

## Podcast interview: Carl Fuldner and Shane DuBay

**PNAS:** Welcome to Science Sessions. I'm Paul Gabrielsen.

Birds in the 19<sup>th</sup> century, especially in industrial areas, flew through much dirtier skies than we see today. Soot from burning coal was thick in the air around the American Midwestern manufacturing belt. So thick that the feathers on museum specimens of birds from that era are a dusty, smoky gray. Birds from more recent years look clean and vibrant. Carl Fuldner and Shane DuBay are interested in the gray birds, the white birds, and all shades in between. They are graduate students at the University of Chicago, and in a recent PNAS paper they showed that the color of birds' feathers tracks changes over time in the amount of coal being burned and the amount of soot in the air.

Fuldner studies art history. He sought out DuBay, who is an ornithologist, to help him lend context to a photography exhibition. After the two toured DuBay's space at Chicago's Field Museum of Natural History, however, they had a different idea. Fuldner explains.

**Fuldner:** We'd try in some way, in the same way that photographs connect these birds in an obvious way to the landscape, we were interested in if we could make that same connection that seemed to be lost with the natural history specimens.

**PNAS:** Here's DuBay.

**DuBay:** We had a drawer open with birds and I was standing there with Carl and curatorial staff, and we could see discoloration on some birds that were supposed to have white-breasted belly feathers. And just within a drawer, we could see that there was what appeared to be soot or black carbon covering some of these specimens. From looking at a tray, we could visually place birds in place and time. So an example would be - there's a red-headed woodpecker that looks like it's really sooty, one of us would be like "Oh, I bet that's from the first decade of the 1900s," and we'd look at the tag, and it is, and it's from right outside Chicago.

**PNAS:** They photographed more than 1,300 birds from museums in Chicago, Ann Arbor, Michigan, near Detroit, and Pittsburgh, Pennsylvania - three cities that were industrial centers in the early 20<sup>th</sup> century. From about 1920 to today, the amount of light reflected by the birds' feathers closely matches the trends of black carbon or soot emissions estimated in the United States. Before the 1950s, though, black carbon emission measurements are sparse. The birds from that era were much sootier than estimates of black carbon emissions would predict, suggesting that emissions may have been much higher than previously thought.

**Fuldner:** There are some historical landmarks that you would expect to see in a trend like this. So, one of those is the 1929 stock market crash, which sent the entire industrial sector into a depression. That shows up in our graph, that 1929 dip, almost to the precise moment. We noticed that some of the specimens from early in the century, a kind of cluster of them from 1906 or so, were some of the darkest specimens and they all

were reported to be collected from Joliet, Illinois. But then we were basically able to go into newspaper archives and historical records and see that Joliet, Illinois, right after the turn of the century, was the site of a consolidated steel mill that was one of the largest, ah, second-largest in the country at the time. And we have archival photographs that show the mill working and the sky around it sort of blackened with smoke. So that's it, right there, right? So that's where these birds came from.

**PNAS:** Fuldner and DuBay turned to scanning electron microscopy, or SEM, to confirm that black carbon was responsible for the early birds' dirty feathers. DuBay describes the moment those extremely small particles first came into focus.

**DuBay:** The person who was helping us with the SEM, we were just tweaking with the settings, and then all of a sudden the particles came into view and it was this eureka moment where it's like "Wow, this is what we expect and that's what we're looking for." One of the things we're really excited about is that these black carbon particles are the particles that were emitted 100+ years ago. And this provides this valuable resource that practicing atmospheric scientists and climate scientists really did not know existed.

**PNAS:** Fuldner says that it's likely no coincidence that the industrial centers of Chicago, Detroit, and Pittsburgh are the sites today of robust natural history collections.

**Fuldner:** It has to do with the kind of industrial wealth that these cities were producing, and then because of that prosperity that this early industrial expansion was bringing, allowed them to branch into putting investments into creating these natural history collections.

Most of the efforts to address urban smoke began at the city level. And they're the result of pressure by citizen groups, reform groups led by women, from the late 19th century. One of the things that excites us is that in a way we can assess those historical policies and we can see how effective those policies were, or likewise how effective certain technological advancements were in terms of addressing the smoke problem.

**PNAS:** The study reaffirms the value of museum natural history collections.

**Fuldner:** The collectors, the naturalists that collected these specimens, would have never had any conception that the specimens that they collected would have been used in this particular way. So, we hope that with our study we will present a new way of thinking about these collections and that will encourage other researchers to approach the collections in new ways, and we hope that that will be generative of new research questions that people can ask of these collections. And so we hope that people will use them in ways that we haven't even thought of yet.

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