MEMORANDUM

Subject: "Clearing the Air" Materials Modification
Date: June 30, 1988
From: NPS "Clearing the Air" Cooperators, The Ohio State University
To: NPS Field Units

A few days ago your area received one or more packages of "Clearing the Air" materials. The responses thus far have been positive.

As we continue to review and update the materials and seek additional input we also gain new insights. In our conversations with a group of independent reviewers they have suggested that Program Sheets number 16 and 24 be deleted because they may be unacceptable to some of the public and some NPS personnel. The specific point in question is the using of the National Anthem in an altered fashion.

Although this point was made in the package's cover memo we are formally requesting that you remove and destroy Programs Sheets 16 and 24 from each of your packages. A revised version of these two program sheets will be sent to each park later. The intent of Program 16 and 24 was to add song and poetry techniques to liven up a serious subject. To the best of our knowledge the use of the National Anthem in an altered state has not been tested in National Parks, nor has its use been suggested by NPS personnel. Thus it is best to delete Programs 16 and 24 from all packages.

A few people have asked specifically how this project was developed. Materials were compiled and edited by The Ohio State University in cooperation with interpretive personnel in field units of the National Park Service. Funding was provided by the National Park Service and The Ohio State University with additional support from the U.S. Man and Biosphere Program in the biosphere reserves of Great Smoky Mountains and Sequoia-Kings Canyon National Parks. The opinions expressed in the materials are those of the author and editors and do not necessarily reflect the opinions of the U.S. Government or the University.

Thank you in advance for removing those Programs Sheets 16 and 24. Please keep us apprised of which of the materials are useful and work well and what does not work so well. Thank you.

GWM:kb
To: National Park Service users of "Clearing the Air" materials
From: The Ohio State University Coordinators
Subject: "Clearing the Air" materials

Attached are fact sheets, program sheets, and a directory or materials relating to acidic deposition and air quality. The materials were developed under a United States Department of State grant and were printed and distributed under a National Park Service purchase order.

The materials are to provide in-house support for the National Park Service efforts to increase the interpretation of acidic deposition and air quality subject matter over the next several years. They were not designed to be reproduced for the general public. Portions of these materials were designed and field tested in National Park Service areas. Some of the ideas were supplied by National Park Service field personnel and were expanded on by project scientists. Other materials were contributed by non-National Park Service sources. Extensive reviews, both in and out of the Service, were conducted for both content and style. Because of the controversial nature of many of the issues, the National Acid Precipitation Assessment Program report (1987) was used as the final point of resolution on the content.

Program 26 is a draft copy of the "Clearing the Air" slide script that has been provided for your reference. The final script and accompanying slides may be obtained from your NPS regional office.

Should you find materials you have questions about or major points you feel should be reviewed, please contact Gary Mullins, Rosanne Fortner or Kim Palmer at (614) 292-2265.

We have found a few items since printing that we would like to bring to your attention:

Program sheet 16  "Air Quality Singin' Songs"

The lyrics on the variation of the National Anthem is only used as a poster idea at Zion National Park. Singing the lyrics has not been tested. Some interpreters at one training session have suggested that certain audiences may object to any variation to the National Anthem.

Program sheet 14  "Air Quality Night Hike"

Under "program description," third paragraph, the first sentence should read: "Have you noticed that the stars seem as if they are brighter and more numerous tonight?"
PROGRAM AND FACT SHEETS
RELATING TO ACIDIC DEPOSITION
AND AIR QUALITY
This project was funded by the U.S. Department of State, Man and Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University. The opinions expressed herein are those of the author and editors, and do not necessarily reflect the opinions of the U.S. Government or the University. The project was administered by The Ohio State University Office of Sponsored Program Development and printing was provided by Editorial and Printing Services of that Office.
Greetings to each and every one of you! As we launch our interpretive initiative on air quality and acid rain, I want to thank you for your commitment and support and give you a few of my thoughts on these critical concerns. My remarks are addressed not just to the trainers and interpreters among you, but to every Park Service employee who may talk to our visitors about these issues.

The National Park Service can be viewed as one of the largest educational institutions in the nation. Through our interpretive activities we reach millions of Americans each year, helping them to enjoy and appreciate the outstanding cultural and natural resources of our country that we are privileged to manage for their benefit.

Each unit of the National Park System has its unique story, and this must be told. But at the same time there are stories of concern to all units of the system, and these, too, should be told. I have selected several for special attention--The Bicentennial of the United States Constitution, The Take Pride in America Program, Biological Diversity, and Air Quality.

In 1988 our systemwide emphasis will be on air quality and acid rain--the "Clearing the Air" program. Those of you who are participants in the workshop on air quality interpretation will strengthen your knowledge of these subjects and will develop plans for training interpreters in your regions. You are, in many ways, the foundation of this major interpretive effort. Those of you who are front-line interpreters will then nourish the seeds of information and interpretive ideas into full-grown trees--walks, talks, and all the other avenues of our communication with the public. I am sure you will do this with your usual imagination, enthusiasm, and professional care.

I selected air quality and acid rain for emphasis because air pollution affects all our parks and, indeed, the whole world. These problems are complex, and they will be with us for a long time. We must understand them so appropriate measures can be taken to remedy them. The American public needs to be well informed so it can support fair, effective action.
As we train our park interpreters I ask you especially to stress the importance of accuracy and objectivity. Our knowledge of some aspects of air pollution--visibility for instance--is good, and we have a lot of information on ozone effects. But in some areas--especially acid rain--our knowledge is more limited. We must take great pains to separate scientifically established facts, suspected facts, and pure speculation. The quality of this interpretive program will depend on such objectivity.

It will also depend on the ability of our interpreters to share their concern about air quality with visitors. Air pollution is not a happy subject, but it must be addressed if we are to protect the resources in our care. I am sure our interpreters will find ways to convey the seriousness of this issue while still being positive about our nation's ability to do something about it. At the same time, we are not to advocate any specific political action. Our job is to convey what we know. It is up to the individual citizen to form his or her own opinion about what should be done.

One positive aspect we can point to is the steps the National Park Service itself is taking to understand the problem. Our research on visibility, ozone, acid deposition and other aspects of air pollution not only is helping to clarify these matters with respect to Parks but is an important contribution to national and international scientific understanding.

I urge every unit in the National Park System to participate in some way in this interpretive initiative on air quality. Because of their situation and resources, some parks will have reason to be much more involved than others, but air quality affects us all. Parks with relatively clean air might point this out to visitors, and explaining why it's clean. Interpretive materials for the public, such as a brochure on air quality, are being prepared and will help field units convey the facts as they are now known.

I wish you a most productive, creative year and will watch with great interest the fruits of your endeavors, as we attempt to "Clear the Air," both literally and figuratively, throughout the National Park System.

Text of a video presentation made by Director William Penn Mott, Jr. at Harpers Ferry, West Virginia, February 8, 1988.
Interpreting Critical Resource Issues in National Parks
Clearing the Air Series

PROGRAMS
1. Roving Interpretation
2. Forest Walk
3. Stream Walk
4. Interpreting Air Quality Effects On Cultural Sites
5. Air Quality Workshop
6. Using The Visibility Wheel
7. Junior Ranger
8. Visitor Center Exhibit
9. Newspaper Articles Example
10. Public Handout Program
11. National Wildlife Federation "Clean Air Week"
12. Science Research Lecture Series Program
13. Acid Rain Terrarium Program
14. Air Quality Night Hike Program
15. Air Quality Role Playing/Theatre Program
16. Air Quality Singin' Songs Program
17. Auto Emission Display
18. Brochure Insert
20. Air Quality High School Program
21. Air Quality Program Ideas
22. Wayside Exhibit
23. Community Relations Program
24. Air Quality Poster Ideas
25. K-8 Air Quality Environmental Education Modules
26. "Clearing The Air" Slide Script
27. "Clearing The Air" Captioned Slide Set

FACT SHEETS
1. "Clearing The Air" Interpretive Program
2. The Atmosphere And Air Pollution
3. Acid Rain
4. Ozone
5. Visibility Impairment: What Is It?
6. Air Pollution And Vegetation Decline In Several National Parks
7. Acidic Deposition Effects On Cultural Materials
8. Acid Rain: Effects On Aquatic Species And Systems
9. Acid Rain And Soils
10. National Park Service Air Quality Research Program
11. National Acid Precipitation Assessment Program
12. Forest Response Program
13. Deposition Monitoring And The National Park Service Atmospheric Deposition Program
15. The Transmissometer Visibility Monitor And The National Park Service Visibility Monitoring Program
16. Ozone Monitoring Chambers
17. Visibility Monitoring
18. How To Use A Conductivity Meter
19. How To Use A pH Meter
20. How To Use A Temperature Sensor
21. Preserving Specimens In Acrylic
22. The pH Scale
23. Interpreting Controversy
24. Clean Air Act
25. Biosphere Reserves
26. Two Articles From Sequoia Bark
27. National Wildlife Federation "Let's Clear The Air" Education Packet
28. Air Quality Puns And Play-On-Words
29. Balsam Woolly Adelgid

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
CROSS-REFERENCE LISTING OF FACT SHEET INFORMATION CONTAINED IN THE "CLEARING THE AIR" INTERPRETIVE INITIATIVE

ACID PRECIPITATION
2. The Atmosphere And Air Pollution
3. Acid Rain
6. Air Pollution And Vegetation Decline In Several National Parks
7. Acid Deposition Effects On Cultural Materials
8. Acid Rain: Effects On Aquatic Species And Systems
9. Acid Rain And Soils
11. National Acid Precipitation Assessment Program
22. The pH Scale
23. Interpreting Controversy
28. Puns And Play-On-Words To Use When Dealing With Air Quality Topics

AIR QUALITY
1. "Clearing The Air" Interpretive Program
2. The Atmosphere And Air Pollution
3. Acid Rain
4. Ozone
5. Visibility Impairment: What Is It?
6. Air Pollution And Vegetation Decline In Several National Parks
7. Acid Deposition Effects On Cultural Materials
8. Acid Rain: Effects On Aquatic Species And Systems
9. Acid Rain And Soils
10. National Park Service Air Quality Research Program
11. National Acid Precipitation Assessment Program
12. Forest Response Program
13. Deposition Monitoring And The National Park Service Atmospheric Deposition Program
14. Interagency Monitoring Of Protected Visual Environments Program
15. The Transmissometer Visibility Monitor And The National Park Service Visibility Monitoring Program
16. Ozone Monitoring Chambers
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AQUATICS
1. "Clearing The Air" Interpretive Program
3. Acid Rain
8. Acid Rain: Effects On Aquatic Species And Systems
11. National Acid Precipitation Assessment Program
22. The pH Scale
23. Interpreting Controversy
28. Puns And Play-On-Words To Use When Dealing With Air Quality Topics

ANIMALS
8. Acid Rain: Effects On Aquatic Species And Systems
21. Preserving Specimens In Acrylic
29. Balsam Woolly Adelgid

HANDS-ON MATERIALS
18. How To Use A Conductivity Meter
19. How To Use A pH Meter
20. How To Use A Temperature Sensor
21. Preserving Specimens In Acrylic

LAWS
10. National Park Service Air Quality Research Program
24. Clean Air Act
25. Biosphere Reserves

NATIONAL PARK SERVICE AIR QUALITY RESEARCH
10. National Park Service Air Quality Research Program
11. National Acid Precipitation Assessment Program
12. Forest Response Program
13. Deposition Monitoring And The National Park Service Atmospheric Deposition Program
14. Interagency Monitoring Of Protected Visual Environments Program
15. The Transmissometer Visibility Monitor And The National Park Service Visibility Monitoring Program
16. Ozone Monitoring Chambers
17. Visibility Monitoring

OZONE POLLUTION
4. Ozone
6. Air Pollution And Vegetation Decline In Several National Parks
16. Ozone Monitoring Chambers

REFERENCE AND EDUCATIONAL MATERIALS
23. Interpreting Controversy
26. Two Articles From Sequoia Bark
27. National Wildlife Federation "Let's Clear The Air" Education Packet

ROVING INTERPRETATION
1. "Clearing The Air" Interpretive Program
2. The Atmosphere And Air Pollution
3. Acid Rain
4. Ozone
5. Visibility Impairment: What Is It?
6. Air Pollution And Vegetation Decline In Several National Parks
7. Acid Deposition Effects On Cultural Materials
8. Acid Rain: Effects On Aquatic Species And Systems
9. Acid Rain And Soils
10. National Park Service Air Quality Research Program
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VEGETATION
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9. Acid Rain And Soils
11. National Acid Precipitation Assessment Program
12. Forest Response Program
21. Preserving Specimens In Acrylic
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VISIBILITY
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5. Visibility Impairment: What Is It?
10. National Park Service Air Quality Research Program
13. Deposition Monitoring And The National Park Service Atmospheric Deposition Program
14. Interagency Monitoring Of Protected Visual Environments Program
15. The Transmissometer Visibility Monitor And The National Park Service Visibility Monitoring Program
17. Visibility Monitoring
24. Clean Air Act

Page 2
Interpreting Critical Resource Issues in National Parks
Clearing the Air Series

PROGRAM 1

TITLE: Roving Interpretation

AUDIENCE: Adult and youth

DURATION: 30 minutes

SITE: National Park Service unit

PROGRAM TYPE: Roving interpretation

FACT SHEET REFERENCE: 2-7, 10, 23, 28

PARK THEME:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage and facilitate appropriate, safe, minimum impact use of the park's resources.

PROGRAM GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to list natural and human caused factors affecting visibility.
2. The audience will be able to name the primary cause of visibility impairment in National Park Service units.

PROGRAM DESCRIPTION:

Materials needed: 1. Telescope with tripod (Available at most department stores for $60.00-$80.00) 2. different percentages of visibility pictures (available through the National Park Service Air Quality Division-Denver) which can be mounted on posterboard, 3. one page scenario on visibility (using statistics and data from your unit)

The following is an example that could be used for a one-page visibility scenario. The example given is visibility impairment message in the Great Smoky Mountains National Park.

"OH, SAY CAN YOU SEE...?"

Great Smoky Mountains National Park is known for a natural blue haze that was caused by compounds given off by the trees in association with the high humidity in this area. But these days that haze is not so blue, and its cause is not so natural. Industrial smoke and vehicle exhaust have reduced how far and how clearly we can see.

Many factors affect the degree of visibility we experience here in the Smokies. The weather on a given day, the changing of the seasons, and the way these mountains act as a block to air masses moving from the west all influence how well we can see the views in the Park. In general, visibility is poorest during the hot, humid summer months. Air masses tend to stagnate, and airborne particles of pollution combine with the natural compounds to shroud the mountain ranges in white or brownish haze.

Visibility in this area has declined by an average of about thirty percent over the last three decades. The single most important

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contributor to visibility impairment in the Smokies is sulfate particles which are released into the air when fossil fuels are burned. Carbon particles are also released in this burning process, and contribute to visibility impairment. Two major sources of both sulfate and carbon particles are automobiles and coal-burning power plants. Many other industries also emit sulfate and carbon along with other pollutants to increase the amount of particles in the air.

Researchers in Great Smoky Mountains National Park have found that during the summer months when visibility is poorest (and when the greatest number of visitors comes to the Park), we can expect to see distances of 155 miles or more only six percent of the time. That is to say, we can expect to see a truly spectacular view only once or twice a month. Most of the time, the visibility range here is about 30 miles—far enough to see a few ranges of hills in the distance. But once or twice a month, we can expect to see almost nothing; about 5% of the time during the summer, the visibility range decreases to only a couple of miles. The haze obscures from our sight all but the closest landmarks.

Visibility impairment is a major cause of concern in our National Parks. After all, it is the chance of experiencing a beautiful vista that brings many of us to the Park in the first place. And if we cannot see the Park through the haze of pollution, why will we go? The only way to be assured of seeing great distances is to improve our air quality. We as a nation must work to comply with and enforce the Clean Air Act which limits the amounts of pollutants that can be emitted into the atmosphere. We as individuals can practice conservation measures at home to reduce the amount of pollution we create. We also must support national and worldwide efforts to clean the air. Our efforts to protect our air quality today provide the chance for us and for future generations to be able to see far into the distance.

(End of visibility scenario)

A one-page visibility scenario should be set up with the background information provided by this example, the "Fact Sheet" series, data from your park, and visuals from the National Park Service Air Quality Division (Denver).

Here are several ways of conveying a visibility pollution message. Set up a telescope viewing a selected point of interest. Have a poster showing pictures of the different percentages of visibility at that point. As visitors approach to see what you are doing with the telescope, ask them to look into the telescope and match the view that they have with the corresponding picture on the poster. After they have done this, share with them a short story about the air pollution in the park. Again, the Great Smoky Mountains National Park example is used. The following dialogue is an example of what took place in the Great Smoky Mountains National Park with this program.

RANGER:

"The Smokies are really beautiful. But as shown in this poster, sometimes it is hard to view all the splendor of the Smokies. The Smokies are known for a natural blue haze that is caused by compounds given off by the trees. But these days that haze isn't so natural. Very small particles of air pollution from industries and automobile exhaust from this and surrounding areas have cut down how far and how clearly you can see. Here is a paper that gives more information on visibility pollution in the Smokies."

Another way to convey a visibility pollution message is to hang the visibility poster up in a kiosk and ask visitors to rate that day's visibility. Then show them the poster, relate the above visibility story to them, and give them the one page hand-out concerning visibility pollution in the park.

A third way to convey a visibility pollution message is to post a daily visibility bulletin at a kiosk or visitor center. When visitors approach the kiosk, inform them about the
visibility of the day. Then show them the visibility poster and share the above visibility story. Finally, give them the visibility handout for more information.

SUGGESTED EVALUATION:
Ask the visitors what they think are natural and human caused factors causing visibility impairment. Ask the visitors to compare this site with the air quality at their homes. Make a written record of your discussion.

BACKGROUND INFORMATION:
Atmospheric conditions, including particles and gases in the air, determine visibility conditions which influence how easily a person can see through the air. There are several different quantitative measures of visibility conditions that characterize different aspects of these conditions.

Air pollution can be visible in three forms: uniform haze, layered haze, and plumes. Uniform haze is a homogeneous haze that reduces visibility in every direction from the observer. It occurs when the air is well mixed and the pollutants are evenly distributed. Layered haze is seen as a band or bands of discoloration, with a noticeable boundary between the more polluted and the cleaner air. A plume is a band of discoloration that can typically be seen to be coming from a nearby source. It is formed when there is a surface wind to carry visible pollutants horizontally from an emission source into a stable atmosphere.

The current status of visibility at National Park Service units is as follows: In excess of 90% of the time, scenic vistas are affected by human-caused pollution at all National Park Service monitoring locations. The best visibility at monitored sites is in eastern Nevada, western Utah, and southern Idaho, while the worst visibility at monitored National Park Service units is in Shenandoah and Great Smoky Mountains National Park. Visual range at National Park Service units is typically best in the winter. It is worst in the summer when meteorological conditions are such that more pollution is transported from urban areas and industrial developments to remote areas, causing more uniform haze to occur in the winter months.

Fine particles are generally responsible for a major share of visibility impairment at monitored National Park Service units. On the average, soil-related material is responsible for 10% to 30% of the visibility impairment.

REFERENCES:


DEVELOPED BY:
Kim Baker
The Ohio State University

Dr. John Peine
Great Smoky Mountains National Park

Interpretive Staff
Lassen Volcanic National Park

National Park Service Air Quality Division (Denver)
Air pollution is a big problem today, even in our National Parks. Some air pollutants are formed naturally by trees, fires, or volcanoes. But most air pollution comes from human activity. Fumes from cars, factories, or coal-burning electric power plants all cause air pollution. Look at this list of air pollution sources. Write an H next to the sources caused by human activity and an N next to the sources caused naturally.

Smoke from a factory  Burning coal to make electricity
Car exhaust            Chemicals released by trees
Volcano erupting       Fire caused by lightning
Campfire

Can you think of some other sources of air pollution?
A-MAZ-ING AIR
This bird is lost in a cloud of pollution. Can you help it find its way to clean air?

What can YOU do?

Which of these activities are you doing at home now to help reduce air pollution?

Which of these COULD you do?

* Walk short distances instead of taking a car
* Use a carpool or ride a bus
* Ride a bicycle
* Run the dishwasher only when it is full
* Use the air conditioner only when it is very hot
* Dry laundry on a clothesline
* Keep your furnace clean and properly adjusted
* Do not burn trash or leaves
* Re-use or recycle paper, glass and aluminum

Can you think of other things you could do to reduce air pollution? List them here.
PROGRAM 2

TITLE: FOREST WALK

AUDIENCE: Mixed adults

DURATION: 20 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Guided walk

FACT SHEET REFERENCE: 2, 3, 4, 6, 12

PARK THEMES:

1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.

2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:

1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.

2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.

3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:

1. The audience will be able to describe sources of air pollutants.

2. The audience will be able to list some of the adverse effects of air pollution on forests.

3. The audience will examine specimens of ozone damaged leaves and red spruce tree core samples.

PROGRAM DESCRIPTION:

Materials needed:

Acrylic specimen blocks of ozone damaged leaves, red spruce tree cores (Red Spruce tree cores can be purchased from the Acid Rain Foundation, 1630 Blackhawk Hills, Saint Paul, Minnesota, 55122. Cost was $9.95 as of 1987.)

When interpreting problems in the forest environment, one can begin by asking the audience to name some sources of air pollutants. Be sure to mention both natural sources (fire and vegetation) and human-caused sources (autos, industry, coal-burning electric plants, burning trash or firewood) if the audience does not come up with examples of each. Stress that although pollutants occur naturally, it is human activity which contributes most to the air pollution problem.

An example that could be used is this: "Have you ever been sitting around a campfire and had the smoke blow in your face? Did your eyes water? Did you cough? You were suffering from air pollution on a small scale. Forests are affected by air pollution, too. Air pollutants like ozone or the sulfur and nitrogen oxides in 'acid rain' can damage forest plants."

Show specimen blocks of damaged leaves. As these are being passed around, an explanation similar to this might be shared: "These leaves have been damaged by ozone. Laboratory tests have shown that ozone can cause burned spots on leaves and interfere with photosynthesis or food production in many plants. Look around you here. Do you see any plants that may have been damaged by ozone?"
Show red spruce or other tree core samples with restricted growth that is related to air pollution. Share with the audience that the red spruce is one of the major types of trees in several National Park Service units, such as the Great Smoky Mountains National Park. But scientists in these parks believe that air pollution is harming the red spruce. Illustrate by saying something like this: "Look at these tree cores. As a tree grows, it forms a ring of new wood each year. These rings show up as lines in the core samples. When the growth rings are thick, the tree has grown a lot in that year; when they are thin, the tree has grown little. Over the last few years, some of the red spruce have virtually stopped growing -- see how very close together the growth rings are at the ends of the samples. Even dry weather does not account for this reduction in growth. Some red spruce are also showing signs of thinning at their tops, and their needles are developing yellowish burned spots. Researchers are working to discover for sure what is causing these problems, but air pollution is a prime suspect."

Wrap up could follow as such: "As we continue our walk, think about what you could do at home to help reduce air pollution both personally and politically!"

SUGGESTED EVALUATION:
- Ask the audience to describe some of the sources of air pollutants.
- Ask the audience to list some of the adverse effects of air pollution on forests. Make written records of visitors comments.

BACKGROUND INFORMATION:
- The high elevation spruce-fir forests of the Great Smoky Mountains National Park are experiencing a decline in vigor and growth. At elevations of 6,000 feet and above, the annual growth rate of red spruce for the last 10 years is half the annual growth rate prior to 1960. In addition, the red spruce are exhibiting other stress symptoms correlated with elevation, such as thinned crowns and dead tops. The upper surfaces of needles on red spruce saplings exhibit necrotic lesions (yellow spots on the needles). Scientists suspect this may be related to ozone pollution. Although concrete evidence has not yet been produced, the consensus among scientists is that red spruce are experiencing damage from air pollution. Furthermore, this damage does not appear to be associated with only one particular pollutant but appears to involve the interaction of as many as three forms of air pollutants.

In Sequoia National Park, over one-third of 540 ponderosa pine trees studied periodically since 1980 show moderate to severe ozone injury. Injury is also common on oak trees and Jeffrey pines. Foliar symptoms, like ozone injury, have been recently observed on giant sequoia seedlings in the park.

REFERENCES:

DEVELOPED BY:
- Marcia Seager
  The Ohio State University
- Jill Blumenthal, Margaret Malm, Candace Tinkler, and Bryant Woods
  Zion National Park
- Maria Fernandez-Ginenez
  Bryce Canyon National Park
- Janet Scharf
  Olympic National Park
PROGRAM 3

TITLE: Stream Walk Input

AUDIENCE: Adult and youth

DURATION: 30 Minutes

SITE: National Park Service units

PROGRAM TYPE: Guided walk

FACT SHEET REFERENCE: 2, 3, 7, 19, 20, 21, 22

PARK THEME:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
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PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to list natural and human-caused factors affecting stream acidity.
2. The audience will be able to list some effects of increased acidity on stream life.
3. The audience will participate in hands-on measurement of stream water pH and conductivity using portable meters.

PROGRAM DESCRIPTION:

Materials needed:
- Portable pH and conductivity meters
- Thermometer
- Containers for stream water samples (e.g. plastic cups)

The conductivity meter, pH meter, and thermometer can be purchased as a set from Whatman Lab Sales, P.O. Box 1359, Hillsboro, Oregon, 97123. The cost was $115.00 as of 1987.

At a suitable place along a stream, have the audience stop to look for salamanders or other stream dwelling organism. One technique to open with could be: "This National Park is one of the best areas to find salamanders. There are a number of different species living here in the park. Some live in the streams, some live near the streams, but they all depend on water to survive. Changes in water quality can affect the salamanders' ability to survive and reproduce. What kinds of things do you think could affect water quality?" Probable answers to this question include pollution from human waste (sewerage), industrial wastes (including toxic chemicals), and acidic deposition. Other answers are possible. Focus on acidity. Suggest to the audience, "Acid rain isn't the only reason streams become acidic. Sometimes natural rock formations play a big part in changing water quality. Some rocks are naturally acidic. When an acidic rock gets into a stream because of erosion or a landslide, the stream water becomes more acidic. But the effects on the
stream are the same, whatever the reason for acidification. As a stream becomes more acidic, fewer fish and amphibians can survive. Some cannot reproduce well -- eggs or young may be harmed by the acidic water. Others die or move to areas where the water is less acidic. Many insects that feed on algae disappear, and rocks along the stream may become covered with green algae. Thus, the algae begin extracting excess amounts of oxygen from the stream."

Take out the pH and conductivity meters. (Make sure they have been calibrated with distilled water before the walk. Distilled water can be purchased at a grocery store.) Convey to the audience that scientists in the national park are working to discover why streams are becoming acidic. Researchers monitor the air quality to find out how much acidic deposition falls in the park. They test soil and rock formations to find natural sources of acidity. And they monitor water quality to find out how streams in the park are affected by acidity. We can do our own tests right here. This is a pH meter. The pH scale ranges from 0 to 14 with 14 being very alkaline, 0 being very acidic, and 7 being neutral. The pH meter measures how acidic or alkaline the water is. Hence, the lower the reading, the more acidic the water is. For example, lemon juice, which has a pH of 2.0, is very acidic; lye, which has a pH of 12.4, is very alkaline. Most rainwater in the eastern United States tends to be acidic with a pH range of 4.9-6.0. Scientists have found that many aquatic creatures have trouble surviving in water with pH less than 5. Let's see how a sample from this stream reads."

Have two or three of the visitors collect water samples in plastic cups. Try to get samples from different places -- from near the bank, the middle of the stream, a quiet pool, fast-running water. Test each sample; compare them to each other. Are they the same? Different? Is the pH less than 5.0 in any of the samples?

Check the conductivity of your samples. You may wish to say to the audience, "Scientists also measure how well water samples conduct electricity. The more acidic water is, the more materials will dissolve in it. The more materials there are dissolved in water, the better it will conduct electricity. Distilled water, with nothing dissolved in it, barely conducts electricity. This meter measures conductivity. The higher the reading, the better the sample will conduct electricity. Let's check the conductivity of our water samples. What are these readings telling us?"

Higher conductivity readings mean more dissolved substances, which indicates more acidic water. Higher conductivity readings should correspond to lower pH readings. Ask the audience, "Do these conductivity readings seem to support the pH tests we just did? What do you think about the water quality in this stream?"

The thermometer can be used as a hands-on activity also. Some aquatic species need a certain temperature range in order to survive or reproduce effectively.

Conclude by asking the audience, as they continue the walk, to think about how deteriorating water quality could affect their lives. Also ask them to generate ideas of how they could help to prevent water pollution. Possible ideas include: being energy efficient, supporting government and industrial efforts to clean up water problems, and learning more about the subject through libraries, television, and special programs such as National Park Service interpretive activities.

SUGGESTED EVALUATION:

Ask visitors what they think are natural and human caused factors affecting stream acidity.

Ask the visitors what they think are some of the effects of increasing acidity on stream life.
BACKGROUND INFORMATION:

Lake, river, and stream waters with a pH below 4.5 have a greatly reduced diversity of fish species. Even at a pH of 5.0 only limited fish populations can survive; populations of frogs, salamanders and many other creatures are greatly reduced. Fish taken from waters which are becoming acidic exhibit high concentrations of mercury and other toxic metals in their tissues—presumably leached out of soils and bedrock. A U.S. government study estimated that 55% of the lakes and 42% of stream-miles in the eastern United States are currently being subjected to acidic deposition which will eventually lead to deterioration. The susceptibility of a lake or stream to acid rain is determined to a large extent by the type of surrounding bedrock. Limestone neutralizes acid. Areas rich in limestone act as a buffer and the waters are not as severely affected. Streams and lakes with a granite foundation, which has little or no buffering capacity, are more easily acidified.

The following information was taken from "Acid Rain: Effects on Fish and Wildlife" by the Fish and Wildlife Service, United States Department of the Interior.

The acidity and alkalinity of a substance is measured on a pH scale. This scale measures the activity of hydrogen ions (H+) in a substance (pH stands for "potential hydrogen"). The scale runs from 0 to 14 where 0 is extremely acidic, 7 neutral, and 14 is extremely alkaline, or basic. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to 3 would be a hundred times (10 x10) increase in acidity.

The subtle process of acidification often remains undetected until damage has occurred. In the vicinity of pH 6.0, several animals decline that are important food items for fish; these include freshwater shrimp, crayfish, snails, and some small mussels and mayflies.

Fish species also differ considerably in their tolerance to low pH. For example, the fathead minnow, Arctic char, brown trout, Eurasian perch, and northern pike are especially sensitive to pH declines. Because early life stages are generally more sensitive to low pH than older fish of the same species, declines in larval fish numbers may be early evidence of acidification—if other variables are not responsible.

The following information is taken from "Acid Deposition: Disruption of a Lake Ecosystem" by the Federation of Ontario Naturalists.

Lakes that are acidified become clearer, allowing light to penetrate deeper. Since more light is available for photosynthesis at or near the bottom of a lake, algal populations can grow at deeper sites, leading to competition for nutrients with plankton (microscopic animals).

Salamanders and frogs are particularly susceptible to increased acidity because they lay their eggs in pools of spring meltwater—which are often highly acidic. Their eggs cannot tolerate the acidity, and so many eggs never reach maturity. Salamander and frog populations are devastated by the impact of the acid, and they begin to die out when the pH dips below 5.5.

REFERENCES:


DEVELOPED BY:
Marcia Seager
The Ohio State University

Teresa Shirakawa and Joy Stiles
Shenandoah National Park
PROGRAM 4

TITLE: INTERPRETING AIR QUALITY EFFECTS ON CULTURAL SITES

AUDIENCE: Adults and youth

DURATION: 3 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Display

FACT SHEET REFERENCE: 2, 3, 7

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.

2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.

2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.

3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
- The audience will be able to comprehend some of the effects acid precipitation has on selected vegetation species.

PROGRAM DESCRIPTION:
Several National Park Service units are experiencing deterioration of cultural materials due to air pollution. The following program describes how one might interpret this critical resource issue to visitors.

When near a monument, ruin, or other suitable site, present a question dealing with the effects of acid rain on materials. The question could be asked: "What effect do you think acid rain has on these historical (or cultural) monuments and ruins?"

Explain to the audience that acid rain does indeed affect materials—in a harmful way. Touch on the fact that air pollutants accelerate the natural weathering and deterioration processes of building materials found in cultural resources. Show the audience signs of material deterioration through photographs or by showing them affected statuary or ruins.

Discuss the conservation efforts of the park and other National Park Service units that deal with this type of deterioration.

Conclude with identifying the need for further studies and what local governments and citizens can do to help the situation.

SUGGESTED EVALUATION:
- Ask visitors for any observations they have made of deteriorating monuments/ruins. Discuss our generation's role in preserving these items.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Former, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
BACKGROUND INFORMATION:
The following is taken from "Acid Rain Invades Our Parks" by the National Parks and Conservation Association.

Air pollutants, namely sulfur oxides, nitrogen oxides, and ozone, accelerate the natural weathering and deterioration processes of building materials found in cultural resources. A few of the building materials include: limestone, marble, carbonate-based paints, and galvanized steel.

STONE:
Stone is affected by acidic deposition in several ways. These include chemical, mechanical, and biological deterioration. The acid pollutants in the rain begin to dissolve calcite, which is the principal material in limestone and marble. Acid deposition can also accelerate the mechanical decay of stone. As the sulfate compounds accumulate in the body of the stone, pressure builds, and finally the stone cracks (Sherwood, 1985).

BRONZE:
Bronze corrosion is also accelerated by sulfur dioxide and its transformation products (sulfuric acid). Bronze alloys, composed of copper zinc, lead and traces of other metals, are typically used architecturally and in the construction of statutes. Thus, an understanding of the effects of sulfur oxides and acid deposition on each of the compounds inherent in the alloy must be understood to adequately explain bronze corrosion.

Bronze, upon exposure to acid pollutants in the environment, will form a black layer of corrosion composed of copper oxides or copper sulfates. The persistence of this layer of corrosion is favored by the presence of the lead in the alloy. A green-black corrosion layer may also form depending on the sulfur oxide concentration in the atmosphere. These various corrosion layers dissolve rapidly at or below pH 4.0, exposing metal surfaces. Additionally, deposition of particles will increase pitting of the copper and create localized areas of corrosion. Finally, removal of the zinc portion of the alloy (dezincification) can also occur, resulting in disfiguration of the surface of the metal (Sherwood, 1985).

DEVELOPED BY:
Michael Panhorst and Karen Rehm
Fredericksburg and Spotsylvania National Military Parks

D.L. Turnbo
Shiloh National Military Park

Dave Roberts
Fort Union National Monument
PROGRAM 5

TITLE: Air Quality Workshop

AUDIENCE: Adults and organized groups, self-selected interest in air quality issues

DURATION: 4 hours (shorter programs can be adapted from this workshop)

SITE: Great Smoky Mountains National Park and Sequoia-Kings Canyon National Parks

PROGRAM TYPES: Workshop/guided activity

FACT SHEET REFERENCE: 1-29

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments.
3. To encourage and facilitate appropriate, safe, minimum impact use of the park’s resources.

PROGRAM GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park’s resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park’s resources and the entire National Park System’s significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to describe air quality research projects which are ongoing in selected National Park Service units.
2. The audience will be able to describe the concept of “prevention of significant deterioration” of air quality.
3. The audience will be able to list the documented effects of ozone pollution on white pines.
4. The audience will be able to list three problems occurring in red spruce trees which are suspected to result from air pollution.
5. The audience will be able to describe the difference between “good” ozone in the upper atmosphere and “bad” ozone close to the earth’s surface.
6. The audience will be able to describe how ozone is formed close to the earth’s surface.
7. The audience will be able to list some harmful effects of ozone pollution.
8. The audience will be able to list natural and human-caused factors affecting visibility.
9. The audience will be able to name the primary cause of visibility impairment in most National Parks.
10. The audience will be able to list natural and human-caused factors affecting stream acidity.
11. The audience will be able to describe some effects of increasing acidity on stream life.
12. The audience will gain an understanding of scientific measurements by participating in hands-on measurement of stream water pH and conductivity using portable meters.
13. The audience will determine what types of activities they are doing/could do personally to reduce air pollution.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
PROGRAM DESCRIPTION:

Overview
The purpose of a workshop such as this is to acquaint the participants with the general principles concerning air quality. Through a variety of activities, the participants will become familiar with sources of air pollutants, effects of air pollution on plants, streams, and human activity, and current air pollution-related research efforts in the National Park Service.

Materials needed
pH, temperature and conductivity meters
(These meters can be purchased from Whatman Bab Sales, Inc., P.O. Box 1359, Hillsboro, Oregon 97123-1359. Cost was $115 as of 1987). See Fact Sheets 4-6.
covered glass or plastic containers for collecting and holding liquid samples
samples of household liquids or solutions (e.g. lemon juice, baking soda solution, dish soap)
stream water samples
(collect with audience or provide at workshop)
acrylic block specimens of ozone-damaged plants, sensitive aquatic insects (Red spruce tree cores can be purchased from the Acid Rain Foundation, 1630 Blackhawk Hills, St. Paul, Minnesota 55122. Cost was $9.95 as of 1987). The scientists of your park or region can probably provide other pollution-damaged specimens.
posters showing sources of air pollution, stream acidity, pH scale and sensitive species (Air pollution posters can be purchased from the Acid Rain Foundation.)
visibility wheel of fortune (See Visibility Wheel program for instructions on how to make a visibility wheel.)
"Clearing the Air" slide presentation
(Available to all National Park Service units through the regional offices).
pencils and writing paper

Transportation
Carpool to a research site in the National Park Service unit, such as a National Acid Deposition Program site, a National Park Service Regional Particulate Monitoring Network site, or an ozone monitoring site.

Introduction
The "Clearing the Air" slide presentation provides an orientation to air quality subject matter. It summarizes major air and water quality problems and research in the National Park Service. It asks people to think about the ethics of protecting and improving air resources both in the park and in general.

Sources of Pollutants
A good way to begin discussing air pollution issues would be to ask the audience to list some sources of air pollution. Make sure the audience is aware that there are natural sources of air pollution as well as human-caused sources. Natural sources to mention are: volcanoes, fires caused by lightning, vegetation. Human-caused sources include automobiles, factories, coal-burning electric power plants, and burning wood or trash. Note that most of these sources have one thing in common—something is being burned. Display a poster of pollution sources and emphasize that air pollutants, natural or human-caused, affect the environment in many ways. Sulfur and nitrogen compounds contribute to acid rain; sulfur compounds and residue from burning petroleum products reduce visibility. This residue can also react with nitrogen compounds in the presence of sunlight to form ozone. In many cases, air pollution harms vegetation, wildlife, buildings, and people.

Explain that scientists in the National Park Service are conducting research to find out what types of air pollutants are reaching the parks and how those pollutants are affecting plants and wildlife. Many National Parks are protected from "significant deterioration" of air quality under the Clean Air Act. This means that the amounts of air pollutants in the parks cannot increase beyond certain set levels. By conducting research about air pollutants, scientists can provide information to help protect...
maintain the air quality in protected areas.

Field Trip

Allow about two hours, including travel time, to visit research site(s).

IMPROVE Modular Aerosol Monitoring Sampler Site

Fine aerosol particles affect remote areas primarily by impairing visibility and secondarily by producing acidic deposition. Measurement of the concentration and composition of these fine particles are necessary to determine the extent of the problem and possible sources of the particles. The National Park Service has particle measuring devices, known as "Modular Aerosol Monitoring Samplers" within many of its units. Here is an example of what you might say when touring one of these sites:

"The National Park Service and the Environmental Protection Agency have been monitoring particulate concentrations at national parks, monuments, forest, wildlife refuges and other remote sites since 1979 using stacked filter samplers. The particulate monitoring program has been expanded to include other federal agencies with the establishment of the IMPROVE (Interagency Monitoring of Protected Visual Environments) program, designed to determine the extent and causes of visibility and acidic deposition. The IMPROVE program uses a sampler unit known as the IMPROVE Modular Aerosol Monitoring Sampler that collects three samples of fine particles (smaller than 2.5 micrometers) and one sample of respirable particles (smaller than 10 micrometers)."

Share with them that the IMPROVE sampler retains the simplicity of the stacked filter sampler but adds several features, including additional filters for measuring nitrates and carbon, twice the flow rate to improve sensitivity, an improved flow rate measurement system, and fewer sample changes.

Transmissometer Visibility Monitoring Site

A transmissometer visibility monitoring site is used by the National Park Service to collect visibility measurements. These measurements, when analyzed, provide the knowledge needed to determine the interrelated effects that the forces of people and nature have on visibility. Here is an example of what you might share with the audience concerning the transmissometer visibility monitor:

"Visibility represents one of the most important aspects of air quality in National Parks. To meet its responsibilities under the Clean Air Act, the National Park Service has designed a visibility monitoring program which includes both parks and monuments.

The information collected from the monitoring program provides baseline information, identifies the effects due to local visibility impairment and analyzes visibility trends. The equipment that collects visibility data is known as the transmissometer visibility monitor.

The transmissometer measures the amount of light transmitted from an optically focused incandescent light source to a computer controlled receiver. Knowing the intensity of the light source, the distance between the source and the receiver, and the intensity of the transmitted light will allow direct calculation of the average atmospheric extinction due to scattering and absorption along the instrument."

Ozone Monitoring Site

When you arrive, explain that scientists at this lab are studying the effects of ozone on various plant species found in the park. Different amounts of ozone are pumped into each test chamber (Figure 1.0), and the effects on the plants are recorded over time. These results can be compared to records of plant damage noted in the open atmosphere at various sites in the park.
In this way, researchers hope to document just how plants in the park are being affected by ozone. They want to be able to pinpoint sensitive species and areas and make recommendations for protecting these resources.

Hands-on Activity—PLANT SPECIMEN BLOCKS

Show audience acrylic specimen blocks of ozone-damaged leaves. Have them pass the blocks around to get a closer look at the evidence of ozone injury—the dark spots on the leaves. These dark areas show where cells have died. With fewer cells to produce food, plants do not get enough nutrients to stay healthy. Ask the audience if they have seen plants showing this type of injury here in the park, and if so, where they have noticed them. It is possible to see many damaged leaves along the roadsides, especially in heavily travelled areas.

Hands-on Activity—RED SPRUCE TREE CORE SAMPLES

Share with the audience the tree core samples. Encourage the audience to look closely at these tree core samples. Point out that the growth rings become very close together. This indicates that the tree has not grown very much.

Over the last ten years, for example, red spruce in the Great Smoky Mountains National Park have almost stopped growing. Even unusually dry weather does not account for the persistent decline in tree growth in the park. Top red spruce branches are fewer and thinner; needles of younger trees show yellowish ‘burned’ spots. Scientists suspect that air pollution contributes to these types of injury.

National Acid Deposition Program Site

The National Acid Deposition Program (NADP) has many air quality monitoring stations in National Parks (See Figure 1.1). Describe the equipment to the audience. Point out that the wet/dry deposition bucket is used to collect samples of both wet and dry air pollutants. When the weather is dry, particles of pollution settle out of the air, much as dust settles. A sample of these particles falls into the bucket marked DRY, and scientists can test this sample to see what kinds of pollutants are reaching this area.

When it begins to rain, the sensor reacts by moving the cover over the DRY bucket to leave the WET bucket open (demonstrate by dabbing a drop of water or saliva on the sensor).

FIGURE 1.0 OZONE MONITORING CHAMBER

FIGURE 1.1 WET/DRY DEPOSITION
BUCKET

Rain collects in this bucket, and scientists can test it to see what kinds of pollutants are washed from the atmosphere in rain.

After reviewing the scientific research site(s), take the group to the nearby stream (if possible) to collect stream water samples if they have not been previously collected. Collect samples from different areas in the stream: for example, from shallow water, from deep water, from close to the bank, from near the middle of the stream. Label the samples and take them back to the workshop site.

Hands-on Activities—pH AND CONDUCTIVITY TESTING (See Fact Sheets 18, 19, 20)

Use the pH and conductivity meters to test the stream water samples and the various household solutions. Lower pH readings indicate more acidic solutions; higher conductivity readings indicate more dissolved solids present, and indirectly indicate more acidic solutions.

Take the temperature of each sample. All other things being equal, warmer solutions generally contain more dissolved solids and so may register higher conductivity readings than similar, cooler solutions.

Record pH, conductivity, and temperature readings for each sample, and discuss the results. Some questions to ask:

How do these readings compare to one another?
Do the conductivity readings support the pH readings (do samples with lower pH have higher conductivity)?
Do the stream samples register the same or different pH readings?
Are the stream samples similar in pH or conductivity to any of the household solutions tested? Which ones?
Compare the pH of the stream samples to the pH chart. Based on this comparison, is the stream pH dangerous to aquatic organisms?

Effects of Acidification on Stream Life

Discuss the effects of acidification on stream life. Here is an example of what you might say: “We have been testing these substances for acidity. But acid rain is not the only reason streams become acidic. Sometimes, a big reason for stream acidification is natural rock formations which are highly acidic themselves. When water comes in contact with these rock formations, the water becomes acidic too. Other contributors to stream acidity are the types of soil and plants found near the stream. For example, soil around most evergreen trees is measurably more acidic than soil under most deciduous trees. A stream flowing through a spruce or pine forest would be likely to be more acidic than a stream flowing through a maple forest, all other factors being equal.”

“Regardless of the reasons for acidification, the general effects of increasing acidity on stream life remain the same. As acidity increases, some aquatic creatures cannot reproduce effectively; the level of acidity is harmful to either eggs or young. Other creatures die out because their gills are damaged, and still others simply move to an area where they can survive. Many aquatic insects cannot survive in acidic water. Some insects, called ‘grazers,’ feed on the algae that grows on rocks in and near the stream. Without these insects to eat the algae, the balance of the aquatic system becomes upset.”

Hands-on Activity—INSECT SPECIMEN BLOCKS (See Fact Sheet 21)

Show the audience the acrylic specimen blocks of pollution-sensitive insects such as the mayfly larva. Explain that these insects cannot live in very acidic water. One way to tell how healthy a stream is is to see how many of these insects are present. Creatures that are sensitive to pollutants are called “indicator organisms.” Their presence or absence is an indication of whether or not a stream is being polluted.
Visibility

Begin by getting the audience to think about how air pollution affects them. Here is an example of a transition you might use: "We have seen some ways in which air pollution can affect plants and wildlife. How does air pollution affect you?" Possible responses include health effects, economic effects, and/or esthetic effects. Focus the discussion on esthetics, especially the value people place on a scenic view. Explain to the audience that a major problem in many parks is a loss of visibility due to increasing amounts of air pollution. Particles of sulfur compounds and residue from burning petroleum products hang in the air, forming a haze which limits how far and how clearly people can see. National Parks are facing the problem of how to maintain clear vistas.

Hands-on Activity—VISIBILITY WHEEL OF FORTUNE (See Program Sheet 6)

The visibility wheel is designed to reflect a visitor's chance of coming to a particular park and seeing a clear, long-distance view of the mountain scene, based on statistics for the summer months when the visibility problem is most severe. (The scientists in your Park or region should be able to provide you with visibility data for summer months.) A visitor has a good chance of seeing a moderate distance, less chance of seeing a very short distance, and least chance of seeing a very great distance. Have the audience spin the wheel to find out how far they can "see." Pictures of the same view taken under different visibility conditions correspond to the chance distances on the wheel. (Slides showing the variations in visibility of the same vista are available for many parks through the National Park Service Air Quality Division in Denver.) Ask the audience which view they would rather see. Ask how much value the audience places on a "good view." For example, you might say, "If you knew in advance that visibility would be poor, would you still want to visit the park?"

Ethics

Review with the audience the topics covered in the workshop so far and ask them to suggest ways to reduce air pollution. You might say something like this: "Think again about the effects of air pollution that we've looked at today. Remember the human-caused sources of air pollution that we discussed. What can people do to help reduce air pollution?" Make a list. Possible items for the list include walking, riding a bike, or using mass transportation instead of driving a car; line-drying laundry instead of using a dryer; waiting for a full load to run a dishwasher; turning off appliances and lights when not in use; recycling paper, aluminum, glass. Many more are possible. Stress that it is each of our responsibilities to become informed on the topic of air pollution in terms of local, national, and world issues. We must know how air pollution affects our health, our environment, and our economy. Point out that it is a complex problem requiring complex solutions...but it will not go away be itself.

Conclusion

Close the workshop by emphasizing the importance of improving air quality and maintaining natural areas. Repeat that there are many ways people can help to reduce air pollution, thus not only protecting natural areas but enhancing the quality of human life. Here is an example of what you might say: "Today we have discussed some of the harmful effects of air pollution, and we have looked at ways each of us can help to reduce air pollution. Natural areas like National Parks provide homes to plants and animals, some of them unique or endangered. They also provide us with places to go for recreation and help support the tourism industry. If air pollution harms wildlife and plants or limits how we can use these natural areas, we all stand to lose. Perhaps the greatest importance in maintaining natural areas is in the choice they represent simply by their existence."
Opportunities to be close to nature do exist, and with care will continue to exist in the future. Protecting natural areas not only preserves life and land, but offers a proof of society's commitment to improving the quality of human life.

NOTE:
Only a limited amount of the range of air monitoring equipment in use today was discussed. It is suggested that you work closely with your park or regional scientists to better understand what equipment is being used in your park and to help you stay abreast of new technologies being introduced.

SUGGESTED EVALUATION:
Have the visitors write one paragraph (provide pencils and paper) on "We as a society can improve our air quality by: ___________. "I as an individual will: ___________.

BACKGROUND INFORMATION:
NATIONAL PARK SERVICE AIR QUALITY RESEARCH PROGRAM

The following section is taken from: Air Quality in the National Parks by the National Park Service, Air Quality Division (Denver).

The National Park Service established an air quality research program in 1979. Air quality research is conducted to determine the current status of air quality in the National Park Service units and to identify any effects air pollution is having or may have on National Park Service resources or visitor experiences. Air quality research is also conducted to determine sources of air pollution in the parks and the sensitivity of park resources to air pollution. The National Park Air Quality Research Program provides information needed to participate effectively in decisions that can affect the air quality in and near National Park Service units, and helps the National Park Service manage air quality resources as a part of its resources protection mandate.

The National Park Service Air Quality Research Program involves an extensive network of monitoring for pollution, visibility conditions, and biological effects in National Park Service units.

ACID DEPOSITION EFFECTS ON CULTURAL MATERIALS

The following is taken from “Acid Rain Invades Our Parks” by the National Parks and Conservation Association.

Air pollutants, namely sulfur oxides, nitrogen oxides, and ozone, accelerate the natural weathering and deterioration processes of building materials found in cultural resources. A few of the building materials include: limestone, marble, carbonate-based paints, and galvanized steel.

ACID RAIN: EFFECTS ON AQUATIC SPECIES AND SYSTEMS

The following information was taken from “Acid Rain: Effects on Fish and Wildlife” by the Fish and Wildlife Service, United States Department of the Interior.

The acidity and alkalinity of a substance is measured on a pH scale. This scale measures the activity of hydrogen ions (H+) in a substance (pH stands for “potential hydrogen”). The scale ranges from 0 to 14 where 0 is extremely acidic, 7 neutral, and 14 is extremely alkaline, or basic. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to 3 would be a hundred times (10 x10) increase in acidity.

Fish species also differ considerably in their tolerance to low pH. For example, the fathead minnow, Arctic char, brown trout, Eurasian perch, and northern pike are especially sensitive to pH declines. Because early life stages are generally more sensitive to low pH than older fish of the same species, declines in larval fish numbers may be early evidence of acidification—if other variables are not responsible.
INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS PROGRAM AND MODULAR AEROSOL MONITORING SAMPLER

The following materials were taken from "IMPROVE Sampler Manual" by Dr Robert Eldred, Air Quality Group, Crocker Nuclear Laboratory.

Fine aerosol particles affect remote areas primarily by impairing visibility and secondarily by producing acidic deposition. Measurements of the concentration and composition of these fine particles are necessary to determine the extent of the problem and possible sources of the particles.

The National Park Service and the Environmental Protection Agency have been monitoring particulate concentrations at national parks, monuments, forests, wildlife refuges and other remote sites since 1979 using stacked filter samplers. The particulate monitoring program has been expanded to include other federal agencies with the establishment of the IMPROVE (Interagency Monitoring of Protected Visual Environments) program, designed to determine the extent and causes of visibility impairment at selected class I areas throughout the United States.

THE TRANSMISSOMETER VISIBILITY MONITOR AND THE NATIONAL PARK SERVICE VISIBILITY MONITORING PROGRAM

The following information was taken from "Plans for IMPROVE: A Federal Program to Monitor Visibility in Class I Areas" by David Joseph, National Park Service Air Quality Division.

Visibility represents one of the most important aspects of air quality in National Parks. To meet its responsibilities under the Clean Air Act, the National Park Service has designed a visibility monitoring program which includes both parks and monuments.

The transmissometer measures the amount of light transmitted from an optically focused incandescent light source to a computer controlled receiver. Knowing the intensity of the light source, the distance between the source and the receiver, and the intensity of the transmitted light will allow direct calculation of the average atmospheric extinction due to scattering and absorption along the instrument.

DEPOSITION MONITORING: WET AND DRY DEPOSITION EQUIPMENT AND THE NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

The following is taken from Acid Rain: "What is it and How is it Measured", by Andy McRae and John Peine, Uplands Field Research Laboratory, National Park Service.

The Environmental Protection Agency has begun a national air quality project which became formally established as the National Atmospheric Deposition Program (NADP) in 1978. The NADP headquarters is located at the University of Illinois in Champaign. Its purpose is to gather data on air quality in this country.

There are 100 plus NADP collecting stations across the country. These sites are set up to collect precipitation (snow, rain, ice, etc.) and dry fallout (the settling of airborne particles to the ground (dust, soot, dirt).

VISIBILITY IMPAIRMENT: WHAT IS IT?

Many people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid 1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas.

DEVELOPED BY:
Kim Baker and Marcia Seager
The Ohio State University

Nancy Muleady and Dawn Vernon
Sequoia and Kings Canyon National Parks
PROGRAM 6

TITLE: Visibility Wheel Program

AUDIENCE: Adults, youth, and students (Grade K-12)

DURATION: 10 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Roving interpretation

FACT SHEET REFERENCE: 1, 2, 3, 4, 6, 23

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to list some common air pollutants.
2. The audience will be able to list the causes of visibility impairment.

PROGRAM DESCRIPTION:
By building on the popular game show, "Wheel of Fortune," the visibility wheel can be a very educational tool when trying to convey a visibility impairment message (See Figure 1.0). The following directions will guide you in making your own visibility wheel.

Materials needed
2 hinges (3" long)
1 2x4x25" pine board
1 sheet .5" plywood
Small finishing nails (1.5" long)
2 larger nails (2" long)
1 medium size rubber band
1 small bolt at least 2.5" long

FIGURE 1.0 VISIBILITY WHEEL

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
Tools needed
Hammer, hacksaw, electric sabre saw, radial saw, piece of string and pencil, yardstick, drill, screwdriver

Lay out the wheel and base on the plywood. Draw a square "x". Now draw from opposite corner to corner to find center. Tack one finishing nail to the center. Tie string to nail loosely. Now take a pencil and tie it to the other end of the string. Roll string on pencil until it lines up with the side of the square. Draw a circle around the nail keeping the string taut. Next draw a rectangle base "x". Cut out with sabre saw or radial saw.

Next cut a 2x4" piece long. Take a hacksaw and cut the head off the pin inside one of the hinges. On the end of the 2x4 drill pilot holes for the screws to attach the hinges to. Attach hinges to each side of the 2x4 flush with the end. Next drill pilot holes in the center of the base and attach hinged 2x4 to base.

Drill a hole a little bigger than the 2.5" bolt from the opposite end of the 2x4. Also drill the same size through the center of the wheel. Attach wheel to 2x4.

Draw 16-20 equal parts on the wheel (pie-shaped). Drive finish nails just deep enough to have one sticking out on every line .5 from the edge. Then drive a nail in the center of every partition .5 inch from the edge.

Make a clicker (pointer). Cut a piece of plywood 3" long by 1" wide. On one end draw a point and cut it out. Drill a hole a little bigger than one of the large nails. Install the clicker so that it is connected to your 2x4 just below the wheel where it will reach the nails on the wheel. Now drive your other large nail 2" inches below the clicker. Then drive a finishing nail into the square end of the pointer and stretch the rubber band across these two nails.

Spin the wheel. It should spin freely and the clicker should click against the nails as the wheel spins. Paint each pie-shaped area to your own preference, and add the respective visibility miles to the areas.

Each of the equal parts should be given a number which represents how many miles you can see of specific days. Based on data from your park, a ratio should be established. On the Great Smoky Mountains National Park visibility wheel two of the 16 units show 6 miles, 14 show 30 miles, and 2 show 155 miles. Thus the visitor to the Smokies has a 1 in 8 chance of seeing 155 miles or of seeing 5 miles. Of course these chances are different based on the particular season.

Here are a few ways of conveying a visibility message using the visibility wheel:

Here is a way of using the visibility wheel to convey a visibility message. As a visitor approaches the visibility wheel, ask the visitor to spin the wheel. Explain that because visibility changes from day to day, some times are better than other times to see a clear view of the park. Relate to the visitor that the miles on the visibility wheel are typical of what occurs during the summer.

SUGGESTED EVALUATION:
Ask the visitors to compare this site with the air quality at their homes.

BACKGROUND INFORMATION:
Atmospheric conditions, including particles and gases in the air, determine visibility conditions which influence how easily a person can see through the air. There are several different quantitative measures of visibility conditions that characterize different aspects of these conditions.

Air pollution can be visible in three forms: uniform haze, layered haze, and plumes. Uniform haze is a homogeneous haze that reduces visibility in every direction from the observer and occurs when the air is well mixed and the pollutants are evenly distributed. Layered haze is seen as a band or bands of discoloration, with a noticeable boundary between the more polluted and the cleaner air. A plume is a band of discoloration that can typically be seen to be coming from a nearby
source, and is formed when there is a surface wind to carry visible pollutants horizontally from an emission source into a stable atmosphere.

The current status of visibility at National Park Service units is as follows: In excess of 90% of the time, scenic vistas are affected to some degree by human-caused pollution at all National Park Service monitoring locations. The best visibility at monitored sites is in eastern Nevada, western Utah, and southern Idaho, while the worst visibility at monitored National Park Service units is in Shenandoah and Great Smoky Mountains National Park. Visual range at National Park Service units is typically best in the winter and worst in the summer when meteorological conditions are such that more pollution is transported from urban areas and industrial developments to remote areas, causing more uniform haze to occur in the winter months.

Fine particles are generally responsible for a major share of visibility impairment at monitored National Park Service units. On the average, soil-related material is responsible for 10% to 30% of the visibility impairment.

Fine sulfate particles, from human-caused sulfur oxide emissions, are the single most important contributor to visibility impairment in National Park Service units except in the northwestern United States where fine carbon from human-caused and natural burning plays a more prominent role.

REFERENCES:


PROGRAM 7

TITLE: Junior ranger

AUDIENCE: Children (age 8-12 years)

DURATION: Two days to complete workbook

SITE: National Park Service unit

PROGRAM TYPE: Junior Ranger Workbook (insert page, self-guided)

FACT SHEET REFERENCE: 2, 3, 4, 27

PARK THEME:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage and facilitate appropriate, safe, minimum impact use of the park's resources.

PROGRAM GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to list natural and human-caused sources of air pollution.
2. The audience will determine what types of activities they are doing/could do personally to reduce air pollution.
3. The audience will complete games and an art activity with air quality themes.

PROGRAM DESCRIPTION:

WE CARE ABOUT CLEAN AIR PUZZLE

Ranger Smith needs to find out why some plants in the park are being damaged. Help the ranger find the answer by matching the symbols and letters to solve the puzzle.

MATCHING
Air pollution is a big problem today, even in our National Parks. Some air pollutants are formed naturally by plants, fires, or volcanoes. But most air pollution comes from human activity. Fumes from cars, factories, or coal-burning power electric power plants all cause air pollution.

Look at this list of air pollution sources. Write an H next to the sources caused by human activity. Write an N next to the sources caused naturally.

- Smoke from a factory
- Car exhaust
- Volcano erupting
- Burning coal to make electricity
- Chemicals released by trees
- Fire caused by lightning
- Campfire

What do almost all of these sources of air pollution have in common? Can you think of other sources of air pollution? List them.

WHAT CAN YOU DO?
Which of the following activities are you doing at home to help reduce air pollution? Which of these COULD you do?
1. Walk short distances instead of taking a car.
2. Use a carpool or mass transportation like buses.
3. Ride a bike instead of taking a car.
4. Turn off lights, radios, televisions when no one is using them.
5. Run the dishwasher only when it is full.
6. Use the air conditioner only when someone is at home and when it is very hot.
7. Dry laundry on a clothesline instead of using a dryer.
8. Keep your furnace properly adjusted.
9. Keep the thermostat in your house set at a lower temperature in winter and wear warmer clothing.
10. Do not burn trash or leaves.
11. Re-use or recycle paper, glass, and aluminum, whenever you can.

Can you think of other things you could do to help reduce air pollution: Make a list.

AIR QUALITY MAZE: (see sketch)

AIR QUALITY BOOKMARK: (see sketch)

NOTE: These activities are designed to fill both sides of a piece of standard 8.5" x 11" paper. See accompanying sample layout.

SUGGESTED EVALUATION:
Ask the children what they think are natural and human caused factors causing air pollution.
Review the air quality workbook insert to see if it was completed correctly.

BACKGROUND INFORMATION:
Air pollution may be defined as any human-caused substance added to the air. Acid deposition is the technical name including all types of acidic deposition ("acid rain") and the deposition or settling out of dry acidic particles. Acidic deposition is thought to cause the death of much animal and plant life in lakes and streams, and may be killing trees in several areas of the world. Marble buildings are also harmed by acidic rains; acid turns marble into gypsum and this crumbles out of the stone.

Acidic deposition is only one problem resulting from polluted air. Reduced visibility, ozone damage, and health problems are also caused by air pollutants. Scientists study the effects of air pollution on the trees, plants, soil, and animals in National Park Service units. Sources of air pollution, such as power plants and industries, which may be hundreds of miles from this area, arrive here with the air masses that move across the continent. Other sources of pollution, such as automobiles, may be found in almost any area. In areas like the Great Smoky Mountains National Park, millions of tourists come during the year by way of cars, buses, and motor homes, exhausts add substantially to the air pollution problem in the area.

The most well known air pollutants and their human-caused sources are:

1. nitrogen oxides
   -automobiles
   -power plants
2. sulfur dioxide
   -power plants
   -industries
   -metal ore smelters
3. ozone (O₃)
   -made from a chemical reaction in the atmosphere of nitrogen oxides and hydrocarbons
4. particulates (solid or liquid fine particles in the air)
   -agricultural practices
   -industry
   -automobiles
5. carbon monoxide
   -automobiles
6. hydrocarbons
   -automobiles

These substances are also produces through natural means such as forest fires, volcanoes, and decay.
VISIBILITY IMPAIRMENT: WHAT IS IT?
Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid 1970's Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas.

The preservation of unique scenic resources is very important to the National Park Service. National Park Service visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected to some degree by human-caused pollution at all monitoring locations within the lower forty-eight United States.

WHAT IS VISIBILITY?
Atmospheric conditions, including particles and gases in the air, determine visibility conditions which influence how easily a person can see through the air. There are several different quantitative measures of visibility conditions that characterize different aspects of these conditions.

Air pollution can be visible in three forms: uniform haze, layered haze, and plumes. Uniform haze is a homogeneous haze that reduces visibility in every direction from the observer. It occurs when the air is well mixed and the pollutants are evenly distributed. Layered haze is seen as a band or bands of discoloration, with a noticeable boundary between the more polluted and the cleaner air. A plume is a band of discoloration that can typically be seen to be coming from a nearby source. It is formed when there is a surface wind to carry visible pollutants horizontally from an emission source into a stable atmosphere.

The following information is taken from "Known Air Pollution Effects on Aquatic Systems in National Park Service Units" by the National Park Service.

The Great Smoky Mountains National Park is experiencing a temporary elevation of sensitive stream acidity following acid deposition events. Isle Royale National Park is experiencing a temporary increase in acidity of surface waters following acid rain events. Shenandoah National Park is experiencing decreases in alkalinity and available soil nutrients in sensitive streams. Sequoia National Park is experiencing temporary increases in lake acidity following summer storms.

REFERENCES:

DEVELOPED BY:
Kim Baker and Marcia Seager
The Ohio State University
PROGRAM 8

TITLE: VISITOR CENTER EXHIBITS

AUDIENCE: Adults and youth

DURATION: 5 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Exhibit

FACT SHEET REFERENCE: 2, 3, 4, 5, 6, 23

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
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PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
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PROGRAM OBJECTIVES:
The audience will be able to describe sources of air pollutants

PROGRAM DESCRIPTION:

Cuyahoga Valley National Recreation Area has developed a three-panel temporary display for use in a visitor center with text and graphics to illustrate:

WHAT GOES UP...
An illustration of sources of air pollutants that cause acidic deposition and how these pollutants interact in the atmosphere.

HOW ACID IS IT?
This will be an interactive section that will allow the visitor to guess the pH values of common substances.

TEST THE WATERS
Another interactive section--visitors will use a pH meter to determine the pH of the most recent precipitation and creek water.

...MUST COME DOWN
Hypothesizes the effects of acidic deposition on park resources

WHAT NEXT?
Suggestions for alternatives that the public can engage in to reduce acidic deposition.

Big Bend National Park has developed a visibility exhibit that includes three photographs showing different visibility increments and their frequencies that occur at the Park. The exhibit also discusses different types of pollutants that impair visibility, and efforts that the National Park Service is making to improve visibility.

Bryce Canyon has developed an air quality visitor center exhibit. Photographs in the exhibit show air quality measuring instruments and different visibility increments. Text surrounding the photographs explains the photographs and discusses the air quality airshed concept.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Can- w Mullins and Rosanne W. Former, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
Assistance for developing such exhibits is available through the National Park Service Air Quality Division (Denver) and your Regional Chief Scientist. The National Park Service has a number of excellent visitor center exhibits and wayside exhibits in place that can serve as examples for your area.

**SUGGESTED EVALUATION:**

Count the number of people who approach and read the exhibit, or gear the evaluation towards the types of questions that are asked concerning the exhibit.

Have an interpreter ask visitors to comment on the exhibit.

**BACKGROUND INFORMATION:**

Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid 1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas. The preservation of unique scenic resources is one primary goal of the National Park Service. National Park Service visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected to some degree by human-caused pollution at all monitoring locations within the lower forty-eight United States.

**DEVELOPED BY:**

Carol Spears  
Cuyahoga Valley National Recreation Area

Robert Rothe  
Big Bend National Park

Margaret Littlejohn  
Bryce Canyon National Park
PROGRAM 9

TITLE: NATIONAL PARK SERVICE NEWSPAPER ARTICLES DEALING WITH AIR QUALITY

AUDIENCE: Mixed adults

DURATION: 10 minutes

SITE: National Park Service unit

PROGRAM TYPE: newspaper

FACT SHEET REFERENCE: 2, 3, 4, 5, 26

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to comprehend some of the effects acid precipitation has on selected vegetation species.

PROGRAM DESCRIPTION:
Air quality articles found in National Park Service newspapers can serve as an effective interpretation tool. A large audience can be reached, since many park visitors read the National Park Service newspapers. Bryce Canyon's "Hoodoo," Great Smoky Mountains' "Smokies Guide," and Sequoia/Kings Canyon's "Sequoia Bark" are just a few of the National Park Service units that incorporate air quality issues into their newspapers.

Here is an example of a air quality article written for the "Sequoia Bark."

"I don't trust air I can't see," is an often heard joke from people who live in smoggy areas. But the joke is on all residents of planet earth. For those of you have come to Sequoia and Kings Canyon National Parks to escape the smog and breathe fresh air, there is smog startling new information. On a typical summer afternoon in Giant Forest, the ozone level is higher at the 6,000 feet elevation level in the Sierra than down in Fresno! Views seen from Moro Rock and other vista points have diminished significantly in the past several decades, and air-pollution-caused damage to living things is now being recorded here in the parks.

In Sequoia and Kings Canyon National Parks, research is occurring to understand the nature of these threats to our air quality. This work is essential because the pollutants invading the parks have the long term capability of significantly changing the vegetation and aquatic systems of these parks.

Human-caused pollutants are invading the parks in at least two different forms--ozone and acid deposition.

Ozone, a relatively rare form of oxygen which is made by the energy of the sun from automobile exhaust, is a caustic has which
burns and damages leafy vegetation on plants. Jeffrey Pines and Black Oaks are particularly susceptible. Ongoing research in the parks is working to both monitor ozone levels and tie them to specific damage to trees.

Acid deposition is receiving a great deal of attention in these parks. Two chemical pollutants, nitrates and sulfates, are of importance because they can combine with atmospheric water to form acids. Nitrates can become nitric acid and sulfates can become sulfuric acid when these acids come into contact with living things they can hurt or even kill. So far, little acidification has been noticed in these parks but intensive study is underway to monitor the levels of acid precipitation received by the parks and to watch for impacts on living things.

In order to understand the Sierra's acid deposition problem the research department in Sequoia and Kings Canyon is carrying out or coordinating over 30 related studies ranging from soil chemistry studies to analyses of microscopic plankton and diatoms in high country lakes.

Most of these studies are being done at one of three special study zones. The first is in the foothill portion of the parks, near Ash Mountain Park headquarters at an altitude of about 2,000 feet. A second study site is at Log Meadow near the south edge of the Giant Forest at an altitude of nearly 7,000 feet. The third site is at a high elevation lake above lodgepole called Emerald Lake. Together the tree sites provide a profile of the natural environments of the southern Sierra.

Why are we studying acid deposition here? Two reasons stand out. First, our particular geography makes this area very susceptible. California's landforms tend to concentrate pollutants from both the Bay Area and the Great Central Valley in the southern San Joaquin Valley area adjacent to Sequoia and Kings Canyon National Parks. The area from Fresno to Bakersfield often has very dirty air in summer.

Secondly, we are studying acid deposition here because these mountains contain many natural systems that are very susceptible to air pollution damage. Sierran soils tend to be naturally acidic, and additional chemical inputs may push them over the line that make environments unfriendly for plants and animals.

In the air quality arena, our research programs have an important role to play. Efforts now underway to document air quality problems may be essential in the long-term survival of the special resources these parks were created to preserve.

(Prepared by Nancy Muleady, Dawn Vernon, and Bill Tweed)

SUGGESTED EVALUATION:
Count the number of newspapers that are distributed over a period of time.
Take the copy of the air quality article to a local newspaper for review and editing, and/or send the copy to the Air Quality Division of the National Park Service located in Denver, Colorado.

BACKGROUND INFORMATION:
Air pollution may be defined as any human-caused substance added to the air. Acid deposition is the technical name including all types of acidic deposition ("acid rain") and the deposition or settling out of dry acidic particles. Acidic deposition is thought to cause the death of much animal and plant life in lakes and streams, and may be killing trees in several areas of the world. Marble buildings are also harmed by acidic rains; acid turns marble into gypsum and this crumbles out of the stone.

Acidic deposition is only one problem resulting from polluted air. Reduced visibility, ozone damage, and health problems are also caused by air pollutants.

DEVELOPED BY:
Margaret Littlejohn
Bryce Canyon National Park

Nancy Muleady, Bill Tweed, and Dawn Vernon
Sequoia/Kings Canyon National Park
PROGRAM 10

TITLE: PUBLIC HANDOUT PROGRAM

AUDIENCE: Adults and youth

DURATION: 5 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Roving Interpretation

FACT SHEET REFERENCE: 2, 3, 4, 5

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park’s resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park’s resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park’s resources and the entire National Park System’s significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to name major air pollutants.
2. The audience will be able to describe the origin of major pollutants.

PROGRAM DESCRIPTION:
One way that interpreters can communicate with visitors is through handouts dealing with air quality topics. It is hoped that through handouts interpreters can encourage the visitor to consider the environmental costs on National Park Service units if poor air quality continues. The following information cites two examples of air quality handouts.

1) A four-page, horizontal format site bulletin that relates the potential environmental problems of acid deposition is currently being developed by Cuyahoga Valley National Recreation Area. Format will include introduction to what is acid deposition, acid deposition research at Cuyahoga Valley, what possible long-term consequences may result from the highly acidic deposition at Cuyahoga Valley, and ozone pollution. Suggested alternatives and things people can do now to address the problems of air quality will also be discussed.

2) The following is an example that could be used for a one-page visibility scenario. The example given is visibility impairment in the Great Smoky Mountains National Park.

"OH, SAY CAN YOU SEE...?"

"Great Smoky Mountains National Park is known for a natural blue haze that was caused by compounds given off by the trees in association with the high humidity in this area. But these days that haze is not so blue, and its cause is not so natural. Industrial smoke and automobile exhaust have reduced how far and how clearly we can see. Many factors affect the degree of visibility we experience here in the Smokies. The weather on a given day, the changing of the...

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seasons, and the way these mountains act as a block to air masses moving in from the west all influence how well we can see the views in the Park. In general, visibility is poorest during the hot, humid summer months. Air masses tend to stagnate, and airborne particles of pollution combine with the natural compounds to shroud the mountain ranges in white or brownish haze.

Visibility in this area has declined by an average of about thirty percent over the last three decades. The single most important contributor to visibility impairment here in the Smokies is sulfate particles which are released into the air when fossil fuels are burned. Carbon particles are also released in this burning process, and contribute to visibility impairment. Two major sources of both sulfate and carbon particles are automobiles and coal-burning power plants. Many other industries also emit sulfate and carbon along with other pollutants to increase the amount of particles in the air.

Researchers here in Great Smoky Mountains National Park have found that during the summer months when visibility is poorest (and when the greatest number of visitors comes to the Park), we can expect to see distances of 155 miles or more only six percent of the time. That is to say, we can expect to see a truly spectacular view only once or twice a month. Most of the time, the visibility range here is about 30 miles--far enough to see a few ranges of hills in the distance. But once or twice a month, we can expect to see almost nothing; about 5% of the time during the summer, the visibility range decreases to only a couple of miles. The haze obscures from our sight all but the closest landmarks.

Visibility impairment is a major cause of concern in our National Parks. After all, it is the chance of experiencing a beautiful vista that brings many of us to the Park in the first place. And if we cannot see the Park through the haze of pollution, why will we go? The only way to be assured of seeing great distances is to improve our air quality. We as a nation must work to comply with and enforce the Clean Air Act which limits the amounts of pollutants that can be emitted into the atmosphere. We as individuals can practice conservation measures at home to reduce the amount of pollution we create. We also must support national and worldwide efforts to clean the air. Our efforts to protect our air quality today provide the chance for us and for future generations to be able to see far into the distance."

**SUGGESTED EVALUATION:**
Keep accurate records on the number of sheets you distribute. Check for discarded sheets in garbage cans and on the ground.

**BACKGROUND INFORMATION:**
Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid-1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas.

The best visibility at monitored National Park Service units is in eastern Nevada, western Utah, and southern Idaho. The next best area is the Colorado Plateau region where the Grand Canyon and several other National Park Service units are located. The worst visibility at monitored National Park Service units is in Shenandoah National Park and Great Smoky Mountains National Park.

**DEVELOPED BY:**
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Kim Baker
The Ohio State University

Dr. John Peine
Great Smoky Mountains National Park
PROGRAM 11

TITLE: "LET'S CLEAR THE AIR" NATIONAL WILDLIFE FEDERATION'S 1987 WILDLIFE WEEK SLIDE PRESENTATION

AUDIENCE: Adults and youth

DURATION: 20 minutes

SITE: National Park Service unit

PROGRAM TYPE: Visitor-activated slide presentation

FACT SHEET REFERENCE: 2, 3, 4, 5, 27

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
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PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to list three human-caused sources of acidic deposition.
2. The audience will be able to explain the global effects of acidic deposition and other air pollutants.

PROGRAM DESCRIPTION:
The National Wildlife Federation, as part of its 1987 air quality theme, produced "Let's Clear Our Air," a slide presentation dealing with air quality. The slide presentation contains 80 slides and runs approximately 15 minutes. Cost of the program is approximately $30.00, which includes the slides/frames, cassette tape, narrative script, and educator's guide. A filmstrip is also available and includes the same materials. The cost for the filmstrip is approximately the same. For further information contact:

National Wildlife Federation
1412 16th Street, N.W.
Washington, D.C. 20036-2266
phone: (202) 797-6800

The program describes major pollutants, what harm they do, and what is being done to help control them. The slide presentation is very simple, yet informative.

One way that the slide presentation could be used would be to install a small portable viewing system in a visitor center and let visitors activate the program at their leisure. Interpreters could be available for any visitor comments or questions concerning the program.

Another way that the slide presentation could be used would be to present the program at regular daily intervals in a visitor center auditorium. Interpreters could then lead a discussion session after the slide presentation is shown.
SUGGESTED EVALUATION:
Count how many visitors who view the slide presentation.
Ask the visitors to comment on the slide presentation.

BACKGROUND INFORMATION:
ACID DEPOSITION EFFECTS ON CULTURAL MATERIALS
The following is taken from "Acid Rain Invades Our Parks" by the National Parks and Conservation Association.

Air pollutants, namely sulfur oxides, nitrogen oxides, and ozone, accelerate the natural weathering and deterioration processes of building materials found in cultural resources. A few of the building materials include: limestone, marble, carbonate-based paints, and galvanized steel.

ACID RAIN: EFFECTS ON AQUATIC SPECIES AND SYSTEMS
The following information was taken from "Acid Rain: Effects on Fish and Wildlife" by the Fish and Wildlife Service, United States Department of the Interior.

The subtle process of acidification often remains undetected until damage has occurred. In some instances, several acid-sensitive aquatic species may serve as indicators of the initial stages of acidification.

The acidity and alkalinity of a substance is measured on a pH scale. This scale measures the activity of hydrogen ions (H+) in a substance (pH stands for "potential hydrogen"). The scale runs from 0 to 14 where 0 is extremely acidic, 7 neutral, and 14 is extremely alkaline, or basic. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to 3 would be a hundred times (10 x10) increase in acidity.

In the vicinity of pH 6.0, several animals decline that are important food items for fish; these include freshwater shrimp, crayfish, snails, and some small mussels and mayflies. Fish species also differ considerably in their tolerance to low pH. For example, the fathead minnow, Arctic char, brown trout, Eurasian perch, and northern pike are especially sensitive to pH declines. Because early life stages are generally more sensitive to low pH than older fish of the same species, declines in larval fish numbers may be early evidence of acidification--if other variables are not responsible.

DEVELOPED BY:
Carol J. Spears
Cuyahoga Valley National Recreation Area
PROGRAM 12

TITLE: AIR QUALITY LECTURE BY A VISITING SCIENTIST OR RESEARCHER

AUDIENCE: Adults and youth

DURATION: 60 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Lecture program

FACT SHEET REFERENCE: 2, 3, 4, 10, 11

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The audience will be able to describe sources of air pollutants.

PROGRAM DESCRIPTION:
Parks that have visiting or resident scientists may take advantage of this resource by having them present programs on their air quality research and results. Cuyahoga Valley National Recreation Area has used this program as part of a three-month special series called the Lyceum series, in which experts are invited to address the topic of their expertise. The Lyceum series programs are presented once a week, January through March.

This type of program might bring in different types of people, including those from communities around the National Park Service unit's borders. This type of lecture series, hence, could be used as part of an air quality community outreach program.

SUGGESTED EVALUATION:
Initiate a question-answer period after the lecture. Gauge program effectiveness according to the amount and types of questions asked.

BACKGROUND INFORMATION:
Air pollution may be defined as any human-caused substance added to the air. Acidic deposition is the technical name including all types of acidic precipitation ("acid rain") and the deposition or settling out of dry acidic particles. Acidic deposition is thought to cause the reduction of animal and plant life in lakes and streams, and may be killing trees in several areas of the world. Marble buildings and other structures are also harmed by acidic deposition; acid turns marble into gypsum and this crumbles out of the stone.

Acidic deposition is only one problem resulting from polluted air. Reduced visibility, ozone damage, and health problems are also caused by air pollutants. Scientists study the effects of air pollution on the trees, plants, soil, visibility, and animals in National Park Service units. Any sources of air pollution such as power plants and industries, are hundreds of...
miles from this area and arrive here with the air masses that move across the continent. Other sources of pollution may be found in almost any area—automobiles, for example. In areas like the Great Smoky Mountains National Park where millions of tourists come during the year by way of cars, buses, and motor homes, exhausts add substantially to the air pollution problem in the area.

The most well known air pollutants and their human-caused sources are:

1. nitrogen oxides
   - automobiles
   - power plants
2. sulfur dioxide
   - power plants
   - industries
   - metal ore smelters
3. ozone (O₃)
   - made from a chemical reaction in the atmosphere of nitrogen oxides and hydrocarbons
4. particulates (solid or liquid fine particles in the air)
   - agricultural practices
   - industry
   - automobiles
5. carbon monoxide
   - automobiles
6. hydrocarbons
   - automobiles

These substances are also produced through natural means such as forest fires, volcanoes, and decay.

DEVELOPED BY:
Carol J. Spears
Cuyahoga Valley National Recreation Area
PROGRAM 13

TITLE: ACID RAIN TERRARIUM EXPERIMENT

AUDIENCE: Adults and youth or classroom activity for grade 3-12

DURATION: 3 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Exhibit

FACT SHEET REFERENCE: 2, 3, 6

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.

2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.

2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.

3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The audience will be able to comprehend some of the effects acid precipitation has on selected vegetation species.

PROGRAM DESCRIPTION:

Materials needed
2 one-gallon pickle jars or 2 small aquaria
Soil
Terrarium-type plants (moss, lichen, etc.)
Boric acid (can be purchased at a drug store)
Water
Plant sprayer

Directions
1. Place soil in bottom of two containers.
2. Add same kinds of plants to each container.
3. Spray one container with water regularly. Spray other container with a boric acid solution regularly (Add one part water to one part boric acid powder).

This experiment should yield one healthy container of plants (those sprayed with water) and one container of stressed plants (those sprayed with the boric acid solution). The containers can then be set up as part of an air quality exhibit. The containers can help visitors to become more aware of the effects acid precipitation has on vegetation.

SUGGESTED EVALUATION:
Count how many visitors who view the exhibit.
Ask the visitors to comment on the exhibit.
Have a sheet of paper available to record comparisons visitors make.
BACKGROUND INFORMATION:
ACID RAIN AND AFFECTS ON VEGETATION

The high elevation spruce-fir forests of the Great Smoky Mountains National Park are experiencing a decline in vigor and growth. At elevations of 6,000 feet and above, the annual growth rate of red spruce for the last 10 years is half the annual growth rate prior to 1960. In addition, the red spruce are exhibiting other stress symptoms correlated with elevation, such as thinned crowns and dead tops. The upper surfaces of needles on red spruce saplings exhibit necrotic lesions (yellow spotting). Scientists suspect this may be related to ozone pollution. Although concrete evidence has not yet been produced, the consensus among scientists is that red spruce are experiencing damage from air pollution. Furthermore, this damage does not appear to be caused by one form of air pollutant, but appears to involve the interaction of as many as three forms of air pollutants.

In Sequoia National Park, over one-third of 540 ponderosa pine trees studied periodically since 1980 show moderate to severe ozone injury. Injury is also common on oak trees and jeffrey pines. Foliar symptoms, like ozone injury, have been recently observed on giant sequoia seedlings under research conditions.

REFERENCES:

Eagar, Christopher. "Forest Damage on Clingman's Dome, Great Smoky Mountains National Park," National Park Service, Science Division, Uplands Field Research Laboratory

DEVELOPED BY:
Candace Tinkler
Zion National Park
PROGRAM 14

TITLE: NIGHT HIKE "THE NIGHT FANTASTIC"

AUDIENCE: Adults and youth

DURATION: 5 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Guided activity

FACT SHEET REFERENCE: 2, 3, 24

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.

2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.

2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.

3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The audience will be able to describe some of the opportunities for night sky viewing and explain why the conditions are favorable for night sky viewing.

PROGRAM DESCRIPTION:
Night hikes or walks can serve as an excellent means of conveying an air quality message. Generally, if visibility is adequate, many stars and star systems can be viewed. If visibility is not so good, however, stars cannot easily be viewed. The following is a way to use the stars and the night to convey a visibility message.

As you begin the night walk, take a deep breath and communicate to the audience how much you enjoy working in a place that has relatively clean air to breathe. This will help to point the audience's thoughts more toward an air quality direction. Here is an example of what you could say next. "The stars sure are beautiful tonight. Let's see if we can locate some of the more common constellations...."

"Have you noticed that the stars seem as if they are more brighter and numerous tonight? What do you think could cause this? I bet most of you would say the absence of clouds, but this is only partially true. Actually air quality has something to do with it also. We are very fortunate in this park to have good air quality. Many of our National Park Service units in the United States do not enjoy this type of high-quality visibility. Atmospheric conditions, including particles and gases in the air, determine visibility conditions which influence how easily a person can see through the air."

You could also convey to them the following information: "The current status of visibility at National Park Service units is as follows: In excess of 90% of the time, scenic vistas are affected by human-caused pollution at all National Park Service monitoring locations. The best visibility at monitored sites is in
eastern Nevada, western Utah, and southern Idaho, while the worst visibility at monitored National Park Service units is in Shenandoah and Great Smoky Mountains National Park. Visual range at National Park Service units is typically best in the winter and worst in the summer when meteorological conditions are such that more pollution is transported from urban areas and industrial developments to remote areas, causing more uniform haze to occur in the winter months."

One might also want to suggest that "light pollution" (pollution caused by lighted cities and industry, for example) could obscure the viewing of stars. The sky is lit up from the glow of industries and cities, making it harder to view stars.

**SUGGESTED EVALUATION:**
Ask the audience to describe visibility problems in the National Park Service.

**BACKGROUND INFORMATION:**

**VISIBILITY IMPAIRMENT: WHAT IS IT?**

Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid-1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas. The preservation of unique scenic resources is very important to the National Park Service. National Park Service visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected to some degree by human-caused pollution at all monitoring locations within the lower forty-eight United States.
PROGRAM 15

TITLE: "ACID RAINED ON OUR PARADE," A PLAY INVOLVING AUDIENCE PARTICIPATION

AUDIENCE: Youth or adults

DURATION: 30 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Guided activity

FACT SHEET REFERENCE: 2, 3, 7, 8

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to describe three contributing sources of acidic deposition.
2. The audience will be able to cite at least two organisms affected by acid precipitation.
3. The audience will be able to cite at least two ways that the amount of acid rain can be lessened.

PROGRAM DESCRIPTION:
As part of a "naturalist choice" program on acidic deposition and clean air, the audience will be involved in a short play.

After a brief introduction, the narrator (ranger) asks for audience participation and assistance in a play. Each character is given a placard to wear around his/her neck. The placard has the character's name written on it in large letters. It might also be possible to give the character a simple prop, such as a raindrop hat or a tree branch.

The characters are:

H₂O -- a water molecule
SO₂ -- sulfur dioxide gas
NOₓ -- nitrogen oxides
Fresno Eddy -- the wind, a pushy fellow
Ms. Sparkles -- a mountain lake
Coal fired power plant -- Polluters: Can be all worn by same person or divided into four characters.
Traffic
Woodburning stoves
Natural forest fire

An eagle fish
A coniferous forest

--food chain members affected by acid rain (varies for your park)

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2255.
The narrator reads the script while the characters improvise their parts. They are instructed to be cued for action whenever they hear their name being mentioned. Participants may be given a brief scenario and cue card to help them before the play. The play should not be too long or too complicated. It should be melodramatic and fun. Invite the audience to respond with cheers, hisses, etc.

THE PLAY NARRATION

Once upon a time, high on a wild granite ridgetop, there lived a sparkling mountain lake that twinkled like a princess’ crown in the sunlight. The lake was the home of many things, and they all were connected in a food chain. Surrounding the lake was a beautiful coniferous forest that painted the landscape green as far as the eye could see, and further. A mountain lion ruled the granite peak, and he in turn was ruled by the wind.

In fact, the wind was the stern ruler of all the land. It ruffled the reflections of the lake. It tousled the feathers of the eagle and caught the golden light of the dragonfly’s wings. It sighed and howled through the tree tops. But nobody ruled the wind.

This place was so very beautiful and peaceful that people began to move closer to it. They built homes far below at the base of the mountain. Soon automobiles, woodburning stoves, coal-fired power plants and factories threw up offerings into the sky to the wind. And some people were careless and set mighty forest fires that also sent clouds of smoke into the sky and to the wind. These gifts of sulfur dioxide and nitrogen oxide were sent high into the air where they met many precious water molecules waiting there. The water molecules were very seductive! They attracted the sulfur dioxide and the nitrogen oxide and they all joined together quite quickly. But together they were far from friendly... they became a mean, acid rain.

The acid precipitated down from the sky as fog, rain, sleet and snow. The acidic water stung and hurt the sparkling lake, and all the organisms that lived in the lake were killed.

The mountain lion was hungry and so was the eagle; they moved away. Slowly and steadily the land was emptied of life. It became a sad place. Even the coniferous forest died, and the lake now sparkled only as a cold mirror of nothing.

The people in the homes far below the mountain did not at first realize that the mountain was being destroyed. And when they did, they became sad. Some moved to new homes under new mountains. But some loved this mountain, and so stayed and studied what to do to save it.

The people:
• redesigned their woodburning stoves
• walked and rode bicycles, took mass transportation or carpoold
• recycled resources to reduce the need for so much industry and to lessen the need for more resources from the earth
• placed efficient scrubbers in the coal-fired smoke stacks.

Without the gases, the water molecules became themselves again and no longer stung the lake and land. But the mountain never was the same.

(end of play)

SUGGESTED EVALUATION:

In order to evaluate the effectiveness of the "play," the ranger should encourage questions from the audience and ask the audience questions about the play, using objectives as guidelines.

BACKGROUND INFORMATION:

ACID RAIN: EFFECTS ON AQUATIC SPECIES AND SYSTEMS

The following information was taken from "Acid Rain: Effects on Fish and Wildlife" by the Fish and Wildlife Service, United States Department of the Interior.

The subtle process of acidification often remains undetected until damage has occurred. In some instances, several acid-sensitive aquatic species may serve as indicators of the initial stages of acidification.
The acidity and alkalinity of a substance is measured on a pH scale. This scale measures the activity of hydrogen ions (H+) in a substance (pH stands for "potential hydrogen"). The scale ranges from 0 to 14 where 0 is extremely acidic, 7 neutral, and 14 is extremely alkaline, or basic. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to 3 would be a hundred times (10 x10) increase in acidity.

In the vicinity of pH 6.0, several animals decline that are important food items for fish; these include freshwater shrimp, crayfish, snails, and some small mussels and mayflies. Fish species also differ considerably in their tolerance to low pH. For example, the fathead minnow, Arctic char, brown trout, Eurasian perch, and northern pike are especially sensitive to pH declines. Because early life stages are generally more sensitive to low pH than older fish of the same species, declines in larval fish numbers may be early evidence of acidification—if other variables are not responsible.

ACID RAIN AND EFFECTS ON VEGETATION

The high elevation spruce-fir forests of the Great Smoky Mountains National Park are experiencing a decline in vigor and growth. At elevations of 6,000 feet and above, the annual growth rate of red spruce for the last 10 years is half the annual growth rate prior to 1960. In addition, the red spruce are exhibiting other stress symptoms correlated with elevation, such as thinned crowns and dead tops. The upper surfaces of needles on red spruce saplings exhibit necrotic lesions (yellow spotting). Scientists suspect this may be related to ozone pollution. Although concrete evidence has not yet been produced, the reasoning of most scientists is that red spruce are experiencing damage from air pollution. Furthermore, this damage does not appear to be associated with only one particular pollutant but appears to involve the interaction of many forms of air pollutants.

In Sequoia National Park, over one-third of 540 ponderosa pine trees studied periodically since 1980 show moderate to severe ozone injury. Injury is also common on oak trees and Jeffrey pines. Foliar symptoms, like ozone injury, have been recently observed on giant sequoia seedlings in experimental conditions.

ACID DEPOSITION EFFECTS ON CULTURAL MATERIALS

The following is taken from "Acid Rain Invades Our Parks" by the National Parks and Conservation Association.

Air pollutants, namely sulfur oxides, nitrogen oxides, and ozone, accelerate the natural weathering and deterioration processes of building materials found in cultural resources. These building materials include but are not limited to: limestone, marble, carbonate-based paints, and galvanized steel.

REFERENCES:


DEVELOPED BY:
Candace Tinkler
Zion National Park
PROGRAM 16

TITLE: "BLUE SKY BLUES"--SONGS ABOUT AIR QUALITY

AUDIENCE: Adults and youth

DURATION: 5 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Evening program or junior ranger program

FACT SHEET REFERENCE: 2, 3, 6, 8

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.

2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.

2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.

3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The audience will be able to evaluate the quality of the air at the time of the writing of the original song compared to general air quality in America today.

PROGRAM DESCRIPTION:
One way of invoking interest in air quality is to come up with a novel way of communicating it to the audience. One way to accomplish this task is to utilize a familiar song (for example, the United States National Anthem) and change its lyrics to fit an air quality message. The following example uses an air quality message sung to the tune of the United States National Anthem.

"Oh, say can you see
by the dawn's hazy light,
the air we have fouled
with our factories and scheming?

Whose broad lands and bright waters
stung by acid's sharp bite,
over the ramparts we watched
the frightening blight.

And the smokestack did bear
poison gas to the air,
and joined in the sky
with the clouds that were there.

Oh, say do the conifer's green branches
yet wave,
over the lake that is dead
and the fish we can't save?"
(end song)

SUGGESTED EVALUATION:
Ask the audience if they had seen any signs of air pollution during their visit to the park. Engage them in a discussion about each person's role and responsibility in "clearing the air."

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This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
BACKGROUND INFORMATION:

VISIBILITY IMPAIRMENT: WHAT IS IT?

Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid 1970's Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas. The preservation of unique scenic resources is very important to the National Park Service. National Park Service visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected to some degree by human-caused pollution at all monitoring locations within the lower forty-eight United States.

CURRENT STATUS OF VISIBILITY AT NATIONAL PARK SERVICE UNITS:

The best visibility at monitored National Park Service units is in eastern Nevada, western Utah, and southern Idaho. The next best area is the Colorado Plateau region where the Grand Canyon and several other National Park Service units are located. The worst visibility at monitored National Park Service units is in Shenandoah National Park and Great Smoky Mountains National Park.

DEVELOPED BY:
Candace Tinkler
Zion National Park
PROGRAM OBJECTIVES:
The audience will be able to describe the effects automobiles have on the atmosphere.

PROGRAM DESCRIPTION:
One excellent way to communicate the effects automobiles have on the atmosphere is through an automobile emission display. A chart can be set up showing the amount of pollution produced from different types of automobiles with different types of smog control devices. Various darkened cheesecloth with data on the vehicles and smog control information can complete the display.

Materials needed
Cheesecloth
Posterboard
10 different types of vehicles with different types of pollution control devices.

DIRECTIONS FOR COLLECTING AND DISPLAYING EMISSION DATA:
1. Select 10 vehicles with different types of pollution control devices.
2. Wrap cheesecloth around exhaust pipe, covering the exhaust hole.
3. Drive for vehicle for 10 miles.
4. Take cheesecloth off vehicle.
5. Mount cheesecloth on posterboard and label each according to type of pollution control device found on vehicle.
6. Assign and post rating score (on a scale of 1 to 10) for each vehicle according to darkness of cheesecloth with "1" being lightest and "10" being darkest.

Once you have the emission display ready, place it in a visitor center. Have interpreters nearby to answer questions concerning the automobile emission display. Hand-outs concerning air pollution in National Park Service units could also be displayed for interested visitors to take with them.
Another option that could be added to the display would be a poster showing "What can you do to help reduce air pollution?"

Possible items for the list include walking, riding a bike, using mass transportation instead of driving a vehicle, car pooling, keeping your vehicle tuned-up and in good working condition; and installing optional pollution control devices on your vehicle.

SUGGESTED EVALUATION:
Count the number of people who approach and read the display, or gear the evaluation towards the types of questions that are asked concerning the display.
Have an interpreter ask visitors to comment on the display.
Have small cards or a form for visitors to complete to indicate the type of vehicle they use most, its pollution control devices, and its probable rating on the scale. Leave a space for comments.

BACKGROUND INFORMATION:
Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid 1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas. The preservation of unique scenic resources is very important to the National Park Service. National Park Service visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected by human-caused pollution at all monitoring locations within the lower forty-eight United States.

The best visibility at monitored National Park Service units is in eastern Nevada, western Utah, and southern Idaho. The next best area is the Colorado Plateau region where the Grand Canyon and several other National Park Service units are located. The worst visibility at monitored National Park Service units is in Shenandoah National Park and Great Smoky Mountains National Park.

DEVELOPED BY:
Nancy Muleady and Dawn Vernon
Sequoia and Kings Canyon National Parks
PROGRAM 18

TITLE: AIR QUALITY BROCHURE INSERT

AUDIENCE: Adults and youth

DURATION: Self paced

SITE: National Park Service unit

PROGRAM TYPE: Brochure insert

FACT SHEET REFERENCE: 2, 3, 4, 6, 29

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The audience will be able to describe sources of air pollutants.

PROGRAM DESCRIPTION:
One way of communicating to visitors about air quality is through a brochure insert. Information can be placed on the front and back of the insert. The following example of an air quality brochure insert is currently being included in a spruce-fir brochure in Great Smoky Mountains National Park.

Materials needed
Once printed, a heavy grade paper can be cut to fit inside a brochure (approximately 8.5" length by 3.5" width). Artwork is suggested.

(front side of brochure insert)
At these higher elevations, red spruce and Fraser fir trees dominate the forest. These trees must be hardy to survive harsh winds and cold winters in the high country, yet this forest is a fragile environment. Human activity has introduced some problems that threaten the spruce-fir forest here in the Smokies.

SOMETHING IN THE AIR
The largest stand of red spruce in the Southern Appalachians is found here in Great Smoky Mountains National Park. But this king-sized stand of red spruce faces some king-sized problems today. Over the last ten years, some of the red spruce have virtually stopped growing; little or no new wood is being laid down in the annual rings. The tops of some of the trees are thinning; fewer

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
branches are being produced and the trees are losing needles. The needles of some young trees are marked with yellowish spots indicating cell damage. Scientists in the Park suspect that air pollution may be contributing to these problems. At air quality monitoring stations around the Park, researchers have detected quantities of ozone which are known to cause plant damage under laboratory conditions. Sulfates and nitrates, which react with water to form "acid rain", have also been detected. While researchers are investigating many possible causes of the red spruce decline, evidence gathered here, together with experience in other areas impacted by air pollution, points to air quality as a significant factor affecting the health of the forest.

(back side of the brochure insert)

BIG TROUBLE IN A SMALL PACKAGE

The Fraser fir stand has a major problem, also. A tiny insect, the balsam woolly adelgid, feeds on the main stems of mature Fraser fir trees. The saliva of these insects contains a toxin which blocks the cells of the trees so that nutrients cannot travel through the trunks, and the trees literally starve to death. The balsam woolly adelgid is an exotic insect, accidentally introduced on trees imported from Europe, and the Fraser fir has no natural defense against this pest.

The balsam woolly adelgid attaches itself to the fir tree with its long, sucking mouth parts. Toxins in the adelgid's saliva disrupt the tree's normal nutrient flow, and the tree eventually dies.

The National Park Service is working to save the Fraser fir. Park rangers spray selected stands of the trees with a soapy insecticide solution which dissolves the insects' waxy protective coating and kills them. The insecticide breaks down very quickly so other creatures are not harmed by it. Aerial spraying is not effective, so the entire trunk of individual trees must be saturated by the insecticide. Thus, only a very small part of the total fir population can be protected. Scientists hope to find a long-term solution to the adelgid problem. Preserving even a small stand of Fraser fir keeps alive the hope that these trees will not permanently disappear.

The Southern Appalachian spruce-fir forest is a unique and fragile environment. Scientists in the Park continue to study the problems in this forest in the hope that ways will be found to preserve these special trees for future generations to enjoy. (end of brochure insert)

SUGGESTED EVALUATION:

Ask visitors to read the insert and then comment on what they learned from the insert. Conduct unobtrusive observation along the trail to see if the brochure users are actually reading the insert. Check garbage cans at the trailhead for discarded inserts and look for inserts littering the trail.

BACKGROUND INFORMATION:

The high elevation spruce-fir forests of the Great Smoky Mountains National Park are experiencing a decline in vigor and growth. At elevations of 6,000 feet and above, the annual growth rate of red spruce for the last 10 years is half the annual growth rate prior to 1960. In addition, the red spruce are exhibiting other stress symptoms correlated with elevation, such as thinned crowns and dead tops. The upper surfaces of needles on red spruce saplings exhibit necrotic lesions (yellow spotting). Scientists suspect this may be related to ozone pollution. Although concrete evidence has not yet been produced, the consensus among most scientists is that red spruce are experiencing damage from air pollution. Furthermore, this damage does not appear to be associated with only one particular pollutant but appears to involve the interaction of as many as three forms of air pollutants.

DEVELOPED BY:

Kim Baker and Marcia Seager
The Ohio State University

Chris Eagar, Stan Canter, and John Peine
Great Smoky Mountains National Park
PROGRAM 19

TITLE: AIR QUALITY BULLETIN BOARD

AUDIENCE: Adults and youth

DURATION: 3 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Exhibit

FACT SHEET REFERENCE: 2, 5

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process developing public support for preserving them.

2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park’s resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park’s resources, values, and of the National Park System in general.

2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.

3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park’s resources and the entire National Park System’s significance and values.

PROGRAM OBJECTIVES:
The audience will be able to describe sources of air pollutants.

PROGRAM DESCRIPTION:
One way to communicate air quality to visitors is through an air quality bulletin board. Most visitor centers have a bulletin board set up with daily weather reports—why not also have bulletin board with a daily “visibility report?” When visitors approach to read the “visibility report,” an interpreter can be of assistance in explaining what “visibility” means. Possible items to include on the visibility board would include: expected percentage visibility for that day, expected pollen count for that day, and expected cloud cover for that day.

SUGGESTED EVALUATION:
Count the number of people who approach and read the bulletin board, or gear the evaluation towards the types of questions that are asked concerning the bulletin board.

BACKGROUND INFORMATION:
WHAT IS VISIBILITY?

Atmospheric conditions, including particles and gases in the air, determine visibility conditions which influence how easily a person can see through the air. There are several different quantitative measures of visibility conditions that characterize different aspects of these conditions.

Air pollution can be visible in three forms: uniform haze, layered haze, and plumes. Uniform haze is a homogeneous haze that reduces visibility in every direction from the observer and occurs when the air is well mixed and the pollutants are evenly distributed. Layered haze is seen as a band or bands of discoloration, with a noticeable boundary...
between the more polluted and the cleaner air. A *plume* is a band of discoloration that can typically be seen to be coming from a nearby source. It is formed when there is a surface wind to carry visible pollutants horizontally from an emission source into a stable atmosphere.

Visual range at National Park Service units is typically best in the winter and worst in the summer when meteorological conditions are such that more pollution is transported from urban areas and industrial development to remote areas, causing more uniform haze to occur in the winter months.

**DEVELOPED BY:**

John Peine  
Great Smoky Mountains National Park

Kim Baker  
The Ohio State University
PROGRAM 20

TITLE: AIR QUALITY ACTIVITIES TO DO WITH JUNIOR HIGH AND HIGH SCHOOL STUDENTS

AUDIENCE: Children, 13-17 years of age

DURATION: 1 Hour

SITE: National Park Service unit (or classroom, depending on activity)

PROGRAM TYPE: Hands-on activities, audio-visual

FACT SHEET REFERENCE: 2, 3, 4, 22

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop student support for preserving them.
2. Exchange information necessary to insure the successful adaptation of students to environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide students with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the student and park management to communicate their thoughts and desires to each other.
3. Provide interested educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The students will be able to comprehend some of the effects acidic deposition has on selected vegetation species.

PROGRAM DESCRIPTION:
There are many different interpretive devices that can be used when trying to convey an air quality message to junior high and high school students.

Cuyahoga Valley National Recreation Area, pending permission from the Public Broadcasting Service (PBS), is planning to use a PBS air quality video. A trained volunteer-in-park (VIP) would take the video to junior high and high schools upon request. After the video the VIP would encourage and lead a group discussion and feedback from the students.

A similar program, developed by Theodore Roosevelt National Park, is presented annually at a local high school. Their air quality presentation, however, uses slides and lecture materials.

Upper Delaware Scenic and Recreational River uses a slide/lecture format similar to that which Theodore Roosevelt National Park uses, but adds a hands-on activity, also. Their program includes an explanation of the pH scale and a classroom experiment testing the acidity/alkalinity of selected household items. The program concludes with group discussion on conservation measures people can take to reduce acidic deposition. Cuyahoga Valley National Recreation Area has a similar pH hands-on activity that is used as part of its school service hikes program (pH test kits can be purchased from a garden center for under $20.00).
SUGGESTED EVALUATION:
Develop a knowledge pretest and postest to administer to the students before and after the program.
Have students write articles about local air quality and their experiments, and put them into a "newspaper" or newsletter to send to schools near other national parks. Evaluate the correctness and appropriateness of the students' writing.

BACKGROUND INFORMATION:
Air pollution may be defined as any human-caused substance added to the air. Acidic deposition is the technical name including all types of acidic precipitation ("acid rain") and the deposition or settling out of dry acidic particles. Acidic deposition is thought to cause the death of much animal and plant life in lakes and streams, and may be killing trees in several areas of the world. Marble buildings are also harmed by acidic rains; acid turns marble into gypsum and this crumbles out of the stone.

Acidic deposition is only one problem resulting from polluted air. Reduced visibility, ozone damage, and health problems are also caused by air pollutants. Scientists study the effects of air pollution on the trees, plants, soil, and animals in National Park Service units. Air pollution from sources such as power plants and industries which are hundreds of miles from this area, arrive here with the air masses that move across the continent. Other sources of pollution may be found in almost any area--automobiles, for example. In areas like the Great Smoky Mountains National Park where millions of visitors come during the year by way of cars, buses, and motor homes, exhaust fumes add substantially to the air pollution problem in the area.

The most well known air pollutants and their human-caused sources are:

1. nitrogen oxides
   -automobiles
   -power plants
2. sulfur dioxide
   -power plants
3. ozone (O₃)
   -made from a chemical reaction in the atmosphere of nitrogen oxides and hydrocarbons
4. particulates (solid or liquid fine particles in the air)
   -agricultural practices
   -industry
   -automobiles
5. carbon monoxide
   -automobiles
6. hydrocarbons
   -automobiles

DEVELOPED BY:
Carol Spears and Jeff Maugans
Cuyahoga Valley National Recreation Area

Shawn Duffy
Upper Delaware National Scenic and Recreational River

Micki Hellickson and Skip Snow
Theodore Roosevelt National Park
PROGRAM 21

TITLE: AIR QUALITY PROGRAM IDEAS

AUDIENCE: Adults and youth

DURATION: Varies

SITE: National Park Service unit

PROGRAM TYPE: Varies

FACT SHEET REFERENCE: 2, 3, 4, 5, 23

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.

2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.

2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.

3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The audience will be able to comprehend some of the effects acid precipitation has on selected cultural and natural resources.

PROGRAM DESCRIPTION:
There are many different ways to convey an air quality message to visitors. The following ideas were submitted by National Park Service interpreters.

SOLAR DEMONSTRATION:
As an alternative source of energy to fossil fuels, the solar demonstration is a great "initiator" of discussion. Here, statistics on auto emissions resulting from fossil fuel use can show the importance of looking toward alternative energy use. Coupled with the knowledge that our fossil fuels are limited while solar power is not, it is a good way to get people thinking about energy and its resulting impact on the environment.

AIR QUALITY DEMONSTRATION
An exhibit could use a time progression of photographs to show a potted plant with the differing degrees of ozone damage.

LICHEN DISCUSSION
When conducting a guided walk, stop by a large boulder or rock wall covered with lichen and moss. After describing what lichens are and some of their connections in an ecosystem, mention that lichens are the "miner's canaries" of air quality. Lichens are not very tolerant of poor or polluted air. Hence, if the air quality were to diminish, the lichens would eventually reflect this through their health declining or numbers diminishing. Although the National Park Service utilizes modern technology to monitor and therefore protect its air resources, nature also acts as a monitor.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
AIR QUALITY SEGMENTS IN CAR OR BUS TOURS:
Insert an air quality segment into existing car or bus tours. For example, interpreters at Lyndon B. Johnson National Historic Site insert an air quality legislation segment in their LBJ Ranch Bus Tour. They discuss the fifty pieces of conservation legislation signed by LBJ and discuss the initial actions toward environmental protection and the on-going need for protection activities.

SUGGESTED EVALUATION:
Ask the audience to comment on their own ideas and beliefs concerning air quality.

BACKGROUND INFORMATION:
Acidic deposition is known or suspected to affect park resources throughout much of the United States. The acid rain/air quality education program, called for by Director William Penn Mott, Jr., is designed to develop public understanding of air quality and corollary issues as they relate to these resources. The program builds on interpretation of this topic already underway in some parks, increasing the level of activity and geographic scope.

The formal program was started in 1987 and will conclude in 1991, with special emphasis in 1988. All units of the National Park System are encouraged to participate, according to degree of local air pollution effects, amount of park research on the subject, staff size, and park funding.

The acid rain/air quality issue touches every employee of the National Park Service, both as a citizen and as a steward of the National Park System. Because of the complexity of the acid rain phenomenon, this communication must reflect the scientific uncertainties that persist. The plan therefore calls for educating National Park Service personnel as well as the public, using results of the best scientific work. To achieve this, the program will enlist the help of scientists both within and outside the Service, including those associated with the National Acid Precipitation Assessment Program (NAPAP).

DEVELOPED BY:
Candace Tinkler
Zion National Park

Nancy Muleady and Dawn Vernon
Sequoia/Kings Canyon National Parks

Dennis Turay
Lyndon B. Johnson National Historical Park
PROGRAM 22

TITLE: WAYSIDE EXHIBITS

AUDIENCE: Adults and youth

DURATION: 5 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Display (wayside)

FACT SHEET REFERENCE: 2, 3, 4

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
The audience will be able to describe sources of air pollutants.

PROGRAM DESCRIPTION

Exhibits (such as those found along a trail or at a scenic overlook where pollution can be clearly seen) serve as excellent communication devices when dealing with the air quality topics. Air quality topics gain more attention and are better understood when the visitor can see pollution effects first-hand on the landscape.

The following information is taken from an overlook wayside exhibit that Cuyahoga Valley National Recreational Area is currently developing.

The two-panel permanent wayside will be erected at the site of the best western overlook of the Cuyahoga Valley in an area of heavy public use. Final design and construction will be through Denver Service Center and Harpers Ferry Center. Park input is basic design as follows:

Panel 1: Introduction to potential threats of acid deposition to Park resource
   Graphic of sources of pollutants that cause acid deposition, with short text.

Panel 2: How the highly acidic deposition in the Cuyahoga Valley affects the environment:
   short-term mechanisms
   long-range mechanisms

   Hope for the future--technologies and strategies that are available today that will alleviate the production of acidic deposition, and suggestions on what people can do to implement the technology.

The following text is part of a visibility impairment exhibit that Sequoia-Kings Canyon National Parks developed for their Moro Rock overlook. Moro Rock is an excellent place to discuss air quality because giant sequoias, the Great Western Divide, and the San Joaquin Valley can be viewed from there. The
omnipresent summer inversion layer, as it climbs into the Park, is a focus for information on agricultural and human health damage in terms of money and lives. The view and lack of visibility are easily focused on, as well as the concept of the parks "not being isolated islands."

TEXT OF MORO ROCK SIGN

WHAT IS ALL THAT HAZE IN THE AIR?

WHAT IT IS
Why can't we see better from Moro Rock? The haze that so often obscures the view is composed of many things and is largely human-caused. Although water vapor and dust make up much of what blocks the view, the haze that fills the San Joaquin contains significant amounts of pollutants, including nitrogen oxides, ozone, sulfur dioxide, and particles of many chemicals.

WHERE IT COMES FROM
Air enters the San Joaquin Valley through low gaps in the Coast ranges immediately east of the San Francisco Bay Area. As the air moves inland and then south it brings with it pollution from the Bay Area and Sacramento. After the air enters the great Central Valley additional pollutants are added by the six million people who live there. Once within this mountain-rimmed basin, the air moves slowly south until it is blocked by the forested areas of the southern Sierra--including Sequoia and Kings Canyon National Parks.

WHAT IT DOES
Air pollution obscures our views, impairs human health, damages forest trees, and acidifies our waters. If not controlled it will change these forests in ways we do not yet understand.

(END MORO ROCK TEXT)

Where to find assistance:
Interpreters, working through their park administration and the regional chief scientist, can secure assistance from the National Park Service air quality division (Denver) and from the appropriate planner and designers at Harpers Ferry, West Virginia.

SUGGESTED EVALUATION:
Count the number of visitors that approach the wayside.
Ask those visitors that approach the sign to make comments about the wayside and about air quality in general.

BACKGROUND INFORMATION:
VISIBILITY IMPAIRMENT: WHAT IS IT?

Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid 1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas.

National Park Service visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected to some degree by human-caused pollution at all monitoring locations within the lower forty-eight United States.

The best visibility at monitored National Park Service units is in eastern Nevada, western Utah, and southern Idaho. The next best area is the Colorado Plateau region where the Grand Canyon and several other National Park Service units are located. The worst visibility at monitored National Park Service units is in Shenandoah National Park and Great Smoky Mountains National Park.

DEVELOPED BY:
Nancy Muleady and Dawn Vernon
Sequoia and Kings Canyon National Park

Carol J. Spears
Cuyahoga Valley National Recreation Area
PROGRAM 23

TITLE: COMMUNITY RELATIONS PROGRAM

AUDIENCE: Mixed adults

DURATION: 30 Minutes

SITE: National Park Service unit

PROGRAM TYPE: Video or slide tape program

FACT SHEET REFERENCE: 2, 3, 9, 10, 15

PARK THEMES:
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

PARK GOALS:
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

PROGRAM OBJECTIVES:
1. The audience will be able to describe sources of air pollutants.
2. The audience will be able to better comprehend their roles in the preservation of National Park Service units.

PROGRAM DESCRIPTION:
One way in which National Park Service units can better reach communities is through a community slide tape program. An example from Great Smoky Mountains National Park follows:

COMMUNITY ROLES IN AIR QUALITY MANAGEMENT GREAT SMOKY MOUNTAINS NATIONAL PARK

[SLOW DISSOLVE FROM DARKNESS TO SUNRISE. WHEN DAWN IS BREAKING, BEGIN NARRATIVE—RECORDINGS OF VISITORS' COMMENTS ON IMPORTANCE OF SEEING MOUNTAINS AND VISTAS FROM THE MOUNTAINS.] [DISSOLVE A SERIES OF 10 FIXED 'F' STOP PHOTOS TAKEN FROM TRIPOD AT SUNRISE ON CLEAR MORNING]

[NO SOUND FIRST 10 SECONDS] [LIGHT BREEZE SOUNDS AND LEAVES RUSTLING 10-20 SECONDS] [BREEZE AND MORNING BIRDS 20-60 SECONDS] [VISITOR'S COMMENTS BEGIN AT 60 SECONDS] [DIFFERENT VOICE FOR EACH COMMENT]

"I just love going up on top of the mountain to watch the sunrise. It seems like you can see forever."

[3 second pause]

"I've come here for years and the view never fails to send shivers down my spine."

[2 second pause]

"The Smokies have a mysterious personality all their own—clouded by a faint blue veil."

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
“But somethings' changing. That blue veil we remember seems soiled. It seems to be turning brown. We used to tease one another that we could see to the coast at sunrise. Now we're lucky to see the car lights in the valley.”

“We've been coming here for years. We love seeing the mountains and streams.”

“Getting up in the morning and looking out to the mountains is part of what makes this place so special.”

Views of the Great Smoky Mountains are threatened. It's strange that the mountains' namesake is the very threat—smoke! Our Smokies have been just that over the years—mountains in a smoky blue haze. But that haze wasn't smoke. It was mostly caused by natural compounds released by the forest trees.

Today, the main sources of that smoke are gases released into the atmosphere by forests of industrial stacks and automobiles, causing reduced visibility and acid rain. Just to give you an idea of the magnitude of the problem today, during the year of its major eruption Mt. St. Helens only emitted one-tenth of the sulfur dioxide that our industry and electrical utilities emitted during the same time. Sulfur dioxide is a major cause of acid rain as well as being responsible for reduced visibility here in the Smokies.

Another major culprit is the group of nitrogen oxides, primarily emitted by cars, trucks and electrical utilities. These nitrogen oxides not only disperse light, making it hazy, but they can be the major cause of the brownish color. And again, the nitrogen oxides are another major cause of acid rain.

All totaled, our industrial processes, electrical utilities, human-caused fires and highway transportation contribute ten times the sulfur dioxide and nitrogen oxides to the atmosphere that natural processes do—even a Mt. St. Helens. Those contributions focus air quality problems of acid rain and visibility reductions on the Smokies.

Acid rain occurs when gas, coal and oil are burned releasing the sulfur dioxides, nitrogen oxides and hydrocarbons. Once airborne, they combine with water to form weak acids and ozone. Then as rain or dust these pollutants fall to the earth as acid deposition or more commonly . . . acid rain.
Here in the Great Smoky Mountains, the problem of airborne pollutants is compounded. The Smokies form a natural barrier to the flow of the prevailing winds, trapping higher than normal amounts of the pollutants. It's sort of like starting your car in the garage.

The Park Service Researchers have recorded acid levels in clouds near Newfound Gap two to five times greater than the acid rain levels in the Park. And those acid rain readings are already 10 times greater than normal rain readings.

Other studies are aimed at finding out the effects of the pollutants as they move through the water cycle.

The research staff at the park is also beginning to grasp the magnitude of the effects on visibility in the Smokies. Their studies show a drop in normal visibility from 32 miles to 14 miles in summer. That's like being on Clingman's Dome and only being able to normally see to the area around Gatlinburg when you could formerly see to Sevierville. Can we afford another similar drop in visibility?

On the bright side, the research staff have noted increases in visibility when TVA and other Eastern U.S. industrial emission sources installed scrubbers on their plant stacks.

More than visibility is being studied. At the Uplands Research Center, growth chambers are documenting the effects of ozone on plant growth to help explain needle damage and slowdowns in tree growth. Park service monitoring indicates that air pollution may be the cause of the red spruce forests on the high ridges losing their vigor. Notice how the growth rings have gotten closer together in recent years indicating slower growth.

In short, there are a number of on-going studies of air quality related problems here in the Smokies and all point to smoke stacks and exhaust pipes as the "smoking guns."

The problem not only affects the environment, it is affecting tourists' perceptions of the environment. Smokies visitors rate clear vistas very high among park attributes considered key to their enjoyment. When asked how much they'd pay for clear air, they reported clear vistas would be worth an additional $10 for their visit. We might say the next ten million Smokies visitors put a one hundred million dollar price tag on clean air and clear vistas.

If clean air and clear vistas are worth that much to the visitors, what could the economic impact be of further deterioration of visibility? Would these same tourists who praise our sunrises from Clingman's Dome be willing to pay to wake up at 5 in the morning, drive 20 miles to watch a brownish haze develop? What dollar value can we put on a view of ridges and valley as far as the eye can see?

Solutions to the Great Smoky Mountains' air pollution problems are not simple. We've identified some of the possible "smoking guns." But those sources of air pollution and acid rain are major providers of jobs and generate our electricity. Those sources have responsibilities to their shareholders to show profits. The cost of cleanup has to come from somewhere. It's unlikely that the sources will forego profits or their employees will forego wages. The park Service is unwilling to accept loss of endangered ecosystems none of us are. It's also unlikely tourists will forego their vistas and we and our neighbors certainly don't relish the idea of a declining tourism economy.

We have to become sensitive to not only the benefits of the 100 jobs a new industry might bring to the region—we have to weigh the costs of the associated air pollution on visibility and ultimately, tourism. [PAUSE] The bottom line is... we lose the view... we lose tourism dollars.

To clear the air, we all have to share the
responsibility and become part of the solution. The Park Service and other agencies have made the Great Smoky Mountains National Park the kingpin of air quality research and education here in the Southern Appalachians. The National Park Service has put up signs communicating the air pollution message to park visitors. The Park Service, City of Gatlinburg and The Ohio State University have already developed a model air quality curriculum being tested in the Pi Phi School in Gatlinburg. This curriculum will be distributed to schools on both sides of the mountains.

By combining forces with the Park Service we can make the surrounding communities models for air quality education and action. Within our community our organizations can actively support the development and integration of air quality education materials into the schools. Our organizations could sponsor public service announcements on air quality. We could even plan and host a clean air day in our communities. More direct actions could include development of additional park and ride shuttle programs around the major tourist communities. This would reduce auto emissions and could generate funds for education and research programs.

Individually and as an organization, we can be aware of acid rain issues and communicate our support for the air quality programs of our North Carolina and Tennessee legislators as well as those of our national representatives and senators. The strides we've made thus far in slowing the deterioration of air quality have been because people like us became concerned. For example, showing a willingness to pay part of the cost of installing scrubbers on the stacks of coal-fired power plants, we have derived benefits like cleaner water, clearer air and improved vistas. This can be a legacy to our children and grandchildren of which we can be proud.

Finally, we can communicate with our peers in Cherokee, Gatlinburg, Pigeon Forge and other Smokies' communities to let our viewpoints be known and what we're doing to become part of the solution to air quality problems in the Great Smoky Mountains.

Let's get together and clear the air!

[END WITH 10 SECOND SEQUENCE OF FIXED POINT AIR QUALITY SHOTS SHOWING IMPROVING CONDITIONS THEN SEQUENCE OF VISITOR SHOTS IN CLEAN AIR ENVIRONMENTS.]

SUGGESTED EVALUATION:
Use a discussion format at the end of the presentation to gather feedback.

BACKGROUND INFORMATION:
Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid-1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas.

DEVELOPED BY:
John Hanna
The Ohio State University
PROGRAM 24

**TITLE:** AIR QUALITY POSTER IDEAS

**AUDIENCE:** Adults and youth

**DURATION:** 3-5 minutes

**SITE:** National Park Service unit

**PROGRAM TYPE:** Guided walk

**FACT SHEET REFERENCE:** 2, 3, 4, 23

**PARK THEMES:**
1. Instill an understanding and appreciation of the value of parks and their resources and through this process develop public support for preserving them.
2. Exchange information necessary to insure the successful adaptation of visitors to park environments and to encourage appropriate, safe, minimum impact use of the park's resources.

**PARK GOALS:**
1. Provide visitors with a variety of services and information to aid them in gaining a deeper appreciation and understanding of the park's resources, values, and of the National Park System in general.
2. Provide a convenient means for the public and park management to communicate their thoughts and desires to each other.
3. Provide interested users and educational groups with the information necessary to develop a thorough understanding of the park's resources and the entire National Park System's significance and values.

**PROGRAM OBJECTIVES:**
The audience will be able to evaluate the quality of the air at the time of the writing of the original song compared to general air quality in America today.

**PROGRAM DESCRIPTION:**

**MATERIALS NEEDED**
posterboard, markers

One way of invoking interest in air quality is to come up with a novel way of communicating it to the audience. One way to accomplish this task is to utilize a familiar song (for example, the United States National Anthem) and change its lyrics to fit an air quality message. The following example uses an air quality message that was written to the tune of the United States National Anthem.

One can construct this air quality poster by just neatly writing out the variation to the lyrics of the song on a piece of posterboard with markers, or display the words and have children make a mural or their own posters of the images.

"Oh, say can you see by the dawn's hazy light, the air we have fouled with our factories and scheming? Whose broad lands and bright waters stung by acid's sharp bite, over the ramparts we watched the frightening blight.

And the smokestack did bear poison gas to the air, and joined in the sky with the clouds that were there.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
Oh, say do the conifer's green branches yet wave, over the lake that is dead and the fish we can't save?" (end song)

Another possibility concerning the use of posters to convey an air quality message is as follows. One could construct a light-hearted, humorous poster dealing with air quality. Puns and play-on-words dealing with air quality could be used (See Fact Sheet 28).

SUGGESTED EVALUATION:

Ask the visitors reading the sign if they have seen any signs of air pollution during their visit to the park. Engage them in a discussion about each person's role and responsibility in "clearing the air."

BACKGROUND INFORMATION:

VISIBILITY IMPAIRMENT: WHAT IS IT?

Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid-1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas. The preservation of unique scenic resources is very important to the National Park Service. National Park Service visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected to some degree by human-caused pollution at all monitoring locations within the lower forty-eight United States.

CURRENT STATUS OF VISIBILITY AT NATIONAL PARK SERVICE UNITS:

The best visibility at monitored National Park Service units is in eastern Nevada, western Utah, and southern Idaho. The next best area is the Colorado Plateau region where the Grand Canyon and several other National Park Service units are located. The worst visibility at monitored National Park Service units is in Shenandoah National Park and Great Smoky Mountains National Park.

DEVELOPED BY:
Candace Tinkler
Zion National Park
PROGRAM 25

TITLE: Our Backyard Biosphere Reserve

AUDIENCE: Grades 2, 3, 4, 8

DURATION: See each lesson plan

SITE: School or National Park Service unit

PROGRAM TYPE: Environmental Education Modules

PROGRAM DESCRIPTION:

The modules provided in this package are part of a larger set of environmental education materials related to the Southern Appalachian Mountains in general and specifically to the Great Smoky Mountains National Park. Only those materials related to acidic deposition and air quality are included.

The lessons and activities in each module were designed to supplement the existing science and social studies curricula in kindergarten through eighth grade.

SUGGESTED EVALUATION:

An evaluation section is included in each module.

BACKGROUND MATERIALS:

Background information is included near the beginning of each module.

DEVELOPED BY:

Kim Tassier
The Ohio State University
OBJECTIVES: Students will be able to list three "good" and "bad" actions people can take to impact air quality.

METHOD: Students will participate in a discussion on clean air and the good/bad things people can do to the air and will then make collage posters from magazine pictures to illustrate these activities.

BACKGROUND: Air pollution may be defined as any human-caused substances added to the air. Acid deposition is the technical name that includes all types of acidic precipitation ("acid rain") and the deposition or settling out of dry acidic particles. Acid deposition is thought to cause the death of some animal and plant life in lakes and streams, and may be killing trees in several areas of the world. Marble buildings are also harmed by acidic rains; acid turns marble to gypsum and this crumbles out of the stone.

Acid deposition is only one problem resulting from polluted air. Reduced visibility, ozone damage, and health problems are also caused by air pollutants. Scientists study the effects of air pollution on the trees, plants, soil, and animals in Great Smoky Mountains National Park Biosphere Reserve. Many sources of air pollution, such as power plants and industries, are hundreds of miles from this area and arrive here with the air masses that move across the continent. Other sources of pollution may be found in almost any area -- automobiles, for example. In areas like the Smokies where millions of visitors come during the year by way of cars, buses, and motor homes, exhausts add substantially to the air pollution problem in the area.

The most well-known air pollutants and their human-caused sources are:

1. nitrogen oxides (NOx)
   - automobiles
   - power plants

2. sulfur dioxide (SO2)
   - power plants
   - industries
   - metal ore smelters

3. ozone (O3)
   - made from a chemical reaction in the atmosphere of nitrogen oxides and hydrocarbons
We Can Help Clean Up Our Air!
-2nd Grade-

4. particulates (solid or liquid fine particles in the air)
   - agricultural practices
   - industry
   - automobiles

5. carbon monoxide
   - automobiles

6. hydrocarbons
   - automobiles

These substances are also produced through natural means such as forest fires, volcanoes, and decay.

**MATERIALS NEEDED:**
drawing/construction paper, markers, old magazines, scissors.

**SUGGESTED PROCEDURE AND "SCRIPT" FOR TEACHERS (underlined):** Boldfaced letters refer to MATERIALS above. As given, this activity will provide students with a well-rounded lesson on ways people affect air quality. Additional individual and class investigations are provided at the end of this guide under EXTENSIONS.

1. SET: Ask students: How clean is the air in our community? Can you make it cleaner? -or dirtier? Today, we are going to learn how you and other people can change the air.

2. DISCUSSION OF HUMAN EFFECTS ON AIR QUALITY: Tell students: Let's think of these things: How does the air become dirty? What are some "bad" things people do to the air? Make a heading on the board or overhead projector entitled, "Bad Things People Do to the Air." Under this, list suggestions by the students. These may include, "smoke cigarettes," "burn trash," "drive cars with bad exhaust," "build factories," "run power plants."

   Tell students: The electricity we use comes from a power plant. A power plant is a factory where electricity is made from burning coal. Burning coal can make smoke that pollutes the air. The more electricity we use, more coal is burned, and more smoke gets into the air. What can you do at school and at home to use less electricity—and make less air pollution? (During this explanation, you may want to draw a power plant on the blackboard with smokestacks, connected by power lines to a house. As the "people" in the house use more electricity, the "power plant" produces more smoke.)

   Make another category on the board for "Good Things People Can Do for the Air." This may take a little more work. If they are having difficulty coming up with ideas, suggest the following. To reduce air pollution from power plants, lower the amount of electricity you use: turn off lights, radio, and TV when no one is using them; run dishwasher only when full, use air conditioner only when someone is home and it's very hot; use a clothes line instead of a clothes dryer; avoid using electrical appliances (especially the dishwasher) during the peak hours of 5 to 7 p.m.; keep the home furnace clean and properly adjusted.

   To reduce air pollution from cars: walk instead of drive a car (or instead of having parents drive you), ride your bike, turn off car motor when stopped.

   To lower the amount of air pollution from trash burning: do not burn leaves or trash, buy products in returnable or non-plastic containers whenever possible (burning plastic gives off poisonous chemicals), and reuse and recycle whenever possible.

   Concentrate on positive things the students can do now. Ask students to commit to doing one of these things this week - or to ask their parents to do one of the more 'adultish' things this week.
We Can Help Clean Up Our Air!
-2nd Grade-

3. "HOW CAN YOU HELP CLEAN UP OUR AIR?" POSTERS: Using the ideas gathered above, have students look through old magazines for pictures showing these ideas. Then, they should cut them out and glue them to construction or poster paper to make posters with the above title/theme. When finished, distribute the posters to various business in the community and display in school. This would be an ideal activity for a "Clean Air Week."

4. CLOSURE: Review the positive actions the students can take to clean our air. Ask why clean air is important. Tell them, Clean air is better not only for you, but for all the trees and animals, too.

EVALUATION: The following are suggested test or quiz questions on the material covered in this module. You could also use pictures of students doing these things.

1. Circle ALL the ways below that are good for the air.
   A. RIDE A BIKE INSTEAD OF ASKING YOUR PARENTS FOR A RIDE IN THE CAR.
   B. BURN LEAVES OUTSIDE.
   C. USE THE AIR CONDITIONER A LOT.
   D. BUY COKE IN RETURNABLE GLASS BOTTLES.

2. What are 2 ways grown ups can clean the air in our community?
   (1) ____________________________
   (2) ____________________________

3. Draw a picture of something YOU can do this week to help clean our air!

EXTENSIONS:


2. Have the class participate in a "Clean Air Week" with other classes in the school. Projects, like the posters from this lesson, could be distributed around the community to increase public awareness about local air quality.

KEYWORDS:
Air pollution - gases, liquids, and solids in the air that come from human-caused things, like cars and power plants and fires.
Sources - things that make air pollution, like cars and power plants and factories and fires.

REFERENCES AND RESOURCES
LET'S SOCK CAR EXHAUST!

-3rd Grade-

OBJECTIVES: Students will be able to: (1) list two sources of air pollution, (2) describe two kinds of air pollution from cars, (3) explain one way to lower the amount of air pollution from cars, and (4) list three ways air pollution from cars hurts people, animals, and/or plants in the Great Smoky Mountains.

METHOD: Students will learn about air pollution from automobiles through a discussion of air pollution (in general) and by investigating the particulate air pollution from automobile exhaust pipes by covering the tail pipes of several cars with white tube socks.

BACKGROUND: Air pollution may be defined as human-caused substances added to the air. The most well-known air pollutants and their human-created sources are:

1. nitrogen oxides (NOx23)
   -automobiles
   -power plants
2. sulfur dioxide (SO2)
   -power plants
   -industries
   -metal ore smelters
3. ozone (O3)
   -made from a chemical reaction in the atmosphere of nitrogen oxides and hydrocarbons
4. particulates (solid or liquid fine particles in the air)
   -agricultural practices
   -industry
   -automobiles
5. carbon monoxide
   -automobiles
6. hydrocarbons
   -automobiles

Five of the six pollutants above may arise from automobile emissions. Vehicles with untuned engines, those lacking catalytic converters, and diesel engines contribute greater amounts of particulates, hydrocarbons, and nitrogen oxides.

In Great Smoky Mountains National Park Biosphere Reserve, park scientists monitor levels of ozone, nitrogen oxides, sulphur dioxide, acid deposition, and visibility (decreased by air borne particulates). Each is affected by the air pollution produced by motor vehicles. In areas like the Smokies where millions of visitors come during the year by way of...
Let's Sock Car Exhaust!
-3rd Grade-
cars, buses, and motor homes, auto exhaust substantially adds to the air pollution problem in the area.

These substances are also produced through natural means such as forest fires, volcanoes, and decay, but not to the extent of human-caused sources.

There are many effects of air pollution. The most well-known is "acid rain," or more correctly, acid deposition. Acid deposition is the technical name which includes all types of acidic precipitation (acid rain, sleet, snow, clouds) and the settling of dry acidic particles. Acid deposition is thought to cause the death of some animal and plant life in lakes and streams, and may be killing trees in several areas of the world. Marble buildings are also harmed by acidic rains; acid turns marble to gypsum and this crumbles out of the stone.

Acid deposition is only one problem resulting from polluted air. Reduced visibility, ozone damage, and health problems are also caused by air pollutants. Scientists study the effects of air pollution on the trees, plants, soil, and animals in Great Smoky Mountains National Park Biosphere Reserve. Many sources of air pollution, such as power plants and industries, are hundreds of miles from this area and arrive there with the air masses that move across the continent. Other sources of pollution, such as automobiles, many be found in almost any area.

MATERIALS NEEDED: A U.S. map, white socks (tube socks), a variety of automobiles. (You might ask students to bring a sock from home—although they will get very dirty.)

SUGGESTED PROCEDURE AND "SCRIPT" FOR TEACHERS (underlined): Boldfaced letters refer to MATERIALS listed above. As given, this activity will provide students with a well-rounded lesson on air pollution from automobiles. Additional individual and class investigations are provided at the end of the guide under EXTENSIONS.

1. SET: Tell students: Today, we will be learning about air pollution. We will learn where it comes from, what it looks like, what it does, and how we can prevent it.

2. DISCUSSION OF POLLUTION SOURCES AND TYPES OF AIR POLLUTION (Objectives 1, 2, 3): Ask students what makes air pollution. List these items on the board. Included in your list should be: automobiles, factories, power plants (where electricity is made), farming (particulates), and wood burning stoves. Emphasize these sources.

Then, make another list of words describing air pollution (dirty, stinky, poisonous, and so on). Air pollution can be visible or invisible — some kinds you can see, and others you cannot see. Some are like the air — these are called gases. Some are like water — they are liquid. Others are solids like dirt or dust. The liquid and solid kinds of pollution are called 'particulates.' That means they are tiny pieces — or particles — floating in the air. (Write the words 'solid,' 'liquid,' 'gas,' and 'particulates' on board.)

Ask students: Do we have air pollution in our community? If we do, where does it come from? Explain to students that some air pollution comes from hundreds of miles away. Use a U.S. map to show the direction of winds across the continent from west to east. These winds bring pollution from a far distance to our community. Do we have air pollution in our community that is made right here? (Automobile exhaust) Today, we will try to discover what kinds of pollution — gases or particulates or both — come from automobile exhausts.
Let's Sock Car Exhaust!
-3rd Grade-

3. SOCK INVESTIGATION (Objective 2): Explain to the students that when a car runs, it burns gasoline. Some of the gasoline is changed into the energy that runs the car. But the leftover gasoline is changed into exhaust, and that comes out the tailpipe. Use a drawing on the board to illustrate this.

Get as many white socks as you can. (You could have the students bring them from home, although all the 'pollution' may not wash out.) Assemble the students outside. Slip a sock over the tail pipe of a car or truck or school bus and then start the engine. CAUTION: Exhaust pipes become very hot. Do not touch when attaching or removing sock. Students should be kept back from the vehicles as some of the gases from the tailpipe are poisonous (carbon monoxide).

Try this on different types of autos: old and new, cars and trucks, diesel. Let the vehicles run for five minutes with the sock on. Then turn the engine off and remove the sock. Label each sock with the kind of car and model year. Note the build-up of particulates inside. Arrange all socks in order from dirtiest to least dirty. Are there differences? What kind of vehicles produced the most pollution? What kind of pollution are you seeing in the socks? (particulates) Is the sock damp? Do cars produce air pollution gases? (carbon monoxide is colorless and can be deadly; it combines with red blood cell instead of oxygen and the victim suffocates; and nitrogen oxides - both gas and solid, the gas is brown in color)

Ask students: What does air pollution from cars do? How does it hurt people, plants, animals? List on board: carbon monoxide - poisonous and can kill animals and people; particulates - make things dirty, hurts lungs and/or breathing of all living things, makes haze worse and you can't see as far; nitrogen oxide - causes acid rain which kills fish and hurts trees; nitrogen oxide + hydrocarbons + energy from the sun = ozone...too much ozone in the air burns plants.

Ask students: How can we have less air pollution in our community? Write replies on board. These may include: have car engines tuned, don't remove catalytic converters (which remove hydrocarbons and so help to decrease ozone), walk or ride your bike instead of having your parents drive you somewhere, join a car pool, ask parents to switch off car engine when they park the car - even if they will only be there a few minutes.

4. CLOSURE: Tell class: Automobiles, like many other sources, produce pollution that we can see and pollution we cannot see. The next time you are riding in the car with your parents or walking down our main street, notice the pollution from all kinds of cars going into our air.

EVALUATION:
1. What are 2 sources of air pollution?
2. Circle all the answers below that tell how air pollution from cars hurts things.
   A. Hurts breathing.
   B. Can cause people and animals to die.
   C. Can cause acid rain.
   D. Burns plants.
   E. Makes cars go faster.
   F. Makes things dirty.
   G. Makes the mountains die.

3. What are 2 things you can do THIS WEEK to help lower air pollution from cars in your community?

4. Is it important to have clean air? Why?

EXTENSIONS:
*1. With parental help, make a display of "exhaust pipe socks" from different types of cars - old, new, diesel, those fueled with unleaded and leaded fuel, trucks, semis, etc. (individual)
Let's Sock Car Exhaust!
-3rd Grade-

*2a. Measure the amount of particulate pollution in your home. Use fly paper or a coffee filter (or microscope slide) covered with a thin coat of petroleum jelly. Set your Particulate Collector in a well-used room of your house for one week. Or use several Collectors - one in each room - to compare the different amounts of particulates in different areas of the house. (Individual)

*2b. Use the same technique as in 2a., but put the collectors in the school building instead of the house. (Individual or class project)

3. Invite a representative of Tennessee Valley Authority power plants to class to discuss how they have reduced air pollution from their plants.

4. Make posters to distribute around the community showing how people can lower the amount of air pollution from their automobiles.

5. See National Wildlife Federation (1987) educational materials on air pollution for more activities.

*Suitable for Science Fair project.

REFERENCES AND RESOURCES


Let's Sock Car Exhaust!

-KEYWORDS-

**Air pollution** - extra solids, liquids, and gases in the air that are human-caused.

**Car exhaust** - when gasoline is burned in a car engine, there are leftover gases and solids. These come out the tailpipe or exhaust pipe. Carbon monoxide, nitrogen oxide, and particulates are in car exhaust.

**Carbon monoxide** - an invisible, odorless gas made by gasoline engines. This gas can kill a person in an enclosed place. Never run a car in a closed garage.

**Catalytic converter** - a part in the car that takes out hydrocarbons. Catalytic converters help keep our air clean.

**Gas** - something that fills whatever it is in. Air is a gas.

**Hydrocarbons** - one of the pollutants in car exhaust. Catalytic converters take this out of car exhaust.

**Liquid** - something that flows. Water, Dr. Pepper™, and milk are liquids.

**Nitrogen oxide** - one of the pollutants in car exhaust. Nitrogen oxide is found in acid rain.

**Ozone** - a gas made from hydrocarbons, nitrogen oxide, and sunlight.

**Particulates** - small pieces of solids or liquids floating in the air.

**Pollutant** - a human-caused solid, liquid, or gas in the air.

**Pollution source** - something that makes air pollution. Cars, factories, and power plants are pollution sources.

**Solid** - something that keeps its shape. Wood, rocks, and tables are solids.
OBJECTIVES: Students will be able to: (1) list five sources of air pollution in their community, (2) describe ways air pollution could be decreased in their community.

METHOD: In small groups, students will use all their senses to search for sources of air pollution in their community, including the use of petroleum jelly-covered glass slides to check for particulates.

BACKGROUND: Air pollution may be defined as any human-caused substances added to the air. Acid deposition is the technical name including all types of acidic precipitation ("acid rain") and the deposition or settling out of dry acidic particles. Acid deposition is thought to cause the death of some animal and plant life in lakes and streams, and may be killing trees in several areas of the world. Marble buildings are also harmed by acidic rains; acid turns marble to gypsum and this crumbles out of the stone.

Acid deposition is only one problem resulting from polluted air. Reduced visibility, ozone damage, and health problems are also caused by air pollutants.

Scientists study the effects of air pollution on the trees, plants, soil, and animals in Great Smoky Mountains National Park Biosphere Reserve. Many sources of air pollution, such as power plants and industries, are hundreds of miles from this area and the pollution arrives here with the air masses that move across the continent. Other sources of pollution may be found in almost any area—automobiles, for example. In areas like the Smokies where millions of visitors come during the year by way of cars, buses, and motor homes, auto exhaust substantially adds to the local air pollution problem.

The most well-known air pollutants and their human-caused sources are:

1. nitrogen oxides (NOx)
   -automobiles
   -power plants

2. sulfur dioxide (SO2)
   -power plants
   -industries
   -metal ore smelters

This project was funded by the City of Gatlinburg, Tennessee, Great Smoky Mountains National Park Biosphere Reserve, and the School of Natural Resources of The Ohio State University. For further information, contact Kimberly Tassier and Gary Mullins, School of Natural Resources, The Ohio State University, 2021 Coffey Road, Columbus, Ohio 43210, (614) 292-9828. February 1988.
3. ozone (O₃)
   - made from a chemical reaction in the atmosphere of nitrogen oxides and hydrocarbons
4. particulates (solid or liquid fine particles in the air)
   - agricultural practices
   - industry
   - automobiles
5. carbon monoxide
   - automobiles
6. hydrocarbons
   - automobiles

These substances are also produced through natural means such as forest fires, volcanoes, and decay.

**MATERIALS:** A Pollution Search sheet (one copy per group), B "What Can You Do?" sheet (one per student).

**ALSO NEEDED:** microscope slides, microscopes or hand lenses, vaseline, pencils.

**SUGGESTED PROCEDURE**

AND "SCRIPT" FOR TEACHERS (underlined): Boldfaced letters refer to MATERIALS listed above. As given, this activity will provide students with a lesson on local air pollution sources. Additional individual and class investigations are provided at the end of the guide under EXTENSIONS.

1. SET: Tell students: Today, we are going to go hunting—for air pollution. You will be searching for air pollution with all your senses, not just your eyes. You will be "looking" for the places that air pollution comes from. These are called sources (write on board).

2. POLLUTION SENSE SEARCH
   (Objective 1): Adapted from "Pollution Search," from the National Wildlife Week 1987 Educator's Guide. Used with permission from National Wildlife Federation.

   Divide class into groups of two to three students. Give each group two microscope slides and a Pollution Sense Search sheet, A.

   First, the students should coat one side of the slide with a thin layer of vaseline. They should place each slide in a different place outside. One area should be near the main street; the other, away from a traffic area. Tell the students to write the locations of their slides on the back of their search sheets.

   Next, lead students around the community. Each group should be on the lookout for sources of air pollution. These should be recorded on the sheet. They should write in the types of pollution they saw, smelled, felt, etc. (e.g., fumes, dust, smoke) on the lefthand side of the sheet as they sense them and the type of polluter/source across the top (such as car, truck, house chimney, business, factory). Every time they sense air pollution, they should make a tally mark in the appropriate box on the chart. Tell the students to be thinking of which sense they use the most to find air pollution.

   The walk through the community should include a heavily traveled street or highway and a residential area. Return to the classroom after about 25 minutes.

3. DISCUSSION (Objective 2): As they return, each group should retrieve their slides—they should be especially careful to remember which one came from which site (if you have a wax pencil or crayons, label the slides). Pass out hand lenses or allow students to look at slides through microscopes. Record observations on the back of the Pollution Sense Search Tally Sheet.

   Explain to the students: The things you see on the slides are tiny pieces of dust, or smoke, or chemicals that float in the air.
These settle out and land on trees, animals, people, and buildings. Sometimes we breathe them in. When air pollution is very bad in cities, the people are warned not to go outside because the air is so bad. Which slide had more particles on it—the one near the street or the one far from the street? Where do the particles come from? (dust from the land, car exhaust, smoke, etc.).

Make a chart on the board (or on an overhead transparency) similar to the data sheet chart. Ask the students to add up the number of marks in each box. Call off the boxes on the board and have the members of each group give the number they have in that box on their chart. Have one student record the numbers for one box as they are read, and then add them. Record the sums in the appropriate boxes.

Ask students: Which sources made the most pollution? What types of air pollution did you find the most? What kind of cars made the most exhaust? How can a car owner make his or her car put out less pollution? (have it tuned up, keep the engine in good shape) When would we have more air pollution from cars? (during the tourist season, when there are more cars). Why is air pollution bad? (hurts your lungs and the lungs of animals, hurts plants, makes the rain dirty).

4. CLOSURE: Tell students: We might think we are far away from air pollution because we do not live in a big city. But there is air pollution even here. What can YOU do to stop air pollution in our town? (Discussion) Pass out the "What Can You Do?" sheets. Go over the sheet with the students and challenge them to do at least one of those things in the next week. Remind students about this. (You may want to make a chart with each student's name on it. When he or she has done their "good deed," that individual can write what it was on the poster next to their name. You could even have a contest to see who could do the most things in the next week to lower air pollution.) Tell students: Take this sheet home and share it with your parents. Ask them if they can think of any other ways to lower air pollution in our town.

EVALUATION
1. Circle the source or sources of air pollution that is NOT in your community.
   A. POWER PLANT
   B. HOUSE CHIMNEY/FIRE
   C. CAR
   D. TRUCK
   E. OIL REFINERY

2. What are 2 ways YOU can make less air pollution in your town?
   a)
   b)

EXTENSIONS
1. Work with other classes to have a "Clean Air Week," where posters, newspaper articles, and activities could be performed by the students to inform the community about local air quality.

2. Have students find magazine articles about air quality to share them with the class. See especially: Newsweek, Time, National Geographic (April 1987), Ranger Rick (October 1986 and March 1987), and several issues of National Wildlife (1987).

3. Make "Air Floats" or mobiles of air pollution sources and "cures."

REFERENCES AND RESOURCES
Air Pollution - very small pieces of human-caused solids, liquids, and gases in the air. These come from cars, fires, factories, electrical power plants, and oil refineries.

Exhaust - the air pollution that comes from burned fuel. Automobile exhaust is the "leftovers" of burned gasoline.

Particulate - a tiny bit of solid or liquid matter in the air. Soot, dust, fumes, aerosols, and mist are a few kinds of particulates.

Pollutant - a harmful chemical given off into the air, water, or soil. Pollutants can be solids, liquids, or gases.

Sources - things that make air pollution. Cars, power plants, and fires are sources of air pollution.
What Can You Do?
From National Wildlife Federation's "We Care About Clean Air" Educator’s Guide (1987)

To Reduce Auto Pollution-
- Walk when you can — ride a bus or train. Join a car pool. Ride a bike.
- Remind your parents to have their car's pollution controls and motor inspected and tuned-up regularly.
- Ask your parents to switch off the motor when they park the car, even if for a few minutes.

To reduce power plant pollution:
- Remember, the less electricity you use, the less electricity power plants need to make. That means less fuel will be burned -- and less air pollution!
- Turn off the lights, radio, and TV when no one is using them.
- Run the dishwasher only when full.
- Use the air conditioner only when someone is home and only when it is very hot.
- Dry your clothes outside instead of using a dryer.
- Avoid using electric appliances, especially the dishwasher, during peak power times (5-7 p.m.)
- Keep the home furnace clean and properly adjusted.
- Keep your home thermostat set no higher than 68 degrees and air conditioner no lower than 72 degrees.

To Reduce Refuse and Trash Burning:
- Do not burn leaves or trash.
- Buy products in returnable or non-plastic containers when possible (burning plastic gives off dangerous chemicals).
- Reuse and recycle whatever you can!
<table>
<thead>
<tr>
<th>Type of Pollution</th>
<th>Cars</th>
<th>Trucks</th>
<th>Factories</th>
<th>Chimneys</th>
<th>Power plants</th>
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<td>1-Smoke</td>
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OBJECTIVES: Students will be able to describe five air pollutants, sources of air pollution, or effects of air pollution.

METHOD: Students will be introduced to air pollutants and their sources by playing a Pictionary-type game.

BACKGROUND: The sky has no limits. The air over the Great Smoky Mountains and the Southern Appalachians comes from the West, and will move on eastward. In the past, we thought our vast skies would be forever clean and blue. As a result, the sky was the receptacle for tremendous amounts of by-products from industrial processes. Our automobiles added their gaseous leftovers to the air.

Today, we know that although the sky has no bounds, there are limits to the amount of pollutants the air can hold before we all feel the results. This poses serious problems for those areas which we have marked for protection—areas such as national parks and biosphere reserves. Air quality is a resource in its own right and a critical factor in determining the quality of the other resources of a biosphere reserve or park. Among National Park Service lands in the International Network of Biosphere Reserves, examples of resource degradation from air pollution include the following:

*Great Smoky Mountains National Park, Tennessee and North Carolina:* Visible ozone injury has been found on white pine tree needles throughout the park. Red spruce trees have been growing more slowly over the past ten years and this may be linked to high levels of ozone, heavy metals in the vegetation and soil, and acidic deposition. Reduced visibility has been recorded in the park; visibility is decreased by minute particles in the air.

*Sequoia and Kings Canyon National Parks, California:* Extensive ozone burns have been found on ponderosa pines and sequoia seedlings. Widespread degradation of scenic views and visibility has been caused by pollution. (You may want...
to explain that the Ponderosa Ranch on the television series, "Bonanza," was named for the ponderosa pine trees. The giant sequoia trees were named for the great Cherokee leader, Sequoyah.)

- Isle Royale National Park, Michigan: High concentrations of sulfur and heavy metals have been found in park streams and, although the cause has not been determined; this may be linked to acid rain.

- Everglades National Park, Florida: Epiphytic plants—which live on air, water, and on another plant—at the eastern edge of the park have high levels of sulfur. Elevated levels of arsenic and mercury have been found in wildlife.

- Big Thicket National Preserve, Texas: A decrease in the abundance of Spanish moss, an epiphyte, is probably related to heavy metal pollution.

- Big Bend National Park, Texas: Visibility has been reduced, probably due to the human-caused sulfates in the air.

The responsibility to protect the resources of these and other protected areas from air pollution degradation is clear. For areas of the National Park Service, the National Park Service Organic Act directs the National Park Service to administer its areas consistent with their "fundamental" conservation purpose. For areas which have been designated as "Class I" air quality areas under the Clean Air Act, that act requires the National Park Service to protect the air quality of its areas from further damage.

For areas designated as biosphere reserves, Unesco's Man and the Biosphere Program created a moral imperative to protect the areas as sites for research, resource management, education and training.

The air is a natural resource in its own right. The air is also critical to the quality of other natural and human-caused resources in parks, biosphere reserves, and other special areas. Gaseous and particulate pollutants emitted from human-created sources travel to protected areas through the air, over short or long distances. Depending on the chemistry of the particular pollutant, the weather, land forms, and other environmental conditions, polluted air can harm protected resources in many ways. For example, air pollution can cause:

- leaching of important nutrients from the soil,

- acidification and other forms of water quality degradation, and

- injury to the structure and/or function of vegetation.

These effects can, in turn, lead to changes in ecosystem structure, diversity, and function. Air pollution can discolor and weather materials, such as historical buildings and monuments, as well as natural rock formations. Air pollution can reduce visibility and impair one's ability to see and appreciate the form, contrast, detail and color of near and distant features. Finally, air pollution can harm human and animal health and well-being.

The Clean Air Act, as enacted in 1970 and amended in 1977, sets out to assure safe and acceptable ambient air quality throughout the nation. The nationwide goal of the Clean Air Act is the attainment and maintenance of national air quality standards.

Among the requirements set by the Clean Air Acts were emission control standards for pollution sources—such as new power plants, national motor vehicle emission standards, state implementation plans, and the designation of certain regions of the country as Class I regions. These Class I areas include several national parks, wilderness areas, memorial parks, and international parks. Sixteen United States biosphere reserves were among those designated, including the Great Smoky Mountains National Park. Congress declared these areas as
deserving of the highest levels of air quality protection. Baseline air quality measurements were made and monitoring continues to determine whether or not maximum levels of tolerated air pollution are exceeded.

Air pollutants may be classified by physical state and source. The two physical state categories are the gaseous pollutants, which include sulfur dioxide, nitrogen oxides, ozone, carbon monoxide, hydrogen sulfide, and hydrogen fluoride, and the particulate pollutants (both solid and liquid) which are further broken into the two categories of fine particulates and toxic particulates. (See the KEYWORDS hand-out.)

Stationary sources of pollutants are those which do not move, such as industries, power plants, or homes. Automobiles are the main kind of mobile sources.

Weather patterns carry pollutants produced in one area to regions perhaps hundreds or thousands of miles away. This has received much attention in the case of acid rain. Great Smoky Mountains National Park Biosphere Reserve and the Southern Appalachians are especially vulnerable to the eastward movement of air masses. The height of the mountains is enough to trap air on the windward (or western) face, and its load of pollutants. Temperature inversions, which is a body of warm air near the ground held in place by cold air above it, are common. During an inversion, a grayish brown haze can often be seen from the higher elevations, pinned below the higher, clear air and a bright blue sky.

Automobiles are thought to greatly contribute to the air quality problems in Great Smoky Mountains National Park Biosphere Reserve and all of the Southern Appalachians, especially during the peak visitor season. Air masses from the Ohio River Valley region bring with them emissions from the many industries and power plants in that area.

Great Smoky Mountains National Park Biosphere Reserve monitors air quality at several sites. Levels of ozone, the acidity of precipitation, visibility, and the effects of pollutants on the ecosystem are continually measured and studied.

MATERIALS NEEDED: Paper, pencils or pens, chalk, and chalkboard.

SUGGESTED PROCEDURE AND "SCRIPT" FOR TEACHERS (underlined): Boldfaced letters refer to MATERIALS above. As given, this activity will introduce students to air pollutants and their sources. Additional individual and class investigations are provided at the end of this guide under EXTENSIONS.

1. SET: Tell students: Today we will be starting a week's worth of lessons on air quality in the Great Smoky Mountains and the Southern Appalachians. We will be learning about some of the specific problems of air pollution we face. In today's lesson, you will become familiar with some of the pollutants, sources, and problems of air pollution.

2. "POLLUTION-ARY" GAME: Distribute KEYWORDS hand-out sheets to students. Briefly discuss the terms defined. Tell students: To become acquainted with the words of air pollution, we are going to play a game called, "Pollution-ary." It is played like "Pictionary" and some of the game shows on television. The object of this game is to draw pictures of a phrase so that your teammates can guess the phrase. All the phrases concern air pollution.

   Divide the class into two to four teams. Each team should chose a name. Write the names of the teams on the chalkboard where you can keep track of the score. One member of a team draws the phrase from the included list, A.
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One member of each team, the drawer, comes to the front of the room. The teacher shows them all the phrase to be drawn for that round. Those players return to their teams and wait for the teacher to say, "Go!" Then, they make sketches to illustrate the phrase while their teammates watch and try to guess the phrase. The first team to guess the phrase gets one point. The team with the most points at the end of the class period wins the game. (Option: Make the last question worth a lot of points to give all teams a last chance to win!) You may want to give the winning team some reward, such as candy bars or a cut in the lunch line!

Variations of "Pollution-ary:"
You may want to vary this game according to your group and discretion. Instead of all groups participating at the same time, have one member of one team draw the phrase on the chalkboard. If his or her team does not guess the phrase after a certain amount of time, the other teams get a chance. You may also want to put blanks on the board to represent the number of words in the phrase (like "Hangman"). Fill in the blanks as those words are guessed.

And if you have a group of "actors" and no "artists," use the standard Charades game to act out the phrases. All of these other games are variations of this old party game.

3. CLOSURE: Tell students: Now that you have an idea of some of the terms and problems caused by air pollution, we will learn more about these in the coming week!

EXTENSIONS:
1. Have students develop other pollution-oriented games from popular board games or game shows, such as Jeopardy (good for reviewing material before a test), Wheel of Fortune, and Trivial Pursuit. Use these games in class and at Parent-Teacher Conferences, Open Houses, or Science Fairs to test Mom and Dad's knowledge of air quality!

REFERENCES AND RESOURCES

The What and Where of Air Quality!

-KEYWORDS-

(From the Educator’s Guide, National Wildlife Week, 1987)

Acid - a sour solution with a pH of less than 7.

Acid rain - a general term referring to acid falling to earth in rain, snow, frost, fog, mist, and gases or as dry particles. Acid rain is caused when sulfur dioxide and nitrogen oxides emitted into the atmosphere become acid through chemical reactions and then fall to earth.

Air monitoring - the measuring of the types and quantities of pollutants in the atmosphere.

Air pollution - the presence of human-caused contaminants in the air in concentrations high enough to harm humans, wildlife, plants, or human-caused things.

Alkaline - a substance is alkaline when it has a pH higher than 7 (base) and can neutralize an acid.

Atmosphere - the layer of air that surrounds the earth.

Buffer - (verb) the ability to neutralize an acidic or alkaline solution, usually in soils or water; (noun) a substance having this ability.

Carbon monoxide (CO) - a colorless, odorless, deadly gas created mainly by the incomplete combustion of fuel in gasoline engines.

Combustion - burning; a chemical reaction that produces heat, light, and other by-products. For example, in a gasoline engine, when oxygen and gas mix and are ignited by a spark, heat, light, carbon monoxide, and water are produced.

Emissions - substances discharged into the air, usually by human activities such as burning fossil fuels.

Fossil fuels - buried deposits of decayed plants and animals that, over millions of years, have been converted to oil, coal, or natural gas by heat and pressure.

Hydrocarbons - compounds produced by the incomplete burning of gasoline and the evaporation of such things as industrial solvents and oil paints. Hydrocarbons contribute to smog and ozone.

Lead (Pb) - a metal added to some gasoline to improve engine performance. As the engine runs, lead particles escape through the exhaust pipe.

Nitrogen oxides (NO and NO₂) - gases produced during high-temperature combustion in motor vehicles and in power plant and industrial furnaces.

Ozone (O₃) - a harmful form of oxygen which is produced when sunlight stimulates a reaction between nitrogen oxides and hydrocarbons. Near the earth’s surface, ozone is a major component of smog.
Ozone layer - a layer of atmospheric gases located in the stratosphere (12 to 30 miles above the earth's surface). The ozone layer protects life on earth by filtering out harmful, cancer-causing ultraviolet radiation from the sun.

Particulate - a tiny bit of solid or liquid matter (soot, dust, fumes, aerosols, mist, etc.) suspended or carried in the air.

pH - a scale numbered from 0 (acidic) to 14 (alkaline) and used to measure the degree of acidity or alkalinity in a substance.

Pollutant - a harmful chemical emitted into the air, water, or soil. Pollutants can be solid, liquid, or gas.

Scrubber - an antipollution device that uses a spray to remove pollutants from a stream of air passing through a smokestack.

Smelter - a plant where metals are melted to remove impurities.

Smog - originally meaning a combination of smoke and fog, smog now refers to air pollution produced by the reaction of hydrocarbons and nitrogen oxides in sunlight. Smog is mostly made up of ozone.

Sulfur dioxide (SO₂) - a gas, released mainly from power plants that burn coal and oil to make electricity.
Show only ONE phrase to students at a time! Use the phrases in order as the easier ones are at the beginning. Students should keep their KEYWORDS sheets in front of them during the game. The drawer may not talk at all during his or her turn. You may want to briefly discuss each of the phrases and how it relates to air quality after it has been guessed.

All words in parentheses ( ) should be given to the teams before the drawer begins. For example, "(Paris) is a big city"—all the students would be told that the first word in the phrase is "Paris;" they would have to guess the other words. Add additional parentheses at your discretion.

Acid rain hurts fish.

The Clean Air Acts are laws against air pollution.

Ozone gas burns plants.

Acid rain hurts the Smokies.

Air pollution lowers visibility.

(Carbon monoxide) comes from cars.

Acid rain is made from the gases of sulfur and (nitrogen oxides).

Lead is in gasoline.

Air pollution hurts the soil, plants, animals, buildings, and people.

Winds bring air pollution from the West.

Acid rain hurts trees in the Great Smoky Mountains.

Mountain life is harmed by air pollution.

Wind

Coal

Fossil fuels

Acid rain

Smog

Ozone

Atmosphere

Smokestacks

Factories make air pollution.

Air is made of gases.
OBJECTIVES: Students will be able to: (1) describe acidity and the pH scale in terms of increasing acidity, (2) describe the range of the different acidic rainfall in the biosphere, (3) compare the acidity of different forms of precipitation, and (4) describe four effects of acid precipitation.

METHODS: Students will learn about acid rain and other forms of acidic precipitation and the pH scale through a participatory demonstration of the pH scale using common household items. Harmful environmental effects caused by acid deposition will be highlighted using an overhead transparency set.

BACKGROUND: (From "Acid Rain: What Is It and How Is It Measured?," available from the Great Smoky Mountains Natural History Association) The pH scale ranges between 0 and 14, with 7 being neutral. A substance with a pH less than 7 is acidic. If greater than 7, the substance is basic, or alkaline. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to pH 3 would be a hundred times (10 x 10) increase in acidity.

Most scientists agree that "normal" rainfall has a range of pH levels from 4.9 to 6.0. Rain in the atmosphere reacts with carbon dioxide (CO₂) to form a weak carbonic acid, lowering the pH of rain (from a neutral pH of 7 for pure water). Acid rain is defined as any form of wet precipitation which has a pH less than 5.6.
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The "rain" becomes acidic when water molecules (H₂O) react with gases in the air. These gases are mainly sulfur dioxide (SO₂) and various nitrous oxides (NOₓ). This combining of gases and water molecules takes place when the water captures hydrogen ions (H⁺) from the gases (ions are electrically charged particles).

From information gathered in the 1930s and 1950s, it appears that the acidity of rainfall in the eastern United States has increased significantly (in Great Smoky Mountains National Park: 1956 - 5.6; 1980 - 4.27). Some scientists dispute this theory, however. The gases SO₂ and the NOₓ are mainly responsible for the increasing acidity. These gases are primarily created by industrial factories, coal-fired power plants, and car emissions.

An estimated 26 million tons of SO₂ and 22 million tons of SO₂ and NOₓ were put into the atmosphere in the United States in 1980. (It would take about 1 billion students to equal that weight!) Natural sources of SO₂ and NOₓ (forest fires, lightning, volcanoes) have a natural effect on acid rain. Areas where the soil has been disturbed, such as mines, forest fires, landslides, and construction sites, may be making the water in streams and lakes more acidic. Many soils are already acidic or contain minerals which react with rainwater, snowmelt, etc., to form acids. These acidic waters are carried into streams and lakes.

The gases SO₂ and NOₓ are thought to be carried long distances by air currents. Storm systems also move long distances, carrying with them any pollutants they may pick up. The interaction of airborne pollutants and clouds is not well understood. Understanding the movement of prevailing air currents and storm systems can greatly aid scientists in discovering where acid rain is coming from and, just as importantly, where the rain is returning to earth. Scientists hope to learn more about the movements of acid rain by studying storm events, high and low pressure movements (high pressure is usually an indication of good, clear weather, whereas low pressure fronts are associated with storms), and occluded fronts. Occluded fronts normally proceed storm events, thus making them a good indicator for tracking storm events. Researchers are attempting to track where the pollution (gases, fly-ash, soot, dust particles) goes when it leaves the heavy industrial and populated areas by making projections of storm event and air current movements.

Currently, there are two primary methods being used by industries and power plants to reduce the amount of pollutants released into the atmosphere. These two methods consist of installing cleansing devices in the exhaust or smokestacks. The two types currently available are called "scrubbers" and electrostatic precipitators. Scrubbers are designed to remove the various gases (SO₂ and NOₓ) from the plant emissions. These are considered to be very effective, and many states require that these be installed.

Electrostatic precipitators are less effective than scrubbers. They are designed to remove the visible soot from emissions. This makes the emissions look clean but does not remove the real culprits of acid rain, SO₂ and NOₓ. At this time there are no commercially produced devices for removing NOₓ from automobile exhaust. Many people think catalytic converters do this job, but this is not true. Converters are designed to remove hydrocarbons which are thought to cause cancer. Hydrocarbons do not react to form acid rain.

Effects of Acid Rain. Acid rain in its many forms is the subject of considerable scientific research and many of the effects are just now being identified. Acid deposition is known to harm aquatic and terrestrial ecosystems, buildings, statues, and monuments. The following effects and statistics were obtained from "The Acid Rain Story," from Environment Canada.

- More than 200 million square kilometers of North America now
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receive rain with a pH of 4.6 or lower, that is 10 times more acidic than "clean rain."

• Lake and river waters with a pH below 4.5 will not support most fish populations. Even at a pH of 5.0, only limited fish populations can survive; frogs, salamanders and many other creatures are decimated.

• Relatively high sulfate and nitrate deposits in remote wilderness areas demonstrate the reality of long-range transport of airborne pollutants.

• In the eastern United States and Canada, emissions from human-caused sources of SO2 are 10 to 20 times greater than emissions from natural sources.

• Fish taken from waters which are becoming acidic exhibit high concentrations of mercury and other toxic metals in their tissues—presumably leached out of soils and bedrock. Drinking water from acidic lakes and rivers has elevated concentrations of toxic metals, too.

• Important evergreen species and other plants exposed to high doses of acid rain show damage to their foliage, sometimes at levels such as pH 4.6. Growth of the whole plant is adversely affected.

• About 200 lakes in the Adirondacks in New York no longer support fish life and thousands more are slowly losing their capacity to buffer acid rain.

• A U.S. government study estimated that 55 percent of the lakes and 42 percent of stream-miles in the eastern U. S. are currently being subjected to acidic rain which will eventually lead to deterioration.

• Scientists are beginning to evaluate the role of acid rain in increasing the vulnerability of trees to diseases and insects. Acid rain may also limit the decomposition of plant litter on the forest floor, reducing the normal recycling capacity and thus, the amount of minerals available to trees and plants.

• Stone buildings, statues, and monuments are eroded by a number of air-borne pollutants including acid rain. This increases the need for replacement and repair of buildings and such structures.

• Increased acidity in soils due to acid rain is thought to free metals in the soil that are toxic to living organisms. These metals include mercury, aluminum, and copper.

• The susceptibility of a lake or stream to acid rain is determined to a large extent on the type of surrounding bedrock. Limestone neutralizes acid, and areas rich in this act as a buffer and are not as severely affected. Lakes with a granite foundation, which has little or no buffering capacity, are more easily acidified.

• Different forms of precipitation have different pH levels, as do different areas of the continent and the world. Wet deposition refers to acid rain, snow, sleet, hail, or even fog. Fog or clouds are more acidic than the others because there is less water to dilute the acid. Rainfall at the beginning of a storm may be more acidic as those early drops collect suspended acid particles in the air on the way down. Snow is not necessarily more or less acidic, but after accumulating all winter, spring thaws release a large amount of acid into the surrounding area. This phenomenon is known as "spring shock." This is
especially harmful as spring is the reproductive season for fish and other aquatic animals. Elevated acid levels have been shown to be detrimental to young aquatic life. Dry deposition is the settling out of pollutants, including SO2 and NOx, without precipitation. Dry deposition may be more harmful than wet deposition because of its concentrated form. Also there is evidence that the dry acids which have settled on vegetation substantially increase the acidity of precipitation as the rain filters through the foliage.

- The average pH of rainfall in the eastern U.S. and Canada is 4.1.
- The average pH of rainfall in Great Smoky Mountains National Park is between 4.3-4.5.
- The lowest rainfall pH recorded in the U.S. was in Wheeling, West Virginia at 1.5.
- The lowest recorded rainfall pH in Great Smoky Mountains National Park was approximately 3.5 in 1984.

MATERIALS: A Directions for making large pH scale, B pH labels: Clean rain 5.6, New England 4.1, Smokies 4.4, Lowest Recorded - West Virginia 1.5, Lowest in Smokies 3.5 C 1-3 set of precipitation symbols, with appropriate pH’s, D Measuring pH worksheet, E overhead transparency on pH levels in the United States, F 1-13 set of overhead transparencies on effects of acid rain, G list of effects for students.

ALSO NEEDED: Large sheets of poster board, heavy construction paper, or cardboard; scissors or knife, markers, yard/meter stick, pH measuring paper - available in most science labs, and 5 small vials or bottles filled with water. Students may be asked to bring some of these from home: lemon juice, vinegar, apples, oranges, milk, distilled water, bleach, baking soda, milk of Magnesia, ammonia, lye (oven cleaner), molasses, Coke, tomato juice.

SUGGESTED PROCEDURE AND "SCRIPT" FOR TEACHERS (underlined): Boldfaced letters refer to MATERIALS listed above. Individual instruction sections 1-6 may be interchanged or used separately. As given, this set of activities will provide students with a well-rounded lesson on acid rain. Additional individual investigations are provided at the end of the guide under EXTENSIONS.

Day 1...

1. SET: Tell students: Today we will be discussing one air quality problem in Great Smoky Mountains National Park Biosphere Reserve, in the Southern Appalachians, and in many areas around the world—acid rain. How many of you have eaten or drunk acid? (Responses.) I’ll bet each one in this room has. (Grapefruit juice, orange juice, lemon juice, and tomato juice are all acidic.) We’ll be discovering what acids and their opposites are, how they’re measured, what acid rain is, and what it does.

2. pH SCALE: (Objective 1) Open pH scale (made as directed in A) on chalkboard. Explain to students: The strength of an acid can be measured by the "pH scale." This scale runs from 0 to 14. Zero represents a VERY strong acid. (Write ACID on the board above that end of the scale.) Something with a pH of 14 would be very strong, too — but it wouldn’t be an acid. Does anyone know what the opposite of an acid is called? (Base or alkali.) Write BASE and ALKALI over the other side of the scale. What would a substance with a pH of 7 be? (Neither. A pH of 7 is neutral—it is neither an acid nor a base.)
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As you move from 7 toward 0, what happens to the strength of an acid? (As the strength of an acid increases, its pH DECREASES.) The stronger the acid, the lower the pH. On the other end, the stronger the base, the HIGHER the pH. These numbers on the scale show increases in the strength of an acid or base, but they increase or decrease in a special way. The difference between two numbers represents an increase in strength of 10 times. This is called a logarithmic scale. Something with a pH of 5 is 10 times more acidic than something with a pH of 6. What would be the difference in strength between a pH of 2 and a pH of 4? (The difference between pH's 4 and 2 is 100 times — 10 x 10 or 10^2.)

3. MEASURING pH'S: (Objective 1): Tell students: We are going to measure the pH of different things you see every day. After you have found the pH value, write the name and pH of your sample over the scale in the right place and draw a line to that value on the scale. Divide students into groups of two or three and give them one or two substances from the MATERIALS list to measure the pH values. Pass out how-to worksheet, D.

Day 2...

4. ACID RAIN AND pH: (Objective 2) Tell students: Some types of air pollution cause rain, snow, and clouds to become acidic. All these are called ACID RAIN, which is short for acid precipitation or deposition. The strength of the acid in acid rainfall can vary quite a bit across North America and the rest of the world. All rain is slightly acidic with an average pH from 5.0 - 5.6 for "clean" rain.

Put a vial or bottle of water (B-1: pH = 5.0 - 5.6) by the 5.6 mark on the pH scale. It is not neutral, like distilled water, because the carbon dioxide mixes with the water vapor in the air and forms weak carbonic acid. What do you drink with carbonic acid in it? (Soda pop.) You could have the students blow into distilled water through a straw to demonstrate how the carbon dioxide in their breath can change the pH of the water. Test for pH before and after. One area of North America is known for the acid rain it receives. Where is that? (New England and eastern Canada.) The average pH of rainfall there is about 4.1. How much stronger is this acid rain than "clean" rain? (More than 10 times stronger.) Put a vial of water (B-2: pH = 4.1) by 4.1 mark on scale.) What do you think the pH of rain in Great Smoky Mountains is? Write guesses on the board. The average is between 4.3 and 4.5. Put water vial (B-3: pH = 4.4) by that value on scale.

The lowest pH of precipitation ever measured for one storm was in West Virginia, and was 1.5. That's almost as strong as battery acid! What happens when battery acid gets on your clothes? (It eats holes in clothes.) Place pH 1.5 (B-4) water vial on scale. The lowest pH for the Smokies was about 3.5 in August 1984. Place water vial (B-5: pH = 3.5) on scale.

Show overhead of acid rain in the United States E on overhead projector. Point out areas with similar precipitation pH values and where the Smokies fall in terms of regional pH values.

5. TYPES OF PRECIPITATION (Objective 3) Tell students: Just as the acidity of precipitation differs from one place to another, so does the pH of different types of precipitation. Rain runs about 4.4 here in the Smokies. Put raindrop with 4.4, C-1, on the scale.

Snow is a little less acidic. This could be because the pollutants in the air do not change to acids as much in colder temperatures. Place snowflake with 4.6, C-2, either on the scale or on the board.

The water in clouds can also be acidic, and the ones sampled on the mountain tops here have had pH values from 2.3 to 7 with a ballpark average of about 3.7. Put cloud with 3.7, C-3, on scale. Fog is formed from
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Water vapor rising from the ground. Because of this, the pH of fog is much higher—or less acidic—than clouds.

We may also get some acid sleet or acid hail, but their pH's run about the same as those for rain. Dry acids can settle out of the air, too. This is called dry deposition. All the other forms we have been discussing are grouped together as wet deposition. Dry acids on the leaves of trees and plants can make the rain falling even more acidic when it dissolves them.

6. SOURCES AND EFFECTS (Objective 4): Tell students: We talked yesterday about the two main ingredients in acid rain. What were they? Sulfur dioxide (SO₂) and nitrogen oxides (NOₓ). Where do they come from? Power companies burning fossil fuels, especially high-sulfur coal, industries, and our automobile exhaust (NOₓ).

Many people are concerned with the effect acid rains have on the biosphere. Give each student hand-out, G, The Effects of Acid Rain. Use set of overhead transparencies F 1-13 to discuss effects of acid rain. Discuss how each may affect the students and Great Smoky Mountains National Park Biosphere Reserve.

7. CLOSURE: Today, you have learned about the pH scale, acids and bases, types of acid precipitation and its effects on the natural and human-caused environment. Acid rain is a very controversial subject. Power companies, environmental groups, coal miners, electricity consumers, fishermen, the forestry industry, and the Canadian and U.S. governments are involved in the debate over what to do about acid rain. But the problem with acid rain is not just in North America. European countries are troubled by it too. Acid rain is a world-wide air quality problem.

EVALUATION:
Correctly identify each item as an acid, base, or neutral.

1. Tomato juice with a pH of 4.
   A. ACID
   B. BASE
   C. NEUTRAL

2. Something with a pH of 13.5.
   A. ACID
   B. BASE
   C. NEUTRAL

3. Distilled water.
   A. ACID
   B. BASE
   C. NEUTRAL

4. "Clean" rain.
   A. ACID
   B. BASE
   C. NEUTRAL

5. Most rain in the Smokies.
   A. ACID
   B. BASE
   C. NEUTRAL

6. How much more acidic is something with a pH of 4 than a pH of 7?
   A. 3 TIMES MORE ACIDIC
   B. 100 TIMES MORE ACIDIC
   C. 300 TIMES MORE ACIDIC
   D. 1000 TIMES MORE ACIDIC
   E. 3000 TIMES MORE ACIDIC

7. About how much more acidic is rain in the Smokies than "clean rain?"
   A. THEY ARE ABOUT THE SAME pH.
   B. ABOUT 1 TIME MORE ACIDIC.
   C. ABOUT 10 TIMES MORE ACIDIC.
   D. ABOUT 100 TIMES MORE ACIDIC.
   E. ABOUT 1000 TIMES MORE ACIDIC.

8. Which is NOT thought to be caused by acid rain or deposition?
   A. FEWER FISH ARE FOUND IN LAKES IN EASTERN CANADA.
   B. IMPORTANT MINERALS ARE LEACHED FROM THE SOIL.
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© THE OZONE LAYER HAS A BIG HOLE IN IT.
D. RED SPRUCE TREES IN THE SMOKIES ARE GROWING SLOWER.

9. List the following in order from lowest acidity to highest acidity.
   A. RAIN --> SNOW --> FOG --> CLOUDS
   B. FOG --> SNOW --> RAIN --> CLOUDS
   C. SNOW --> RAIN --> FOG --> CLOUDS
   D. CLOUDS --> RAIN --> SNOW --> FOG

10. Fog and clouds are formed in different ways and this causes them to have different pH levels. Which do the red spruce trees on top of the Smokies "feel" most often? How does this affect the trees on the mountain tops? Explain your answer in a paragraph.

EXTENSIONS: (*Projects suitable for Science Fair.)

*1. Grow one kind of seed in several containers, watering each with water of a different pH. Use sulfuric acid to lower the pH. Keep daily records of the growth of the plants. Do this for 1-3 months. You may want to use a quick growing plant like radishes or peas, and then compare the vegetables from the different pH levels.

*2. Monitor weather patterns and precipitation. Compare the weather maps in the paper each day with the precipitation and its pH. Note where the winds came from prior to the more acidic storm events. Continue the project for several months.

3. Contact area fish hatcheries and report on past fish kill that followed storms in the area. Report on this and studies that were done on this.

REFERENCES AND RESOURCES


**Acid Rain**

-**KEYWORDS**-

**Acid** - A substance with a greater concentration of hydrogen ions (H+) than hydroxide ions (OH\(^-\)). Acids have pH values less than 7.

**Acid deposition** - The all-inclusive term for precipitation with a pH value less than 5.6 and the deposition of dry acid particles.

**Acid precipitation** - Precipitation with a pH value less than 5.6. See "acid rain."

**Acid rain** - The commonly used term for precipitation with a pH value below 5.6. Acid rain includes rain, snow, sleet, hail, clouds, and dry deposition of acid particles.

**Alkali** - Another name for a base.

**Base** - A substance with more hydroxide ions than hydrogen ions. Base pH values range from greater than 7 to 14.

**Dry deposition** - The settling of pollutant particle in the atmosphere on the earth. In this lesson, it refers to the deposition of sulfur dioxide and nitrogen oxides.

**Neutral** - A substance with a balance of hydrogen- and hydroxide ions. A neutral substance has a pH of 7.

**pH** - The logarithmic measure of the strength of acids and bases. pH values range from 0 to 14, with 0-7 being acids and 7-14 being bases.

**Wet deposition** - The term used for acid particles reaching the earth via precipitation. Wet and dry deposition together are called acid deposition.
"How to Build a Better pH Scale"
-or-
Instructions for Making Visual Aide & The pH Scale

**Materials Needed:** Large sheets of poster board, heavy construction paper, or cardboard; scissors or knife, markers, yard/meter stick.

1. Tape or staple the poster board or other large paper sheets together to form a large rectangle with dimensions of roughly 1 1/2 feet by 8 feet. This is the foundation for your pH scale.

```
8'
```

```
1 1/2'
```

2. On this, make a number line from 0 to 14. Highlight the numbers: 0, 7, and 14.

3. This is how your pH scale should look when you are finished. You may also want to color in the scale from 5.0-5.6, as this is the margin of "clean" rain. You could also make the numbers from 0-6 in one color (acids), 7 in another (neutral), and 8-14 in another (bases).
pH LABELS FOR pH SCALE

DISCUSSION

"CLEAN RAIN"
\[ \text{pH} = 4.9-6.0 \]

AVERAGE pH OF RAIN IN NEW ENGLAND
\[ \text{pH} = 4.1 \]

AVERAGE pH OF RAIN IN THE SMOKIES
\[ \text{pH} = 4.4 \]

LOWEST pH OF RAIN EVER RECORDED:
West Virginia
\[ \text{pH} = 1.5 \]

LOWEST pH OF RAIN RECORDED IN THE SMOKIES
\[ \text{pH} = 3.5 \]
PRECIPITATION SYMBOLS
C 1-3

Smokies
Snow
pH = 4.6

Smokies
Rain
pH = 4.4

Smokies
Clouds
pH = 3.7
MEASURING pH
(WORKSHEET D)

1) Use the pH measure to find the pH of your sample. Do this 3 times on the same sample to make sure. Average those three numbers.

2) Write the name of your sample and the pH value on the board above its value on the scale.

3) After every group has their pH's on the board, compare the acids. How do the edible ones taste? Have you eaten any acids today? CAUTION: NEVER EAT SUBSTANCES YOU ARE WORKING WITH IN A LAB ACTIVITY UNLESS YOU ARE INSTRUCTED TO BY YOUR TEACHER.

4) How does it feel when distilled water gets in a cut? Vinegar? Lemon juice? Milk? Stronger acids, in general? How would you like to live in air as acidic as vinegar?

Wet and Dry Deposition Collector
pH of Acid Rain in 1985

From the Annual Report, 1985
The National Acid Precipitation Assessment Program
Acid rain could be killing trout and salmon in northeastern U.S. lakes

F-1 Possible Effects of Acid Rain

Great Smoky Mountains
Low pH = High Acid Levels

Fish eggs and fry die.

Surviving fish grow slowly.
High acid levels kill the eggs of frogs and salamanders.
Higher acid levels in lakes

↓

Fewer microscopic plants and animals

↓

Less food for fish and other aquatic animals

↓

Fewer fish!

I'm so hungry!
Many fish have died after rain storms around Great Smoky Mountains NP. This may be related to acid rain.
Minerals are leached from the soil by acid rain.
Acid rain frees Aluminum in the soil.

Freed aluminum kills plant roots.

Mercury and copper are also harmful to plants and animals.
SPRING MELT

Acidic snow melting in the spring releases its acid—all at once.

Very high acid levels = "Spring Shock"

Spring – egg-laying time for frogs and salamanders.
Acid rain may cause plants and trees to be more easily infected by fungus and disease.

F-9 Effects of Acid Rain
The slow decay of leaves means the slow recycling of nutrients.
Red Spruce trees in the Smokies may by growing more slowly because of acid rain.
Acid rain "melts" stone buildings, statues, and monuments.
Some areas are more sensitive to acid rain than others.

Areas with limestone bedrock are "buffered" against the effects of acid rain.
1. The build up of acids in lakes and rivers in northeastern U.S. may be responsible for the elimination of certain kinds of fish (like trout and salmon).

2. Abnormally high acid levels have been shown to kill fish eggs and fry, cause malformed fish, and reduce growth rates.

3. Frog and salamander eggs can die if acid levels are high. The food chain suffer because these are food for larger animals.

4. In acidified lakes, there are fewer microscopic plants and animals (plankton), which are eaten by larger aquatic animals.

5. Large numbers of fish in hatcheries around Great Smoky Mountains National Park Biosphere Reserve have died after some storms -- this may be linked to acid rain.

6. Minerals are leached from the soil by acid rain.

7. Aluminum, which is poisonous to plant roots, can be freed in the soil due to acid rain. Mercury and copper can also be freed and are harmful to plants and animals at certain levels.

8. When the snow melts in the spring, large amounts of acids that have been building up all winter can be released into lakes and streams. These levels can be much greater than that from one rainfall. This comes at an especially bad time — fish, salamanders, and frogs and toads lay their eggs at this time.

9. Laboratory experiments have shown that plants become more easily infected by diseases or infested with insects or fungus when they have been exposed to acid rain.

10. Leaf litter decomposes more slowly when acid rain is present. This means that the minerals in the dead leaves are not cycled back to the living plants as quickly.

11. Acid rain is believed to lower the growth rates of trees, such as the red spruce in the Great Smoky Mountains National Park Biosphere Reserve.

12. Acid rain "melts" or deteriorates structures such as stone buildings, statues, and monuments. Acid rain is suspected of contributing to the damage of the Capitol Building, Egyptian temples, as well as gravestones, and other historic monuments across the country.

13. Certain areas are more sensitive to acid rain than others. Limestone acts as a buffer, and neutralizes much of the acid. (You can add vinegar to Alka-seltzer or Rolaids to do the same thing. Afterwards, the pH of the mixture is closer to 7.) Areas with limestone bedrock are not as sensitive to acid rain. Areas with bedrock of granite, which cannot neutralize acids, are very sensitive. Some of these areas are also places that receive very acidic rain.
OBJECTIVES: Students will be able to: (1) list three physical properties of ozone, (2) list four man-made and natural sources of the pollutant from which ozone is derived, (3) describe the process by which ozone is produced, (4) identify ozone damage on vegetation, and (5) relate how ozone damage can endanger a whole forest ecosystem.

METHOD: Students will view a slide presentation on ozone and identify and collect data on ozone damage to trees on the school grounds.

BACKGROUND: From "The Sky Has No Limits: Air Pollution and Biosphere Reserves," by Molly N. Ross, Assistant Chief of the Air Quality Division of the National Park Service.

Ozone is an unstable, colorless, slightly sweet-smelling gas. It is produced in nature from the products of volcanoes and forest fires and forms a protective layer in the atmosphere, shielding the earth from the sun's harmful ultraviolet radiation. It is a "derivative" substance formed by the interaction of hydrocarbons and nitrogen oxides in the presence of sunlight. In addition to natural ozone, it is the most important of the pollutants which create smog. Automobiles, power plants, and other chemical industries produce the substances needed to create this pollutant.

Ozone is the most toxic pollutant to vegetation commonly found. Its natural background levels are about 0.03-0.04 parts per million (ppm), and injury to sensitive vegetation has been found at 0.05 and 0.06 ppm. Ozone can cause serious injury to eastern white pines, ponderosa pines, Jeffrey pines, hardwoods, crops, and other vegetation. Respiratory problems and impaired breathing, irritated eyes, nose, and throat, damaged paint, discolored dyes, and the accelerated disintegration of rubber also result from exposure to high levels of ozone.

Major human-caused sources of ozone are the major sources of its precursor...
pollutants. Hydrocarbons are produced by
diesel and gasoline-fired motor vehicles as
well as operations involving petroleum and
petroleum products.

Nitrogen oxide is a pungent, brownish
gas that results from combustion at high
temperatures and pressures. Major sources
of nitrogen oxides are coal-fired power
plants, diesel and gasoline-fired motor
vehicles, and industrial boilers. In the
atmosphere it can turn into nitrate,
pollutants associated with acidic deposition
and visibility impairment. In the presence
of sunlight, nitrogen oxides can react with
hydrocarbons to form ozone.

Nitrogen dioxide can irritate the eyes,
nose, and throat, and increase susceptibil­
ity to infection. It can suppress plant growth
and cause blanching of the chlorophyll in
leaves. It can create a brown cloud, seen
frequently over certain urban areas, or a
brown plume, associated with many
coal-fired power plants. Although natural
sources of nitrogen oxides, such as
biological decay and forest fires, produce
nitrogen oxides, it is the human-caused
sources that contribute to significant
pollution problems in particular areas.

MATERIALS: A Slide set, cassette
tape, and script for "The Mystery of the
Burned Needles,"* B instruction and data
sheets for outdoor ozone-damage search.

*Slides and cassette tape for "The
Mystery of the burned Needles" presenta­
tion are available from your school district
office or Great Smoky Mountains National
Park. See the Teacher’s Guide for more
information.

ALSO NEEDED: slides of ozone-
burned needles (use those from the Slide Set
A), slide projector, movie screen, cassette
tape player, meter sticks (one per group),
and hand lenses, if available.

SUGGESTED PROCEDURE
AND "SCRIPT" FOR TEACHERS
(underlined): Boldfaced letters refer to
MATERIALS listed above. Individual
instruction sections 1-4 may be
interchanged or used separately. As given,
this set of activities will provide students
with a well-rounded lesson on ozone.
Additional investigations are provided at
the end of the guide under EXTENSIONS.

Day 1...

1. SET: Tell students: Today we'll be
learning about a toxic air pollutant and the
problems it causes here in the Smokies.

2. SLIDE/TAPE PROGRAM ON
OZONE AND ITS EFFECTS: (Objectives 1,
2, 3, 5) Introduce this section by telling
students: Sometimes scientists work like
detectives to find the cause of a problem, but
today we are going to see a couple of famous
detectives talking about science and "The
Mystery of the Burned Needles."

Begin the slide/tape presentation, "The
Mystery of the Burned Needles," A. (Script
is attached. The script should be used to
determine when the slides should be
advanced. If you do not have access to a tape
recorder, have students act out the parts
while you advance the slides.)

Questions for discussion after
presentation:

1. What are three characteristics of
ozone? (Sweet smelling, bluish, made of
three oxygen atoms, burns leaves,
unstable.)

2. What does ozone come from? (From
nitrogen oxides, hydrocarbons, and energy/
sunlight.)

3. Where do nitrogen oxides come
from? (The burning of fossil fuels,
especially coal in power plants and car
emissions.)
The Infamous Ozone!
-8th Grade-

4. Why is ozone a problem? (Ozone burns leaves, needles; damages paint, dyes, rubber; and causes respiratory and eye irritations.)

5. How does burning the leaves or needles hurt the whole tree? (Burning the leaves cuts down on the space available for photosynthesis. Since photosynthesis makes food for the tree, the tree or plant doesn't have as much food available to it.)

Day 2...

3. OUTDOOR SEARCH FOR OZONE DAMAGE: (Objectives 4, 5) If there is an eastern white pine tree nearby or on the schoolgrounds, perform the following activity with your students. Tell students: Now that you have seen and heard about some of the problems caused by high ozone levels, we're going to do a little sleuthing ourselves. Damage due to ozone is quite easy to detect on some plants, like the eastern white pine. Yellow needles are the things to look for. An increase in ozone levels does not occur gradually, but at a specific time. When this happens, the vegetation is damaged — and how badly it is damaged depends upon how high the ozone levels are and how long the levels stay high (duration).

We have an eastern white pine tree growing on the schoolgrounds and we will be looking for signs of ozone damage on its needles today. Show slide of ozone-damaged white pine needles from the previous slide presentation. These are pictures of needles with ozone damage. When the needles are yellow on the tips, that indicates the air was rich with ozone when the needles where first coming out. Yellow spots on the sides indicate the ozone damage occurred after the needles where out.

Pass out worksheet on recording needle damage on white pines, B, and divide students into groups of two or three. Use this worksheet to record the number of needles per branch with ozone damage. Each of you will be assigned a branch and will count the number of smaller branches on it. Then, you will select two smaller branches near the tree on the main branch, in the middle of the main branch, and at the outer tip of the main branch. On these smaller branches, you will count the number of total number of needles and the number of needles showing ozone damage. From these numbers you will find the percentage of needles at the three places along the branch with ozone damage.

As you are counting the number of damaged needles, you should record where on the needle the damage occurs -- either at the tip, the middle, the base, or the whole needle. This is outlined on the worksheet. You just fill in the boxes. Afterwards, you'll come back inside, record your averages on the board (or overhead projector), and we'll look at your results. (If small hand lenses are available, they will be helpful to use in examining the needles). When the students are outside, remind them that the tree is living and branches and needles should NOT be broken off.

After re-grouping indoors, have students determine their average percentage of damaged needles per small branch. These should be written on the board on a chart. A total tree percentage can be found by averaging all class percentages.

Ask students what limitations they encountered (could not reach the upper branches of the tree, not enough time, etc.). Then ask how these limitations may cause their results to be inaccurate (there could be more ozone damage on higher branches so their percentages would be low). Ask students to estimate when most of the needles were "ozoned"—when they were first coming out or later in their lives. Ozone "happens" for a definite period of time, not like other pollutants which may be continually in the air. Ask students how they would like to do this sort of thing all summer long—walk from white pine to white pine in Great Smoky Mountains
The Infamous Ozone! -8th Grade-

4. Which of the following BEST describes ozone damage on white pine.
   A. THE BARK PEELS.
   B. THE NEEDLE TIPS TURN YELLOW.
   C. THE TOP OF THE TREE DIES.
   D. THE BOTTOM BRANCHES BREAK OFF.

EXTENSIONS:

*1. Students could do the same investigation on other white pine trees as is described in this lesson. A survey of the white pines in your community could be performed by the class, or an individual could record data from the trees on his or her family property.

2. Write a report on current ozone monitoring and experiments in the Great Smoky Mountains National Park and Biosphere Reserve. For information, write the Director at Uplands Lab, Great Smoky Mountains National Park, Gatlinburg, TN 37738, or phone 615-436-7120.

* Suitable for Science Fair Project.

REFERENCES AND RESOURCES


EVALUATION:

1. Which of the following are all true of ozone?
   A. IT IS A BLUISH, STABLE GAS MADE OF MOLECULES OF 3 OXYGEN ATOMS.
   B. IT IS A COLORLESS, STABLE GAS MADE OF MOLECULES OF 2 OXYGEN ATOMS.
   C. IT IS A BLUISH, UNSTABLE, SWEET SMELLING GAS.
   D. IT IS A BLUISH, UNSTABLE, SWEET SMELLING LIQUID.

2. True or false? Ozone is harmful to life wherever it is found.
   A. TRUE
   B. FALSE

3. Ozone is made
   A. FROM NOx AND SUNLIGHT.
   B. BY VOLCANOES.
   C. BY GAS-BURNING CARS.
   D. OF LIGHTNING.
   E. FROM NITROGEN AND OXYGEN.
Magazine articles on ozone:


The Infamous Ozone!

-KEYWORDS-

**Emissions** - substances discharged into the air, usually by human activities such as burning fossil fuels.

**Hydrocarbons** - compounds produced by the incomplete burning of gasoline and evaporation of such things as industrial solvents and oil paints. Hydrocarbons contribute to smog and ozone.

**Nitrogen oxide** (NO & NO₂) - gases produced during high-temperature combustion in motor vehicles and in power plant and industrial furnaces.

**Ozone** (O₃) - a harmful form of oxygen which is produced when sunlight stimulates a reaction between nitrogen oxides and hydrocarbons. Near the earth's surface, ozone is a major component of smog. Ozone burns some types of plants, such as white pine trees and milkweed.

**Unstable** - a chemical substance which has a tendency to break apart or chemically combine with other substances. Ozone tends to break down into oxygen atoms: 2 O₃ → 3 O₂.

Ozone Generator (lower left) and Chamber for Monitoring Ozone Damage to Plants
The Mystery of the Burned Needles
-Script-
(A)

1. Sherlock Holmes and Watson

1. Watson: I say! What a mystery! Look at all the yellow needles on these trees! They look as though they've been burned.

2. Sherlock Holmes: Good observation, Dr. Watson. But it's no mystery to scientists... or to me. These trees have been burned, but not by fire.

3. Watson

3. W: Not by fire? By what then?

4. "Ozone"


5. Watson

5. W: Ozone? Now I am in the dark again. My good man, what is ozone?

6. Holmes

6. H: Ozone is the answer to the question, what is the name of a bluish, sweet-smelling gas? Or, what gas is made by lightning and "baked" air pollution? What gas causes burns on leaves and needles in the Great Smoky Mountains, Isle Royale, and the Everglades National Parks and Biosphere Reserves? What gas is the most toxic part of air pollution when it comes to harming vegetation? Only one ingredient in air pollution fits that description, Watson. Our suspect is ozone.

7. Watson & Holmes

7. W: Good show, sir! But... exactly what is ozone?

H: Well, Watson, good chap, ozone is a gas like air, except that ozone smells - well, it smells a bit sweet. If you get enough of the stuff together it's pale blue in color. And Watson....

8. Holmes

8. W: Yes, sir?

H: It's unstable.

W: Unstable!

9. 02 and 03

9. H: Yes, Watson, unstable. The gas molecules are made of three oxygen atoms. The oxygen we breathe and need to live is made of two oxygen atoms put together. Seems with oxygen, as with other things, two's company and three's a crowd. The three oxygens in ozone keep trying to get away from each other, making a molecule of ozone unstable.

10. Both men

10. W: I see, sir. Ozone is a bluish, sweet-smelling, unstable gas — made of three oxygen atoms chemically combined. I had not heard of this gas before. Where does it come from? Is natural or made by humans?

11. Both men

11. H: Good inquiry, Watson. The answer is both. Ozone is made by Mother Nature herself. Lightning causes ozone to form, as does sunlight. In every million parts of air, only 4 to 5 one-hundredths are ozone particles. But, Dr. Watson, humans are responsible for adding to these levels.

W: How, sir? We don't make lightning!

H: Electric motors produce ozone. But we increase the level of ozone by putting more of what it is made from into the air — and that is nitrogen oxide.

12. "NOx"

12. W: Excuse me, sir, but isn't nitrogen oxide one of the chemicals involved in producing acid rain? Is it also responsible for another type of air pollution?
13. Acid Rain
poster
13. H: Watson, you've hit the nail on the head — good observation! Yes, nitrogen oxides or NOx are connected with acid rain. NOx is also necessary for ozone production — if there is no NOx in the air, there will be no ozone. However, there are always some nitrogen oxides in the atmosphere.

14. Volcano
14. Volcanoes, forest fires, and the natural decay of dead plants and animals give off nitrogen oxides into the air where a complex set of chemical reactions break apart one molecule and stick it with another. But, when all is said and done, NOx and energy are needed to produce ozone.

W: And lightning supplies that energy.

H: Yes! I say, Watson, rather sharp today, aren't we? Lightning can serve as the energy source — as can sunlight.

15. Smokestacks
15. Additional NOx in the air is produced by burning fossil fuels — and especially coal and petrol, or gasoline as they say here in America. That means power plants that burn coal to generate electricity produce NOx as a by-product and it goes up the smokestacks and into the air.

16. Both men with cars
16. Automobile exhaust also contains much NOx, and in America where there are so many automobiles, the exhaust from all those cars adds up to a great amount of NOx. This is a part of the smog over London, Los Angeles, and other places where there are industries or many autos. Wretched stuff.

17. Watson
17. W: Let me see if I have all the facts. NOx is made from natural processes such as volcanoes and fires, but is also made through burning coal and gasoline — from power plants and autos? And this NOx, through chemical reactions with the addition of energy from the sun produces ozone? I say!

18. Holmes

19. Both men
19. W: I say, this is rather involved! Sun-baked air pollution changes form to another type of air pollution! What does this ozone do to living things?

H: Plenty, Watson, plenty. First off, ozone is a rather good chap when it is in its proper place. There's a layer of the stuff around the earth — 20-30 miles up. This band protects the earth from the sun's harmful ultraviolet rays. Sun tanning and burning and skin cancer are the results of what little ultraviolet radiation does get through this ozone layer. Without it, we would be burned up, spit-spat.

W: But I thought ozone was harmful — a part of air pollution?

20. Both, numbering off.
20. H: That it is, near the earth's surface. Naturally occurring ozone is at a level that is not harmful to vegetation nor animals. But, the man-made sources put higher than normal amounts of NOx into the atmosphere — and with the sun's energy, this NOx is baked and produces ozone. Remember: natural levels are around 0.03 - 0.04 parts per million — but injury to sensitive plants by ozone occurs when levels reach 0.05 and 0.06 ppm. That's not much higher than the natural levels.

21. White pine tree
21. In America, eastern white pine trees are quite sensitive to ozone — it causes needles to turn yellow and die. It works much like a sunburn. The longer you are in the sun, the more burned you become. With ozone, the longer the trees are exposed to high levels of ozone, the more damage to the plant there will be.
22. Both

22. W: Remarkable! The stuff that prevents burning radiation from entering the atmosphere miles above the earth is the same substance that causes burns on plants at ground level! Are these white pine trees the only living things harmed by ozone?

23. Maple

23. H: No! If only that were true, my dear Watson. Other pines—such as ponderosa and Jeffrey pines—in addition to hardwoods like maple, crops and other plants are quite sensitive to ozone damage.

24. Plant

24. Scientists use some of these as "indicator species" to tell whether ozone levels have risen. The damage on these trees is as good an indication of high ozone levels as expensive equipment.

W: Ozone harms plants — does it do anything nasty to animals — or people?

25. Both, numbering off

25. H: Unfortunately, the answer is yes. High ozone levels can irritate the eyes, nose, and throat, and may be especially bothersome to individuals with respiratory problems like asthma. But the problem doesn't stop there. Ozone is responsible for damaging paint, discoloring dyes, and speeding the breakdown of rubber. It is one of the most harmful of the ingredients in smog and in air that may not even seem polluted.

26. Watson

26. W: Let me see if I have the facts in this case. Ozone is a gas— a combination of three oxygen atoms that aren't at all happy at being stuck together; it's bluish in color and smells sweet. The stuff is produced from NOx which comes from power plants and auto emissions, and together with the sun's energy, NOx is changed to ozone. This irritates the eyes and breathing passages of animals and people, and can do nasty things to paint, dyes, and rubber. It burns plants and the longer a thing is exposed to ozone, the greater the damage done.

27. Holmes

27. H: By jove, I think he's got it!

28. Oak leaf

28. W: Now the leaves of plants and trees are the site of photosynthesis, correct?

H: Correct, Watson. Photosynthesis is the process by which a plant makes its own food. What's your point?

29. Both

29. W: If the leaves are damaged, the tree won't be able to make as much food for itself, now, will it?

H: Why, you're right, Watson. Brilliant!

30. Dying forest

30. W: And because trees and other plants supply food and shelter for animals, that will eventually affect the life dependent on the forest — or the field crops. Ozone could be responsible for a decrease in food production, couldn't it?

31. Both

31. H: This ozone is worse than I'd first suspected! We must get to work on stopping this foul villain.
W: Yes. To stop ozone from damaging plants, animals, and property, we must find ways to reduce the amount of human-caused ozone getting into the air.

32. Distant smokestacks

32. H: The best way to do that, I suppose, would be to decrease the amount of human-caused nitrogen oxides.

W: Cleaning the emissions put out from electric power plant smokestacks would help a great deal.

33. Car

33. H: As would doing the same for auto emissions. Driving slower would also help. But how can these things be accomplished?

34. "Laws" graphic

34. W: The American Congress did pass the Clean Air Act in the 1970s to reduce the amounts of many air pollutants - including nitrogen oxides and ozone - with some success. But ozone levels are rising. New laws are needed to "encourage" utilities and motorists to clean up the emissions and exhaust getting into the air. Holmes, old man, this mystery is clear to me now! Shouldn't everyone know about this ozone scoundrel? Mothers, fathers, teachers, lawyers, shopkeepers, doctors, Scotland Yard?

35. Holmes

35. H: Ah, too true, Watson! Students, as well, should know—they will be making the decisions on these matters in the future. Students in all grades — high school, junior high school, grammar school....

36. Watson

36. W: Grammar school? You mean...?

37. Holmes

**Instruction**: When you are assigned a branch:

1. Fill in the information at the top of the sheet. The site of the tree is "schoolgrounds." Measure the height of your branch above the ground in centimeters, using the meter stick. Measure from the bottom of the tree branch to the ground at the tree trunk and record that on the data sheet.

2. Count the number of smaller branches and keep track of which is which (have a numbering system set up — the first smaller branch near the tree trunk is #1, the second is #2, and so on).

3. On each smaller branch, count and number the branchlets. If the branchlets are on the 3rd small branch, they would be numbered 3-1, 3-2; where the "3" stands for the number of the small branch, and "1" and "2" are the 1st and 2nd branchlets from the base to the small branch.

4. List these branchlets as described on the attached data sheet.

5. On each branchlet, count and record the total number of needles, the number of needles showing ozone damage, and the location of the damage on the needles (either "tip," "middle," "base," or "whole"). Use the hand lens, if available, to examine the needles.

6. While one team person is counting needles, another can be figuring the percentage of damaged needles per branchlet. Example: if branchlet 10-2 has 20 total needles and 4 of them show ozone damage, the percentage would be found by dividing 20 into 4. That would give you .2 or 20%. Take turns with each task so that everyone gets a chance at counting/recording and figuring percentages.

7. Under the last column, "Additional Observations," you can record anything else that you notice about the tree's needles.

8. After you have recorded the numbers of all you needles and have figured your percentages, divide your main branch into thirds (only in your mind!) and compare the percentages for the small branches close to the trunk, in the middle, and at the end furthest from the trunk. Where is there the most damage? Why? Were most of the needles burned near the ends or at the middle? What does that tell you about when the "ozone event" affected the needles?
THE SEARCH FOR OZONE DAMAGE
-DATA SHEET-

Detective team members: Date of Investigation:

Site of Tree in Question:

Distance of Branch from Ground (in centimeters):

<table>
<thead>
<tr>
<th>Branchlet ID #</th>
<th>Total # Needles</th>
<th># of Damaged Needles</th>
<th>% Damaged</th>
<th>Where Damaged</th>
<th>Additional Observations</th>
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OBJECTIVES: Students will be able to: (1) explain the effect of suspended particulates on visibility in the Smokies, (2) recognize the value of visibility to area tourism, and (3) write an "advertisement" for area tourism in the year 2000, while taking probable decreased visibility into consideration.

METHOD: Students will learn of the relationship between particulates and visibility through a demonstration. Students will become "ad agents" for a popular motel or hotel in the community in the year 2000 and will write an ad encouraging patrons to come, even though the view of the Great Smoky Mountains may be severely reduced by that time because of suspended particulates. An optional demonstration of the particulates generated by automobiles is also described.

BACKGROUND: Because of the importance of "the view" to visitors in most of our nation’s parks, the National Park Service conducts research on visibility. Fine particles from agriculture, forest fires, industry, mining, coal-burning power plants, automobiles, and other sources may remain air-borne for long periods of time and as such, may be carried over long distances by prevailing winds.

Such substances may be both liquid and solid, toxic and harmless, organic and inorganic, and visible and microscopic.

The Great Smoky Mountains area is troubled by air stagnation, as are Los Angeles, California, and Denver, Colorado. The mountains create a large wind barrier for air moving westward, across the continent. As a result, the air

Age: 8th grade
Subject: Earth Science (Weather)
Duration: (1) Set - 2 min., (2) description of visibility - 10 min., (3) demonstration - 10 min., (4) travel ad - 10+ min. (homework), (5) optional demonstration - 40 min., and closure - 5 minutes.
Group size: Any
Tennessee Objective 853K5: To understand the work of meteorologists.
Location in Text: Heath EARTH SCIENCE: Chapter 7, "Weather," pgs. 125-143. (May be used as a chapter summary.)
Setting: Indoors (optional outdoor demonstration)
Keywords: Emissions, particulates, teleradiometer, visibility.
over this area may contain suspended particulates from hundreds of miles away—particulates from the industrial and agricultural Midwest.

The blue haze that gave the Smokies and the Blue Ridge their names is now seldom seen. The natural "smoky" substances from the trees are now mixed with aerial human-caused pollutants. This can affect the enjoyment of the vistas experienced by area residents and visitors. Clear viewing days are becoming increasingly rare in the mountains.

The following is an excerpt from the National Park Service Park Science journal (Summer, 1986) on "Visibility and Particulate Monitoring."

The NPS Air Quality Division has been monitoring visibility and particulates that affect visibility at more than 30 park sites [including the Great Smoky Mountains]. It has also studied the influence of visibility impairment on visitor enjoyment and use of park resources.

Visibility is recorded with both color photography and teleradiometry. The color photography documents the important elements of the scene and how they vary with changing air pollution levels, weather conditions, and sunlight. Teleradiometry uses a special telescope to measure the contrast between the sky in the background and dark landscape features so that changes in contrast caused by pollution or climatic [conditions] can be recorded. Together, the photography and teleradiometry can be used to establish standard visual ranges — the distance from an observer at which a large dark object such as a forested mountain would just disappear against the horizon.

Results to date of visibility monitoring include the following:

1) More than 90 percent of the time, human-caused pollution affected scenic views at all NPS monitoring sites. 2) The best average visibility is in northern Nevada, Utah, and southern Idaho. Next best is the Colorado Plateau, where Grand Canyon, Bryce Canyon, and Canyonlands National Parks are located. 3) The lowest visibility in the West is in the coastal areas of California and Washington, probably because of natural weather conditions and smoke from prescribed burns. 4) The worst visibility recorded by NPS is in the eastern United States, where relative humidity and air pollution levels are high. In the summer of 1983, for instance, the median visibility range at Shenandoah National Park was 19 kilometers, as compared with 100 to 200 kilometers for most western parks. 5) Visibility is generally best in the winter and worst in the summer.

NPS research and monitoring indicate that particulates are the major contributor to visibility impairment in parks; especially the very fine particulates (those smaller than 2.5 micrometers in diameter), which scatter light much more effectively than do large particles, which form a large percentage of the pollution mass.

The present visibility situation (1980-1986) in Great Smoky Mountains National Park is as follows:

- Visibility of 155 miles or more occurs 6% of the time.
- Visibility of 30 miles or more occurs 45% of the time.
- Visibility of 6 miles or more occurs 5% of the time.
Oh Say Can You See?
-8th Grade-

Measurements of visibility have only recently begun (1980); therefore, no data exists for comparing present visibility to that of past decades within the park. Nearby airports, however, provide regional visibility trends. Several studies "indicate the annual average visibility in the region surrounding Great Smoky Mountains National Park has decreased by about 30 percent from the late 1940s until the 1970s" (Reisinger and Valente, 1985). Increased air quality standards may help to curb this trend through decreasing automobile emissions and the installation of "scrubbers" and other industrial stack-emission cleansing devices. This threat remains: if the view of the mountains is increasingly limited due to human-caused particulates, tourism and the revenue it generates could see a downward swing in and around Great Smoky Mountains National Park. If you can't see the Smokies because of the pollution, why go?

MATERIALS: A Text and layout for Visibility Poster of Mount LeConte,* B particulate demonstration model construction and operation instructions.

*Have photographs made for this poster from the three visibility slides of Mount LeConte. These slides may be borrowed from your school district office or from Great Smoky Mountains National Park. See the Teacher's Guide for more information.

ALSO NEEDED: large sheet of construction paper for poster, a flashlight, sieve or sifter, dust or ashes, paper, large cardboard box with Smokies scene painted on the back (see instructions, B), and pencil. (Optional exercise requires a vacuum cleaner with a hose, filter paper or coffee filters and a heavy duty rubber band, and possibly a long extension cord.)

SUGGESTED PROCEDURE
AND "SCRIPT" FOR TEACHERS (underlined): Boldfaced letters refer to MATERIALS listed above. Individual instruction sections 1-6 may be interchanged or used separately. As given, this set of activities will provide students with a well-rounded lesson on visibility.

1. SET: Tell students: The Great Smoky Mountains are known for a natural blue haze: but these days, that haze isn't so natural. Very small particles of air pollution from industries far away and from car exhaust from this and surrounding areas have cut down how far you can see. Today, we will be discussing "visibility" in the area in and around Great Smoky Mountains National Park Biosphere Reserve, and how a decreased view of the mountains could affect the tourism business in our area.

2. DESCRIPTION OF VISIBILITY AND PARTICULATES: (Objective 1) Tell students: Mount LeConte is the best known
mountain of all those in the national park. Display poster of LeConte (instructions-A), and ask students which view of LeConte is the one they see most often — a clear view, a partly hazy view, or no view. Point out the information on the poster about this. Ask them: On what does the view of LeConte depend? (Responses will likely include type of weather, season, and possibly air pollution).

Tell students: Weather and season have a definite effect on visibility — summer is the season with the poorest visibility. Ask: How does air pollution affect the air in the Smokies? Discuss the transport of particulates from industrial areas to this area via prevailing winds and the "air block effect" of the Smokies. Also, heavy traffic in the tourist season adds to the problem.

3. DEMONSTRATION OF SUSPENDED PARTICULATES' EFFECT ON VISIBILITY: (Objectives 1, 2) Use the "particulate demonstration model" described in B, i.e., the box, to demonstrate the light scattering effect of particulates in the air and how that cuts the visibility. Position the box so that the students may see into the front and may see the "scenic vista" in the back. Shine the flashlight into the hole on the side (have a student hold the flashlight there). Using the sifter/sieve, slowly shake the "particulate matter" (dust) over the top opening so that it falls into the box in front of the scenic vista. Ask students: What is happening to your view of the mountains? Where do real suspended particles come from? (Agricultural areas, coal-burning power plants, car exhaust.) If you lived in New York City and wanted to come to the Smokies, would you change your mind if you knew you probably would not get to see much of the view because of this problem?

4. WELL-KNOWN HOTEL WITH A VIEW TRAVEL AD: (Objective 3) In this exercise, students will become travel ad writers for a well-known hotel with a view in the year 2000. The Hotel's big selling point it offers to its patrons is the view of the Great Smoky Mountains. If visibility decreases, however, that view may be in danger, and with it, the tourism business in this area.

Instruct the students to write an ad for television, radio, or newspapers for the Park Vista, "selling" the view that is not there, without advertising falsely. You may want to limit the ads to 50 or 100 words. Encourage them to include cut-out pictures, or other things to make their ads look "professional." Ads for television may be videotaped; and radio ads may be tape-recorded. Another idea would be to make this assignment a contest and, in cooperation with the local newspaper, have the best ad and a story about the assignment appear in the local newspaper. (This is designed to be a take-home assignment.)

5. OPTIONAL EXERCISE: PARTICULATES ALONG MAIN STREET(Objective 1): To demonstrate the amount of particulates in the air produced by automobiles, take the students, a vacuum cleaner, filter paper (coffee filters work), a rubber band, and possibly an extension cord to the parkway or main street or highway. (You should check beforehand on the availability of an electrical outlet there.) Put the filter paper over the nozzle on the vacuum cleaner hose and secure with the rubber band. Plug the vacuum in, turn it on, and let it run for 15-30 minutes. While the vacuum is running, have the students watch for autos producing very dirty exhaust. They could keep track of cars per minute and the number of especially dirty exhausts per minute. At the end of the vacuum run, shut it off, carefully remove the rubber band and filter paper. Based on the particulate matter collected, ask student how in-town merchants are affected by the automobile exhaust. Extend that to the plants and wildlife in Great Smoky Mountains National Park along the highway.
6. CLOSURE: Tell students: Visibility in this area may cause a problem for tourism in your lifetime. The particulates carried in the air affect humans, plants, animals, water, and soil. We've seen today how suspended particles decrease how well you can see, and how that may keep people from coming to the Smokies.

REFERENCES AND RESOURCES


**Emissions** - The gas by-products made by burning fossil fuels, like gasoline and coal.

**Particulate pollutants** - The term "particulate matter" includes many pollutants. They can be either liquid or solid, toxic or harmless, from living or non-living things, and visible or microscopic. Most of these kinds of particulates "hang" in the air. Large particles from mining and agriculture can cause soiling and be a nuisance. Fine particle pollutants and toxic particle pollutants are more dangerous for protected areas, like national parks. These include the sulfur and nitrogen compounds responsible for acid precipitation and deposition ("acid rain"). Other sources of particulates are automobile emissions, volcanoes, forest (or other types of) fires, and wood-burning stoves.

**Teleradiometer** - a modified camera used to measure visibility.

**Visibility** - How far and how clearly distant objects can be seen. Poor visibility is caused by particles in the air. These particles come from human-caused and natural sources which include forest fires, volcanoes, agricultural practices, mining, automobile exhaust, wood-burning stoves, and industries. Visibility in the Smokies is especially affected by the weather, season, direction of the wind, and the tendency of the mountains to act as a wind block to air masses that move from west to east.
ABOUT 22 DAYS EVERY YEAR, THE AIR IS SO CLEAR IN THE SMOKIES YOU CAN SEE MOUNT LeCONTE FROM 155 MILES AWAY!

YOU CAN SEE LeCONTE FROM 30 MILES AWAY ON ABOUT 164 DAYS - NEARLY 1/2 OF THE YEAR.

BUT! ON A FEW DAYS EACH YEAR, ABOUT 18 DAYS, YOU WILL HAVE TO BE WITHIN 6 MILES BEFORE YOU CAN SEE THIS MILE-HIGH-PLUS MOUNTAIN!

CAUSES OF POOR VISIBILITY
PARTICLES IN THE AIR COME FROM: AGRICULTURE, FIRES, VOLCANOES, AUTOMOBILES, MINING, POWER PLANTS, AND FACTORIES.
VISIBILITY: HOW FAR AND HOW CLEARLY YOU CAN SEE OBJECTS FAR AWAY.
Visibility Poster Lay-out  
(use a large sheet of construction paper)

**TITLE**

About 22 days every year....

You can see....

But! On a few days....

Visibility: How far and....

Causes of visibility....
Particulate Demonstration Model
Construction and Operation Instructions

1. Get a large cardboard box, about 2 to 3 feet long on each side.

2. Cut out these sections

3. Draw a picture of mountains on the back inside wall (blue sky, green mountains).

4. Shake the sieve with ashes/dust over top hole. Shine flashlight in side hole. This causes a "visibility problem."
OBJECTIVES: Students will be able to: (1) list three requirements of the Clean Air Acts and (2) describe one current issue relating to air quality.

METHOD: Students will participate in a discussion about the Clean Air Acts and break into small groups to locate and analyze current air quality issues from newspapers and magazines.

BACKGROUND: In response to a growing concern for all parts of the environment in the 1960s and 1970s, Congress passed legislation in 1970 and amendments in 1977 to help clean our air. These laws are known as the Clean Air Acts.

The primary purpose of the Clean Air Acts was to adequately protect public health, and then to protect the national welfare, within a specified time period. "Welfare," according to the Acts, includes effects on soils, water, crops, vegetation, human-caused materials, animals, wildlife, visibility, climate, economic well-being, and comfort. Six pollutants were specifically named and standards were set according to levels of: sulfur dioxide, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead.

The Environmental Protection Agency (EPA) was given charge of seeing the requirements of these laws carried out. The Clean Air Acts required: (1) control standards for the amount of air pollution emitted by power plants and industries, (2) acceptable levels of six air pollutants, (3) state governments to develop their own pollution control plans, (4) car makers to reduce the amount of pollution from their automobiles through new emissions control devices, and (5) very low levels for acceptable air pollution around special reserves, like national parks and biosphere reserves, including Great Smoky Mountains National Park Biosphere Reserve.

Since then, air quality monitoring has become a big business—and continues to be a controversial subject. The debate between "environmentalists" and "industrialists" is still a hot topic. Following the Clean Air Act restrictions is expensive for power plants and industries. The devices needed to clean pollutants from the emissions of

Age: 8th grade
Subject: Earth science, social studies
Skills: Analysis, evaluation, observation.
Duration: (1) Set - 2 min., (2) discussion - 20 min., (3) article analysis - 25 min. or longer, and (4) Closure - 2 min.
Group size: Any
Tennessee Objective 85401: To understand the cause, effects, and solutions of environmental pollution problems.
Location in Text: Heath EARTH SCIENCE: Chapter 7, "Weather," pgs. 125-143. (This module set may be used as a chapter summary.)
Keywords: Air quality standards, bias, Clean Air Acts, compliance, scrubbers.
smokestacks and automobiles are costly, and often consumers are the ones who pick up the tab.

Our air quality situation today is not as bad as it may have been if Clean Air Acts had not been passed. In many parts of the United States, the air has become measurably cleaner. "Some studies say that improved air quality now saves about 14,000 lives and about $21.4 billion a year in health, cleaning, and other costs."

For the most part, the dates set for meeting the Clean Air Act requirements were not met. This law ran out in 1987, and (at the time of this writing) new bills were making their way through Congress to extend and improve the old Clean Air Acts.

**MATERIALS:** A Two overhead transparencies on the Clean Air Acts, B discussion sheets for air quality articles. Also needed: overhead projector, current newspapers, magazines (Newsweek, Time, U.S. News and World Reports, Audubon, National Geographic, National Wildlife, etc.), access to the library.

**SUGGESTED PROCEDURE AND "SCRIPT" FOR TEACHERS**

(underlined): Boldfaced letters refer to MATERIALS listed above. Individual instruction sections 1-4 may be interchanged or used separately. As given, this set of activities will provide students with a well-rounded lesson on the Clean Air Acts.

1. SET: Tell students: So far this week, we have discussed a number of air quality problems. It can be depressing to find how many problems we have without looking at what can be done about them. Today, we will be learning about the steps our government has taken to make our air cleaner.

2. DISCUSSION OF CLEAN AIR ACTS

(Objective 1): If you were in Congress and you wanted to write a bill to lower air pollution, what sorts of things would you want to talk about? Allow students to brainstorm and write their ideas on one side of the chalkboard or on an overhead transparency. This can be a great way to review the material covered on the lessons of previous days. Lead the discussion toward listing the major polluters and pollutants in the country and what can be done about them.

Next, make two columns on the chalkboard: air pollutants and sources of air pollution. List the ones that have been brought about in the discussion. Draw lines from the pollutant to the source, like so, nitrogen oxides ------- cars. From here, write in the "law" ideas of the students next to the appropriate sources.

When you have "exhausted" (is that a pun?) your ideas, tell students: Back in the 1970s, when you were either not on the scene yet or in diapers, the U.S. Congress did pass laws to reduce air pollution. Put overhead A-1 on the projector. The Clean Air Acts of 1970 and 1977 were not the first air quality legislation, but they were the most far reaching up until that time. Here are the goals of those laws: (read goals from overhead).

Now, let's see how OUR clean air act compares to the ones Congress passed. Put overhead A-2 on the projector. Compare the chart on the board with what the requirements of the Clean Air Acts were. How are they similar? How do yours and the "real" ones differ?

These laws were only the starting point. After they were passed, the Environmental Protection Agency, or EPA, was given the job of seeing that the requirements were met. How do you think they did that? (State EPA's set their standards, companies were to pay fines if they had not met the requirements by the specific date, "watchdog" groups - or groups of concerned citizens, like the Sierra Club or the Audubon
Society - kept an eye on the situation and contacted Congress and the EPA if there were problems.) What problems do you think the EPA has run into in the years since the Clean Air Acts were passed? (Problems have included the requests by industries to lengthen the time period for them to meet the deadlines, lawsuits, or the payment of fines by industries which have decided that is less expensive than installing emissions cleaners.)

3. SMALL GROUP ANALYSIS OF NEWSPAPER/MAGAZINE ARTICLES ON AIR QUALITY (Objective 2): Divide class into groups of 3 to 4 students. Give each group several sheets B. Tell class: The media - newspapers, magazines, radio, and television - have provided us with a lot of news about air quality, legislation about air quality, and the controversies about air quality legislation. Each group will look at magazine and newspaper articles to discover what we have been told about this issue. Look through the stacks of issues here in the room for air quality articles. When you find these articles, analyze them to answer the questions on the sheet. You will have about 20 minutes to look and analyze, so look for air quality articles - not sports or fashion news! The articles you are looking for can be about any aspect of air quality we have discussed this last week. Your group will be the judge on the bias of the article and of who has the best argument - for or against air pollution control.

If few articles are found in the first few minutes, refer students to those listed under REFERENCES AND RESOURCES. Be sure to have these publications on hand.

4. CLOSURE: Tell students: Today we have looked at what has been done about air pollution in our country. NOW, as informed citizens, you can be on the look-out for current news about air quality. New air quality laws are in Congress right now! Treaties may be negotiated among countries to clean the air they share. Be aware of the news that affects you, how you live, and your surroundings.

EVALUATION:
1. What did Clean Air Acts do or require?
   A. THEY SET SAFE LEVELS OF MAJOR POLLUTANTS.
   B. THEY REQUIRED STATE GOVERNMENTS TO MAKE POLLUTION CONTROL PLANS.
   C. THEY PROTECTED THE AIR IN SPECIAL PLACES, SUCH AS NATIONAL PARKS.
   D. THEY REQUIRED FACTORIES AND POWER PLANTS TO FOLLOW POLLUTION STANDARDS.
   E. THEY DID ALL THE THINGS LISTED IN A. - D.

REFERENCES AND RESOURCES


Sources for Article Analysis:


The Clean Air Acts
-8th Grade-


—Each 1987 edition of National Wildlife contains at least one article on air quality.
The Clean Air Acts

-KEYWORDS-

**Air quality standards** - rules for limiting the amounts of air pollution in the air.

**Bias** - a preference for one side of an issue or another.

**Clean Air Acts** - two laws passed in 1970 and 1977 to reduce the amount of air pollution. The Clean Air Acts set acceptable levels of air pollution and required industries and automobile makers to lower harmful emissions.

**Compliance** - doing what is required. When auto makers put the right emissions control devices in cars, they are in compliance with the Clean Air Act regulations.

**Scrubber** - "an antipollution device that uses a spray to remove pollutants from a stream of air passing through a smokestack." (National Wildlife Federation, 1987)
THE CLEAN AIR ACTS
Laws To Reduce Air Pollution

Most recent changes: 1977 (1988?)

When...
Jimmy Carter was President,
Great Smoky Mountains National Park
became a Biosphere Reserve with the
Man and the Biosphere Program,
the United States was 201 years old,
and
YOU were ___ years old.

The 2 Main Goals of the
Clean Air Acts:

1. to adequately protect the public health, within a certain time period,
   and
2. to protect the national welfare.

"National Welfare" = soil, water,
crops, vegetation, human-created materials, animals, wildlife, weather,
visibility, and climate, and personal comfort and well-being.
WHAT THE CLEAN AIR ACTS DID:

1) Set "OK" levels for 6 air pollutants:
   a. sulfur dioxide or SO$_2$ (acid rain)
   b. nitrogen oxides or NO$_x$ (acid rain and ozone)
   c. particulates (visibility)
   d. carbon monoxide (poisonous gas from cars)
   e. ozone
   f. lead

2) Required new power plants and industries to meet low level emissions standards.

3) Required auto makers to lower the amount of pollutants in car exhaust.

4) Required states to make their own specific air pollution control plans.

5) Set very low air pollution standards for special natural areas – like national parks and biosphere reserves.
Air Quality Article Analysis Sheet B

Group Members: ____________________________________________________________
__________________________________________________________________________

Name of Article Source: ____________________________________________________

Date of Publication: _________________________________________________________

Title: _____________________________

Page number: ______________________

What was the main idea of the article? _______________________________________

__________________________________________________________________________

Is the article biased? —in other words, is a viewpoint expressed or is the writer neutral? ________________

__________________________________________________________________________

If the article is biased, what is the key argument? _______________________________

__________________________________________________________________________

If the article is biased, why? Who are the readers this publication reaches? Or, who would buy this publication? ________________

__________________________________________________________________________

What is the opinion of your group about the article’s argument? ________

__________________________________________________________________________
Slide presentations, like air pollution, come in many forms. This is one suggested approach. The materials herein have been extensively reviewed by a number of NPS scientists and interpreters for accuracy, validity and utility in conveying the complex messages of air quality and acidic deposition. You are encouraged to use the materials in the manner you deem appropriate for your park and your audience.

Clearing The Air
A Slide Presentation Script

(Dramatic Reading)

There is so much to see ... so much space, fresh air, wildlife, a chance to get away from the hustle and bustle. But lately things have not been the same. The view up here used to be tremendous... you could see for miles. But now it just is not what it used to be. The air just is not as clear anymore. This is a sample statement of what is now heard all across our National Park System.

When we think of our National Parks, we think of wildlife, forests, rivers... historic monuments and buildings. But there is a very important resource we often overlook, our air. Now, we are beginning to understand that our air is just as valuable a resource as our water, forests and wildlife. Air is valuable, and we think it is worth looking into.

Note to Interpreter: Structure the program with your name and NPS identification if you have not already done so. Introduce the program topic, what the program involves, how long it will last, what is expected of the audience and what the audience should get out of it.

Our air is undergoing changes, and these changes may be altering our National Parks for many years to come.
The National Park Service is placing a special emphasis on air quality and air pollution during 1988 and throughout the next several years. Sometimes this all falls under the big popular name of acid rain. The National Park Service is focusing on this topic because the air resources in and around the National Parks, as well as across our nation, are being impacted by human-caused air pollution.

Let's talk about clearing the air.

Once thought of as protected islands, our National Parks are now being affected by the same pollutants we find in our cities. Some of the most insidious of these pollutants are those found in our air. The familiar scenes that make up our memories of family vacations, camping trips and weekend getaways are being altered.

The three major air quality concerns for our National Parks are the reduction in visibility, plant injury from ozone and the effects of acid rain on natural and cultural resources. Each one of these can have a direct impact on your visit to your favorite National Park.

Air pollution comes in many forms. Tiny particles and gaseous pollutants, such as sulfates, nitrogen oxides and hydrocarbons from oil refining, coal-fired power plants, automobile emissions and agricultural burning, create a haze that reduces our visibility, the first major threat. In excess of 90% of the time scenic vistas are affected to some degree by human-caused pollutants at all National Park Service visibility monitoring locations in the lower 48 United States.

These tiny particles and gaseous pollutants are carried by winds from their sources to areas where you would least expect air pollution--our National Parks.

While being carried, these materials are transformed along the way into other polluting substances.

This long distance transport of pollutants has made Shenandoah National Park one of the hardest hit areas for visibility impairment. At one time, the U.S. Capitol building and Washington Monument--65 miles away--could be seen from these familiar mountains.

Today, however, the view from these mountains is often less than ten miles.

The Sierra Nevada of California has often been praised for its spectacular views and clear mountain air. Mark Twain said of these mountains...

"The air up there... is very pure and fine, bracing and delicious. And why shouldn't it be?-It is the same the angels breathe."
But now, Sequoia and Kings Canyon National Parks border the second dirtiest airshed in California.

The magnificent vistas that motivated people to preserve these parks are now obscured by a haze. A haze produced by human sources.

But it is not just the haze obscuring our views that is changing these parks. In addition to visibility problems that need to be cleared up, we are faced with the effects of ozone, a second type of air pollution.

On many summer days in Sequoia and Kings Canyon National Parks, ozone levels exceed the Environmental Protection Agency's maximum standards for public health.

Ozone naturally occurs well above the earth, where it absorbs life threatening ultraviolet light. However, ozone close to the earth's surface may be responsible for some serious damage.

Most air pollutants are emitted directly into the air. But ozone is formed when emissions from power generating plants, oil refineries and automobiles react in sunlight. Ozone is one of the major components of smog and can be one of the air pollutants most toxic to vegetation.

Ozone enters plant leaves and attacks the food-producing cells. As the plant weakens, it becomes more susceptible to insects and disease.

Yellow spotting on Ponderosa Pine needles in Sequoia and Kings Canyon National Parks are signs of ozone injury. Over one-third of the Ponderosa Pines among the western boundary of these parks show moderate to severe injury from ozone.

Similar symptoms have been seen on Giant Sequoia seedlings under research conditions. Giant Sequoias, the most massive living organisms on our earth, grow only in the Sierra Nevada. One purpose for the establishment of these parks was to preserve these magnificent remnants of the past. Now ozone may be endangering their continued preservation.

On the other side of the country, the natural resources of the Great Smoky Mountains National Park are also being affected by air pollution.

Named for its blue haze caused by natural compounds released by the trees, Great Smoky Mountains National Park is now shrouded in polluting gases and particles from industrial and urban centers miles away. Again, ozone may be playing a major role in the injury of some plants of the Great Smoky Mountains.
On more than three-quarters of the days during recent summers in the Smokies, ozone levels have exceeded the amount known to injure sensitive plants in the laboratory.

Ozone levels have resulted in injury to white pines and tulip poplar trees at Great Smokies.

Red spruce trees on Clingman's Dome in Great Smoky Mountains National Park may also be experiencing damage from air pollution; further investigations are needed to determine the exact cause.

Researchers at more than a dozen national parks are observing potential ozone damage to plants.

A third concern of our National Parks is the effects of acid rain on our natural and cultural resources.

How does rain, snow and fog become acidic? It begins when fossil fuels such as gas, coal and oil are burned. When these are burned in our power plants, factories, automobiles, and home furnaces, sulfur dioxides, nitrogen oxides and hydrocarbons are released into our air.

Like other air pollutants, these compounds are carried by winds high into the atmosphere where they can then be transported to remote areas including, our National Parks.

Sulfur dioxides and nitrogen oxides in the presence of hydrocarbons mix with water in clouds and form acids. They are carried long distances and can be deposited in the form of rain, snow, fog, mist or even as dry particles.

We are finding this acidic deposition in National Parks throughout the country, even in remote places like Isle Royale National Park in Lake Superior.

Snow can accumulate acids from acidic deposition over an entire winter season. A snow pack melts in the spring and the water enters into the surrounding streams and lakes. This and other factors increase the acid at a time when aquatic plants and animals are involved in new growth, spawning or hatching—the time when they are apt to be the most sensitive.

If this were to cause a decline in an important species in the food web, it could seriously impact the entire ecosystem.

The effects of acid rain on lakes and their ecosystems are fairly well understood. However, it is difficult to generalize about the effects. Some lakes and streams naturally buffer the most harmful effects of acid rain. Others do not. Soil, bedrock, and the surrounding watershed all influence how a lake or stream may react to acid rain.
We know that some of our forest and other terrestrial systems are changing. These changes are very complex. Many factors are potentially involved. Acidic deposition may be one such factor.

More research is still needed to determine the effects of acid rain on our lakes and forests to be able to make appropriate decisions.

Long-term research projects, such as at Shenandoah National Park, are particularly useful. There scientists have documented changes in soils and streams over the past decade.

National Park Service researchers have found a five-fold increase in stream acidity in a watershed with shallow soils.

No changes were recorded for a stream in a deep soil watershed.

Meanwhile, parks that have been minimally affected by acid rain, such as Olympic National Park, are able to provide scientists with natural background levels of pollutants. If changes due to acid rain begin to occur, we may be able to address the situation before any major damage is recorded.

In addition to biological impacts, acid rain damages buildings and monuments that represent our country's historical and cultural heritage.

Gettysburg National Military Park in Pennsylvania contains over 1,300 outdoor statues and monuments, the largest collection in the United States.

The hundreds of memorials, dedicated by veterans and citizens of thirty states, are being subjected to accelerated deterioration because of the pollutants in the air and rain.

Gettysburg is receiving rain that is as acidic as tomatoes and soft drinks. Both acids in the rain and sulfur pollutants in the air affect cultural resources.

First, sulfur pollutants attack both stone and bronze to form a "crust." In stone the crust is black or orangish, in bronze it is green. In areas sheltered from rain, this sulfur-containing crust builds up, disfiguring the artistic intent of sculpture and making buildings look dirty.

In exposed areas, the crust dissolves in rain and is washed away, taking with it some of the original surfaces and leaving fresh material to react with sulfur pollutants to form yet another "crust." The process continues.
Acids increase the power of the rain to dissolve stone, bronze and crusts that may have formed by reaction with sulfur or nitrogen pollutants.

At Mesa Verde National Park, we have measured sandstone decay rates and pollution levels since 1984 to establish a baseline reading. The sulfur and nitrogen pollutant levels are quite low, and the sandstone decay rates are very slow.

At Gettysburg National Military Park, we are measuring air and rain pollution levels, and collecting the runoff from bronze and marble monuments to estimate the loss of material that is washed away during rain events.

At Independence National Historic Park, we have documented the condition of the marble in the 1830's Merchant Exchange building, using stereophotogrammetry. In April 1988, we installed an environmental monitoring station on two of the columns to measure the pollution and micrometeorology around the building and the effects on the marble decay.

These memorials are irreplaceable, and the cost of cleaning and protecting them from further damage can be costly. This acid rain deterioration was not expected by those who originally dedicated these stone and metal tributes for posterity.

*Note to Interpreter: Discuss the state of air pollution at your park and insert appropriate slides.*

What can be done to reduce the impact that air pollution is having on our valuable resources? Clearing the air is not an easy task; there are no simple solutions. Perhaps the first place we can start is to ask: What can a park do about pollution that comes from sources far outside park boundaries?

In 1977 Congress approved an amendment to the Clean Air Act. This amendment set limits on how much pollution can be added to the air in clean air areas of our nation. Congress established a classification system for the protection of these clean air areas.

A protective Class I designation allows that only the smallest amount of pollution be added to the air. This includes National Parks and Monuments which exceed 6,000 acres in size and wilderness areas which exceed 5,000 acres in size.
To effectively enforce this law, the National Park Service must know the effects of visibility reduction, ozone damage, and acid rain on our natural and cultural resources.

A monitoring system has been set up throughout the National Park Service units to observe the air, document present conditions and build a solid base of information about the effects of air pollution.

National Park Service scientists and resource managers are investigating the effects of the pollutants on the water cycle.

Researchers are studying mountain cloud chemistry to determine impacts of acid mists and fogs.

Some of our soils and forests are subject to increasing acidification. Scientists are investigating relationships between a variety of stresses, including air pollution on trees and other plants. These studies include analyzing the chemistry of rain as it moves from leaves at the top of the tree all the way down to the soil.

National Park Service rangers are developing and integrating educational materials on air quality and acidic deposition into school curricula and working with community organizations to help people better understand pollution issues.

Clean air is a valuable natural resource to you, me and the National Park Service.

The National Park Service and other government agencies are working to improve air quality. But government agencies alone can not do the job.

We must all help clear the air. Each one of us can improve the air of our earth by things we do every day.

Careful, conservative use of electricity can lower the energy output needed from power plants. Less energy produced means less pollution generated. Supporting efforts to utilize available technology will cut down on the most harmful air pollutants.

Recycling saves 90% of the energy used to make new containers and cuts back on pollution from processing.

Using public transportation or carpooling are still another ways
you can improve our air quality. Using durable products rather than disposable ones also saves energy and raw materials.

Clearing the air means awareness and getting involved in your community air quality issues. Each of us needs to understand local, national and world issues related to air pollution and how we each contribute to the problem.

With all these efforts we will be better able to find and use realistic solutions which sustain our society,
our economy and
our environment.

Our National Parks are too valuable to let disappear in a cloud of pollution. Won't you join us in clearing the air?

REFERENCES:


Great Smoky Mountains National Park, "Challenges in the Spruce-Fir Forest" (brochure) 1987

Chief, Science Division, GSMNP. "Air Quality Effects In GSMNP." (Memorandum) September 9, 1986.


NPS Air Resources Management Manual

DEVELOPED BY:
Kim Palmer and Gary W. Mullins
The Ohio State University
PROGRAM 27

TITLE: CAPTIONED SLIDE LIBRARIES

To assist National Park Service communicators with interpreting air quality and acidic deposition issues, a set of captioned slides is available from each regional office.

The topics represented in the set are:
- Effects on aquatic resources
- Effects on cultural resources
- Effects on terrestrial resources
- Graphics (general)
- Research equipment

For more specific slides on air quality, a set of captioned slides is available from the NPS Air Quality Division (Denver).

The topics represented in the set are:
- Sources of Air Pollution
- Effects of Air Pollution on Resources
- Visibility Impairment Due to Air Pollution
- Visibility Monitoring and Research Equipment
- Air Pollution Effects on Biological Resources, Monitoring and Research Activities
- Mandatory Federal Class I Clean Air Areas

For more information about this set, contact:
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FACT SHEET 1

THE "CLEARING THE AIR" PROGRAM

Acid rain and related air pollutants are known or suspected to affect park resources throughout much of the United States. The acid rain/air quality education program, called for by Director William Penn Mott, Jr., is designed to develop public understanding of air quality and corollary issues as they relate to these resources. The program builds on interpretation of this topic already underway in some parks, increasing the level of activity and geographic scope.

The formal program was started in 1987 and will conclude in 1991, with special emphasis in 1988. All units of the National Park System are expected to participate, according to degree of local air pollution effects, amount of park research on the subject, staff size, and park funding.

The acid rain/air quality issue touches every employee of the National Park Service, both as a citizen and as a steward of the National Park System. Because of the complexity of the acid rain phenomenon, this communication must reflect the scientific uncertainties that persist. The plan therefore calls for educating National Park Service personnel as well as the public, using results of the best scientific work. To achieve this, the program will enlist the help of scientists both within and outside the Service, including those associated with the National Acid Precipitation Assessment Program (NAPAP). With this scientific support, and the considerable communication skills and facilities within the Service, the 1987-91 interpretive focus on acid rain and air quality will make a substantial and lasting contribution to the environmental well-being of both the federal parks and the nation.

National Park Service air quality research and monitoring are coordinated and conducted by the Air Quality Division. This division has air quality information available for park interpretive programs and has worked with various park units Servicewide on the design and development of air quality exhibits, slide presentations, informational pamphlets, and other interpretive material.

This program is not to be viewed as merely an education effort. It is a designed and deliberate action to preserve park resources. Without public support and action, the effects of acid rain and deteriorating air quality will have cumulative and permanent impacts upon park resources. The program is intended to counter this threat.

The intent of the program is to provide materials and support to the field interpreter who will determine the success or failure of this program. The program is producing:

- slide program
- videotape
- fact sheets
- sample programs
- information database
- captioned slides
- bibliography
- accessible database

These tangible materials, when combined with appropriate training and good field support are expected to greatly enhance National Park Service role in interpreting critical resource issues.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 2

THE ATMOSPHERE AND AIR POLLUTION

The atmosphere can be conveniently divided into two layers. The lowest layer is the troposphere, and the upper layer is called the stratosphere. The air we breathe comes from the troposphere.

FACTS ABOUT AIR AND AIR POLLUTANTS:

The following information is taken from the National Wildlife Federation’s “We Care About Clean Air” Educator’s Guide.

Each day the average person will breathe in 35 pounds of air. That amounts to 625 million breaths in a lifetime.

Clean air is a mixture of invisible and odorless gases, mostly nitrogen and oxygen, but with small amounts of water vapor, argon, carbon dioxide, neon, helium, and hydrogen.

There are six common pollutants that are found in our atmosphere. They include: carbon monoxide, sulfur dioxide, nitrogen oxides, lead, particulates, and ozone. Carbon monoxide, sulfur dioxide, and nitrogen oxides are gases. Lead is a metal. Particulates are tiny liquid droplets or small pieces of smoke, dust, metal, or other materials that float in the air. These first five are called primary pollutants; they are released directly into the air.

The gas ozone, a major element in smog, is considered a secondary pollutant. Rather than being released directly into the air, ozone is produced when two chemicals, nitrogen oxides and hydrocarbons, combine into a dangerous mixture in sunlight. These chemicals come from motor vehicles, gas stations, dry cleaners, and household solvents. Ozone formed in this way is found in the troposphere. Ozone found is the stratosphere is beneficial. It absorbs the sun’s harmful ultraviolet rays.

Carbon monoxide, a colorless, odorless, deadly gas, comes mainly from automobiles. When the carbon in gasoline does not completely burn, the leftover carbon combines with oxygen and turns into carbon monoxide and carbon dioxide.

Sulfur dioxide is released from coal and oil burned in home furnaces, in industrial furnaces, and in power plants. Coal and oil contain sulfur. As these fuels burn, the sulfur combines with oxygen and turns into sulfur dioxide.

Nitrogen oxides are produced during high-temperature combustion. About half of the nitrogen oxides in the air are produced by cars, trucks, buses, and airplanes. The other half comes from industrial and power plant furnaces.

Lead used to be added to almost all gasoline to improve engine performance. However, because lead particles escape through the exhaust pipe and pollute the air as an engine runs, manufacture and use of leaded gasoline has been sharply reduced by law. No new cars are allowed to use leaded fuel.

Some lead is also released by metal smelters and battery-acid plants. These sources tend to have a more local effect than that of automobiles.

Particulates are tiny droplets of liquid or minuscule particles of dust, metal, or other materials that float in the air. Particulates come from industries such as coal-burning power plants, steel mills, mining operations and from natural sources such as forest fires and volcanoes.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 3

ACID RAIN

The following is taken from "Acid Rain: What is it and How it is Formed?" by John Peine and Andy McRae.

The pH scale ranges between 0 and 14, with 7 being neutral. A substance with a pH less than 7 is acidic. If greater than 7, the substance is basic, or alkaline. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to pH 3 would be a hundred times (10^2) increase in acidity.

Most scientists agree that "normal" rainfall has a pH range of 4.9-6.0. Rain in the atmosphere reacts with carbon dioxide (CO2) to form a weak carbonic acid, lowering the rain's pH (from a neutral pH of 7 of pure water). The "rain" becomes acidic when water molecules (H2O) react with gases in the air. These gases are mainly sulfur dioxide (SO2) and various nitrogen oxides (NOx). This combining of gases and water molecules takes place when the water captures hydrogen ions (H+) from the gases (ions are electrically charged particles).

From information gathered in the 1930s and 1950s, it appears that the acidity of rainfall in the eastern United States has increased significantly (in Great Smoky Mountains National Park: 1956-5.6; 1980-4.27). Some scientists dispute this theory, however.

The gases SO2 and the NOx are mainly responsible for the increasing acidity. These gases are primarily created by industrial factories, coal-fired power plants, and automobile emissions. An estimated 26 million tons of SO2 and 22 million tons of NOx were put into the atmosphere in the United States in 1980. Some scientists believe that natural sources of SO2 and NOx (forest fires, lightning, volcanoes) have an equally important effect on acid rain (pH levels) as human-caused sources.

Areas where the soil has been disturbed (mines, forest fires, landslides, construction sites) may be making the water in streams and lakes more acidic. Many soils are already acidic or contain minerals which react with rainwater, snowmelt, etc., to form acids. These acidic waters are carried into streams and lakes. The gases SO2 and NOx are thought to be carried long distances by air currents. Storm systems also move long distances, carrying with them any pollutants they may pick up. The interactions of airborne pollutants and clouds are now well understood. Understanding the movement of prevailing air currents and storm systems can greatly aid scientists in discovering where acid rain is coming from and, just as importantly, where the rain is returning to earth.

Currently, there are two primary methods being used by industries and power plants to reduce the amount of pollutants released into the atmosphere. These two methods consist of installing cleansing devices in the exhaust or "smoke" stacks. The two types currently available are called "scrubbers" and electrostatic precipitators. Scrubbers are designed to remove the various gases (SO2 and NOx) from the plant emissions. These are considered to be very effective, and many states require that they be installed. Electrostatic precipitators are less effective than scrubbers. They are designed to remove the visible soot from emissions. This makes the emissions look clean but does not remove the real culprits of acid rain, SO2 and NOx.
EFFECTS OF ACID RAIN:

Acid rain in its many forms is the subject of considerable scientific research and many of the effects are just now being identified. Acid deposition is known to harm aquatic and terrestrial ecosystems, buildings, statues, and monuments. The following effects and statistics were obtained from "The Acid Rain Story," from Environment Canada.

--More than 200 million square kilometers of North America now receive rain with a pH of 4.6 or lower.

--Lake and river waters with a pH below 4.5 will not support fish populations. Even at pH 5.0 only limited fish populations can survive; frogs, salamanders and many other creatures are decimated.

--Relatively high sulfate and nitrate deposits in remote wilderness areas demonstrate the reality of long range transport of airborne pollutants.

--Fish taken from waters which are becoming acidic exhibit high concentrations of mercury and other toxic metals in their tissues—presumably leached out of soils and bedrock.

--Drinking water from acidic lakes and rivers has elevated concentrations of toxic metals too.

--Important evergreen species and other plants exposed to high doses of acid rain show damage to their foliage, sometimes at levels such as pH 4.6.

--About 200 lakes in the Adirondacks in New York no longer support fish life and thousands more are slowly losing their capacity to buffer acid rain.

--Scientists are beginning to evaluate the role of acid rain in increasing the vulnerability of trees to diseases and insects. Acid rain may also limit the decomposition of plant litter on the forest floor, reducing the normal recycling capacity and so, the amount of minerals available to trees and plants.

--Stone buildings, statues, and monuments are eroded by a number of airborne pollutants including acid rain. This increases the need for replacement and repair of buildings and such structures. It is thought acid rain contributed to the damage done to the Statue of Liberty.

--Increased acidity in soils due to acid rain is thought to free metals in the soil that are toxic to living organisms. These metals include mercury, aluminum and copper.

--The susceptibility of a lake or stream to acid rain is determined to a large extent by the type of surrounding bedrock. Lakes with a limestone foundation, which has a high buffering capacity, are not as severely affected. Lakes with a granite foundation, which has little or no buffering capacity, are more easily acidified.

--The lowest rainfall pH recorded in the U.S. was in Wheeling, West Virginia at 1.5.

--Wet deposition refers to acid rain, snow, sleet, hail, or even fog. Fog or clouds are more acidic than the others as there is less water to dilute the acid. Rainfall at the beginning of a storm may be more acidic as those early drops collect suspended acid particles in the air on the way down. Snow is not necessarily more or less acidic, but after accumulating all winter, spring thaws release a large amount of acid into the surrounding area. This phenomenon is known as "spring shock." Impacts of spring shock are compounded by the forced concentration of the acidic deposition in the unfrozen lower levels of the lake. It is especially harmful because spring is the reproductive season for fish and other aquatic animals.

--Dry deposition is the settling out of pollutants, including SO2 and NOx, without any precipitation. Dry deposition may be more harmful than wet because of it concentrated form. Also there is evidence that the dry acids which have settled on vegetation substantially increase the acidity of precipitation as the rain filters down from the canopy.
FACT SHEET 4

OZONE

The following is taken from National Park Service Air Resource Management Manual, National Park Service, WASO Air Quality Division:

Ozone, a highly reactive and unstable form of oxygen, is the most toxic pollutant to plants commonly found. It is a by-product of a complicated series of atmospheric photochemical reactions, involving nitrogen oxides, hydrocarbons, and carbon monoxide. Ozone has a pungent odor and a blue tint.

Ozone is produced by both natural processes and human-caused activities. In the upper atmosphere—the stratosphere—ozone is produced naturally in the presence of oxygen, nitrogen oxides, and intense ultra-violet radiation. Ozone produced in the stratosphere protects the earth's surface from dangerous levels of ultraviolet radiation. Substantial amounts of ozone from the stratospheric layer occasionally enter the lower atmosphere—the troposphere—by natural processes.

The principal source of human-caused ozone is the internal combustion engine. Although ozone is not a primary emission, the nitrogen oxides, carbon monoxide and hydrocarbons emitted from automobiles react in the presence of sunlight to form ozone.

Ozone is known to cause potentially serious injury and growth damage to various forms of vegetation including eastern white pines, hardwoods, and ponderosa and Jeffrey pines. Additionally, its effects include damage to textiles, discoloration of dyes and accelerated cracking and disintegration of rubber.

Ozone levels in Great Smoky Mountains National Park frequently exceed levels known to damage sensitive plants. Sensitive species can be injured by as little as 40 parts per billion (ppb) for 8 hours, and intermediate species by 70-120 ppb for 8 hours. In a typical summer, ozone exceeds 40 ppb for at least 6 consecutive hours on over three-quarters of the days, and 60 ppb for at least 6 consecutive hours on nearly half of the days. Although ozone levels are high only during the daytime at most low elevation sites, they remain high all night at mountaintop sites in Great Smoky Mountains National Park. This results in substantially higher average exposures.

Here is an example of how certain species of trees are being affected by ozone in different National Park Service units in the United States:

Injury to eastern white pine has been documented at Cape Cod National Seashore, and Cuyahoga Valley National Recreational Area. In the Indiana Dunes area, yellow spotting from ozone is common on white pine, jack pine, and other forest species. In the West, almost all of the 225 ponderosa pine trees studied in 1984 at Saguaro National Monument showed foliar injury due to ozone. Several species in the coastal sage community at Santa Monica Mountains National Recreation Area show extensive foliar injury due to ozone. Extensive injury to milkweed was noted at Shenandoah National Park and Catoctin Mountain Park.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 5
VISIBILITY IMPAIRMENT: WHAT IS IT?

BACKGROUND:
Most people have had the experience of visiting a beautiful park only to find fog, haze, or rain obscuring the scenery. In the mid-1970s Congress was made aware of the possibility that human-caused pollution is affecting visibility even in remote areas of the country. In the 1977 Clean Air Act Amendments, Congress responded to this concern by establishing a national goal of remedying any existing visibility impairment and preventing any future human-caused visibility impairment in major national parks and wilderness areas.

The preservation of unique scenic resources is very important to the National Park Service (NPS). NPS visibility monitoring has shown that in excess of ninety percent of the time scenic vistas are affected by human-caused pollution at all monitoring locations within the lower forty-eight United States.

WHAT IS VISIBILITY?
Atmospheric conditions, including particles and gases in the air, determine visibility conditions which influence how easily a person can see through the air. There are several different quantitative measures of visibility conditions that characterize different aspects of these conditions.

Air pollution can be visible in three forms: uniform haze, layered haze, and plumes. Uniform haze is a homogeneous haze that reduces visibility in every direction from the observer and occurs when the air is well mixed and the pollutants are evenly distributed. Layered haze is seen as a band or bands of discoloration, with a noticeable boundary between the more polluted and the cleaner air. A plume is a band of discoloration that can typically be seen to be coming from a nearby source. It is formed when there is a surface wind to carry visible pollutants horizontally from an emission source into a stable atmosphere.

CURRENT STATUS OF VISIBILITY AT NPS UNITS:

The best visibility at monitored NPS units is in eastern Nevada, western Utah, and southern Idaho. The next best area is the Colorado Plateau region where the Grand Canyon and several other NPS units are located. The worst visibility at monitored NPS units is in Shenandoah National Park and Great Smoky Mountains National Park.

Visual range at NPS units is typically best in the winter and worst in the summer when meteorological conditions are such that more pollution is transported from urban areas and industrial development to remote areas, causing more uniform haze to occur in the winter months.

CAUSES OF VISIBILITY IMPAIRMENT AT NPS UNITS:
Fine particles are generally responsible for a major share of visibility impairment at monitored NPS units.

On the average, soil-related material is responsible for 10% to 30% of the visibility impairment.

Fine sulfate particles are the single most important contributor to visibility impairment in NPS units except in the northwestern United States where fine carbon from human-caused and natural burning plays a more prominent role. Sulfate particles are primarily the result of human-caused sulfur oxide emissions.
FACT SHEET 6

AIR POLLUTION AND VEGETATION DECLINE IN SEVERAL NATIONAL PARKS

The following information is taken from "Air Quality Effects in the Great Smoky Mountains" by Uplands Field Research Laboratory, Great Smoky Mountains National Park.

The statements below summarize main points concerning the extent and effects of high elevation forest decline in the Great Smoky Mountains National Park.

The high elevation spruce-fir forests of the Great Smoky Mountains National Park are experiencing a decline in vigor and growth. At elevations of 6,000 feet and above, the annual growth rate of red spruce for the last 10 years is half the annual growth rate prior to 1960.

In addition, the red spruce are exhibiting other stress symptoms correlated with elevation, such as thinned crowns and dead tops. The upper surfaces of needles on red spruce saplings exhibit necrotic lesions (yellow spotting.)

Although concrete evidence has not yet been produced, the consensus among scientists is that red spruce are experiencing damage from air pollution. Furthermore, this damage does not appear to be associated with only one particular pollutant but appears to involve interaction of several forms of air pollution.

The following information related to Shenandoah National Park was taken from "Known Air Pollution Effects On Vegetation In National Parks."

Elevated concentrations of sulfur and lead are found in lichens. At some sites, the concentrations are above the normal range for lichens from unpolluted areas. Such concentration have been associated with lichen decline and food web effects in other studies.

Widespread ozone injury in 1982 and 1984 was reported on white pine, tulip poplar, black locust, wild grape, and milkweed. Injury on the most sensitive species (milkweed) occurred on 90% of the plants observed each year. About 8% of the least sensitive species (black locust) were injured. The injury appears to be correlated with decreased productivity and plant diversity. A survey of trees at elevations above 3000 feet revealed abnormally high mortality of some species.

The following information highlights the main points concerning the extent and effects of air pollution on vegetation in Sequoia National Park.

Over one-third of 540 ponderosa pine trees studied periodically since 1980 show moderate to severe ozone injury. Injury is also common on oak trees and jeffrey pines. Foliar symptoms resembling ozone injury, have been recently observed on giant sequoia seedlings in the park.

There are many other parks experiencing vegetation degradation that is suspected to be related to air pollution. Here are just a few of the other National Parks involved: Acadia National Park, Saguaro National Monument, Cuyahoga Valley National Recreational Area, Isle Royale National Park, and Gettysburg National Military Park.
FACT SHEET 7

ACID DEPOSITION EFFECTS ON CULTURAL MATERIALS

The following is taken from "Acid Rain Invades Our Parks" by the National Parks and Conservation Association.

Air pollutants, namely sulfur oxides, nitrogen oxides, and ozone, accelerate the natural weathering and deterioration processes of building materials found in cultural resources. A few of the building materials affected include: limestone, marble, bronze, carbonate-based paints, and galvanized steel.

The following information will discuss two building materials affected by air pollution: stone and bronze.

STONE:
Stone is affected by acidic deposition in several ways. These include chemical, mechanical, and biological deterioration. The acid pollutants in the rain begin to dissolve calcite, which is the principal material in limestone and marble. Acid deposition can also accelerate the mechanical decay of stone. As the sulfate compounds accumulate in the body of the stone, pressure builds, and finally the stone cracks.

BRONZE:
Bronze corrosion is also accelerated by sulfur dioxide and its transformation products (sulfuric acid). Bronze alloys, composed of copper zinc, lead and traces of other metals, are typically used architecturally and in the construction of statues. Thus, an understanding of the effects of sulfur oxides and acid deposition on each of the compounds inherent in the alloy must be understood to adequately explain bronze corrosion.

Bronze, upon exposure to acid pollutants in the environment, will form a black layer of corrosion composed of copper oxides or copper sulfates. The persistence of this layer of corrosion is favored by the presence of the lead in the alloy. A green-black corrosion layer may also form depending on the sulfur oxide concentration in the atmosphere. These various corrosion layers dissolve rapidly at or below pH 4.0, exposing metal surfaces. Additionally, deposition of particles will increase pitting of the copper and create localized areas of corrosion. Finally, removal of the zinc portion of the alloy (dezincification) can also occur resulting in disfiguration of the surface of the metal (Sherwood, 1985).

The following is taken from "Acid Rain: Looking Ahead" by the Environmental Protection Agency.

Cultural materials in many National Park Service units are being affected by air pollution. The Washington Monument, the Lincoln Memorial, Gettysburg National Military Park, Mount Rushmore National Memorial, and Custer Battlefield National Memorial are just a few of the sites with air pollution damage. The damage to buildings, statues, and monuments is not confined to the United States, either. In Canada, the Houses of Parliament and many legislative buildings and churches have been affected by acid deposition. A statue of the Virgin Mary, that was placed by devout Poles in the 15th Century, now stands with an eerily blank face, its features having been erased by airborne pollutants. The Parthenon of ancient Greece, which neither people nor nature could destroy in 2,500 years, may be threatened by acid rain in our lifetime.
FACT SHEET 8

ACID RAIN: EFFECTS ON AQUATIC SPECIES AND SYSTEMS

The following information was taken from "Acid Rain: Effects on Fish and Wildlife" by the Fish and Wildlife Service, United States Department of the Interior.

The subtle process of acidification often remains undetected until damage has occurred. In some instances, several acid-sensitive aquatic species may serve as indicators of the initial stages of acidification.

The acidity and alkalinity of a substance is measured on a pH scale. This scale measures the activity of hydrogen ions (H+) in a substance (pH stands for "potential hydrogen"). The scale runs from 0 to 14 where 0 is extremely acidic, 7 neutral, and 14 is extremely alkaline, or basic. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to 3 would be a hundred times (10 x10) increase in acidity.

Near pH 6.0, several animals decline that are important food items for fish; these include freshwater shrimp, crayfish, snails, and some small mussels and mayflies.

Fish species also differ considerably in their tolerance to low pH. For example, the fathead minnow, arctic char, brown trout, Eurasian perch, and northern pike are especially sensitive to pH declines. Because early life stages are generally more sensitive to low pH than older fish of the same species, declines in larval fish numbers may be early evidence of acidification --if other variables are not responsible.

The following information is taken from "Acid Deposition: Disruption of a Lake Ecosystem" by the Federation of Ontario Naturalists.

Lakes that are acidified become clearer, allowing light to penetrate deeper. Since more light becomes available for photosynthesis at or near the bottom of a lake, algal populations can grow at deeper sites. The algae then compete for nutrients with zooplankton (microscopic animals).

Salamanders and frogs are particularly susceptible to increased acidity because they lay their eggs in pools of spring meltwater—which are often highly acidic. Their eggs cannot tolerate the acidity, and so many eggs never reach maturity. Salamander and frog populations are devastated by the impact of the acid, and they begin to die out when the pH dips below 5.5.

The following information is taken from "Known Air Pollution Effects on Aquatic Systems in National Park Service Units" by the National Park Service.

The Great Smoky Mountains National Park is experiencing a temporary elevation of sensitive stream acidity (lowered pH) following acid deposition events. Isle Royale National Park is experiencing a temporary increase in acidity of surface waters following acid rain events. Shenandoah National Park is experiencing decreases in alkalinity and available soil nutrients in sensitive streams. Sequoia National Park is experiencing temporary increases in lake acidity following summer storms.
FACT SHEET 9

ACID PRECIPITATION EFFECTS ON SOILS

The following information is adapted from "Acid Deposition" by the Federation of Ontario Naturalists.

Soil is the foundation of terrestrial communities. Plants, animals, and microorganisms have aided soil development and together have established an intricate cycle of nutrient uptake and release.

The death and decomposition of flora and fauna have always generated acids in the soil, naturally. If the acids developed faster than the natural processes could neutralize them, the soils gradually acidified—a process which continues today. However, in addition to this natural process, some forestry practices and acid deposition are also contributing to soil acidity in forests, although the relative contribution of natural versus non-natural sources varies from place to place. In some forestry practices, the whole tree is taken, rather than leaving the slash on the forest floor. The amount of plant nutrients lost to the ecosystem, particularly the soil, is thereby increased. With fewer nutrients in the soil, one consequence will be that more acid will be left unneutralized.

Soils are not equally susceptible to acid deposition since factors such as cation exchange capacity, soil texture and structure vary widely. Possible effects of soil acidification include the following:
1. dissolving and leaching away of essential plant nutrients
2. concentration of some nutrients in toxic amounts
3. build up of highly toxic heavy metals in the soil
4. alteration of the plant and animal community

In general, soil is made up of negatively charged humus and clay particles. These clay particles are able to attach themselves to positively charged clay particles. These clay particles are able to attach themselves to positively charged cations such as magnesium, calcium, phosphorous, and sodium. These elements are essential for plant growth and are taken up by tree roots and replaced through the decomposition of vegetation and the weathering of rocks. Acid deposition adds hydrogen ions to the soil, which displace the nutrients from their positions bound to the soil particles. Without these nutrients, plants can be stressed, and the soil can become increasingly acidic. The acidification of soil can also stress certain species of plants. The addition of sulfates and nitrates to soil via acid deposition can have a "fertilizing effect" initially, but eventually can contribute to loss of nutrients in forest soils.

Acid deposition results in the increased solubility of toxic metals such as aluminum, manganese, iron, mercury, cadmium and lead in the soil. These metals become more easily absorbed by plant roots and can also be transported through the groundwater into aquatic ecosystems. These metals are not only toxic to the plants at certain levels but also to fish and humans at certain higher levels.

Increased soil acidity can result not only in chemical changes, but also in changes in the populations and species composition of bacteria, fungi, algae, earthworms, etc. Since these creatures are vital to the nutrient cycling processes in the soil, the impact of their loss or disruption may be far reaching.

When soil pH changes, some plants will die out while others may thrive. The resulting change in species composition will, in turn, have an impact on the animal community.

To better understand the influence of acidic deposition on soil, long range studies are needed. One such study in Shenandoah National Park is showing that shallow soil areas are much more impacted than are deep soil areas when exposed to acidic deposition.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 10

NATIONAL PARK SERVICE AIR QUALITY RESEARCH PROGRAM

The following section is taken from: Air Quality in the National Parks by the National Park Service, Air Quality Division.

The National Park Service established an air quality research program in 1979. Air quality research is conducted to determine the current status of air quality in the National Park Service units and to identify any effects air pollution is having or may have on National Park Service resources or visitor experiences. Air quality research is also conducted to determine sources of air pollution in the parks and the sensitivity of park resources to air pollution. The National Park Air Quality Research Program provides information needed to participate effectively in decisions that can affect the air quality in and near National Park Service units, and helps the National Park Service manage air quality resources as a part of its resources protection mandate.

The National Park Service Air Quality Research Program involves an extensive network of monitoring for pollution, visibility conditions, and biological effects in National Park Service units. The monitoring program includes:

- Transmissimeters for measuring visibility at over thirty parks.
- Cameras for measuring visibility at over thirty parks.
- Fine particulate monitors for identifying the causes and sources of visibility impairment at over twenty-five parks.
- The use of biomonitors (species of plants known to be sensitive to air pollution) to identify the presence of air pollutants in several parks.
- Ozone monitors at over fifteen parks for assisting the ozone effects research and evaluation of new pollution sources.
- Sulfur dioxide monitors at over ten parks for assisting the sulfur dioxide effects research and evaluation of new pollution sources.

Air quality modeling is developed and used to study the transport and transformation of pollutants in the atmosphere. Along with air quality models, information from the visibility monitoring network is used to determine the effects of human-caused air pollutants on visibility at National Park Service units. The National Park Service uses the information obtained from the air quality research program to help guide its participation in:

- Resource management planning within the National Park Service.
- Permit reviews concerning potential effects from increased emissions from proposed new major industrial and energy facilities outside park boundaries.
- Participation with State and local officials and industry in reaching decisions to minimize or eliminate potential impacts to park resources and to visitors' experiences.
- Reviews of environmental impact statements developed by other Federal agencies concerning activities that might affect National Park Service units.
- Regulatory and legislative analyses.
- Development of interpretive programs for park visitors and training courses for National Park Service employees.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 11

National Acid Precipitation Assessment Program

The National Acid Precipitation Assessment Program (NAPAP) is coordinated by an interagency task force on acid precipitation, and focuses federally funded research on the development of a firm scientific basis for policy decisions that pertain to the phenomenon most typically referred to as "acid rain."

The task force is made up of several different task groups. These task groups include: emissions and controls, atmospheric chemistry, atmospheric transport, atmospheric deposition and air quality monitoring, terrestrial effects, effects on materials and cultural resources, and aquatic effects.

The emissions and controls task group provides the National Program with highly accurate emissions data bases for use in regional acid deposition modeling and in the development, evaluation, and testing of source/receptor hypotheses.

The atmospheric chemistry task group uses laboratory, field, and modeling research to improve the measurement and estimation of natural emissions and the characterization of chemical and deposition processes.

The atmospheric transport task group has developed "RADM II," a state-of-the-science regional acid deposition model. This task group also produced the first major evaluation of linear chemistry models since the inception of the National Program.

The atmospheric deposition and air quality monitoring task group provides high quality atmospheric deposition data through its operation of and/or cooperation with a series of North American and global monitoring networks. This task group is also in charge of a dry deposition monitoring network.

The terrestrial effects task group has reviewed present knowledge of the impacts of regional air pollution. The Forest Response Program is contained within this task group. In the Forest Response Program, controlled exposure studies on seedlings were initiated on major species of the forest types.

The aquatic effects task group efforts have resulted in the first regional-scale estimates of surface water quality in the western United States and the Southern Appalachian states. The task group has also conducted a regional-scale soil chemistry survey. This survey will help to provide data required for predicting the future response of surface waters in the Northeast and the southern Appalachian States.

The effects on materials and cultural resources task group has been working toward determination of incremental damage from acidic deposition in order to define dose/response functions for key materials.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Former, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 12

FOREST RESPONSE PROGRAM

The Forest Response Program is a joint effort between the Environmental Protection Agency and the U.S. Forest Service and is contained within the terrestrial effects task group of the National Acid Precipitation Assessment Program.

Overall objectives of the Forest Response Program are to:

1. Determine the effect on productivity and health of major tree species from exposure of the foliage to near-ambient levels of acidic deposition, gaseous sulfur dioxide and nitrogen oxides, and associated oxidants (foliar-mediated effects).

2. Estimate the long-term effect on productivity and forest health from acidic deposition on a wide variety of forest soils at near-ambient levels (soil-mediated effects).

3. Identify the major factors causing visible damage to forests above cloudbase in the high mountains of the eastern United States.

4. Initiate biochemical, physiological, and ecological research to study whether causal relationships exist between acidic deposition and related air pollutants and forest conditions where adverse changes are demonstrable (mid-term to long-term mechanistic studies).

5. Establish a long-term program for monitoring forest conditions.

The research is organized and conducted regionally in major forest types: eastern spruce-fir, southern pine, eastern hardwood, and western conifer. Most of the research is carried out by the Forest Response Program through the four forest region research cooperatives (eastern spruce-fir forests, southern commercial forest, eastern hardwood forest, and western conifer forest) and three support groups (National Vegetation Survey, Mountain Cloud Program, and synthesis and integration groups within the Forest Response Program).
FACT SHEET 13

DEPOSITION MONITORING: WET AND DRY DEPOSITION EQUIPMENT AND THE NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

The following is taken from Acid Rain: What is it and How is it Measured, by Andy McRae and John Peine, Uplands Field Research Laboratory, National Park Service.

There are 110 NADP collecting stations across the country. These sites are set up to collect precipitation (snow, rain, ice, etc.) and dry fallout (the settling of airborne particles to the ground (dust, soot, dirt). In order to have data which can be compared in different parts of the country, NADP collects the samples from every site on the same day each week. These samples are then shipped to the headquarters in Illinois for analysis.

WET AND DRY DEPOSITION EQUIPMENT:
Figure 1.0 shows an older but still used model of the standard wet material-dry material catchment container for collecting wet and dry fallout. The sensor (a) is triggered through rain falling on its grid. This in turn operates the motor for the lid (b), which swings it off of the wet bucket (c), and onto the dry bucket (d), thus protecting the dry bucket from the rain and opening the wet bucket. This remains open until the storm event is over. The lid returns to its original position over the wet bucket (adapted from Lippincott et al. 1982).

FIGURE 1.0 WET AND DRY DEPOSITION EQUIPMENT

The Environmental Protection Agency has begun a national air quality project which became formally established as the National Atmospheric Deposition Program (NADP) in 1978. The NADP headquarters is located at the University of Illinois in Champaign. Its purpose is to gather data on air quality in this country.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 14

INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS PROGRAM AND MODULAR AEROSOL MONITORING SAMPLER

The following materials were taken from “IMPROVE Sampler Manual” by Dr. Robert Eldred, Air Quality Group, Crocker Nuclear Laboratory.

Fine aerosol particles affect remote areas primarily by impairing visibility and secondarily by producing acidic deposition. These fine particles are generally human-caused, although some are produced by smoke and windblown dust. Most naturally produced particles are coarse and have a smaller effect on visibility and acid rain. Measurements of the concentration and composition of these fine particles are necessary to determine the extent of the problem and possible sources of the particles.

The National Park Service and the Environmental Protection Agency have been monitoring particulate concentrations at national parks, monuments, forests, wildlife refuges and other remote sites since 1979 using stacked filter samplers. The particulate monitoring program has been expanded to include other federal agencies with the establishment of the IMPROVE (Interagency Monitoring of Protected Visual Environments) program, designed to determine the extent and causes of visibility impairment at selected class I areas throughout the United States. The National Park Service maintains additional sampling sites through the National Park Service Criteria Pollutant Monitoring program. The two programs use the same sampler and nearly identical sampling protocols and are operated by the Air Quality Group of Crocker Nuclear Laboratory at the University of California at Davis.


Monitoring Sampler that collects three samples of fine particles (smaller than 2.5 micrometers) and one sample of respirable particles (smaller than 10 micrometers). At the National Park Service Criteria Pollutant Monitoring sites, a fifth filter measures gaseous sulfur dioxide. The unit includes four filter modules, a controller module and a pump house containing four pumps. The IMPROVE sampler retains the simplicity of the stacked filter sampler but adds several features, including additional filters for measuring nitrates and carbon, twice the flow rate to improve sensitivity, an improved flow rate measurement system, and fewer sample changes.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 15

THE TRANSMISSOMETER VISIBILITY MONITOR AND THE NATIONAL PARK SERVICE VISIBILITY MONITORING PROGRAM

The following information was taken from "Plans for IMPROVE: A Federal Program to Monitor Visibility in Class I Areas" by David Joseph, National Park Service Air Quality Division.

Visibility represents one of the most important aspects of air quality in National Parks. To meet its responsibilities under the Clean Air Act, the National Park Service has designed a visibility monitoring program which includes both parks and monuments.

The information collected from the monitoring program provides baseline information, identifies the effects due to local visibility impairment and analyzes visibility trends. The scientific data collected from the monitoring program provides the knowledge needed to determine the interrelated effects that the forces of people and nature have on visibility and provides for proper resource protection in the parks.

The transmissometer measures the amount of light transmitted from an optically focused incandescent light source to a computer controlled receiver. Knowing the intensity of the light source, the distance between the source and the receiver, and the intensity of the transmitted light will allow direct calculation of the average atmospheric extinction due to scattering and absorption along the instrument.

The transmissometer operates by having a transmitter station which emits light from a quartz halogen lamp. The light is chopped into a square wave to distinguish its light from ambient sources. A typical sampling strategy may consist of the receiver measuring 1.5 minutes of the transmitted signal. The receiver measures the ratio of the high and low points of the transmitted square wave and compares it to the known outputs of the incandescent lamp. Its outputs are 1.5 minute averages of the atmospheric extinction along the path that can be subsequently averaged to representative one-hour values.

The transmissometer system is usually located within Class I areas. It is normally placed in close proximity to seasonal sources, special use areas being considered, or near the location of other air quality monitoring equipment.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 16

OZONE MONITORING CHAMBERS

Ozone (O₃) is a pollutant of primary concern in the United States. In several places, the National Ambient Air Quality Standard of ozone has been exceeded. To date, most research addressing the effects of ozone on National Park Service resources has been subjective and passively observational. While these approaches were appropriate for the initial assessments of ozone-related impacts, current projects include a program of quality controlled experimental research. Such a program is known as ozone monitoring, and the overall goal of the project is to establish whether there are effects of ambient air on native species in natural communities and to tie any observed effects to known ozone exposures.

The first objective of the study was to use an open-topped fumigation chamber system to determine the ozone sensitivity as indicated by visible foliar injury and, when appropriate, by selected growth parameters of native plant materials collected in the National Park unit. The second objective was to determine the effects of ambient ozone concentrations on native species in natural communities at differing elevations within the park.

The ozone is regulated by direct control of the generator output by a data logger machine. Ozone enters twelve chambers through a six-port manifold in the center of the ozone compound, and the flow to each chamber is controlled by a variable area flowmeter.

Four species of plants are exposed for a seven week period. There are 108 plants exposed for each species tested. This consists of nine plants per each of the twelve chambers.

Measurements are kept throughout the fumigation period, and a final harvest growth measure is taken. All plants are removed from the chambers, their height from the root collar is taken, and they are dried and weighed.

Assessing and describing foliar injury under controlled conditions can be useful in two ways:

1. It determines how much functional foliage has been reduced by exposure to ozone.
2. It develops guides for identifying observed field damage.

Several species that are being studied in ozone chambers include: yellow poplar, yellow birch, white oak, sugar maple, white shankeroo, manna grass, red maple, table-mountain pine, poke, milkweed, grape sp., black cherry, white ash, green ash, sycamore, eastern white pine, American beech, red spruce, and sweetgum.
FACT SHEET 17

VISIBILITY MONITORING

The following is taken from "Visibility Monitoring using 35mm Cameras: Equipment and Siting Criteria," by Air Resource Specialists, Inc.

Automatic 35mm photographic monitoring equipment can be used to collect optical data for the calculation of an atmospheric extinction or standard visual range. The primary electro-optical measurement of target/sky horizon contrast can be made by microdensitometry analysis of 35mm slides. To achieve these goals, the following equipment and siting criteria must be met.

EQUIPMENT:
1. Rugged, reliable 35mm camera body with automatic film winder. The camera's automatic exposure meter must be designed so that it is on only during the actual time of exposure and not continuously.
2. 35mm lens with UV filter.
3. Databack capable of imprinting on the film the day and time the exposure was taken.
4. Battery powered programmable timer capable of triggering the camera at least three times per day.
5. The complete system must be able to operate within the ambient temperature range of -30°F to 130°F.
6. The complete system must be able to be housed in a small, stand-alone environmental enclosure.
7. The system must be able to operate unattended for at least 10 days.

SITING CRITERIA:

The overall configuration of the monitoring site depends on the characteristics of the site and target. In most cases, the site will be in an undeveloped location with a quality view.

The monitoring view should be selected by personnel experienced in photographic exposure techniques and familiar with the practical aspects and limitations associated with slide microdensitometry. As many as possible of the following siting criteria should be met when selecting a visibility monitoring site and targets.

1. The monitoring location should be reasonably accessible and secure year round.
2. The view must contain at least one horizon visibility target with the following characteristics:
   --Large--subtend at least 0.1 degrees of solid angle (i.e., approximately 20% of the size of the full moon).
   --Easily identifiable on topographic maps of the area.
   --Dark--preferably covered with coniferous vegetation.
   --Number of targets--at least one quality target is required. Two or three targets at various distance are preferred.
   --Elevation angle--the site and target should be at approximately the same elevation. The observer-target elevation angle should be within ±1.
   --The targets should be located in the center of the camera view finder (center 30% of the slide).
   --For evaluation of regional air quality, the observer-target sight path should not be affected by local sources of visual air pollution.
   --The target should be selected to be as free of snow during the winter months as possible. Standard visual range values cannot be calculated for snow-covered targets.
   --Avoid exceptionally bright or dark foreground objects that would adversely affect the camera's ability to accurately meter the monitoring view.
   --Sun angle--it is best to orient the camera to avoid the possibility of sun shining directly into the lens.
3. The monitoring site and target should be selected so that as much of the sight path as possible runs through areas of administrative concern.
FACT SHEET 18

HOW TO USE A CONDUCTIVITY METER

Not all conductivity meters are created equal. The one that has been described here is the Whatman conductivity meter. This conductivity meter is designed to be used by anyone, including children. It is not as accurate as conductivity meters found in laboratory conditions, but its size (it fits in a pocket) and easy-to-read digital window make it very versatile and simple to use.

READING THE METER
1. The meter measures electrical conductivity on a scale of 0 (no dissolved solids = no conductivity) to 1990 (many dissolved solids = high conductivity).
2. The higher the reading, the more dissolved solids are present in the sample and the better the sample will conduct electricity.
3. Since acidic solutions can dissolve many substances, a conductivity reading can also indirectly indicate the pH of a sample. If the conductivity is high, the pH is likely to be low (the sample is likely to be acidic).

CALIBRATING THE METER
1. Remove the cap and turn on the meter.
2. Dip the meter up to the immersion level in distilled water. The meter should read 00 (no dissolved solids).
3. If the meter shows a different reading, use a small screwdriver to adjust the calibration trimmer until the meter does read 00. The meter is now ready for use.

TESTING LIQUID SAMPLES
1. Remove the cap and turn on the meter.
2. Dip the meter up to the immersion level in the sample.
3. Stir gently and wait a few seconds.
4. Read the total dissolved solids in the sample from the meter.
5. Gently shake excess liquid from meter before testing a new sample.
6. Be sure to turn meter off and replace cap when testing is complete.

MAINTAINING THE METER IN GOOD CONDITION
1. Make sure the meter is off and the protective cap is in place when the meter is not in use.
2. To improve performance, clean the electrodes by dipping the meter in alcohol for a
few minutes every few weeks.
3. Never immerse the meter above the display level.
4. If readings become slow or erratic, change the batteries. Pull out the battery case and insert four new 1.4V batteries (DURACELL MP 675H or equivalent). New batteries should last for about 200 hours of use.

The conductivity meter can be purchased as part of a set from Whatman Lab Sales, P.O. Box 1359, Hillsboro, Oregon, 97123. A thermometer and a pH meter are included in the set, and the cost is $115.00 as of 1987.

Conductivity meters measure the amount of dissolved solids found in water. The more acidic water is, the more things will dissolve in it. When there is a high conductivity reading, it usually indicates more acidity in the water. Some aquatic species need a certain pH range in order to survive, and so it is important to know the conductivity and pH of a body of water.
FACT SHEET 19

HOW TO USE A pH METER

The following instructions are for the Whatman pH meter.

READING THE METER
1. The meter will register pH from 0.0 to 14.0, where 0.0 is very acidic, 7.0 is neutral, and 14.0 is very basic.
2. The lower the reading below 7.0, the more acidic the sample. The higher the reading above 7.0, the more basic the sample.

CALIBRATING THE METER
1. Remove the cap and turn the meter on.
2. Dip the meter up to the immersion level in distilled water. The meter should read 7.0 (neutral).
3. If the meter shows a different reading, use a small screwdriver to adjust the calibration trimmer until the meter does read 7.0. The meter is now ready for use.

TESTING LIQUID SAMPLES
1. Remove the cap and turn the meter on.
2. Dip the meter up to the immersion level in the first sample.
3. Stir gently and wait for a few seconds.
4. Read the pH of the sample from the meter.
5. Gently shake excess liquid from meter before testing a new sample.
6. Be sure to turn the meter off and replace the cap when testing is complete.

MAINTAINING THE METER IN GOOD CONDITION
1. Make sure the meter is turned off and the protective cap is in place while the meter is not in use.
2. To improve performance, dip the meter up to the immersion level in tap water for a few minutes at least once a week.
3. Never immerse the meter above the display window.
4. If readings become slow or erratic, replace the batteries. Pull out the battery case and insert four new 1.4V batteries (DURACELL MP 675H or equivalent). New batteries should last for about 1000 hours of use.

The pH meter can be purchased as part of a set from Whatman Lab Sales, P.O. Box 1359, Hillsboro, Oregon, 97123. A conductivity meter and a thermometer are included in the set, and the 1987 cost is $115.00.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
The acidity and alkalinity of a substance is measured on a pH scale. This scale measures the activity of hydrogen ions (H+) in a substance (pH stands for “potential hydrogen”). The scale runs from 0 to 14 where 0 is extremely acidic, 7 neutral, and 14 is extremely alkaline, or basic.

"Natural rain" is considered to have a pH of about 5.6. This natural acidity results from the reaction of gases such as CO2 (carbon dioxide), given off by green plants during respiration, combining with air moisture to form a very weak carbonic acid. For thousands of years, natural acids in the atmosphere have been, for the large part, neutralized by dust and airborne chemicals like calcium and potassium, depending on location.
FACT SHEET 20

HOW TO USE A TEMPERATURE SENSOR

READING THE SENSOR
The sensor measures temperatures from -58 to +338 degrees Fahrenheit.

CALIBRATING THE SENSOR
1. Remove the protective cap, screw in the probe, and turn the sensor on.
2. Allow a mixture of ice and water to stand for several minutes; the temperature will stabilize at 32 degrees Fahrenheit. Dip the probe in the mixture, stir gently, and wait a few seconds. The sensor should read 32.3 degrees Fahrenheit. If the sensor shows a different reading, use a small screwdriver to adjust the calibration trimmer until the sensor does read 32.3. The sensor is now ready for use.

TESTING LIQUID SAMPLES
1. Remove the protective cap, screw in the probe, and turn the sensor on.
2. Dip the probe in the sample.
3. Stir gently and wait a few seconds.
4. Read the temperature of the sample in degrees Fahrenheit from the sensor.
5. Gently shake excess liquid from probe before testing a new sample.
6. Be sure to turn the sensor off and replace the protective cap when testing is complete.

MAINTAINING THE SENSOR IN GOOD CONDITION
1. Make sure the sensor is off and the protective cap is in place when the sensor is not in use.
2. Never immerse the probe above the point where it connects to the sensor.
3. If readings become slow or erratic, change the batteries. Pull out the battery case and insert four new 1.4V batteries (DURACELL MP 675H or equivalent). New batteries should last for about 1000 hours of use.

The temperature sensor can be purchased as part of a set from Whatman Lab Sales, P.O. Box 1359, Hillsboro, Oregon, 97123. A conductivity meter and a pH meter are included in the set, and the 1987 cost is $115.00.

Figure 1.0 The Temperature Sensor

(Prepared by Marcia Seager.)
FACT SHEET 21

PRESERVING SPECIMENS IN ACRYLIC

Acrylic specimens are a great hands-on tool for interpreters to use. Many different kinds of specimens can be preserved in acrylic, including pine needles, leaves, flowers, tree core samples, fungi, salamanders, insects, fish, mollusks, and shells. Here are six easy steps to preserving specimens in acrylic.

Acrylic mixes can be purchased at most craft stores for approximately $60.00/gallon. Molds range in price from .50-$2.00.

1) MEASURE: Add, by using a graduated container, exactly one part resin to exactly one part hardener by volume.

2) MIX: Mix the measured resin and hardener in a clean container. Stir until the material is thoroughly blended. Mixing should be completed after 2 minutes of vigorous mixing. The importance of thorough mixing cannot be overemphasized.

   The two components must be whipped, much like mixing a cake batter. If bubbles get whipped into the mixture, do not be concerned; the bubbles can be easily removed later. Improper mixing can result in soft or sticky spots.

3) POUR: Pour a small amount of the mixture into a plastic food container. Place specimen on top of mixture. Carefully pour over the surface of the specimen in an even pattern. Spread where necessary by using a piece of stiff paper to help liquid flow together. The acrylic will harden very suddenly!

4) DE-GAS: After about 5 minutes, the air bubbles created while stirring will rise to the surface. They can be easily and effectively broken by gently exhaling on them until they disappear (avoid inhaling fumes).

5) CURE: For best results, use the mixture at temperatures between 70 degrees F and 80 degrees F. Place a cardboard box over the item to keep dust off the surface during the curing cycle.

6) CLEAN UP: While liquid, the material can be cleaned up with alcohol. After it has cured, it can only be removed by long exposure to epoxy stripper or sanding.

   The acrylic specimen can be lifted out of the mold once it is completely hardened. The time that it will take for the acrylic to become completely hardened depends on the temperature, the size of the cast, and the thickness of the cast.

Specimens such as leaves and plant parts should be thoroughly dried before applying acrylic to them. Leaves and plant parts can be dried by placing them in between two sheets of newspaper and then placing a book on top to assure specimen flatness. If the specimens are not dry, they will release gases which will cause bubbles in the acrylic.

   Animals should be placed in alcohol, a killjar, or formaldehyde before being placed in acrylic. Dry them thoroughly after they have been in these fluids. Specimens such as salamanders and insects should be handled delicately so as to assure that all body parts will remain intact.
FACT SHEET 22

THE pH SCALE

The following information was taken from "What Is Acid Deposition?" by the Federation of Ontario Naturalists.

The acidity and alkalinity of a substance is measured on a pH scale. This scale measures the activity of hydrogen ions (H+) in a substance (pH stands for "potential hydrogen"). The scale runs from 0 to 14 where 0 is extremely acidic, 7 neutral, and 14 is extremely alkaline, or basic. Each one-unit change in pH is a tenfold increase or decrease in the strength of the acid or base being measured. A unit change from a pH of 5 to pH 3 would be one hundred times (10x10) increase in acidity.

Figure 1.0 illustrates the pH scale, giving commonplace examples of materials which correspond to different degrees of acidity/alkalinity.

"Natural rain" is considered to have a pH range of 4.9-6.0. This natural acidity results from the reaction of gases such as CO2 (carbon dioxide), given off by green plants during respiration, combining with air moisture to form a very weak carbonic acid. In addition, natural sources of sulfates (such as volcanoes and sea spray) and nitrates (such as bacterial processes and forest fires) contribute a small amount (in northeastern North America) to the formation of low ionic strength sulfuric acid (H2SO4) and nitric acid (HNO3), respectively. For thousands of years, natural acids in the atmosphere have been, for the large part, neutralized by dust and airborne chemicals like calcium and potassium, depending on location. Research has shown that ice which was originally deposited as snow in Greenland less than 200 years ago was almost neutral.

However, in the last half century, the levels of acid-forming ingredients entering the atmosphere have increased dramatically, so that "natural rain" is a thing of the past in eastern North America.

Here are some interesting facts about the pH of rainfall in the United States:

The lowest rainfall pH recorded in the United States was in Wheeling, West Virginia, at 1.5.

The average pH of rainfall in the eastern United States and Canada is 4.1.

| LIME 12.4 | 11.0 AMMONIA |
| MILK OF 10.5 | 8.0-8.5 GREAT LAKES |
| MAGNESIA | 8.2 BAKING SODA |
| SEA WATER 8.3 | 7.0 NEUTRAL-DISTILLED WATER |
| HUMAN BLOOD 7.4 | 5.6 "CLEAN" OR NATURAL RAIN |
| MILK 6.6 | 4.0-4.2 RAIN IN CANADA |
| CARROTS 5.0 | 2.2 VINEGAR |
| TOMATOES 4.2 |
| APPLES 3.0 |
| LEMON JUICE 2.0 |
Fact Sheet 23

INTERPRETING CONTROVERSY

If interpretation is to play a significant role in protecting park resources, interpreters must address controversial subjects. Parks that are threatened must have these threats discussed, even if the threats are directly related to the livelihoods of surrounding communities. Parks with controversial but necessary management programs need to explain these programs to park users. To accomplish these tasks park managers need to use their interpretive programs.

The interpretation of controversial subjects is not fundamentally different from other interpretive efforts, but special concerns do come into play. The most important of these is the rigorous pursuit of accuracy. Information presented by interpreters should always be accurate, of course, but another level of discretion is required here. (Few visitors react strongly to a value statement when the subject is wildflowers, but if the conversation comes around their life-style and livelihood, expect stronger reactions.) This discretion needs to come in at least two forms. The first is the careful collection and presentation of certified facts. A discussion of air quality damage to the park, for example, needs to make clear the distinction between what is clearly demonstrated to be fact and what is merely suggested or hypothesized. Information from this second category need not necessarily be avoided, but it must be put in an accurate theoretical context.

The second level of discretion unavoidably appears when the time comes to draw conclusions (and especially value judgments) from the facts presented. In theory, interpreters are not to proceed into this realm, or so many park managers assert. In reality, of course, conclusions and value judgements result unavoidably from the presentation of problem-related information. The concept here is that interpreters should "plant" problems in visitors minds, and them let the visitors' minds move independently to value-judgement-maturity. What we must avoid is telling visitors how to react to a problem. Again, this does not mean that these subjects cannot be discussed. We can ask visitors how they think matters should proceed, and encourage visitors to share information and opinions with each other. We cannot tell them what we think they should think.

The presentation of controversial or troublesome materials to visitors is another area requiring a bit of thought. Few visitors come to interpretive activities (or parks for that matter) seeking "bad news." Interpretive activities traditionally are perceived as pleasant, recreational activities. Too much bad news, presented unexpectedly, can result not in problem awareness, but rather in the rejection of the message altogether. This situation places a judgemental responsibility upon the individual interpreter. He/she needs to define the expectations of the audience, their immediate mood, and how they can be best addressed. Often these kings of messages must include not only a factual segment, but also some subtle emotional one, that is through the expression of our own emotions we can suggest to visitors how these issues should be perceived. (In this context we should generally avoid the use of the "angry" context as it leads often to a defensive response. Emotional contexts based on sadness, concern, or loss are often far more effective.)

Another aspect of this question is choosing the time and place to present controversial subjects. In-depth activities which provide detailed information on a subject may seem safer to interpretive program designers since they offer considerable opportunity for
exploring all aspects of a subject, but because they appeal to relatively few visitors, their usefulness is quite limited. A more effective approach is to "shotgun" your message through the broadest possible spectrum of your program, keeping the individual dose level low, of course. This has the advantage of spreading your message much more widely, this has the advantage of spreading your message much more widely, which is the goal after all.

A final aspect of this issue is that interpretive program managers and supervisors must not underestimate the negative effects of controversial subjects on their staff members. For most field interpreters public acceptance and appreciation is their greatest single psychological reward. controversial (i.e. "negative") subjects may lead to a very significant reduction in positive visitor feedback. (Even concerned and supportive park visitors may not really enjoy hearing about park problems.) The implications of this are that subjects that are not always received well by park visitors may well be avoided (either consciously or unconsciously) by park interpreters who rely upon park visitors for their feedback acceptance.

(Prepared by William Tweed)
FACT SHEET  24

CLEAN AIR ACT

The following is taken from Air Quality in the National Parks: A Summary of Research Findings, National Park Service, Air Quality Division.

The Clean Air Act, as amended in August 1977, provides one of the most important mandates for protecting air resources in National Park Service areas. In section 160 of the Act, Congress states that one of the purposes of the Act is "to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreation, scenic, or historic value."

The Clean Air Act also establishes stringent requirements for "class I" areas—national parks over 6000 acres and national wilderness areas over 5000 acres that were in existence on August 7, 1977. Federal Land Managers (defined as the Secretaries of the Interior and Agriculture) and the Federal official charged with direct responsibility for each area have been given an affirmative responsibility to protect air quality related values in these areas from adverse impacts. Air quality related values are defined by the National Park Service as "visibility and those scenic, cultural, biological, and recreation resources of an area that are affected by air quality."

Determination of an adverse impact on air quality related values requires identification of a current or potential impact and consideration of how it might affect park resources and visitor experiences.

This determination combines information gathered from National Park Service research, information provided by a proposed new pollution source applicant, and the Federal Land Manager's judgment and experience about whether allowing this effect would be consistent with the National Park Service Organic Act.

The Clean Air Act also defines a national goal of remedying existing visibility impairment and preventing future visibility impairment in Class I areas. The Act requires that States incorporate measures in their State Implementation Plans that will ensure reasonable progress toward this goal.

THE CLEAN AIR ACT AND IMPLICATIONS FOR NATIONAL PARK SERVICE MANAGEMENT:

In order to carry out the above responsibilities, the National Park Service established the National Park Service Air Quality Research Program in 1979. Air quality research is conducted to determine the current status of air quality in the National Park Service units and to identify any effects air pollution is having or may have on National Park Service resources or visitor experiences. Air quality research also determines sources of air pollution in the parks and the sensitivity of park resources to air pollution. The National Park Service air quality research program provides information needed to participate effectively in decisions that can affect the air quality in and near National Park Service units, and helps the National Park Service manage air quality resources as a part of its resources protection mandate.

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 25

BIOSPHERE RESERVES

In 1968, the United Nations Educational, Scientific, and Cultural Organization, also known as UNESCO, made plans for a world-wide strategy to conserve natural resources. These plans developed into The Man and the Biosphere Program (MAB), which began in 1970. The major goal of the program is to demonstrate how people and the natural world can live in harmony with each other.

The first accomplishment of MAB was to distinguish major regions of the world with similar plant and animal communities. These communities reflect a continuity of geological formations and climatic conditions. Such areas were christened "biogeographical regions," with this name representing both the living and land formation components. One hundred ninety-three biogeographical regions were identified.

The next accomplishment was the identification of at least one reserve area within each global biogeographic region. These areas, whether already established as national parks, forests, or newly designated reserve areas, were to provide a place of protection for the genetic material within their bounds and a place of demonstration of ways in which people and the environment may co-exist harmoniously.

Biosphere reserves are to serve as demonstration areas where the development and study of natural resources practices, the training of environmental scientists and managers, and the education of the public and surrounding communities on relevant local environmental and social issues may take place.

As of 1987, 260 MAB reserves existed in 70 countries; the United States is home to 43, of which the Great Smoky Mountains National Park is one. The Great Smoky Mountains National Park Biosphere Reserve was a charter member of the program in 1976, and represents the Eastern Forest biogeographic region. It contains plants, animals, land formations, and climate of ecosystems found in the southern Appalachians.

The Great Smoky Mountains National Park Biosphere Reserve conducts an international training program for biosphere reserve managers and researchers, tries to eliminate exotic species from the park, and tries to save native reserve species from extinction, as the preservation of all native plants and animals is central to the purpose of biosphere reserves and national parks.

The Great Smoky Mountains National Park Biosphere Reserve is also initiating a community involvement plan, so that people can become more aware of their reserve. People can make the difference in the protection and wise use of natural resources, and so adjacent communities are key to the success of the biosphere reserve concept.

FACT SHEET 26

TWO ARTICLES FROM SEQUOIA BARK

The following two articles are examples of articles that were written for the Sequoia Bark, the newspaper for Sequoia-Kings Canyon National Park.

"I don't trust air I can't see," is an often heard joke from people who live in smoggy areas. But the joke is on all residents of planet earth. For those of you who have come to Sequoia and Kings Canyon National Parks to escape the smog and breathe fresh air, there is smoke startling new information.

On a typical summer afternoon in Giant Forest, the ozone level is higher at the 6,000 feet elevation level in the Sierra than down in Fresno! Views seen from Moro Rock and other vista points have diminished significantly in the past several decades, and air-pollution-caused damage to living things is now being recorded here in the parks.

In Sequoia and Kings Canyon National Parks, research is occurring to understand the nature of these threats to our air quality. This work is essential because the pollutants invading the parks have the long term capability of significantly changing the vegetation and aquatic systems of these parks.

Man-made pollutants are invading the parks in at least two different forms--ozone and acid deposition.

Ozone, a relatively rare form of oxygen which is made by the energy of the sun from automobile exhaust, is a caustic gas which burns and damages leafy vegetation on plants. Jeffrey Pines and black oaks are particularly susceptible. Ongoing research in the parks is working to both monitor ozone levels and tie them to specific damage of trees.

Acid deposition is receiving a great deal of attention in these parks. Two chemical pollutants, nitrates and sulfates, are of importance because they can combine with atmospheric water to form acids. Nitrates can become nitric acid and sulfates can become sulfuric acid. When these acids come into contact with living things they can hurt or even kill. So far, little acidification has been noticed in these parks but intensive study is underway to monitor the levels of acid precipitation received by the parks and to watch for impacts on living things.

In order to understand the Sierra's acid deposition problem the research department in Sequoia and Kings Canyon is carrying out or coordinating over 30 related studies ranging from soil chemistry studies to analyses of microscopic plankton and diatoms in high country lakes.

Most of these studies are being done at one of three special study zones. The first is in the foothill portion of the parks, near Ash Mountain Park headquarters at an altitude of about 2,000 feet. A second study site is at Log Meadow near the south edge of the Giant Forest at an altitude of nearly 7,000 feet. The third site is at a high elevation lake above Lodgepole called Emerald Lake. Together the tree sites provide a profile of the natural environments of the southern Sierra.

Why are we studying acid deposition here? Two reasons stand out. First, our particular geography makes this area very susceptible. California's landforms tend to concentrate pollutants from both the Bay Area and the Great Central Valley in the southern San Joaquin Valley area adjacent to Sequoia and Kings Canyon National Parks. The area from Fresno to Bakersfield often has very dirty air in summer.

Secondly, we are studying acid deposition here because these mountains contain many natural systems that are very susceptible to air pollution damage. Sierran soils tend to be naturally acidic, and additional chemical inputs may push them over the line that makes environments unfriendly for plants and animals.

In the air quality arena, our research programs have an important role to play. Efforts now underway to document air quality problems may be essential in the long-term survival of the special resources these parks were created to preserve.

(Prepared by Nancy Muleady, Dawn Vernon, and Bill Tweed)
"AIR POLLUTION KNOWS NO BOUNDARIES"

"WHEN SEQUOIA AND KINGS CANYON NATIONAL PARKS WERE CREATED IT COULD NOT BE PREDICTED THAT AIR POLLUTION GENERATED MILES FROM THE PARKS’ BOUNDARIES WOULD BE TRAPPED BY THE VERY LANDSCAPE SO WORTHY OF PROTECTION."

“At your feet lies the great Central Valley, glowing golden in the sunshine, extending north and south farther than the eye can reach, one smooth, flowery lake-like bed of fertile soil. Along its eastern margin rises the mighty Sierra, miles in height, reposing like a smooth cumulus cloud in the sunny sky."

"Such a view as described by John Muir in 1894 from Packeco Pass can only be found in the mind’s eye today. One can only imagine the view possible from Moro Rock or Beetle Rock if air pollution did not obscure the San Joaquin Valley floor and the Coast Range beyond."

The legislation which created Sequoia and Kings Canyon National Parks spoke not only of the preservation of the giant sequoia, but also of the clear mountain vistas found throughout the Parks. Unfortunately, it could not be predicted that air pollution generated miles from the Parks’ boundaries would be trapped by the very landscape so worthy of protection.

Sequoia and Kings Canyon National Parks are located along one of the most polluted areas in the country. A morning inversion traps pollution in the valley. The top of this inversion layer can be seen distinctly from park vistas to the west in the morning. By afternoon vistas from Moro Rock become obscured, as winds transport this air pollution into the Parks.

The two most abundant pollutants found in these Parks are ozone and tiny particles (particulate matter).

In nature ozone is found well above the earth in the stratosphere, where it absorbs ultraviolet light. Ozone in these Parks, however, is from sources such as oil refineries and automobiles. Currently, ozone concentrations are being monitored in two locations in Sequoia National Park. It is not unusual in summer to document many days when ozone levels exceed Environmental Protection Agency (EPA) maximum standards for public health.

OZONE DAMAGE TO PINES

The effects of ozone include not only respiratory problems in humans, but also damage to cells of sensitive plant species in the Parks. Sensitive species such as ponderosa and jeffery pines experience chlorotic mottling—a translucent, yellow spotting on the needles—when their chlorophyll cells are damaged. Present research includes surveying the amount of trees experiencing this mottling as well as loss of needles due to ozone. Scientists are also trying to determine what such damage could mean to the vigor of a tree. Controlled experiments are also taking place to determine what injury sequoia seedling may be suffering.

LOSS OF VISIBILITY

Particulate matter is the pollutant most responsible for the loss of park vistas. Particulates also can be injurious to human respiratory systems. Man-made sources include agricultural burning, oil refining and automobile emissions, especially from diesel engines. Presently, particulate matter is being monitored in these Parks as part of the State monitoring network and by several research projects in conjunction with acid rain studies.

WHAT IS BEING DONE?

Probably the most important protection for these Parks is the Clean Air Act. Both Sequoia and Kings Canyon are designated Class I areas under this Act, which is the highest level of protection possible. This means future air pollution sources will be controlled to ensure that only a small amount of air quality loss occurs. Also, State programs such as gas pump vapor shields were created specifically to reduce the pollutants mentioned above.

On an individual level, keeping your car tuned-up and conserving gas by carpooling or bicycling will help. When visiting Sequoia and Kings Canyon, walking a bit instead of driving among the giant trees will be a contribution to improving air quality in the Parks.

(Prepared by Linda Mazzu)
FACT SHEET 27

NATIONAL WILDLIFE FEDERATION'S "WE CARE ABOUT CLEAR THE AIR" EDUCATIONAL PACKET

This packet of materials, published by The National Wildlife Federation, was designed as an educational tool for teaching about air and air pollution. Included in the packet is the Educator's Guide which is organized into three themes:

1. understanding clean air
2. understanding air pollution
3. learning ways to control air pollution.

The first theme, understanding clean air, examines what air is and why it is important to all living things. The second theme, understanding air pollution, describes what air pollution is and what problems it causes. The third theme, learning ways to control air pollution, discusses laws that have been passed and ways that individuals can help reduce air pollution. Various activities and background information are included for each theme.

In addition to the Educator's Guide, the "We Care About Clean Air" package includes the following materials:

1. a brochure by the Environmental Protection Agency which deals with the problem of ozone
2. a theme poster that discusses air quality
3. stamps that can be distributed to visitors
4. four Copycat Pages which include a variety of puzzles, problems, and information concerning different types of air pollution.

A filmstrip or slide/tape presentation entitled "Let's Clear the Air" is also available from the National Wildlife Federation for a small fee. The program explores many of the polluting substances, the harm they do, and the efforts being made to control them. Included with this fifteen minute presentation is the narrative script and an educator's guide.

The Copycat pages included in the educational packet could be used extensively in a Junior Ranger handbook or in a Junior Ranger or "Just For Kids" program.

ORDERING INFORMATION

"We Care About Clean Air" packet: free

"Let's Clear the Air"

- 79495 filmstrip............$24.95
- 79491 slide/tape............$26.95

Send check or money order to:

NATIONAL WILDLIFE FEDERATION
1412 Sixteenth Street, N.W.
Washington, D.C. 20036-2266
(202) 797-6800

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mullins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 28

AIR QUALITY PUNS AND PLAY-ON-WORDS

Effects on vegetation:

"As we sit around the campfire tonight, think about the trees that are burning for fuel our fire. There is another type of "tree-burning" that occurs in this park--and it is not caused by fire--it is caused by a form of air pollution.

"Why the pines are pining away"

"The king-size stand of (name of tree) has many king-sized problems"

"Air pollution has really got me tree'd"

"Air pollution isn't poplar"

"Help spruce up our air quality"

"Ash me if I care about clean air"

"Clean air is oak-kay"

"I wish acid rain would leaf us alone"

Air Pollution

"Acid rain--it's not just a pHrase."

"Acid reign."

"pHase out acid rain."

"The solution--stop pollution!"

"Ozone--good or bad? friend of foe?"

"Acid Rain-BIG trouble in a small package"

"Who'll Stop the Rain?"

Visibility impairment

"Oh Say Can You See?"

"Clearing the Air"

"Let's don't cloud the issue."

Streams and Water Quality

"Water we learning about our streams"

Ozone Pollution

"The Wizard of Ozone"

Nighttime Air Quality

"The Night Fantastic"

Effects on Animals

"Shrew or False--Is Air pollution found in this park?"

"I toad you air pollution hurts aquatic species too!"

"Air pollution is un-bear-able"

"Ewe otter care about clean air!"

"Deer me! air pollution is everywhere!"

"I'm skunked over air pollution"

"I'm berry nuts over clean air"

This project was funded by the U.S. Department of State, Man and the Biosphere Program of the National Park Service, and the School of Natural Resources of The Ohio State University (OSU). Kim A. Baker (OSU) served as research associate. For further information, contact the Project Coordinators: Gary W. Mulins and Rosanne W. Fortner, School of Natural Resources (OSU), 2021 Coffey Road, Columbus, Ohio 43210, 614/292-2265.
FACT SHEET 29

THE BALSAM WOOLLY ADELGID

The insect known as the balsam woolly adelgid (uh-dell-gid) feeds on the main stem of Fraser fir. This insect is a native of Europe and was accidentally introduced into North America around 1900 in Maine and eastern Canada where it infected balsam fir. It was detected in the southern Appalachians in 1957 and in Great Smoky Mountains National Park in 1963.

The adelgid has a 5-part life cycle. Eggs incubate approximately 12 days, producing the first larvae, called "crawlers" as only in this stage can the adelgids move. These crawlers are light purple, extremely small (0.35-.45 millimeters long), and may move as far as 30 meters, usually on the same tree on which they were hatched. Because they are so small and light, these larvae may be carried by winds, though how far is not known.

To feed they insert their long thread-like mouthpiece called the stylet into the bark of the tree in search of food—the tree sap. In doing so, a substance is secreted into the inner tissues of the tree bark, which aids in the uptake of the nutrient fluid to the adelgid. The fluid also causes the enlargement of cells in the bark tissues, restricting the upward flow of nutrients inside the tree trunk. Once the adelgid begins feeding, it turns dark purple, loses its legs and antennae, and begins to produce the waxy strands or "wool" for which the species in named.

Two other larval stages and eventually adulthood follow. Adults are always female and reproduce asexually. Between 100 and 200 eggs are laid over a period of up to 5 weeks, and soon after that the adult dies.

One adelgid on one fir tree would not be detrimental; hundreds and thousands are. Once infested, the trees die within 20 years. Three causes of death are: (1) the production of abnormal cells that interfere with the upward movement of vital fluids (2) the killing of the outer bark by the toxic saliva of many adelgids, and (3) the production of extra tissues which interfere with the exchange of gases in tissues. In other words, these trees starve, have "skin diseases," and suffocate.

At this time, no solution exists to the balsam woolly adelgid problem. However, a soapy concoction of fatty acids and their salts, when sprayed directly on affected trees, has been shown to substantially reduce the number of adelgids. This solution must be directly applied to individual trees using a high powered water pump. Therefore it is not feasible on a large scale.