

PART I: OUR CONVERGING CRISES

Pollution

In nature, waste from one organism is food for another. However, that principle sometimes breaks down and waste becomes poison. For example, about 2.5 billion years ago cyanobacteria began to proliferate; because they performed photosynthesis, they gave off oxygen—far more of it than could be absorbed by the environment. This huge, rapid influx of oxygen was toxic to anaerobic organisms, and the result was a mass extinction event. So, humans aren't the only possible sources of environmental pollution.

But these days the vast majority of pollution *does* come from human activities. That's because we humans are able to use energy and tools to extract, transform, use, and discard ever-larger quantities of natural resources, producing wastes of many kinds and in ever-larger quantities.

Humans were already causing pollution in pre-industrial times—for example, when mining tin or lead, or when tanning leather near streams or rivers. Today, however, with much higher population levels, and with much higher per capita rates of extracting and using resources, examples of environmental pollution are far more extensive, serious, and numerous.

Fertilizer runoff from modern farming creates dead zones thousands of square miles in extent around the mouths of rivers. **Plastic particles** in the Pacific Ocean have formed giant floating gyres, and it's been projected that by 2050 the amount of plastic in the oceans will outweigh all the remaining fish. **Air pollution from burning coal** in China is so bad that it causes nearly 5,000 deaths per year. Millions more face shortened lives. And the haze from all that coal combustion sometimes drifts as far as the West Coast of the United States.

Soil in areas around the melted-down nuclear reactors in Fukushima in Japan, and Chernobyl in Ukraine will be radioactive for centuries or millennia.

But by far the most serious example of pollution in the world today is **climate change**, caused by human-produced greenhouse gases. While other pollution may compromise the viability of local ecosystems, climate change threatens the entire global ecosystem.

The main greenhouse gases and their primary sources are: One, **carbon dioxide**, released from fossil fuel combustion; two, **methane**, released by farm animals and by the natural gas industry (natural gas is basically methane); and three, **nitrous oxide**, released by agriculture and fossil fuel combustion.

We contribute to climate change when we burn coal or natural gas for electricity, or oil for transportation--releasing carbon dioxide and nitrous oxide. The cattle we raise for food emit methane. Industrial agriculture and timber harvesting release carbon stored in soils and vegetation into the atmosphere as carbon dioxide.

At the dawn of the industrial age, the carbon dioxide content of the atmosphere was 280 parts per million. Today it's over 400 parts per million and rising fast.¹ Greenhouse gases trap heat in the atmosphere, causing the overall temperature of Earth's surface to rise. It's risen by over one degree Celsius so far. It's projected to rise as much as five degrees more by the end of this century.

Now, a few degrees may not sound like much. And in the middle of winter it might even sound comfortable. But the planet's climate is a highly complex system. Even slight changes in global temperatures can create a ripple effect in sea levels, weather patterns, and the viability of species that have evolved to survive in particular conditions.

Moreover, climate change doesn't imply a geographically consistent, gradual increase in temperatures. Different places are being affected in

¹ NOAA: <http://www.esrl.noaa.gov/gmd/ccgg/trends/data.html>; CDIAC: <http://cdiac.ornl.gov/trends/co2/lawdome-data.html>

different ways. The American southwest will likely be afflicted by longer and more severe droughts. At the same time, a hotter atmosphere holds more water, leading to far more severe storms and floods in other places. Melting glaciers are causing sea levels to rise, leading to storm surges that can inundate coastal cities, placing hundreds of millions of people at risk.

Since the 1990s the United Nations has sought to rally the world's nations to reduce greenhouse gas emissions. After 21 years of international meetings and failed negotiations, 196 nations finally agreed in December 2015 on a collective goal of limiting temperature increase above pre-industrial levels to 2 degrees Celsius—which is 3.6 degrees Fahrenheit—with the ideal being 1.5 degrees or less. But actual emissions have so far not been capped.

Some of the difficulty in reaching consensus on action comes from the fact that most historic emissions have come from the world's wealthy and politically powerful nations, which continue burning fossil fuels at high rates, while many poorer nations, which have less historic responsibility, are rapidly increasing their fossil fuel consumption in order to industrialize.² Some of the very poorest nations are also the ones most vulnerable to climate change. All of this makes it hard to agree who should reduce consumption and how fast.

There are many areas of uncertainty in climate science, even though the basic mechanism of global warming is clear. So far, actual ecosystem impacts have come faster than scientists have forecast, but we don't know whether future impacts will adhere more closely to the experts' models or continue to accelerate. Also there are uncertainties about how to best account for and assign responsibility for greenhouse gas emissions. For example, if China burns coal to produce goods for American shoppers, should the resulting emissions be credited to China or the United States?

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<http://www.globalcarbonatlas.org/?q=en/emissions>

There is controversy as well about how we might capture carbon from the atmosphere and sequester it for a long time. As the threats of the climate crisis become increasingly clear, our remaining “carbon budget” shrinks. More and more attention is being paid to what are called **negative emissions technologies**. But many of these technologies—with the exception of natural ways to sequester carbon in soils and trees—are theoretical, unproven, or unscalable.

Altogether, climate change poses a series of enormous challenges, including:

- How can we rapidly reduce the use of fossil fuels without risking unacceptable economic contraction?
- How can we reduce the use of fossil fuels **fairly**?
- How can we protect nations and communities that are most vulnerable to climate change?
- How can we take carbon out of the atmosphere and store it so as to reduce the severity of climate change?

The stakes could hardly be higher. Climate change threatens not just our own species, but millions of others as well. If we don't solve this single pollution problem, the fate not just of civilization, but of most of the planet's species may hang in the balance.