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The Sixth Extinction

Niles Eldredge

An ActionBioscience.org original article

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article highlights

Can we stop the devastation of our planet and save our own species? We are in a biodiversity crisis — the fastest mass extinction in Earth's history, largely due to:

- human destruction of ecosystems
- overexploitation of species and natural resources
- human overpopulation
- the spread of agriculture
- pollution

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About 30,000 species go extinct annually.

There is little doubt left in the minds of professional biologists that Earth is currently faced with a mounting loss of species that threatens to rival the five great mass extinctions of the geological past. As long ago as 1993, Harvard biologist E.O. Wilson estimated that Earth is currently losing something on the order of 30,000 species per year — which breaks down to the even more daunting statistic of some three species per hour. Some biologists have begun to feel that this biodiversity crisis — this "Sixth Extinction" — is even more severe, and more imminent, than Wilson had supposed.



Tyrannosaurus rex skull and upper vertebral column, a victim of the fifth major extinction. Palais de la Découverte, Paris, photo by David Monniaux.

Extinction in the past

The major global biotic turnovers were all caused by physical events that lay outside the normal climatic and other physical disturbances which species, and entire ecosystems, experience and survive. What caused them?

The previous mass extinctions were due to natural causes.

- **First major extinction (c. 440 mya):** Climate change (relatively severe and sudden global cooling) seems to have been at work at the first of these—the end-Ordovician mass extinction that caused such pronounced change in marine life (little or no life existed on land at that time). 25% of families lost (a family may consist of a few to thousands of species).
- **Second major extinction (c. 370 mya):** The next such event, near the end of the Devonian Period, may or may not have been the result of global climate change. 19% of families lost.
- **Third major Extinction (c. 245 mya):** Scenarios explaining what happened at the greatest mass extinction event of them all (so far, at least!) at the end of the Permian Period have been complex amalgams of climate change perhaps rooted in plate tectonics movements. Very recently, however, evidence suggests that a bolide impact similar to the end-Cretaceous event may have been the cause. 54% of families lost.

- **Fourth major extinction (c. 210 mya):** The event at the end of the Triassic Period, shortly after dinosaurs and mammals had first evolved, also remains difficult to pin down in terms of precise causes. 23% of families lost.
- **Fifth major extinction (c. 65 mya):** Most famous, perhaps, was the most recent of these events at the end-Cretaceous. It wiped out the remaining terrestrial dinosaurs and marine ammonites, as well as many other species across the phylogenetic spectrum, in all habitats sampled from the fossil record. Consensus has emerged in the past decade that this event was caused by one (possibly multiple) collisions between Earth and an extraterrestrial bolide (probably cometary). Some geologists, however, point to the great volcanic event that produced the Deccan traps of India as part of the chain of physical events that disrupted ecosystems so severely that many species on land and sea rapidly succumbed to extinction. 17% of families lost.

How is the Sixth Extinction different from previous events?

At first glance, the physically caused extinction events of the past might seem to have little or nothing to tell us about the current Sixth Extinction, which is a patently human-caused event. For there is little doubt that humans are the direct cause of ecosystem stress and species destruction in the modern world through such activities as:

- transformation of the landscape
- overexploitation of species
- pollution
- the introduction of alien species

And because *Homo sapiens* is clearly a species of animal (however behaviorally and ecologically peculiar an animal), the Sixth Extinction would seem to be the first recorded global extinction event that has a biotic, rather than a physical, cause.

Yet, upon further reflection, human impact on the planet is a direct analogue of the Cretaceous cometary collision. Sixty-five million years ago that extraterrestrial impact — through its sheer explosive power, followed immediately by its injections of so much debris into the upper reaches of the atmosphere that global temperatures plummeted and, most critically, photosynthesis was severely inhibited — wreaked havoc on the living systems of Earth. That is precisely what human beings are doing to the planet right now: humans are causing vast physical changes on the planet.

What is the Sixth Extinction?

We can divide the Sixth Extinction into two discrete phases:

- Phase One began when the first modern humans began to disperse to different parts of the world about 100,000 years ago.
- Phase Two began about 10,000 years ago when humans turned to agriculture.

The first phase began shortly after *Homo sapiens* evolved in Africa and the anatomically modern humans began migrating out of Africa and spreading throughout the world. Humans reached the middle east 90,000 years ago. They were in Europe starting around 40,000 years ago. Neanderthals, who had long lived in Europe, survived our arrival for less than 10,000 years, but then abruptly disappeared — victims, according to many paleoanthropologists, of our arrival through outright warfare or the more subtle, though potentially no less devastating effects, of being on the losing side of ecological competition.

Everywhere, shortly after modern humans arrived, many (especially, though by

The current mass extinction is caused by humans.

We are bringing about massive changes in the environment.

Humans began disrupting the environment as soon as they appeared on Earth.

no means exclusively, the larger) native species typically became extinct. Humans were like bulls in a China shop:

- They disrupted ecosystems by overhunting game species, which never experienced contact with humans before.
- And perhaps they spread microbial disease-causing organisms as well.

The fossil record attests to human destruction of ecosystems:

Wherever early humans migrated, other species became extinct.

- Humans arrived in large numbers in North America roughly 12,500 years ago-and sites revealing the butchering of mammoths, mastodons and extinct buffalo are well documented throughout the continent. The demise of the bulk of the La Brea tar pit Pleistocene fauna coincided with our arrival.
- The Caribbean lost several of its larger species when humans arrived some 8000 years ago.
- Extinction struck elements of the Australian megafauna much earlier-when humans arrived some 40,000 years ago. Madagascar-something of an anomaly, as humans only arrived there two thousand years ago-also fits the pattern well: the larger species (elephant birds, a species of hippo, plus larger lemurs) rapidly disappeared soon after humans arrived.

Indeed only in places where earlier hominid species had lived (Africa, of course, but also most of Europe and Asia) did the fauna, already adapted to hominid presence, survive the first wave of the Sixth Extinction pretty much intact. The rest of the world's species, which had never before encountered hominids in their local ecosystems, were as naively unwary as all but the most recently arrived species (such as Vermilion Flycatchers) of the Galapagos Islands remain to this day.

Why does the Sixth Extinction continue?

The invention of agriculture accelerated the pace of the Sixth Extinction.

Phase two of the Sixth Extinction began around 10,000 years ago with the invention of agriculture-perhaps first in the Natufian culture of the Middle East. Agriculture appears to have been invented several different times in various different places, and has, in the intervening years, spread around the entire globe.

Agriculture represents the single most profound ecological change in the entire 3.5 billion-year history of life. With its invention:

- humans did not have to interact with other species for survival, and so could manipulate other species for their own use
- humans did not have to adhere to the ecosystem's carrying capacity, and so could overpopulate

Humans do not live with nature but outside it.

Homo sapiens became the first species to stop living inside local ecosystems. All other species, including our ancestral hominid ancestors, all pre-agricultural humans, and remnant hunter-gatherer societies still extant exist as semi-isolated populations playing specific roles (i.e., have "niches") in local ecosystems. This is not so with post-agricultural revolution humans, who in effect have stepped outside local ecosystems. Indeed, to develop agriculture is essentially to declare war on ecosystems - converting land to produce one or two food crops, with all other native plant species all now classified as unwanted "weeds" — and all but a few domesticated species of animals now considered as pests.

The total number of organisms within a species is limited by many factors-most crucial of which is the "carrying capacity" of the local ecosystem: given the energetic needs and energy-procuring adaptations of a given species, there are only so many squirrels, oak trees and hawks that can inhabit a given stretch of habitat. Agriculture had the effect of removing the natural local-ecosystem upper limit of the size of human populations. Though crops still fail regularly, and famine and disease still stalk the land, there is no doubt that agriculture in the

main has had an enormous impact on human population size:

Earth can't sustain the trend in human population growth. It is reaching its limit in carrying capacity.

- Estimates vary, but range between 1 and 10 million people on earth 10,000 years ago.
- There are now over 6 billion people.
- The numbers continue to increase logarithmically — so that there will be 8 billion by 2020.
- There is presumably an upper limit to the carrying capacity of humans on earth — of the numbers that agriculture can support — and that number is usually estimated at between 13-15 billion, though some people think the ultimate numbers might be much higher.

This explosion of human population, especially in the post-Industrial Revolution years of the past two centuries, coupled with the unequal distribution and consumption of wealth on the planet, is the underlying cause of the Sixth Extinction. There is a vicious cycle:

Overpopulation, invasive species, and overexploitation are fueling the extinction.

- More lands are cleared and more efficient production techniques (most recently engendered largely through genetic engineering) to feed the growing number of humans — and in response, the human population continues to expand.
- Higher fossil energy use is helping agriculture spread, further modifying the environment.
- Humans continue to fish (12 of the 13 major fisheries on the planet are now considered severely depleted) and harvest timber for building materials and just plain fuel, pollution, and soil erosion from agriculture creates dead zones in fisheries (as in the Gulf of Mexico)
- While the human Diaspora has meant the spread, as well, of alien species that more often than not thrive at the detriment of native species. For example, invasive species have contributed to 42% of all threatened and endangered species in the U.S.

Can conservation measures stop the Sixth Extinction?

Only 10% of the world's species survived the third mass extinction. Will any survive this one?

The world's ecosystems have been plunged into chaos, with some conservation biologists thinking that no system, not even the vast oceans, remains untouched by human presence. Conservation measures, sustainable development, and, ultimately, stabilization of human population numbers and consumption patterns seem to offer some hope that the Sixth Extinction will not develop to the extent of the third global extinction, some 245 mya, when 90% of the world's species were lost.

Though it is true that life, so incredibly resilient, has always recovered (though after long lags) after major extinction spasms, it is only after whatever has caused the extinction event has dissipated. That cause, in the case of the Sixth Extinction, is ourselves — *Homo sapiens*. This means we can continue on the path to our own extinction, or, preferably, we modify our behavior toward the global ecosystem of which we are still very much a part. The latter must happen before the Sixth Extinction can be declared over, and life can once again rebound.

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learnmore links

Consequences of the Sixth Extinction

The article "How Will Sixth Extinction Affect Evolution of Species?," on our site, describes how the current loss of biodiversity will affect evolution in the long run.

http://www.actionbioscience.org/newfrontiers/myers_knoll.html

BioScience Article

"Global Conservation of Biodiversity and Ecosystem Services."

Habitat destruction has driven much of the current biodiversity extinction crisis, and it compromises the essential benefits, or ecosystem services that humans derive from functioning ecosystems.

Securing both species and ecosystem services might be accomplished with common solutions. Yet it is unknown whether these two major conservation objectives coincide broadly enough worldwide to enable global strategies for both goals to gain synergy. In this November 2007, *BioScience* article, Will Turner and his colleagues assess the concordance between these two objectives, explore how the concordance varies across different regions, and examine the global potential for safeguarding biodiversity and ecosystem services simultaneously. Read the abstract, or log in to purchase the full article.

<http://caliber.ucpress.net/doi/abs/10.1641/B571009>

Biodiversity in the next millennium

American Museum of Natural History's nationwide survey (undated) "reveals biodiversity crisis — the fastest mass extinction in Earth's history."

<http://cbc.amnh.org/crisis/mncntnt.html>

National Geographic

A 2/99 article about the Sixth Extinction, with views from several leading scientists.

<http://www.nationalgeographic.com/ngm/9902/fngm/index.html>

Extinction through time

Find out about cycles of life and death and extinction patterns through time.

<http://www.carleton.ca/Museum/extinction/tablecont.html>

Is Humanity Suicidal?

Edward O. Wilson asks us why we stay on the course to our own self-destruction (5/93).

<http://www.well.com/user/davidu/suicidal.html>

A Field Guide to the Sixth Extinction

Niles Eldredge writes in 1999 about a few of the millions of plants and animals that won't make it to the next millennium. The second link takes you to the site's main page, entitled "Mass Extinction Underway — The World Wide Web's most comprehensive source of information on the current mass extinction," which provides links to numerous other resources.

<http://www.well.com/user/davidu/fieldguide.html>

<http://www.well.com/user/davidu/extinction.html>

Global Environment Outlook 3

The United Nations Environment Programme released this major report in May 2002. The report collated the thoughts of more than 1,000 contributors to assess the environmental impact of the last 30 years and outline policy ideas for the next three decades. It concluded that without action, the world may experience severe environmental problems within 30 years. The entire report can be read online or purchased online.

<http://www.unep.org/qeo/qeo3/index.htm>

Test your environmental knowledge

This quiz covers issues that have been discussed in the media. The questions are designed to tell us how much accurate information people are getting from television, newspapers, magazines, and other sources.

<http://www.neefusa.org/resources/roper2001-b.htm>

World Atlas of Biodiversity — interactive map

The United Nations Environment Programme (UNEP) released the first *World Atlas of Biodiversity* in August 2002. This link takes you to their online interactive map that helps you search for data about species/land/water loss, extinction over time, and human global development. Click on the "?" for a help page that explains how to interact with this map.

<http://stort.unep-wcmc.org/imaps/qb2002/book/viewer.htm>

The Sixth Great Extinction: A Status Report

Earth Policy Institute's 2004 update on the status of loss of biodiversity.

<http://www.earth-policy.org/Updates/Update35.htm>

Read a book

- » *The Biodiversity Crisis: Losing What Counts* by The American Museum of Natural History (New Press, 2001).
- » *The Sixth Extinction: Patterns of Life and the Future of Humankind* by Richard Leakey and Roger Lewin (Doubleday and Company, 1996).

getinvolved links

The Nature Conservancy

Select a state from the menu and find out how you can become an environmental volunteer in that state.

<http://www.nature.org/volunteer/>

Information for Action

"This website explains the environmental problems & offers solutions to fix them. There are many valuable resources available" including lobbying info, contacts database, & news updates.

<http://www.informaction.org/>

Harmony

"Harmony Foundation is all about education for the environment. We offer publications and programs... 'Building Sustainable Societies' offers innovative training for educators and community group leaders to support local action on important environmental issues."

<http://www.harmonyfdn.ca>

Earth Talk: Environmental advocacy for professionals

This discussion community and learning network seeks to contribute to global ecological sustainability by enabling communication connections between those working on behalf of forests, water, and climate.

<http://www.ecoearth.info/>

articlereferences

General References:

- » Cohen, J.E. 1995. *How Many People Can the Earth Support?* W.W. Norton, New York.
- » Eldredge, N. 1998. *Life in the Balance. Humanity and the Biodiversity Crisis.* Princeton University Press, Princeton.
- » Wilson, E.O. 1993. *The Diversity of Life.* Harvard University Press, Cambridge.

educatorresources

ActionBioscience.org original lesson

This lesson has been written by a science educator to specifically accompany the above article. It includes article content and extension questions, as well as activity handouts for different grade levels.

Lesson Title: *Extinction: Is It Inevitable?*

Levels: high school - undergraduate

Summary: This lesson explores the cycle of extinction and biotic recovery, with special emphasis on the causes of extinction. Students can chart extinction patterns, research La Brea Tar Pit, debunk dinosaur extinction myths, debate endangered species vs. human water needs... and more!

Download/view lesson. (To open the lesson's PDF file, you need [Adobe Acrobat](#))

[Reader](#) free software.)

Lessons for middle school

The following links will take you to middle school lessons available on other web sites:

- » Dinosaur Detectives Students learn how paleontologists (just like the author, Niles Eldredge) solve dinosaur mysteries.

<http://school.discovery.com/lessonplans/programs/dinosaurdetectives/>

- » Hunting Elephants For Ivory Students debate the ivory wars.

<http://school.discovery.com/lessonplans/programs/ivorywars/>

Useful links for student research

In addition to the links in the "learn more" section above:

- » Klamath Basin Crisis Farmers in the Klamath Basin region of northern California are fighting with environmentalists about the use of water — for irrigation or for the protection of endangered salmon and suckerfish. These sites are useful for students conducting the debate listed in Handout 2 of the ActionBioscience.org lesson "Extinction: Is It Inevitable?"

<http://www.klamathbasincrisis.org/articles/highanddry-Jasper.htm>

- » The World Resources Institute Their biodiversity page has an overview of biological diversity issues and information.

<http://biodiv.wri.org/>

Be sure to also check out their section for information on threats to biodiversity.

http://pubs.wri.org/pubs_content_text.cfm?ContentID=1291

- » Geologic Time Concise explanation of geologic time, relative time, radiometric time, and major divisions of geologic time.

<http://pubs.usgs.gov/gip/geotime/contents.html>

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