AIR QUALITY MONITORING

in Protected Areas & Wilderness
CSS 496

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AIR QUALITY MONITORING

Adapted from NPS UCBN Vital Signs Workshop
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Air Quality Terms

- Clean Air Act of 1977 gives Federal land managers "…an affirmative responsibility to protect the air quality related values (including visibility)… within a class I area."
- AQRVs – air quality related values
- PSD – preventing significant deterioration

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AIR QUALITY MONITORING NETWORKS

- GPMN - http://12.45.109.6/
  - Gaseous Pollutant Monitoring Network
    - Ozone and meteorological monitoring – 40 NPS sites
- NADP/MDN - http://nadp.sws.uiuc.edu/
  - National Atmospheric Deposition Program
    - Wet acid deposition – 37 NPS sites
    - Mercury deposition – 8 sites nationwide
- CASTNet - http://www.epa.gov/castnet/
  - Clean Air Status and Trends Network
    - Dry acid deposition – 70 sites nationwide
    - Rural ozone and meteorology
- IMPROVE - http://vista.cira.colostate.edu/improve/
  - Interagency Monitoring of Protected Visual Environments
    - Visibility – 50 NPS sites

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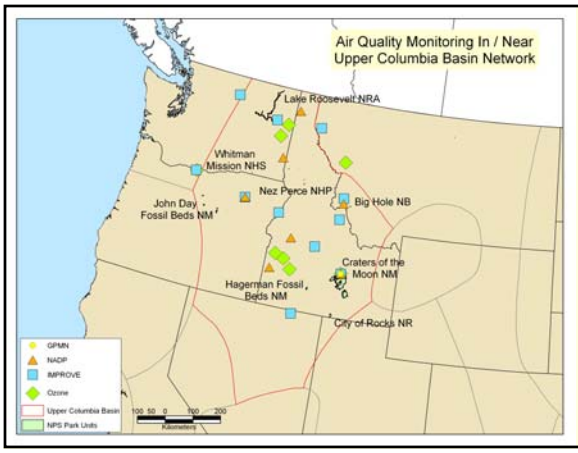

CRATERS OF THE MOON

- Ozone and Meteorology – GPMN
  - Includes solar radiation?
- Wet acidic deposition – NADP
  - No dry deposition
  - No mercury
- Visibility – IMPROVE
  - No optical
- Dioxin?

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AIR QUALITY MONITORING

- Ozone
- Acid Deposition – wet and dry
- Visibility
- Other

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OZONE EFFECTS

A "secondary" pollutant formed from organic compounds, NOx, and sunlight

- Respiratory problems in humans and perhaps wildlife
- Vegetative effects
  - Foliar injury
  - Reduced growth
  - Increased susceptibility to other stressors (insects, drought, disease)

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OZONE PARAMETERS

Ozone can be expressed as concentration (ppm/ppb) or cumulative dose (ppm or ppm-hr):

- 2nd Highest 1 hour
- 4th Highest 8 hour
- No. of 8 hours >85 ppb
- No. of 1 hours > 100 ppb
- SUM06 3 Month
- SUM0 3 Month
- W126

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OZONE MONITORS

- **Continuous**
  - Require electricity
  - Expensive
  - Document hourly levels of pollution in real-time
    - Data can be used to evaluate diurnal patterns, peak exposures, hours of exposure over a set level (e.g., SUM06), total seasonal exposure (e.g., W126), compliance with national ambient standards, etc. – each of which has different ecosystem implications
- **Passive**
  - Do not require power
  - Inexpensive
  - Provide an integrated measurement over time, usually one week
    - Spatial gradient studies (e.g., within a park or within a canopy)
    - In conjunction with biomonitoring plots to relate observed ozone injury to vegetation to an actual ozone exposure.
    - Also used to asses how representative a fixed, continuous monitoring location is of ozone levels in surrounding biomonitoring plots
  - Important research tool
- **Biomonitoring**
  - Ozone sensitive species
  - Bioindicator plant species

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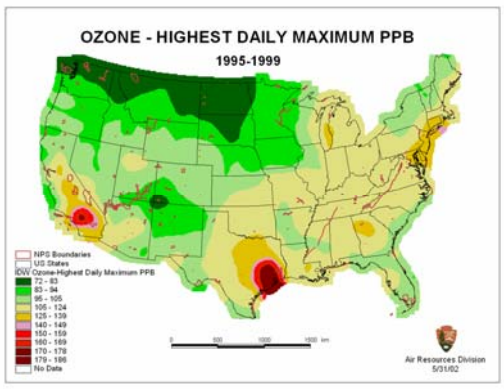

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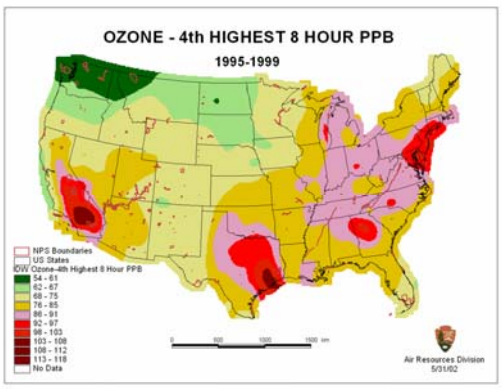

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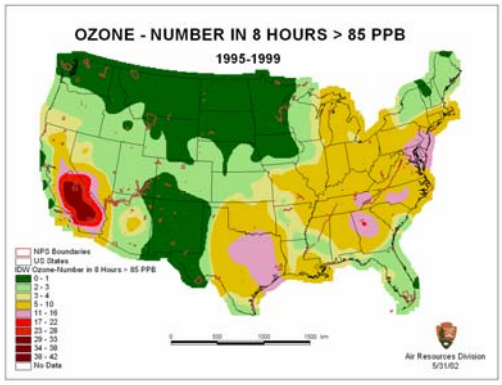

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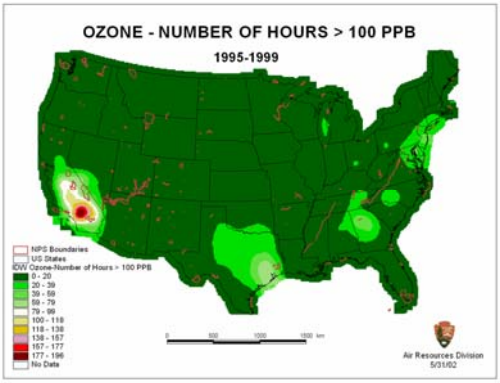

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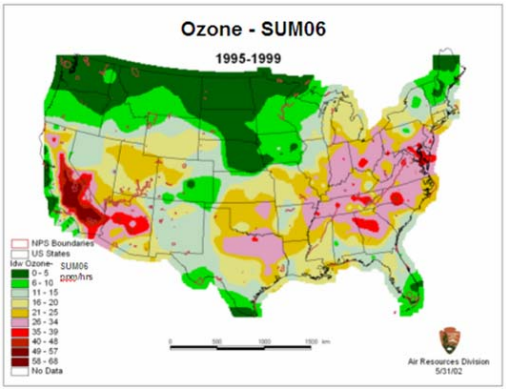

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ACID DEPOSITION EFFECTS

- Acidifies soils and surface waters
- Increases availability of aluminum (which may be toxic to plants and animals)
- Decreases availability of selenium
- Changes soil processes
- Increases mercury methylation (sulfur only)
- Can cause shifts in plant community composition (nitrogen only)
- Can cause eutrophication (nitrogen only)

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ACID PARAMETERS

NADP collects **rain/snowmelt** in a bucket and analyzes for sulfate, nitrate, hydrogen ion (measure of acidity), ammonia, chloride, and base cations (calcium, magnesium, potassium). Values are provided for each component and summed as:

- Total sulfur from sulfate ions (in kg/ha/yr)
- Total inorganic nitrogen from ammonium and nitrate ions (in kg/ha/yr)

CASTNet uses a **3 filter pack system** that is analyzed once/week for sulfate, nitrate and ammonium ions. Atmospheric concentrations are calculated based on the mass of analyte in each filter extract and the volume of air sampled.

Cloud/Fog component – new methods being developed in the east

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NADP 'MONITOR'

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ACID DEPOSITION RISK

Criteria to consider:

- Ability of lakes, soils to neutralize acid deposition (e.g., underlying geology)
- Potential for subtle changes in aquatic and terrestrial ecosystems including changes in species composition
- Potential for damage to cultural or natural resources
- Magnitude of potential changes in emission sources (e.g., increased agricultural emissions)

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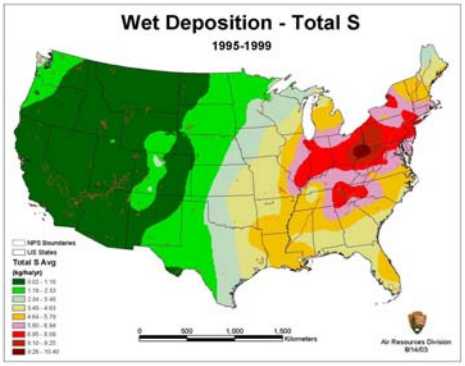

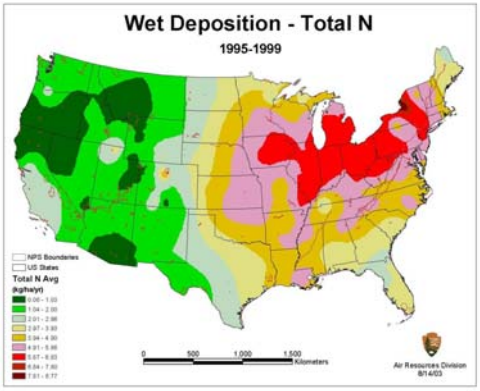

VISIBILITY EFFECTS

- **Fine particles** suspended in the atmosphere obscure the scenes' colors, forms, and textures
- In relatively clean areas like the UCBN parks, small increases in particle pollution perceptibly **degrade visibility**
- Pollutants that degrade visibility also contribute to **acid deposition** (sulfates and nitrates), ozone formation (NOx, organics), and to human health effects (diesel smoke, wood smoke, car emissions, etc.)

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VISIBILITY PARAMETERS

Visibility is measured several different ways:

- Visual range in kilometers
- Atmospheric extinction in inverse megameters or deciviews
- Amount of light scattering as particle scattering coefficient (bsp)/m
- Amount of particulate (total or speciated) as ug/m3

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VISIBILITY MONITORS

Three types of Visibility monitoring :

- View monitoring using a digital or webcam
- Optical monitoring measuring:
  - The amount of light scattered by particles using an instrument called an integrating nephelometer
  - The amount of light scattered plus the amount of light absorbed – called the atmospheric extinction – using an instrument called a transmissometer
- Aerosol monitoring by directly measuring the light absorbing and scattering particles in the atmosphere:
  - Fine mass (PM2.5) and course mass (PM10)
  - Speciated* as:
    - particulate sulfate and nitrate
    - elemental carbon (soot)
    - organic material

*The speciation of particles helps determine the chemical-optical characteristics and the ability of the particle to absorb water and is important for determining the origin of the aerosol.

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IMPROVE Monitoring Equipment

Every IMPROVE site deploys an aerosol sampler to measure speciated fine aerosols and PM10 mass. Select sites also deploy Transmissometer and Nephelometers to measure light extinction and scattering respectively, as well as automatic camera systems to measure the "scene".

The IMPROVE Modular Aerosol Sampler which, measure fine and total aerosol mass. The sampler was developed and refined by the IMPROVE program, and has been in operation since 1987.

The receiver for an Optec LPV-2 transmissometer, which measures the light extinction coefficient by measuring the attenuation of light from a light source.

The Optec NGN-2 integrating nephelometer, which estimates the atm. scattering coefficient by directly measuring light scattered by aerosols and gases in a sampled air volume.

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VISIBILITY RISK

Criteria to consider:

- Value of "clear" skies (including night skies) or historic views to your park/network
  - Visitor experience
  - Economic value
  - Management concern
- Magnitude of potential changes in emission sources (e.g., agricultural/silvicultural burning, increased truck traffic on interstates)

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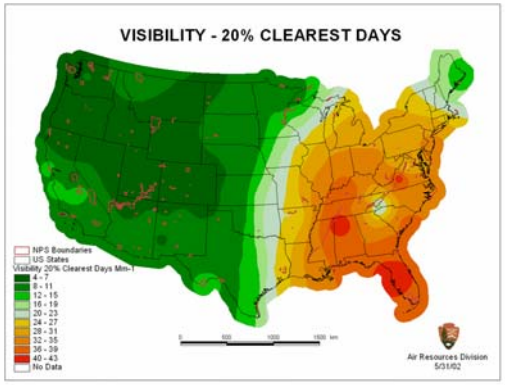

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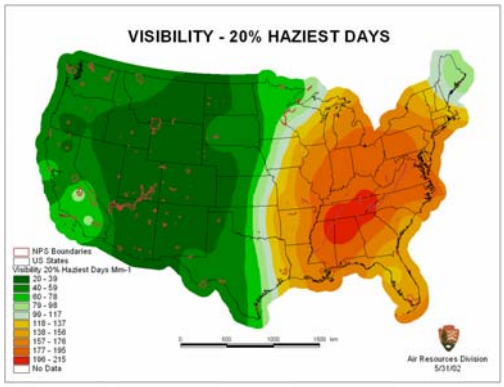

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OTHER MONITORING

- **Mercury**
  - Expensive – only 8 MDN sites nationwideOften measured "indirectly" – e.g., mercury in fish
  - Transported long distances, deposited and redeposited – especially at higher elevations
- **Toxics** (e.g., PCBs, DDT, Dioxin, Brominated Fire Retardants)
  - Same issues as mercury
- **Lichen** as Air Pollution Indicators
  - Sensitive to relatively low levels of sulfur, nitrogen, fluorine, and some metals
  - Concentrate some pollutants
  - Data may be difficult to interpret
  - http://www2.nature.nps.gov/air//pubs/Lichen_Studies.pdf
- Satellite Imagery

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AIR QUALITY ISSUES - GENERAL

- Global climate change
  - Water quality, quantity, and availability
  - Invasive species
  - Increased ozone
- Toxics – regional and global transport
  - Mercury
  - Banned chemicals
    - PCBs, DDT
  - Currently used chemicals
    - Pesticides
    - Flame retardants

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AIR QUALITY ISSUES – UCBN

- **Ammonia emissions from agriculture** are forecast to increase significantly
  - Acid deposition
  - Visibility
  - Fertilization (enhances competitiveness of invasive species)
  - Water quality (nitrates persist in ground water and streams)
- **New coal fired power plants** proposed in northern Nevada
  - Acid deposition
  - Visibility (NV does not participate in the WRAP)
  - Ozone
- LARO – metals in water/sediments
- CRMO, CIRO – radionuclides?
- CIRO – ozone, nitrogen deposition?

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OTHER MONITORING ISSUES

- Accessibility
  - Remote
  - Wilderness designation
- Power – it's a wilderness
- Trees – they grow
- Animals
  - Bears and anemometers
  - Beavers and stream flow gauges
- Weather
  - Snow
  - Rain
  - Wind

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WHICH CAME FIRST?

What is the 'vital sign' - inputs to the ecosystem or changes in the ecosystem in response to inputs?

Measuring **Inputs**

- **Direct measurement may be better** where:
  - Instrumentation is more 'sensitive' to changes than is the ecosystem
  - Ecosystem changes are subtle (e.g., ozone at relatively low levels)
- Data are 'robust'
  - Quantitative
  - Can be easily compared to data from other sites
  - Readily understood by air quality community
- May not tell you what is happening in the ecosystem – especially where the ecosystem response is complex (e.g., knowing the amount of mercury methylated may be more important than the total amount of mercury deposited)

Measuring **Ecosystem Response**

- **Direct ecosystem monitoring may be better** where:
  - Instrumentation is expensive relative to ecosystem monitoring
  - A specific effect is of management concern (e.g., mercury in fish)
  - Monitoring is already occurring for other reasons (e.g., acidity of water as part of water quality monitoring, invasive species monitoring)
- Data may be difficult to interpret
  - Is the ecosystem effect the result of air pollution or some other stressor?
  - Data may not be accepted by those who have the ability to regulate the sources of air pollution
  - Data may be difficult to compare to monitoring at other sites
- Data can be very dramatic (e.g., change in mercury levels in fish in Everglades)

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Vegetative Indicators--Air Quality

- ***Visible foliar injury*** (vascular plants)
  - leaf spotting, reduced flowering
  - difficult for field staff to distinguish foliar injury from pollutants from frost, drought, insects
  - must be observed in the field at proper time
  - sensitive vegetation must be widely distributed

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Vegetative Indicators--Air Quality

- ***Lichens***
  - more sensitive--absorb water & air directly from atmosphere rather than through roots
  - long lived, no deciduous parts--accumulate pollutants
  - abundant and widely distributed
  - "shrubby" fruticose forms hanging from trees most sensitive. "leafy" foliose & "encrusting" crustose forms
- ***Mosses***
  - absorb pollutants directly from atmosphere & accumulate in tissue (particularly mercury pollution)

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AIR QUALITY RESOURCES

- NPS Air Atlas
  http://www2.nature.nps.gov/ard/gas/airatlas-du/viewer_index.htm
- NPS Air Quality Internet
  http://www2.nature.nps.gov/air/
- NPS Air Resources Division Intranet
  http://www2.nrintra.nps.gov/ard/
- Air Resources Division
- Pacific West Region
- Climate Change
  http://tao.atmos.washington.edu/PNWimpacts/

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