tracking air quality

Article and photography by Roberta Burnes
Division for Air Quality

On a warm, summer day, Johnathan Jernigan prepares to dive into a tall grass meadow in the northwest corner of Mammoth Cave National Park. After applying plenty of sunscreen and tick repellent, strapping on snake gators (to protect against rattlesnake and copperhead bites), and grabbing clipboard and hand lens, Jernigan is ready. His goal? To search for evidence of plant injury caused by air pollution.

As a scientist with the National Park Service Air Resources Division and Cumberland Piedmont Network, Jernigan monitors the health of living systems in Mammoth Cave National Park. This includes native trees and other plants that are particularly sensitive to ground-level ozone pollution.

"It's been a cooler than usual summer," says Jernigan. "Ozone levels haven't been that high, so we may not see much damage."

In Kentucky, ground-level ozone (O_3) is primarily a summertime pollutant. It is created through a photochemical reaction when emissions from vehicles, power plants and other sources "cook" in the warmth of the summer sun. Ozone concentrations generally measure the highest during July and August in Kentucky.

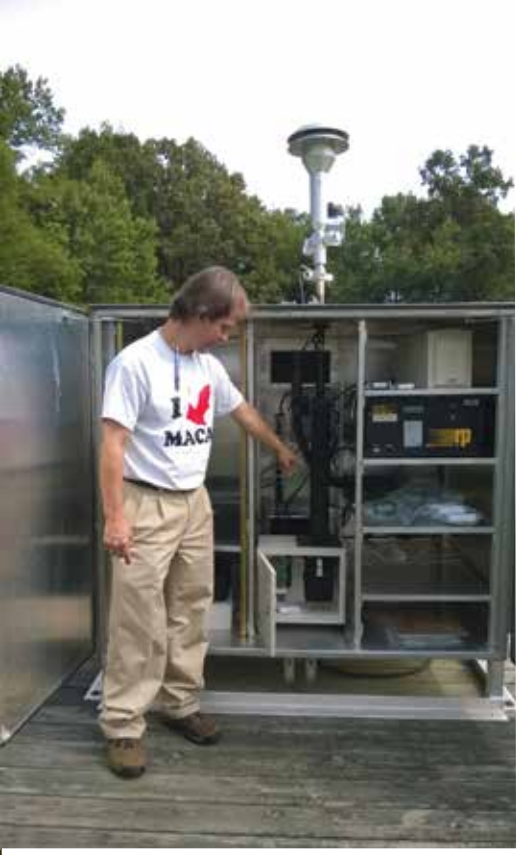
Peering at a milkweed leaf through a hand lens, Jernigan finally sees what he's been looking for—dozens of tiny, dark spots that may indicate the early stages of ozone damage. After recording his findings on his data sheet, Jernigan removes and tags the leaf, then places it in a plant press to preserve it. Specimens like this one will be sent to a lab for confirmation.

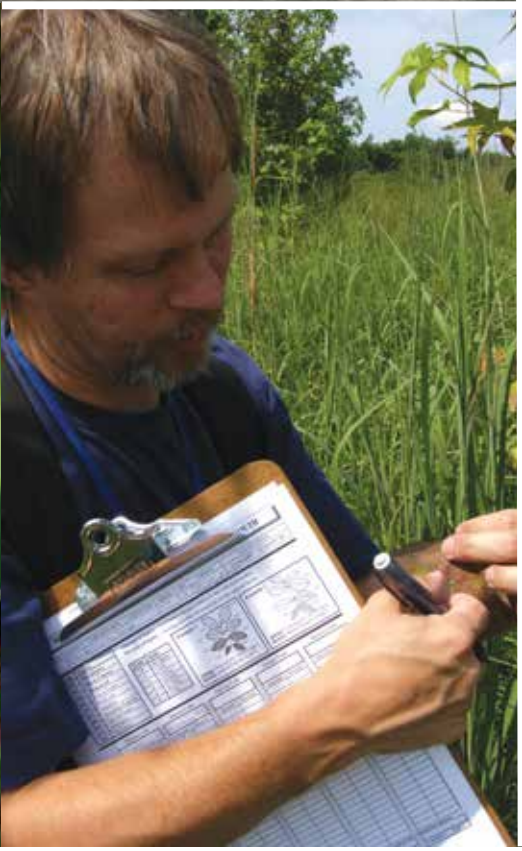
"The results of this survey can help us track the effects of air pollution in the park," says Jernigan.

Good Up High, Bad Nearby

Is ozone good or bad? Both, actually—and it's all about location.

When it is high in the atmosphere in the earth's ozone layer, ozone protects us





Study monitors the effects of ozone on plant life at Mammoth Cave National Park

from the sun's harmful ultraviolet radiation.

But when ozone forms at ground level, the highly reactive ozone molecule creates serious health problems for many living things, including humans. So in a sense, ozone is good when it's up high, but bad when it's nearby.

In humans, ozone damages the cells that line the airways of the lungs. This causes respiratory problems such as coughing and wheezing. People with asthma and other respiratory diseases are especially sensitive to ozone pollution.

Plants also breathe, through tiny openings in the upper leaf surface called *stomata*. When a plant is repeatedly exposed to ozone, the stomata can suffer damage. Early symptoms of ozone leaf injury appear as dark pigmented areas known as *stippling* between the veins, usually on the leaf's upper surface. Severe ozone damage may cause the leaf—and eventually the entire plant—to yellow and die prematurely.

Some plants are more sensitive to ozone than others. In the park, Jernigan searches for sweet gum, tulip poplar, black cherry, milkweed and blackberry—all of which are indicator species for ozone damage. Like the proverbial canary in the coal mine, an indicator species can provide an early warning that something is out of balance in the environment.

The National Park Service has been conducting ozone injury surveys at several of its parks since 2008. Results of the surveys are checked for correlation with measured ozone levels in each park. Generally, you'd expect leaf injury to increase as ozone levels go up—but that isn't always the case.

Take the summer of 2012, for example. Record-breaking temperatures contributed to unusually high ozone levels across Kentucky and much of the southeast. Yet, Jernigan's surveys revealed no confirmed ozone injury on plants at Mammoth Cave.

Continued on Page 12

OPPOSITE PAGE: ***Monarch on milkweed.*** **CLOCKWISE** ***(from top left): Johnathan Jernigan stands beside a DAQ continuous particulate matter (PM) monitor; small filters used by the monitor to measure PM; ozone injury to a milkweed leaf (***photo by National Park Service***); Jernigan examines a sweet gum leaf looking for signs of ozone damage.***

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Continued from Page 10

FAR LEFT and LEFT: Milkweed leaves that were collected and tagged will be studied at a laboratory. Bobby Carson shows off several of the park's air quality monitors.
Photos by Roberta Burnes

"Turns out, Mammoth Cave was in the midst of a drought in 2011-2012," says Jernigan. "During those periods, plants close their stomata and gas exchange decreases. This results in decreased plant exposure to ozone, even when the ozone concentration is higher."

Native plants aren't the only species sensitive to ozone pollution. Each year, agricultural crops in the U.S. suffer billions of dollars in crop losses due to ozone damage. Wheat, soybeans, tobacco, cotton, squash and potatoes are some of the cash crops most susceptible to ozone injury.

Working Together for Clean Air

Biomonitoring for ozone damage is just one of the ways that Mammoth Cave National Park is keeping tabs on air quality in the region. The park's air monitoring site houses equipment that measures ozone, acid rain, sulfur dioxide, and particulate matter, just to name a few. A complete meteorological station provides data on weather conditions, which may impact air quality as well.

Bobby Carson is the chief of the Science and Resources Management Division at Mammoth Cave. He heads up the air monitoring program at the park and works closely with the Kentucky Division for Air Quality (DAQ), sharing monitoring data and even housing one of the division's air monitors in the park. DAQ frequently includes the site's data in air quality analyses and conducts quarterly performance audits of the park's continuous monitors to ensure data quality.

Carson also gives the division a "heads up" whenever the park is planning to do a prescribed burn. Prescribed fire helps park staff manage natural areas by preventing the spread of invasive weeds and recycling nutrients in the soil. Prior to any burn, Carson is careful to check meteorological conditions such as wind speed, wind direction and humidity.

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Bobby Carson
Chief of Science and Resources Management
Mammoth Cave National Park

"Our goal is to minimize the impact of smoke on people," says Carson.

Perhaps most significantly, Carson and Jernigan both partner with DAQ on Kentucky's regional haze plan, which requires states to restore natural visibility conditions at Class I areas like Mammoth Cave by the year 2064. The Clean Air Act grants Class I areas the highest level of air quality protections, especially regarding visibility degradation.

Regional haze affects visibility over large regions including national parks, forests and wilderness areas. It is typically caused by fine particle pollution, often transported across great distances.

"Mammoth Cave National Park used to be one of the worst national parks in the nation for regional haze," says Carson, "but thanks to pollution controls required by the Clean Air Act, things have improved significantly."

DAQ Environmental Scientist Martin Luther agrees. Luther recently submitted Kentucky's Five-Year Periodic Report on Regional Haze to the EPA.

"Kentucky has made great strides in the past decade toward cleaner air and improved visibility," says Luther. "We are on track to meeting our goals for regional haze improvements."

Of course, the same pollutants that impact visibility or plant life in Mammoth Cave National Park also impact human health. And that means everyone benefits from this joint venture for cleaner air.

"Working with partners like Mammoth Cave National Park allows us to gain a better understanding of how air pollution is impacting living systems in our most biologically sensitive areas," says DAQ Director Sean Alteri. "The progress we're making in air quality improvements means healthier air for all Kentuckians."