

Dirty Birds and Tar Balls

Up until the 1950s, most of our global carbon emissions came from burning coal. You can see this in **Figure 1**, where the solid line represents total carbon emissions, and the short dashed line represents the proportion of those emissions from coal. For about a century, coal was our primary energy source, used to cook, warm homes, and generate electricity. There were few limits or regulations on the ways in which people could burn coal, so much of the coal combustion was poorly managed. This resulted in dirty incomplete combustion, which produced large amounts of chemical compounds besides carbon dioxide and water that were damaging to people, the environment, and the planet.

Sooty Emissions

A major component of the emissions from coal-fired power plants is black carbon, or soot. Starting around 1950, other sources of fossil fuels (especially petroleum and natural gas, long dashed and dotted lines in **Figure 1**) grew in popularity which, while not as dirty as coal, still emit carbon into the atmosphere.

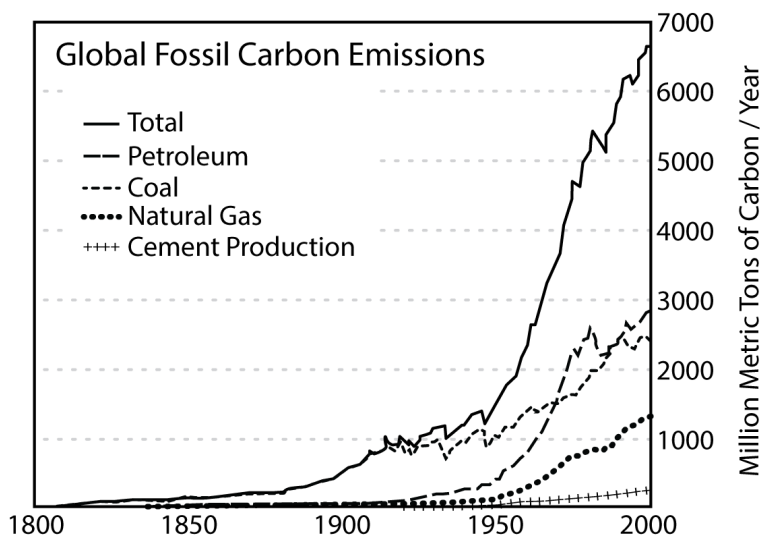


Figure 1. Global Fossil Carbon Emissions. This graph shows the yearly global emissions of different types of fossil fuels from 1800–2000. *Source:* Adapted from [Wikimedia Commons](#).

Today, we have many alternative sources of energy including nuclear, wind, solar, and natural gas. In addition, current coal power plants use technologies that limit the amount of black carbon (and other emissions). But carbon emissions are still a worldwide problem, driving changes in our global climate.

An Unusual Approach to Studying Past Pollution

To understand the impact of emissions today, climate scientists want to understand the impacts of emissions in the past. However, we do not have a good idea of the amount of emissions that occurred back when humans began burning coal as a primary source of energy and heat.

Recently, a group of researchers figured out a way they could use an entire other branch of science—the biological science of ornithology, or the study of birds—to get an estimate of what black carbon emissions were before 1900. They could do this because ornithologists have been collecting samples of dead birds and preserving them in archives called “skin labs.” The skin lab collection is very large and very well organized. Every bird includes a label that describes where it was collected, what year it was collected, and who prepared it for preservation in the skin lab.

Using Proxy Measurements to Estimate the Unobservable

This group of scientists were able to examine old samples of bird feathers and measure the amount of soot present. **Figure 2** shows two Field Sparrows (*Spizella pusilla pusilla*) from an Illinois skin lab. Both birds were collected near Chicago, Illinois. The bottom bird was collected in 1996 and the top bird was collected in 1906. From this, we can estimate the relative amounts of soot emissions at different times.

In this study, the variable of interest (soot emissions) was not directly observed or measured. Instead, the researchers used a variable that could be directly observed to provide an estimate of the unobservable variable. In this study, the scientists measured the **reflectance** (how much light is reflected off a surface) of each bird's feathers on a scale from 0 to 100 with 0 being pure black and 100 being pure white. The reflectance is a **proxy measurement** for soot emissions. Soot emissions darken bird feathers, so if we can measure the reflectance of the bird feathers in 1906 vs. 1996, we can compare the amount of soot that was present in those years as well. They compared the reflectance data to records of fossil fuel emissions and used the results to gain a better understanding of the year-to-year emissions of fossil fuels and the impact on the environment.



Figure 2. Historical and Recent Bird Samples. The top bird sample was collected in 1906 while the bottom bird sample was collected in 1996. The feathers from the 1906 sample are darkened by the presence of soot. *Source:* Adapted from [DuBay, 2017](#).

Reference

Dubay, Shane G., and Carl C. Fuldner. "[Bird Specimens Track 135 Years of Atmospheric Black Carbon and Environmental Policy](#)." *Proceedings of the National Academy of Sciences* 114, no. 43 (September 2017): 11321–26.

BiteScientist Profiles



Benjamin Brown-Steiner studies atmospheric chemistry, climate science, and the impact of emissions that come from fossil fuels, industry, wildfires, and other sources. At home, he performs chemical experiments in the kitchen (a.k.a. he cooks and he bakes!) and he enjoys fermenting weird things. He is also a cloud watcher, a bird watcher, and a science fiction reader.



Shannon Morey teaches physics at Abbott Lawrence Academy in Lawrence, Massachusetts. She is a 2015 Knowles Teacher Initiative Fellow. In her free time she enjoys spinning, cooking, and yarn crafts. She also loves to travel for fun and to learn more about the world. She is pictured here on Isabela Island in the Gálapagos Islands as part of a Knowles Teacher Initiative professional development.