Biology and Society

Unit Seven: The Human Impact

Topic Three: Biodiversity

What is the human impact on biodiversity?

How many species are there?

We currently have identified and named approximately 1.5 million species. But even that is only an estimate. There is no catalog or computer data base for the species we have already identified.

This number includes only about 45,000 species of vertebrates of which there are approximately 10,000 species of birds, and 5000 species of mammals. These are the species we know best, but birds and mammals, indeed all vertebrates, represent only a small fraction of named species.

How many species are there that haven't been cataloged?

The estimates for the total number of species range widely from 7 to 30 million species. The most conservative of these estimates is 10 to 12 million. Using 10 million species, it will take scientists, at their current rate, until the year 3000 to identify and name all the species on Earth.

Isn't species extinction natural?

Yes it is. The estimate of the number of species that have lived on Earth and have gone extinct is 99%. Ninety-nine percent of all the species that have ever existed have gone extinct. But that shouldn't surprise you if you think of species as individuals in a population (a very serious proposal by very serious scientists). It is easy to understand that there have been millions upon millions of humans that have lived and died in the past. Current estimates are that 106 billion humans have lived beginning 50,000 years ago. With 6.18 billion alive today that gives 5.7% of all the humans on Earth for the last fifty thousand years are alive now.

The issue is not that species go extinct,
but at what natural rate do they go extinct?

To answer that question we need to know the average lifespan of species.

What is the average lifespan of a species?

— 1 million years —

The long and short of it is that Stuart Pimm took six pages of his book to explain how this number is arrived at, so, in the interest of time, I refer you to his book.

The World According to Pimm: a scientist audits the Earth
by Stuart Pimm (2001)

What then is the natural extinction rate for all species?

— 10 per year for all species —

With an average lifespan of 1 million years that would mean that out of a million species, on average, one would go extinct every year. If there are 10,000 species of birds that means that the natural extinction rate for birds is one species extinct every 100 years or one per century. These numbers assume a stable "population" of species where new species are evolving to replace old ones constantly over time.

The estimate for just birds is one natural bird extinction worldwide every 100 years.

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species / ave. life span = natural extinction rate

10 million species / 1 million years = 10 species extinctions per year

10,000 bird species / 1 million years = 0.01 bird species extinction per year

0.01 x 100 years = 1 bird species extinction per 100 years natural extinction rate

“That’s it.

You are not allowed even one more bird extinction.

Just one more, anywhere in the world within a century, would be cause to accuse humanity of the crime of shortening species’ lifetimes.”

(Pimm, 2001)

How many species have humans already driven to extinction?

Or to put it another way:

What is our “track record” for stewardship of life’s biodiversity?

The Pleistocene Over-kill

In North America 73% of all genera weighing more than 100 pounds went extinct between 12,500 to 11,000 y.a., not long after humans arrived on the continent (Ward, 1997; Flannery, 1999).

Asia and Europe also lost their Pleistocene megafauna, the mammoths are a case in point, but much early than the Americas.

Australia suffered the most severely of all the continents, losing every terrestrial vertebrate species larger than a human," (Flannery, 1999). Most telling is that the Australian extinctions again coincided with the arrival of humans, only this time around 50,000 years ago during a period of climate stability, and at least 30,000 years before humans reached the Americas.

That humans caused these extinctions is not proven. Rather, it is a working hypothesis that so far accounts for all the evidence. But can we prove humans have caused unnatural rates of extinction in the past?

Islands

What is the history of human settlement on islands?

It is estimated that on the Hawaiian islands alone there were 80 to 90 species of birds, now known only from fossils, that went extinct in the thousand years between the arrival of the Polynesians and the arrival of Europeans. In addition it is estimated that:

> "As the Polynesians colonized the Pacific from New Zealand to Hawaii and east to Easter Island they exterminated 1000 to 2000 species of birds." "Using the lower estimate, this comes to 10 percent of the world's bird species. **The extraordinary conclusion is that double-digit human caused extinction percentages are part of Earth's recent history, not merely wild speculations about its future.** These numbers mean that the rate of extinction was, an unnatural, one species every *few years*—not the expected one species per *century*." (Pimm, 2001)

The story is not over.

Since James Cook found the Hawaiian Islands in 1778, eighteen species of birds have gone extinct. That is almost one extinction every decade for the last 200 years.

The message is clear: Bird species are lost at the rate of about one per year. That is about a 100 times faster than the benchmark of one extinction per 100 years among the 10,000 species of birds.

But what of already endangered species?

What if they are added to the total?

What is the current estimate for the rate of human caused species extinction?

— 1000 times the natural rate of extinction —

Stuart Pimm

"The fossil record suggests that most species live 1 million years or more. The DNA evidence provides confirmation. So the destined hour for species will be measured in the millions of years. At this rate only 1 species in 1 million or more should encounter its natural end each year.

The unnatural number is already closer to 1 species in 10,000—a number 100 times larger. Looking at the numbers of species that we have already wounded and making a grim assessment of how long they are likely to live, we find that the number is closer to 1 in 1000, which is 1000 times larger than the natural rate. **Humanity's impact has reduced species' lifetime form a metaphorical hour to a minute, and it soon may be a matter of seconds.**

These reductions in species' lifetimes are not only large but ubiquitous. They happen throughout the planet's diverse ecosystems." (2001)

The Future of Biodiversity

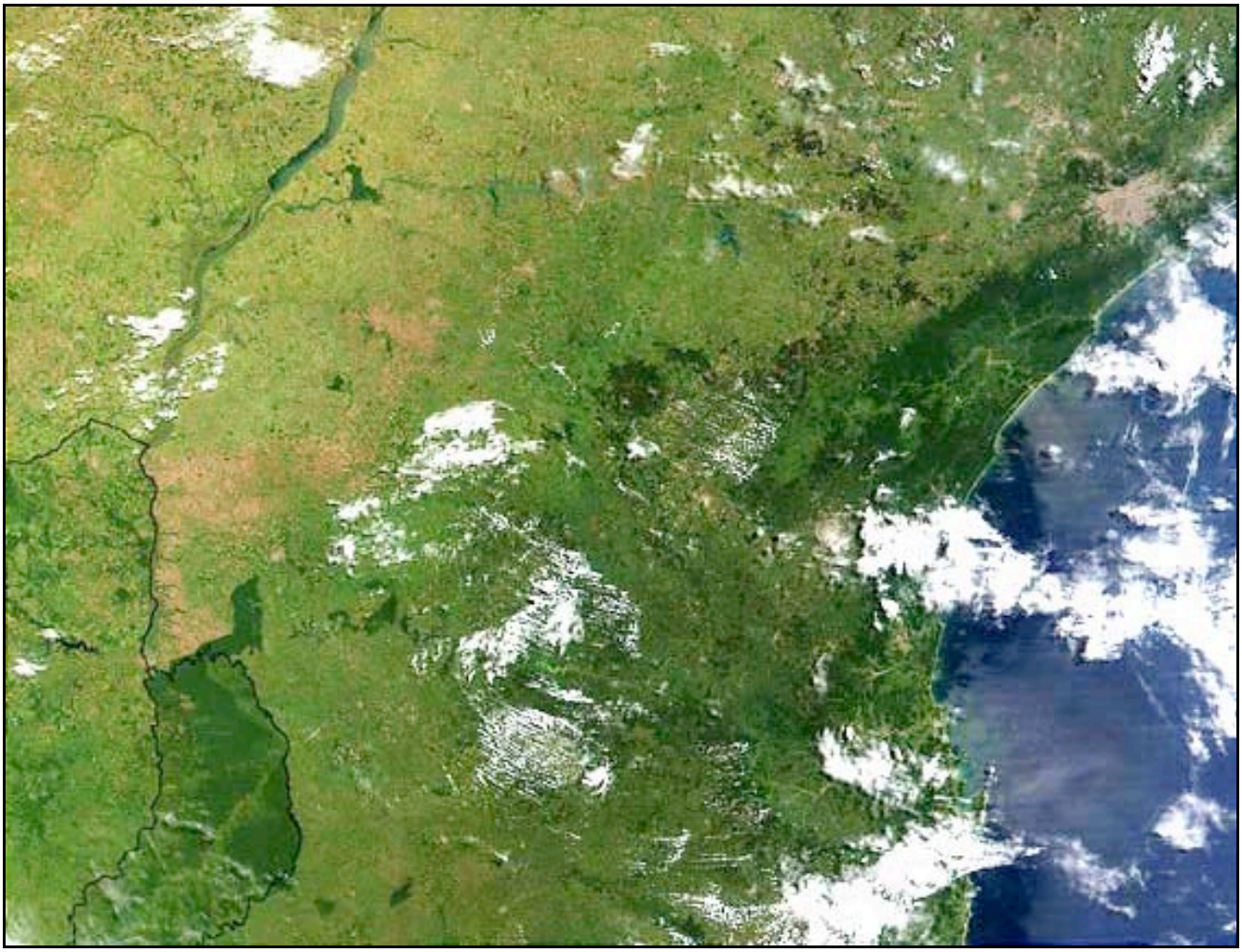
Nature's Eggs in a Few Baskets

Biodiversity Hot Spots:

Areas where endemic species with small ranges are concentrated.

"Not all are in the tropics, but most are. Hot spots can be extraordinarily concentrated; thousands of species may be found within an area the size of a U.S. eastern state. Species with small ranges are particularly vulnerable to impacts. Nature has put her eggs in a small number of baskets, and we are in danger of dropping them. It is estimated that only about 2 million of the original 17 million square kilometers of hot spots remain."

"Most—perhaps two-thirds—of the remaining species, those not found in hot spots, are in tropical moist forests in the Amazon, Congo, and insular Southeast Asia. Ten percent of these forests are being cleared per decade, perhaps more, and certainly the rate is accelerating." (Pimm 2001)



Biodiversity Hot Spots: Brazil's Atlantic Rainforest

The peninsular, northeastern arm of Argentina is home to some of the last remaining remnants of a South American ecosystem known as Atlantic Rainforest, which used to run all along Brazil's coast for thousands of miles. This March 18, 2002 MODIS image of southeastern Brazil shows the Misiones region of Argentina (lower left), where the original Atlantic Forest veered inland from the coast. Portions of the forest can be seen along the coast south of the city of Sao Paulo (brownish patch at the far upper right).

The Brazilian city of Sao Paulo (right of center) is easy to see from satellite perspective. In this MODIS image from May 15, 2002, the grayish cluster of pixels that mark the location of the city stand out starkly from the lush vegetation of the Atlantic coast. Dark green areas along the coast are some of the last remaining stretches of Atlantic Coastal Rainforest, and even these last stands are under pressure from logging and seashore development.

Distinct from the Amazon Rainforest, the forests have some of the highest rates of biodiversity and endemic species (species found only in a particular location) known in the world despite the fact that, by most estimates, the Atlantic Coastal Rainforest covers only 5-8% of its original extent. The forest and many, though not all, of the plants and animals it contains remained distinct from the Amazon Rainforest farther north because they were separated by the Cerrado, a drier area of tropical savanna and grassland on Brazil's central plateau.

Biodiversity Hot Spots: The Florida Everglades

For more on the Florida Everglades go to:
http://fire.biol.wwu.edu/trent/alles/Everglades.pdf

The Causes of Species Extinction

What are the human activities that cause species extinctions?

Drivers of Change

Population size and per capita consumption are assumed to be the two greatest drivers of global environmental change. Humans currently appropriate ~ 40% of the production of terrestrial ecosystems and ~ 60% of usable freshwaters, have doubled terrestrial nitrogen supply and phosphorus liberation, have manufactured and released globally significant quantities of pesticides, and have initiated a major extinction event.

Global population, which increased 3.7-fold during the 20th century, to 6 billion people, is forecast to increase to 7.5 billion by the year 2020 and to about 9 billion by 2050.

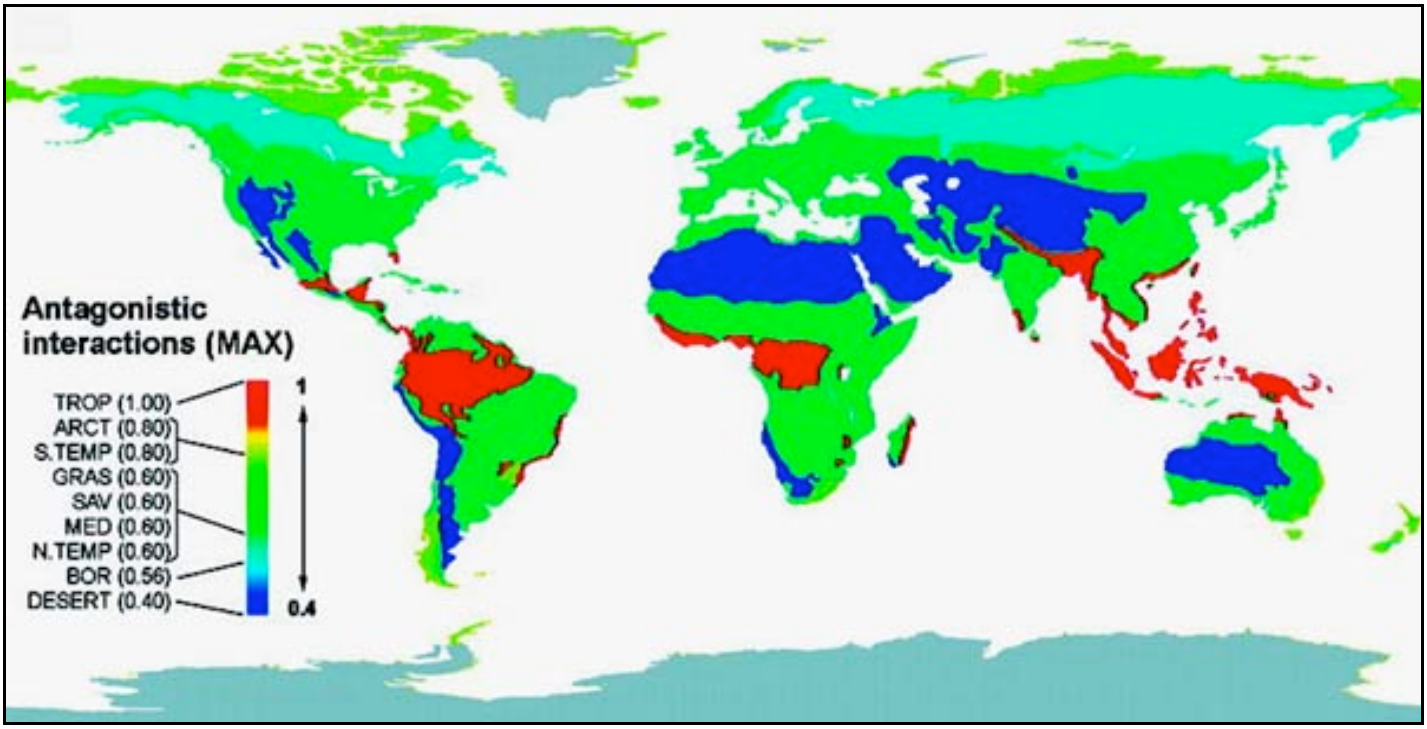
Constant-dollar global per capita gross domestic product (GDP) increased 4.6-fold in the 20th century and is projected to be 1.3 times current levels by 2020 and 2.4 times current levels by 2050.

Global Biodiversity Scenarios for the Year 2100

by Sala, O. E., et al. (2000)

"Scenarios of changes in biodiversity for the year 2100 can now be developed based on scenarios of changes in atmospheric carbon dioxide, climate, vegetation, and land use and the known sensitivity of biodiversity to these changes. This study identified a ranking of the importance of drivers of change, a ranking of the biomes with respect to expected changes, and the major sources of uncertainties.

For terrestrial ecosystems, **land-use change probably will have the largest effect**, followed by climate change, nitrogen deposition, biotic exchange, and elevated carbon dioxide concentration."



Areas in red are projected to suffer the greatest impacts caused by land-use changes.

Forecasting Agriculturally Driven Global Environmental Change

by Tilman, D. et al. *(*2001)

"During the next 50 years, which is likely to be the final period of rapid agricultural expansion, **demand for food** by a wealthier and 50% larger global population will be a major driver of global environmental change."

"If the past links between the global environmental impacts of agriculture and human population and consumption continue:

• one billion hectares of natural ecosystems would be converted to agriculture by 2050. This is an area larger than the continental U.S..

• This would be accompanied by 2.4 to 2.7-fold increases in nitrogen- and phosphorus-driven eutrophication of terrestrial, freshwater, and near-shore marine ecosystems, and comparable increases in pesticide use.

• This eutrophication and habitat destruction would cause unprecedented ecosystem simplification, loss of ecosystem services, and species extinctions.

• The efforts required to meet the demands for food of an additional 3 billion people in the next 50 years will be immense even if little or no effort is made to preserve biodiversity.

The Future of Biodiversity

The Bottom Line

Adding the species endangered in hot spots to those endanger in tropical moist forests, **we could lose between 1/3 and 1/2 of all species** within the next hundred years.

References

Flannery, T. F. (1999). Debating Extinction. *Science*, 283(Jan 8), 182-183.

Flannery, T. (2001). *The Eternal Frontier An Ecological History of North America and Its Peoples*. New York: Atlantic Monthly Press.

Pimm, S. L. (2001). *The World According to Pimm*. New York: McGraw-Hill.

Sala, O. E., et al. (2000). Global Biodiversity Scenarios for the Year 2100. *Science*, 287(10 March 2000), 1770-1774.

Tilman, D. et al. (2001). Forecasting Agriculturally Driven Global Environmental Change *Science*, 292(April 13), 281-284.

Ward, P. D. (1997). *The Call of Distant Mammoths*. New York: Copernicus.

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