcoming). Gross national product (GNP) was the only other variable adding any explanatory power to the residual variation in levels of threatened species. Other variables, including agricultural land use and species richness, were not as strongly correlated with the changes in densities of threatened species and added nothing to the model. In other words, once one accounts for population density and GNP, other variables just become statistical noise.

ADDRESSING THE ISSUES FOR THE FUTURE

Human population growth and the environmental dominance that has characterized the human enterprise set in motion a global mass extinction that is now accelerating due to continued human population growth. Whereas we can document past extinctions and current threats of species extinctions, this measure is not the sole indicator of a compromised ecosystem. There is also a significant depletion of genetic biodiversity, which puts species at an even greater risk of extinction, as adaptability and evolvability are compromised. At the other end of the spectrum, ecosystem diversity is also jeopardized by human population growth. This comes from both ecosystem collapse as well as homogenization of habitats due to invasive species, thereby compounding threats to sustainability even further.

It is odd that many environmentalists have been reluctant to address human overpopulation as an important issue, as it is at the core of understanding what is happening to biodiversity. Any cogent conservation strategy must include an agenda to curb population growth, lest it be doomed to ultimate failure. Why are we willing to cull elephants in South Africa to protect the environment but are not willing to even open a dialogue on the conservation imperative of curbing human population growth?

This is not to say that common conservation strategies cannot be effective. There are a number of countries, such as Kenya, that have achieved success, with declining numbers of threatened species despite continued population growth. These countries can temporarily buck the trends relating biodiversity loss to increased population density by implementing sound and scientifically based conservation strategies. But there is always a potential reversal of fortunes if human population growth continues to mount further pressure. And many countries do not have the economic incentive of countries like Kenya, where ecotourism is important, to do all they can for the species that inhabit their lands.

All else being equal, the future looks bleak for wild animals, plants, and ecosystems if we do nothing about human population growth. Using population projections with the 2010 model, the average nation with a growing population can expect a 3.3 percent increase in the number of threatened mammals and birds by 2020, based on population growth alone, and a 10.8 percent increase by 2050, when it is projected that global population will exceed nine billion people (McKee, Chambers, and Guseman forthcoming). Amelioration of population threats to some species by 2050 in the twenty-one countries with projected *declining* human populations are predicted to be more modest, with an average reduction in threats of 2.5 percent; in those nations, that amounts to a maximum of four fewer threatened species and a mean of only about one fewer per nation.

However, there are opportunities to combine conservation strategies with knowledge of human population dynamics. The nation-by-nation data show that of the twelve countries with declining human populations from 2000 to 2010, nine had a concomitant reduction in the number of threatened animal and bird species. This does not appear to be a mere correlation, suggesting yet again both the validity of the human population/biodiversity connection and the potential for a novel conservation strategy. Nations and areas with shrinking populations could be targeted for wildland reclamation and proactive introduction and restoration of native species, besides the ones that are making a comeback on their own.

Our population footprint has become increasingly evident and must be urgently addressed. In his classic essay on the "tragedy of the commons," Garrett Hardin (1968) stated that "a finite world must have a finite population." It is up to our generation to define "finite population" and to do something about it. Nine billion people in 2050 would go far beyond what is sustainable for Earth's ecosystems. If we are to stave off further losses in the first mass extinction to be induced by a single sentient species, then swiftly stabilizing and humanely reducing our oversized population will have to become integral to conservation strategies.

BIBLIOGRAPHY

Barnosky, Anthony, Nicholas Matzke, Susumu Tomiya, Guinevere Wogan, Brian Swartz, Tiago Quental, Charles Marshall, Jenny McGuire, Emily Lindsey, Kaitlin Maguire, Ben Mersey, and Elizabeth Ferrer. 2011. "Has the Earth's Sixth Mass Extinction Already Arrived?" *Nature* 471 (March): 51–57.

Darwin, Charles. 1859. *On the Origin of Species by Means of Natural Selection.* London: John Murray.

Hardin, Garrett. 1968. "The Tragedy of the Commons." *Science* 162 (3859): 1243–1248.

International Union for Conservation of Nature (IUCN). 2010. *The IUCN Red List of Threatened Species.* Accessed from www.iucnredlist.org/about/summary-statistics.

Klein, Richard. 2000. "Human Evolution and Large Mammal Extinctions." In *Antelopes, Deer, and Relatives, Present and Future: Fossil Record, Behavioral Ecology, Systematics, and Conservation*, edited by Elisabeth Vrba and George Schaller. New Haven, Conn.: Yale University Press. 128–139.

Luck, Gary. 2007. "A Review of the Relationships between Human Population Density and Biodiversity." *Biological Reviews* 82: 607–645.

McKee, Jeffrey. 1995. "Turnover Patterns and Species Longevity of Large Mammals from the Late Pliocene and Pleistocene of Southern Africa: A Comparison of Simulated and Empirical Data." *Journal of Theoretical Biology* 172 (2): 141–147.

———. 2001. "Faunal Turnover Rates and Mammalian Biodiversity of the Late Pliocene and Pleistocene of Eastern Africa." *Paleobiology* 27 (3): 500–511.

———. 2003. *Sparing Nature: The Conflict between Human Population Growth and Earth's Biodiversity.* New Brunswick, N.J.: Rutgers University Press.

McKee, Jeffrey, Erica Chambers, and Julie Guseman. Forthcoming. "Human Population Density and Growth Validated as Extinction Threats to Mammal and Bird Species."

McKee, Jeffrey, Paul Sciulli, David Fooce, and Thomas Waite. 2004. "Forecasting Global Biodiversity Threats Associated with Human Population Growth." *Biological Conservation* 115: 161–164.