On a Clear Day You Can See Forever

Figure 1a. On a bright March 2003 morning with an Air Quality Index (AQI) reading of 15, downtown St. Paul and the Minneapolis skyline are clear. Photo: MPCA staff

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Figure 1b. On a hot June 2003 day with an AQI of 125, a haze dims the St. Paul landscape and Minneapolis disappears. Photo: MPCA staff

Part I—It's a Small, Small World

December 5, 1952, dawned clear and cold in London, England. The air was damp and stagnant. Heavy black smoke rose from chimneys as Londoners lit the coal they burned to cook and heat their homes. Fog began to roll in. By dusk, the smoke-filled fog had turned an impenetrable yellowish black.

By the time the smoky fog lifted four days later, 2000 Londoners were dead of heart and lung complications.
Another 2000 died during the following two weeks, as the persistent health impacts of the five-day fog continued. When researchers compiled statistics, they estimated that during the next two months, 8000 more died of causes directly related to that deadly fog.

The culprit in London's killer fog wasn't the fog itself. It was thousands of tons of tiny particles that clung to the stagnant fog and filled residents' lungs. Thick soot from the city's coal-burning home hearths, diesel buses, and factories hung near the ground, trapped by a slow-moving temperature inversion. Black smoke concentrations measured during those five days reached more than 50 times normal levels.

For hundreds of years, Londoners have experienced discomfort related to particles in smoky fog (dubbed smog in1905). Recently, it has become clear that those fine particles are more than uncomfortable.

The most serious effects of small particles are associated with aggravation of heart or lung disease. Numerous studies have related particles in the air to increased hospital admissions, emergency room visits, and mortality. Aggravation of lung diseases, including asthma attacks and acute bronchitis, has been correlated with short-term exposure. In people with heart disease, particles have been linked to heart attacks and irregular heart rhythms.

According to Dr. Joel Schwartz of the Harvard School of Public Health, it's not a small problem. By one estimate, 70,000 people in the U.S., primarily older adults, die prematurely each year when fine particle pollution increases to unhealthy levels. "This," says Schwartz, "is larger than the death rate from breast and prostate cancer combined."

Minnesota is a long way from the London of the 1950s—or even the troubled cities of the industrial northeast United States. It has its own unique problems with smoke-related pollution, however, as documented in the following article.

The material on this page is excerpted from "Out of a Clear Blue Sky: Regional Haze Mars Scenic Vistas, Even in Minnesota" by Ralph Pribble, Minnesota Environment, Summer 2003, Vol. 3(3), p. 10.

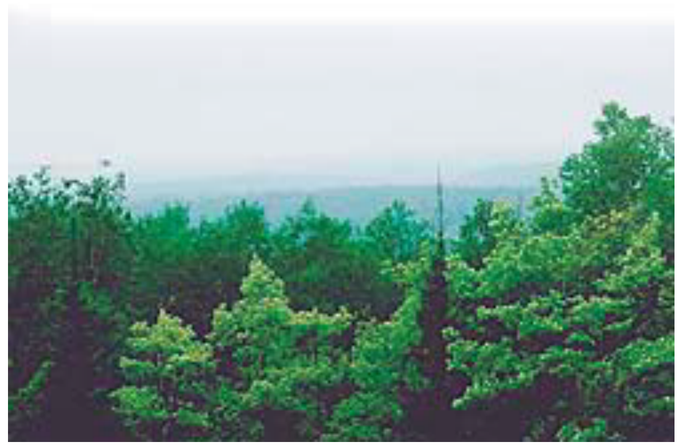

Figure 2. A Forest Service improve automated monitoring station just outside the BWCAW shows the distinct difference between a clear day (more than 125 miles visibility, above) and a hazy one (less than thirty, below). Photos: USDA Forest Service

Air pollution affects not only urban areas, but national parks and wilderness areas as well. On bad days, "regional haze" cloaks some of the United States' most treasured "purple mountain majesties" in brown or white gauze. Many of the 280 million Americans who each year visit parks such as the Grand Canyon or Glacier National Parks are surprised to find they can't get a clear view of the scenic wonders they have come to see.

The cause might surprise outdoor enthusiasts. It is fine particles similar to those that blight our urban skies. Some haze is natural, part of prevailing climate dynamics. After all, the Great Smoky Mountains were known by that name long before the mid-South industrialized. Dust, organic compounds, smoke from forest fires, and humidity figure into what is considered natural (unpolluted) visibility.

In pre-settlement days, the farthest a person could expect to see on a clear day was between 110 to 115 miles in the Western U.S., and 60 and 80 miles in the East. Today, however, typical visual range in the West is 60 to 90 miles. In the East, it's only 15 to 30 miles. The culprit in this deterioration appears to be human activities.

In 1999, the U.S. Environmental Protection Agency (EPA) issued regulations designed to further reduce haze and protect visibility, as well as specific programs to reduce particle air pollution overall. For example, the U.S. Department of Agriculture National Forest Service's improve (Interagency Monitoring of Protected Visual Environments) network collects air samples and provides monitoring data on visibility and fine particulates at 163 Class I locations, including Voyageurs National Park and the Boundary Waters Canoe Area Wilderness (BWCAW), both located in northern Minnesota.

The equipment at IMPROVE sites includes automated samplers to measure airborne particles and particle mass, along with light-monitoring equipment and a camera. According to Trent Wickman of the Forest Service's Duluth office, "The contributions of pollutants at the [BWCAW] are clear. A large portion is ammonium sulfates, which are pretty clearly tied to coal combustion." He added there's not sufficient data yet to provide trend analysis, but that "we're getting to that point."

Regardless of their source, trying to describe fi ne particles is like trying to describe animals to someone from another planet. Just as animals can be large or small, feathered or furred, dangerous or benign, particles can be varying sizes, solid pieces or liquid droplets, man-made or natural, dangerous or benign.

Some particles are emitted directly into the air, and some form in the air from chemical reactions of nitrogen oxides, sulfur oxides, volatile organic compounds, and ammonia. Particles can cling to moisture droplets or simply drift in the air. Scientists call particles "particulate matter," abbreviated pm. Regulators generally divide particulate matter into two categories on the basis of size: PM10 and PM2.5.

Questions

1. What do "PM10 and PM2.5" mean?
2. Which of these particles are the most harmful?
3. How do fine particles cause health effects?
4. What groups are most vulnerable to fine particle air pollution?

Part II—Life's Better at the Cabin

<u>Particles are both urban and rural</u>

Fine particle pollution is everywhere, as are the combustion processes that create them. There is no way to avoid it. The smokestacks and tailpipes of cities and towns produce a large part of pm, but sources exist in rural areas as well. Fine particles can ride the wind to locations thousands of miles from the original sources and stay in the air for a long time.

Even rural areas, including remote national parks, are plagued by "regional haze," a benign-sounding term for fine particle pollution that has blown in from elsewhere and obscures famous views. If tourists at Arizona's Grand Canyon, South Dakota's Badlands, and Tennessee's Great Smoky Mountains pick the wrong day to visit, they find the dramatic scenery veiled by a gauzy haze. Although not as badly affected as other areas, Minnesota's Voyageurs Figure 3. Measurements based on one year of monitoring at urban Minnesota sites. National Park also shows signs of regional haze.

One goal of the Clean Air Act is to restore the view of these national treasures to the clarity that onlookers enjoyed before the advent of man-made air pollution. Class I areas, as defined in the Act, are 156 national parks, monuments, and wilderness areas in the United States. Even remote, far-north Class I areas such as Voyageurs and the BWCAW become hazy from transport of fine particles high in the atmosphere, where they can be carried long distances.

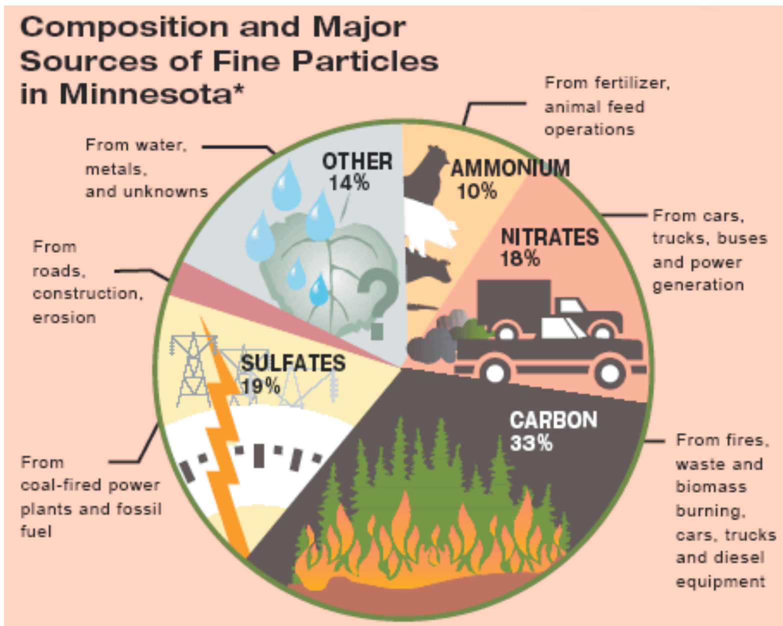

Figure 3. Measurements based on one year of monitoring at urban Minnesota sites.

Short-term exposure is enough

London's 1952 fog carried very high concentrations of fine particles. But can fine particles at elevated levels really do so much damage so quickly? Recent research suggests that they can. Measurable changes in the body may take place within hours of increased exposure, particularly in people with existing cardiovascular or respiratory conditions.

The Health Effects Institute, an institution jointly funded by the EPA and industry, commissioned a nationwide study in the late 1990s on the short-term effects of air pollution, the National Morbidity, Mortality and Air Pollution Study (NMMAPS). The study found strong evidence linking daily increases in particle pollution to increases in mortality in the 90 largest U.S. cities (including the Twin Cities), particularly from heart and lung diseases.

Re-analysis of the study due to a statistical problem did not change the basic conclusions:

- There is an association between short-term increases in particles and death, as well as hospital admissions for heart diseases and chronic obstructive pulmonary disease.
- This association is strongest for respiratory and cardiovascular causes of death.
- The association was not attributed to other air pollutants.

Over 10 years ago, researchers at the Harvard School of Public Health released the results of a study following 8000 adults in six cities during a dozen years (Dockery et al., 1993). They found that people in the city with the highest fine particle pollution had a 37 percent higher risk of death due to cardiopulmonary causes than the residents of the least-polluted city.

Another study supports the Harvard findings. In the March 6th 2002 issue of the Journal of the American Medical Association, Dr. George Thurston of the New York University School of Medicine and Brigham Young University researcher C. Arden Pope reported on their landmark study that followed a half million people in 116 U.S. cities for 16 years (Pope et al., 20002). Comparing health data to air pollution records, they found that populations with prolonged exposure to particulate air pollution had significantly higher risk of dying of lung cancer and other lung or heart diseases.

"Long-term exposure to air filled with fine particles carries almost the same risk of lung cancer and heart disease as breathing secondhand smoke over a long period," says Thurston. This wasn't his only finding after years of PM research.

"We also found that, if you are aged 75 and older, you have a considerably increased risk of having a heart attack within two hours of a high fine particle episode," says Thurston. "That risk doubles if you already have heart or respiratory disease."

But it isn't only older adults who are at risk, says Thurston. He believes that babies from one month to one year are also more at risk, for three reasons: they breathe more air per pound of weight; they tend to have a high rate of respiratory ailments already, which leaves them more vulnerable; and they are developing rapidly. As science zooms in on fine particles, we will learn more about their effect on us. But don't expect the news to get better. "Basically," says Thurston, "everyone is at risk from air pollution—it's just a question of how much."

Questions

1. What are the major sources of anthropogenic air pollution?

The following material is excerpted from "Where There's Smoke, There's Smoke-Related Pollution" by Anne Perry Moore, Minnesota Environment, Summer 2003, Vol. 3(3), pp. 7–9.

<u>When wildfires burn, the smoke stops here</u>

Smokey the Bear never said it would be like this. Kids of all ages know they are responsible for preventing forest fires. What they may not know is that fire-related air pollution can have health consequences—for people living both nearby and thousands of miles away.

Wind sent smoke from the 2003 Colorado, Arizona, and Canadian mega-fires across whole states. The blowdown area in the BWCAW remains a tinderbox. In the spring of 2004 grass fires in Minnesota raced across many communities, clouding the air with smoke. As summer heat and storms escalate, we can learn what to do if weather conditions send harmful wildfire smoke in our direction.

<u>Smoke gets in your eyes</u>

Ninety percent of wildfire-related emissions are carbon dioxide (a major contributor to global climate change) and water vapor. The rest includes particles in a range of sizes. Fine particles remain suspended in the air from a few seconds to several months.

To help the general public and high-risk groups identify and reduce potential health problems related to wildfires and smoke exposure, experts in several western state agencies offer easy-to-understand, visibility based guidance. (See an example at the Oregon Department of Environmental Quality at http://www.deq.state.or.us/aq/burning/wildfires/ wildfire-health.htm#using%20visibility.) The bottom line: The more visible the smoke, the more likely the health concern.

Though these visibility guides were developed for local use, they apply far from active fires as well. Air emissions travel: Airborne arsenic from Beijing smelters turns up in Hawaii, U.S. factory pollutants land in Europe, Saharan Desert dust falls in the Caribbean. Wildfire pollution has the same airborne transmission potential.

For example, during the 1997-98 El Nino, smoke from drought-related forest fires sent hundreds of Malaysians, Indonesians, and Brazilians to local clinics with respiratory complaints. The larger the population downwind from any big fire, the greater number of people potentially exposed.

The statistics are staggering. Each year forest fires worldwide emit an estimated:

- 85 million tons of carbon dioxide
- 13 million tons of carbon monoxide
- 2.2 million tons of nitrogen oxides (a precursor of ground-level ozone)
- particulate matter
- hydrocarbons (such as benzene)
- aldehydes (such as formaldehyde)
- trace minerals

In the United States, according to the National Interagency Fire Center (http://www.nifc.gov/stats/wildlandfirestats.html), an estimated 6.9 million acres of wild land burned in 2002, costing federal agencies $1.6 billion to suppress.

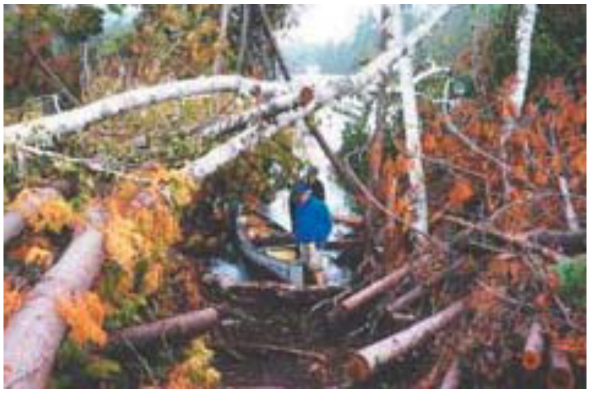

Figure 4. During the summer of 1999, powerful storms ripped through the Boundary Waters Canoe Area Wilderness, damaging nearly 400,000 acres of timberland. Controlled burns will be used to lessen the possibility of a massive fire. Photos: Superior National Forest

Fire starter

Dry twigs, needles, and moss can combust if they connect with an electrical spark, a discarded cigarette or an abandoned campfire. High winds can fan flames over larger twigs and brush, followed by branches and logs—a perfect recipe for a very hot, very intense, multi-day burn.

Living forests are not exempt: they are vulnerable to severe fires during the growing season if two weeks pass without rain. Mother Nature “sets” fires, too: Lightning strikes are a significant cause of wildfires, particularly in late summer when the ground is dry.

Large forest fires scorch the soil and send burning embers up to five miles away. Once a forest canopy or large pile of logs is engulfed, a thick “plume” of pollutant-filled smoke rises into the atmosphere. In the best case, winds disperse the smoke. In the worst, wind transports the smoke to populated areas, then a temperature inversion prevents it from vertical mixing. Wind and weather conditions can be predicted only up to 24 hours; after that, it’s anybody’s guess which way the wind, fire, and related pollutants will blow.

To better understand fire movement, near-real-time global fire mapping is helping scientists anticipate a wildfire event—and prepare for its impacts. Satellites originally designed to collect weather data can now observe and monitor dry areas, active fires, fire hot spots, burned areas, and air emissions (see the National Oceanic and Atmospheric Administration Web site for satellite photos at http://www.osei.noaa.gov/).

More than 1500 U.S. weather stations collect and assess current wildfire conditions, produce fire danger maps, and make fire weather observations and next-day forecasts. State and federal agencies compile data into larger fire-assessment tools and cooperate with fire-watchers worldwide.

Figure 5. Smoke from an Alberta, Canada wildfire in May 2001 blows southward across the Great Lakes (seen in the lower right of this satellite photo), hiding much of Lake Superior from view. Photo: The SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE

Questions

1. What are the major sources of natural air pollution?

Measuring PM in Minnesota

So, as an example, what is being done about it in the land of 10,000 lakes and numerous forests, located downwind from other particulate sources? Special PM2.5 monitors are currently measuring the concentration of fine particles in the ambient outdoor air. The Minnesota Pollution Control Agency (MPCA) operates PM2.5 monitors in Duluth, Rochester, St. Cloud, and several Twin Cities locations. Plans are in the works for monitors in other regions of Minnesota as well.

"We've already learned something interesting from this monitoring," says Rick Strassman, supervisor of the MPCA's air monitoring unit. "Unlike some other air pollutants, fine particle concentrations rise and fall rapidly throughout the day and night. This makes it a challenge to get timely word out to the public if they need to act."

In Minnesota, sulfate is an important component of haze. Nitrate and organic carbon are significant in winter and summer, respectively. Since some fine particle pollution blows into Minnesota from other states and some is homegrown, monitors help the MPCA learn where particles are coming from, when, and where they are headed. Imported and homegrown air pollution sometimes combine to create even less healthy concentrations.

So far, says Strassman, PM2.5 rises to concentrations considered unhealthy for sensitive people (people with heart or lung disease, older adults and children) no more than a few days a year. "And, knock on wood, we've seen only one day when PM2.5 has risen to the next category, unhealthy for everyone."

Now that regional PM2.5 monitors are connected to the MPCA's web site (this occurred in summer 2003), citizens in each monitored community are able to check local air quality by going to the MPCA's Air Quality Index (AQI) web page (http://AQI.pca.state.mn.us/hourly/). The AQI signals if the air quality could adversely affect you or your family.

The MPCA also sends out e-mail Air Pollution Health Alerts when PM2.5 or ozone (at ground level, another air pollutant) rises to unhealthy levels. Since accumulation of PM2.5 is not dependent upon summer sunlight as is ground-level ozone, PM2.5 concentrations are watched 24 hours a day, 365 days a year.

When the AQI for PM2.5 is headed for 100 and the "unhealthy for sensitive groups" category, do you stay home from work? Crawl into bed? Ignore it all?

The best advice medical science can offer during times of high PM2.5 is this: take it easy. Try not to overexert yourself, no matter who you are. Reduce the time you spend on outdoor exertion or substitute a less intense exercise plan (walking instead of jogging, for example). Those with heart and lung conditions should especially play it safe, taking it easy when the AQI is in the "high moderate" category.

When particle levels are high outdoors, they can also be high indoors. To reduce particles, turn on an air conditioner or air cleaner (for more information on air-cleaning devices, see the American Lung Association web site at http://www.lungusa.org/air/aircleaners_factsheet.html). Don't use a humidifier, ozone generator, or "energized oxygen" device, all of which could make matters worse. Reduce other indoor air emissions (cigarette smoking, cooking, burning wood, gas or propane in stoves or furnaces, vacuuming, burning candles or incense).

And while you're taking it easy, remember to help cut off additional PM2.5 at the source. We may not be able to control what blows into Minnesota, but we can control what we add to the air: e.g., drive less, mow less. As the Greek physician Hippocrates advised 2400 years ago: "make a habit of two things—to help, or at least, to do no harm."

Questions

1. Should wildfires be stopped altogether to protect our forests, our air, and our health?
2. What is the Clean Air Act?
3. What are the EPA and MPCA doing about pm?
4. How do National Ambient Air Quality Standards regulate anthropogenic air pollution?

Figure 6. This composite photo of the St. Paul skyline provides a visual comparison of two different levels of fine particles—PM2.5 levels of 5μg/m^3 (left) to 35μg/m^3 (right). Notice the difficulty in seeing buildings in downtown St. Paul on the right half of the picture. The daily standard for PM2.5 is 6μg/m^3 (micrograms of particles per cubic meter of air). Photo: Midwest Hazecam