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Executive Summary

Accomplishments

- ☞ **Established nearly 600 long term lichen monitoring plots** to help determine whether air pollution coming from large urban areas is having adverse effects on ecosystem processes. **First glimpse:** looks like nitrogen fixing lichens on National Forests near large urban areas have disappeared, or are disappearing, and nitrogen 'loving' lichens are starting to appear.
- ☞ **Changed air quality monitoring** from a camera based system to 3 IMPROVE protocol monitoring stations. These monitoring sites are part of a large interagency effort to determine effects of air pollution on visibility in Class I wildernesses as well as helping to understand deposition of air pollution on National Forest ecosystems.
- ☞ **Helped reduce thousands of tons** per year of sulfur and nitrogen urban pollution from being dumped on National Forests, by working with state and federal air regulators during permitting of new industrial sources of air pollution.
- ☞ **Published** "Guidelines for Evaluating Air Pollution Impacts on Class I Wilderness Areas in the Pacific Northwest" (Peterson 1992). This publication has been used by State air regulators and dozens of industrial sources to test whether new sources of air pollution would have adverse impacts on National Forest ecosystems.
- ☞ **Published** "Visual Air Quality in the Pacific Northwest, An Analysis of Camera Data 1983-1992" (Boutcher 1994). This documents background visibility in most Class I Wildernesses in the region, and is used by new industrial sources to see how much, if any, degradation of visibility there will be from their proposed industry.
- ☞ **First of a kind:** Worked with fire management to develop a model that would demonstrate how increasing the use of fuel treatment, e.g. prescribed fire, could benefit air quality.
- ☞ **First of a kind:** Worked with Fire Management to demonstrate, via modeling, that wildfires commonly violate 24 hour health standards, whereas prescribed fires, even ramped up 16 times the 1990 baseline, would not violate 24 hour health standards.
- ☞ **Developed effective interagency relationships** with state and federal air regulators that deal with both urban area air pollution impacts on National Forests as well as impacts of smoke we create on urban areas.
- ☞ **Established monitoring of three lakes** to help determine whether high elevation sensitive lakes are becoming acidic from air pollution. **First glimpse:** data suggests that low ANC lakes may be headed toward acidity.
- ☞ **Established an interagency ozone monitoring network** on National Forests in western Washington.
- ☞ **Published "A Strategic Plan for Air Resource Management"** for the Pacific Northwest Region.

Air Program Current And Future Priorities

- ☞ Determine if lake acidification is occurring from air pollution coming from large urban areas--such as Puget Sound, Portland/Vancouver, Klamath basin areas.
- ☞ Determine whether tropospheric ozone impacts are adversely impacting National Forest and wilderness ecosystems.
- ☞ Continue inventory and analysis of lichens as sensitive receptors to air pollution.
- ☞ Determine air pollution impacts to visibility and ecosystems in the CRGNSA and high risk Class I Wildernesses.
- ☞ Work with wilderness managers to determine natural visibility conditions--how much smoke is "natural" in wilderness?
- ☞ Continue development of smoke management programs that address increased use of prescribed fire for ecosystem management.
- ☞ Continue information management activities and model development.

The Air Program Determines the Impacts of Air Pollution from:

*Urban areas on National Forests
National Forests on urban areas*

The Value of Clean Air

When asked why they visit parks and wilderness, one of the things people most frequently mention is how much they enjoy the clean, fresh air (figure 1). Such a simple pleasure is easy to take for granted. Next time you're in the forest or some other wild place, close your eyes, breath deep. The innocent pleasure that you're experiencing is an "air quality related value" (AQRV)! Run your eyes along the horizon, take in the distant ridges and peaks, notice the detail: colors, textures, patterns. This sweeping vista is another value of clean, clear air¹.



Figure 1 — Thousands of people trek through National Parks and Wildernesses to enjoy their many attributes such as clean water and air.

In fact, many things that people value are linked to clean water and fresh air. In some places, the color of large land forms that you see from

a distance comes from masses of lichens growing across rock surfaces. Lichens often cover plants, rocks, and soil. They grow along the trunks and branches, right up into the tips of trees in northwest forests (figure 2). They are important food for squirrels, deer, insects and other foragers, and provide soft, clean nesting material for birds and small mammals. They are an integral part of the water and nutrient cycles of forests. Because they can be very sensitive to air pollution, they serve as an early warning system for all the other plants that may be affected by polluted air. The flowers, trees, mosses, the dazzling diversity of wild plants, is greatest where the



Figure 2 — Oregon lung lichen, one of hundreds of lichens found in National Forests of the Pacific Northwest. Photo by: Sylvia and Stephen Sharnoff®

¹ AQRV are values with Legal significance defined in the 1977 Clean Air Act.

air is clean.

Today, airborne chemicals from industrial activities and urban areas drift across even the most wild landscapes. The lichen are among the first to react to the onslaught. And among the first to disappear.

Oddly enough, one of the most air pollution sensitive parts of wild places isn't the air at all. It's the water. Imagine a childhood without tadpoles. Sulfur and nitrogen deposition from air pollution causes acidification of lakes and streams. The acid erodes the surprisingly delicate and largely invisible web that ultimately produces tadpoles. Tadpoles (and frogs) aren't

only reasons why people value sparkling clean lakes and streams. There's trout. And just knowing that there are some places and things that people haven't changed.

But the National Forests can also be pollution emitters. A number of common land management and permitted activities produce air pollution significant enough to cause us to consider the impacts and look for mitigation. Our prescribed fire programs are perhaps the most common and obvious source of air pollution from forest lands but other activities such as road building, mining, ski area

development, sand and gravel processing, firewood sales, power development, off-road vehicle use, and many others must also be analyzed for air quality impacts.

So now you know the two primary goals of the Forest Service Air Resource Management Program: **we work to protect the public resources we manage from air pollution, and we consider and minimize possible public health and welfare effects when our management activities produce air pollution.** How do we accomplish these goals and more specifically, what's going on in Air here in



Summit Lake, Clearwater Wilderness, Mt. Baker-Snoqualmie National Forest.

Impacts of Air Pollution from Urban Areas on National Forests

The Wilderness Act and the Clean Air Act work in partnership to provide the Forest Service opportunities to protect our nations most pristine areas from air pollution caused change. The Wilderness Act states that wilderness is to be “protected and managed so as to preserve its natural conditions...”. The Clean Air Act gives Federal Land Managers the “affirmative responsibility to protect the air quality related values...within a class I area”. Class I areas are wildernesses greater than 5,000 acres that were in existence as of August 7, 1977 (figure 3). Because of these laws, the Air program places special emphasis on wilderness, and on Class I wilderness in particular, when working to protect ecosystems from air pollution.

Visibility Protection

Air pollution effects to visibility or scenic quality is a major concern of ours. Many people just accept that, especially in the summer, scenic views will appear hazy. Is haze just the natural way things are? Well not really. Some haze from wind blown dust or soil, pollen, fire, and marine particles is natural, although many argue that even wind blown dust is ultimately caused by human activity. Most of the deterioration you see when your favorite mountain peak fades from view is from air pollution. Light coming from the sun is both scattered and absorbed by very small particles or gases. Most of these particles are sulfur, nitrogen, carbon, organics, and soil.

Our affirmative role in visibility protection in Class I wildernesses is specifically outlined in the Clean Air Act—“Congress hereby declares as a national goal the prevention of any further and the remedying of any existing



Figure 3 — Impacts to ecosystem processes from the air pollution in the Pacific Northwest are occurring, but are very subtle, and require close monitoring to detect change. The best way to keep these national treasures clean and pure is early detection of change caused by urban growth and then implementation of prevention measures. The PSD program under the Clean Air Act affords this kind of prevention.

impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution”. Is visibility impaired in our Class I areas? And if so, what is the cause? These are questions we must answer if we are to protect and improve visibility.

Currently we operate three

sophisticated visibility monitoring sites in the region (figure 4 & 5). They are located at Snoqualmie Pass near Alpine Lakes Wilderness, in the Columbia River Gorge National Scenic Area (CRGNSA), and in the Mckenzie River drainage near the Three Sisters Wilderness.

The Snoqualmie site is a

partnership between the Mt. Baker-Snoqualmie and Wenatchee National Forests. The primary site operator is Gary Fudacz on the Cle Elum District. The Gorge site is managed by the CRGNSA office in Hood River by Laura Mayer and Lee Schisler. Mike Cobb on the Mckenzie District of the Willamette NF takes care of the site which overlooks the Three Sisters Wilderness from Carmen Ridge.

Our visibility sites use the Environmental Protection Agency's (EPA) IMPROVE-protocol which was designed specifically for monitoring visibility conditions in wilderness and National Parks. IMPROVE stands for **I**nteragency **M**onitoring of **P**rotected **V**isual **E**nvironments. There are close to 100 IMPROVE visibility monitoring sites across the country including five in the Pacific Northwest (figure 6). The visibility monitoring equipment includes four particulate monitors (figure 7) which sample the chemical spectrum with emphasis on tracers for identifying pollutant sources, and on nitrate, sulfate, carbon, soil, and organics-the primary compounds responsible for visibility impairment. The sites also have meteorological equipment and instruments that measure atmospheric optical properties (nephelometers) which relate closely to visual quality.

camera equipment which records the scene for comparison to the sampler data. The three Forest Service sites have been operating since the summer of 1993 and complement two others operated in the Northwest by other agencies.

Figure 6 shows the type of pollutants found to be causing visibility impairment during a recent sampling period. When these data are broken into shorter time periods and combined with

meteorological information, it is possible to make reasonable determinations of the likely sources responsible for haze (work that is yet to be completed for data from these samplers).

Prior to 1993, the region operated a network of camera sites dating back to 1983. These sites were used to estimate the visual quality across the region. In 1995 we published a report of both numeric and visual data that

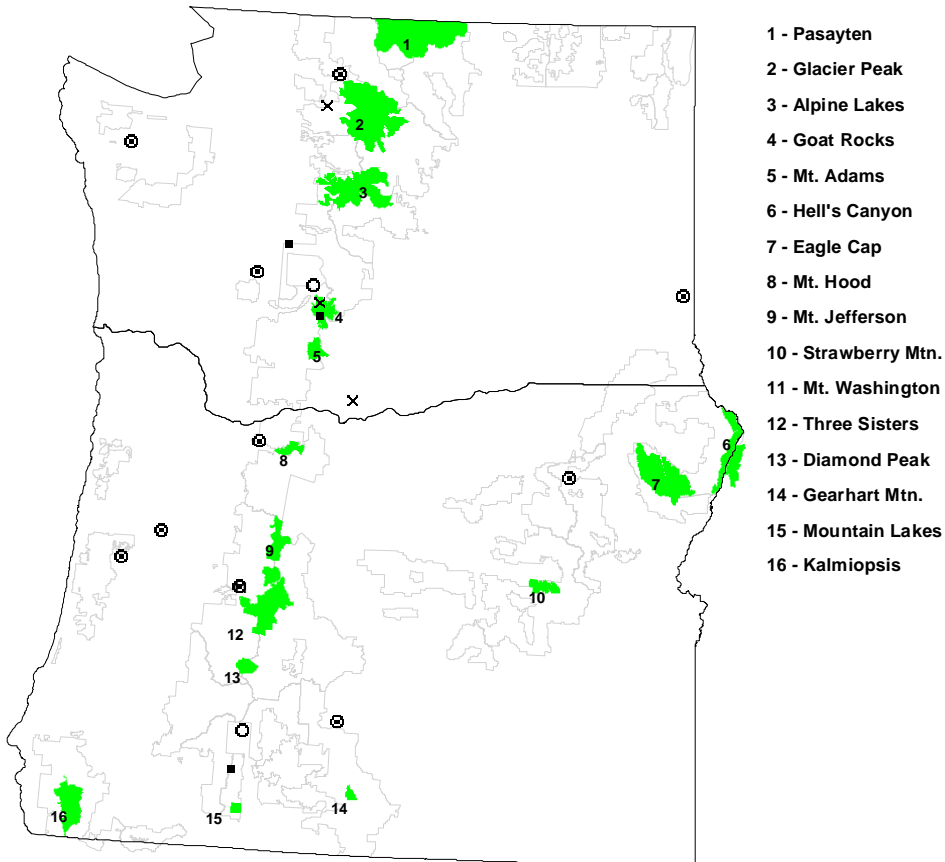


Figure 7 — One of the IMPROVE air quality monitors.



Figure 4 — The IMPROVE air quality monitoring site in the CRGNSA.

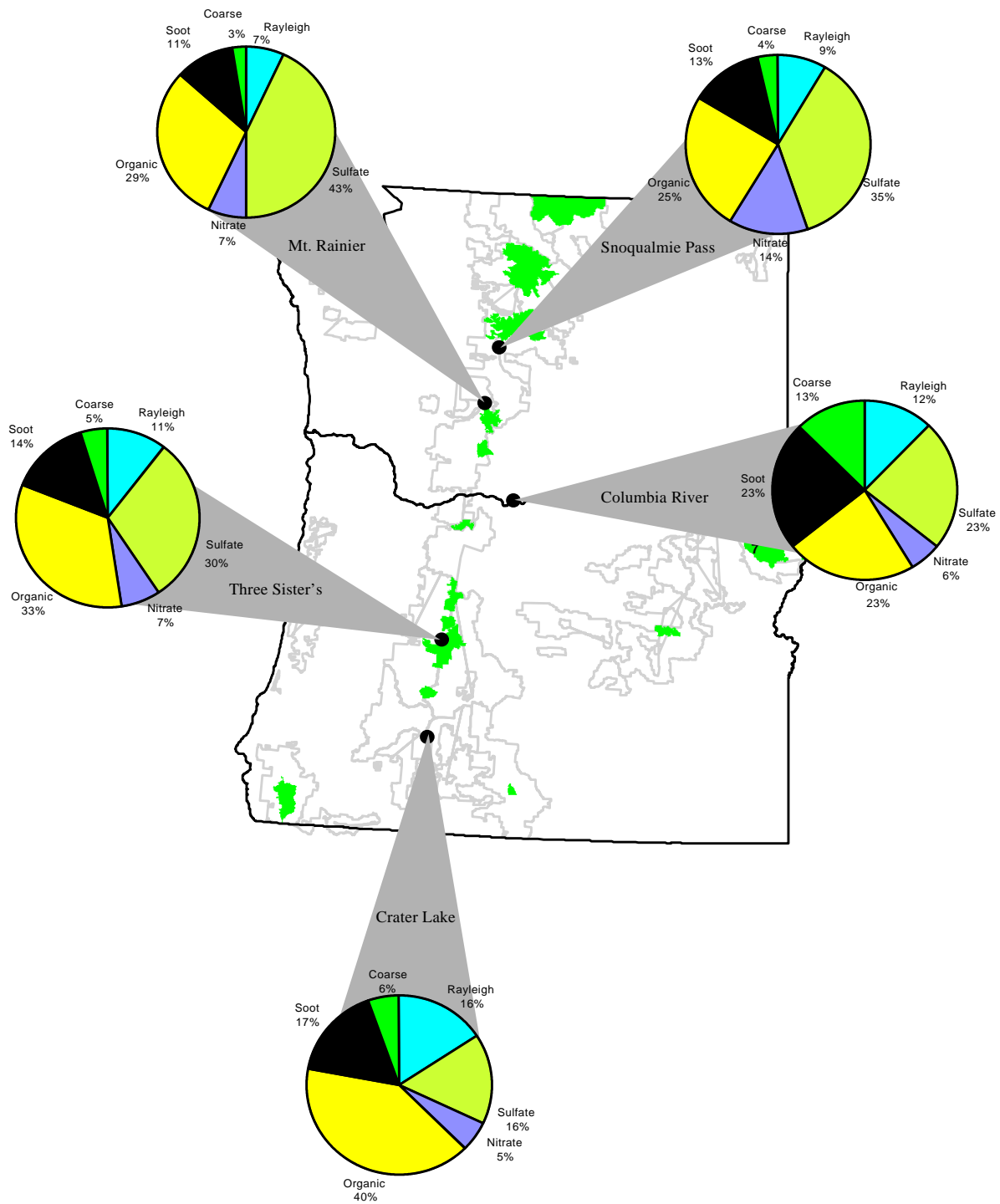
Class 1 Wildernesses In Region 6



Class 1 Wildernesses = Those Wildernesses that are 5,000 acres and larger, and were in existence in 1977.

- ⊗ NADP Monitoring Sites
- ⊙ National Park IMPROVE Sites
- × OZONE Monitoring Sites
- Water Quality Monitoring Sites
- State Boundaries
- Class 1 Wildernesses
- National Forests

Figure 5 — The Pacific Northwest region has 16 Class I wildernesses as defined by the Clean Air Act. A Wilderness is defined as Class I, if it was in existence in 1977 and is 5,000 acres or larger.



Common Sources of Pollutants:

Sulfate: Coal/Oil fired power plants, Refining and Smelting activities

Nitrate: Automobiles, Any combustion source

Organics: Biogenics (Natural Emissions), Smoke, Industrial solvents

Soot: Diesel exhaust, Smoke

Figure 6 — Summary of IMPROVE data from March 1994 to February 1995 showing major sources of air pollution that cause visibility impairment in the Pacific Northwest Region.

Aquatic Resources

Sulfur and nitrogen compounds found in air pollution, wash over watersheds depositing on soil, water, and vegetation. This deposition can affect sensitive alpine lake systems, vegetation, and soils by causing them to become acidic or, in the case of nitrogen, by providing an unnatural fertilizing effect. We have little knowledge about deposition rates--it is a very difficult thing to measure and there is wide disagreement among scientists about how it should be modeled. The most effective approach we can take is to look for signs of current resource impacts.

A number of factors influence the sensitivity of lakes to acidification from sulfur and nitrogen air pollution, including, bedrock geology, soil and vegetation type, hydrologic characteristics, lake chemistry and biology, and precipitation volume.

Lakes in the western United States are among the most sensitive aquatic systems to acid deposition found anywhere in the world. Individual lakes in this region are the most dilute aquatic systems reported anywhere and are similar to distilled water. Some of these lakes

differ relatively little from the chemistry of current atmospheric deposition, meaning the quality of these resources is closely linked to air quality (figure 8). Acidifying compounds from the atmosphere can enter the lake through dry deposition or after being captured by rain or snow (figure 9).

Changes in lake pH due to air pollution can have a

Individual lakes in this region are the most dilute aquatic systems reported anywhere and are similar to distilled water.

variety of direct and indirect effects on aquatic communities and ecosystem processes. Decreased pH can have a direct toxic effect on organisms. Direct effects on one, or a

group of organisms, may then indirectly influence other organisms, primarily through food chain interactions. Changing pH may also influence the solubility of nutrients or toxic compounds and elements (such as

aluminum) which in turn may affect organisms either directly or indirectly. PH changes of less than 0.5 are capable of producing considerable change in the biotic communities of either lakes or streams.

Two intensive lake chemistry studies are currently underway in Region 6. Summit Lake in the Clearwater wilderness on the Mt. Baker-Snoqualmie National Forest was the most sensitive lake sampled in Region 6 during the 1985 Western Lakes Survey. The lake was re-sampled in 1993 and found to have lost even more buffering capacity and was showing signs of pH change. The most likely cause appeared to be sulfate inputs. A three year study was commenced to determine whether the chemistry of the lake and the excess sulfate is due to natural processes or if lake chemistry is being modified by air pollution. The Summit Lake study



Figure 8 — Water clarity, Acid neutralizing capacity, and pH are measured at Summit Lake, Clearwater Wilderness on the Mt. Baker-Snoqualmie National Forest.



Figure 9 — To better understand how much sulfur and nitrogen deposition is occurring, pits have been dug along a transect and samples taken for estimates of winter time air pollutant impacts on ecosystems in the Cascades.



Figure 11 — Lake sediment core from Summit Lake, Clearwater Wilderness.

includes periodic checks of lake and snow chemistry, sulfur isotope analysis to determine the sulfate source, an aquatic biota community analysis, detailed lake bathymetric mapping (figure 10), and analysis of lake

sediment cores (figure 11) as an indicator of historic atmospheric deposition and lake chemistry. Preliminary study results show why we are concerned; in 1985 the pH of Summit Lake measured 5.9 whereas the average of three samples taken in 1995 was 5.3.

in surrounding watersheds. The study may show a trend in whether the quality of these resources is improving or deteriorating. The study is not designed to be sensitive enough to detect a change in these parameters due to the expansion of the industrial facility but will contribute greatly to our general knowledge of aquatic resource risk.

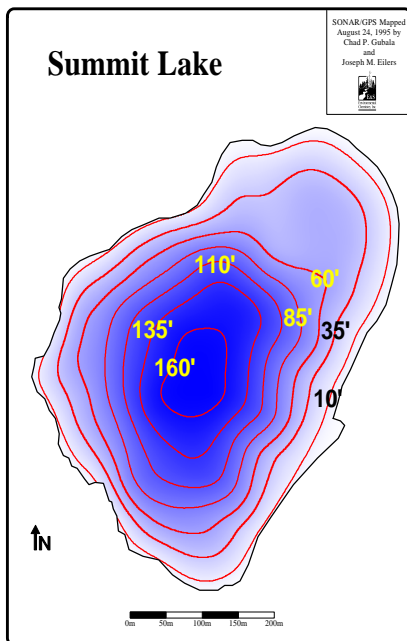


Figure 10 — Contours showing the depth of Summit Lake, Clearwater Wilderness. These data are being used to help determine the cause for the lake's loss of buffering capacity.

The second lake study covers two lakes in the Goat Rocks Wilderness on the Gifford Pinchot National Forest. The study is sponsored by Weyerhaeuser Paper Company as required by a state air permit to expand their industrial facilities in Longview, WA. Water chemistry of Gertrude Lake and Cedar Pond, and snow chemistry at six sites in the southern Washington Cascades will be monitored for two years prior to, and three years after the industrial expansion. This study will quantify the current condition of the two sensitive lakes and the quality of snow deposited

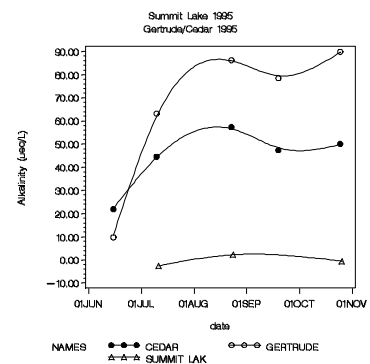


Figure 12 — These graphs show that the alkalinity of the three lakes is depressed during the Spring and recover during the summer, with the exception of Summit Lake. The summit lake study is trying to determine what causes the depression. Some believe it is caused by winter time air pollution deposition.

Terrestrial Resources

A primary threat to terrestrial ecosystems in the northwest is from ozone. Ozone, a toxic pollutant commonly known as smog, is formed on warm sunny days from emissions of hydrocarbons and nitrogen dioxide — both pollutants are very common in urban airsheds with cars and trucks the biggest problem. Ozone is generally a problem only in the summer in the warm plume of intermingling pollutants as they flow downwind of major urban centers. Toxic to both humans and vegetation, ozone damages the most sensitive vegetative species at much lower concentrations than is harmful to humans. Effects are subtle, but can ultimately be fatal—entire species can disappear from the landscape before we know it. Possible effects include visible leaf injury, reduced photosynthetic capacity, increased respiration, premature leaf death, and reduced plant growth.

Also of concern to us is the effect of acidic precipitation and cloudwater on vegetation and soils. Certain lichen species are also extremely sensitive to sulfate and nitrate pollution.

Ozone Monitoring

The air program currently measures ozone using sophisticated electronic monitors at three locations. Darrington for Glacier Peak Wilderness, Packwood Lake for Goat Rocks Wilderness, and Wishram in the Columbia River Gorge. These sites are operated through cooperative efforts of the Forest Service and the Washington Department of Ecology. In addition, we are participating in several studies involving laboratory ozone exposures of herbaceous plants and passive ozone sampling networks.

Recent studies have demonstrated that ozone profiles similar to those experienced during a Pacific Northwest summer could be damaging common herbaceous species.

Transects of passive ozone samplers are being used to measure average ozone values in wilderness where electronic sensors cannot be used (figure 13). These passive monitors use inexpensive coated filters which react chemically when exposed to ozone. Combining electronic and passive sampling with the laboratory exposure information sets the stage for

plots need to be established where the herbaceous species, screened as sensitive to ozone, are known to be present. The objective is then to look for foliar injury symptoms similar to those seen in the lab. If foliar injury in the field is similar to ozone injury from the lab, it is reasonable to conclude that ozone exposures are also similar.

Our knowledge of tropospheric ozone impacts to vegetation in the northwest took a leap forward recently with the publication of a paper by the Forest Service air quality lab in Macon, Georgia. This study exposed plants germinated from seed

Unlike stratospheric ozone, which protects us from ultraviolet rays from the sun, tropospheric ozone, created from nitrogen oxides, volatile organic compounds and sunlight, is unhealthy for humans as well as plant life.



Figure 13 — Passive ozone samplers were used on the GIP and MBS to determine average ozone concentrations impacting the west slope of the



Figure 14 — Seeds were collected from 8 western species of woody plants and germinated and exposed to ozone at levels that are similar to that found in the Pacific Northwest.

typical Western US ozone profiles (Figure 14). The “high” profile was similar to ozone found in the Sierra Nevada, “medium” was similar to that found in western Washington and Oregon, and “low” was similar to a rural profile that would occur east of the Cascades.

Species exposed were: ninebark, chokecherry, serviceberry, sagebrush, blackberry (2 species), elderberry, and huckleberry. Six of these species showed statistically significant and compelling adverse effects to leaf conductance, photosynthesis, and biomass gain due to ozone (figure 15). All species showed a variety of foliar damage for both the high and medium ozone profiles. The authors felt that results for three species (small

blackberry, ninebark, and chokecherry) were so compelling that they could be used as bioindicator species for field monitoring of ozone exposure.

All tested species are found in wildernesses in Region 6, and as such, fall under the Clean Air Act requirement to protect Air Quality Related Values. Our intent is to

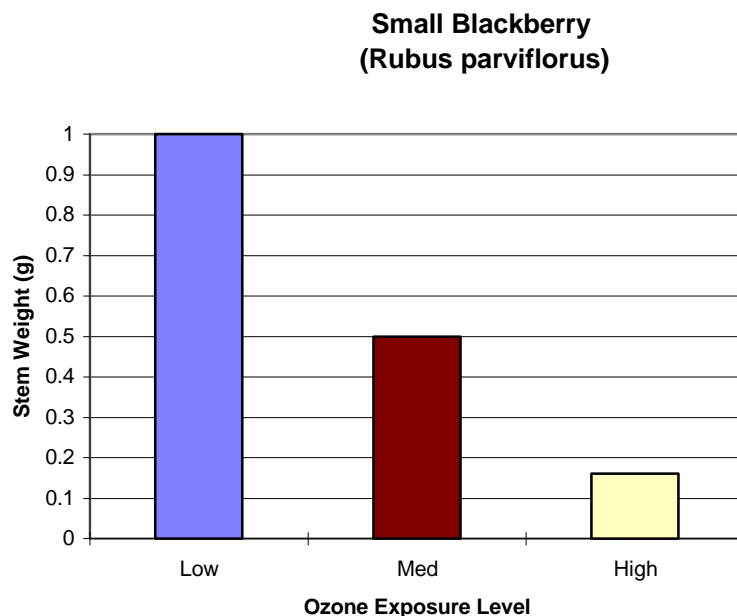


Figure 15 — Loss of stem weight in *Rubus parviflorus* by increasing ozone concentrations.

establish vegetation monitoring plots in the highest ozone exposure areas downwind of the Puget Sound and Portland urban areas.

We are currently sponsoring laboratory screening of additional herbaceous plant species believed to be sensitive to ozone. Plans are underway to conduct biomass/ozone studies to correlate ozone exposure with productivity of

Acidity of Cloudwater

Water in clouds and fog can become acidic through interaction with atmospheric pollutants. This moisture then comes in contact with vegetative surfaces where it may be taken up directly by the plant or first condense and drip to the ground where it is later taken up by roots. Acidic cloudwater can inhibit growth of sensitive species. Cloudwater monitoring took place during the summer of 1991 at Stampede Pass and at Granite Peak in Alpine Lakes wilderness, and during the summer of 1994 at Green Mountain in Glacier Peak wilderness. The minimum pH of cloudwater collected in 1991 for both sites was 3.6. This is far more acidic than necessary to inhibit growth in certain species. Unfortunately, the only information we currently have about impacts to local species is for conifer seedlings exposed to acidic fog under controlled conditions. More information is needed about

the effects of acidic cloudwater, and injury thresholds to local species before we can determine if there is cause for concern.

Using Lichens And Mosses to Monitor Air Pollution

Lichens (E.g., figure 16) are sensitive to many common pollutants in the Pacific Northwest: sulfur dioxide, oxidants such as ozone, acid rain, fluorine and some metals and are thus good summarizers of the effect of regional pollution mixes on vegetation. Because different lichens have differing sensitivities to air pollution, the ratio of sensitive:tolerant species present at a site can be an indicator of the quality of the air. Lichens and mosses cannot maintain constant internal moisture levels, as most plants do. Daily drying and wetting cycles concentrate pollutants dissolved in rain, fog or dry deposited as dust. This process makes lichens excellent accumulators of sulfur, nitrogen and metals, as well as more elusive but long-lived pollutants such as radioactivity and pesticides. By analyzing the concentration of these pollutants in lichen and moss samples, it is possible to map deposition patterns and "hot spots" of specific air pollutants.

The Mt Baker-Snoqualmie National Forest has been establishing lichen biomonitoring plots to assess

air quality influences on species distribution and chemistry since 1991. In 1993, the Siuslaw, Willamette, Deschutes, Mt. Hood, and Gifford Pinchot National Forests, and the Columbia River Gorge National Scenic Area (CRGNSA) joined together to establish a coordinated program of air quality biomonitoring using lichens and mosses. We hope to be joined by the BLM Roseburg District in 1997.

The lichen/moss biomonitoring program consists of Forest-wide lichen surveys and chemical analysis of eight commonly occurring lichens and mosses. Although many sensitive lichens are found widely distributed on the Forests, initial analyses are showing a curious absence of leafy, nitrogen-fixing (air pollution sensitive) lichens and an high frequency of nitrogen-loving (pollution tolerant) lichens in the Willamette Valley and western parts of the CRGNSA and Mt Hood NF. Analysis of lichen chemistry also shows higher lead levels in the Mt. Hood Wilderness than for the same lichens in other areas. Curiously, data from the CRGNSA visibility monitoring site also shows unusually high lead. No explanation exists yet for these high lead levels.

We are simultaneously determining air pollution sensitivities of the common lichens of the Pacific Northwest (Tables 1 & 2). To

Table — 1

Effects of Declining Air Quality On Lichens and Lichen Communities in the Pacific Northwest		
Air Quality	Effect on lichens and lichen communities	Indicator species
Good	The most sensitive lichens are present and healthy. Overall diversity and biomass of lichens is high.	Healthy presence of large, epiphytic leafy nitrogen-fixing lichens (e.g. Lobaria, Pseudocyphellaria, Sticta, Nephroma, Leptogium, Peltigera) and pendant forage lichens (Alectoria, Bryoria, pendant Ramalina/Usnea spp). See Figs. 2 and 16.
Decline beginning	Cyanolichens/pendant forage lichens overgrown by other lichens, algae or showing a high frequency of parasitism, slowed growth, thickened thalli, discoloration or hyperproduction of dispersal propagules, absence of young individuals.	Same as above, but abnormal incidence of unhealthy individuals.
Decline clearly visible	Cyanolichens/pendant forage lichens missing on conifers, other lichens still abundant. High diversity and biomass of remaining lichens.	Absence of sensitive lichens mentioned above. Continued healthy presence of the intermediate sized non-nitrogen fixing, leafy epiphytes: Hypogymnia, Platismatia, Cetraria, Parmelia, Evernia, shrubby Ramalina and Usnea species.
Poor	Cyanolichens missing on hardwoods, some of the remaining lichens showing pollution effects (reddening or bleaching of algal partner, hyper production of asexual dispersal propagules, parasitism by other fungi). Diversity/biomass intermediate to high.	Same as above but abnormal incidence of unhealthy individuals. Increasing occurrence of the small, leafy nutrient-loving lichens (Xanthoria, Physcia, Physconia, Chrysothrix, Candelaria) if pollution contains nitrogen compounds.)
Very poor	No cyanolichens/pendant forage lichens. Remaining lichens showing pollution effects, diversity/biomass intermediate.	Lichen community either sparse or dominated by pollution tolerant lichens mentioned above. Hypogymnia physodes, Parmelia sulcata, Evernia prunastri and a few dwarfed, shrubby Usnea spp. are the most tolerant mid-sized macrolichens
Extremely poor	All lichens showing strong pollution effects, i.e. high frequency of dwarfed, shrubby compact growth forms, discoloration, parasitism and hyper production of asexual dispersal propagules. Diversity and biomass low to non-existent.	Free-living green algae on tree trunks, overgrowing above lichens (when pollution is nutrient rich). High percentage of crustose lichens are either sterile or sorediate.

Table — 2

Effects of Declined Air Quality on Lichens and Lichen Communities in the Pacific Northwest	
Summary trends	<ul style="list-style-type: none"> ☞ Decreasing biomass and diversity of cyanolichens and pendent forage lichens first, followed by mid-sized leafy lichens, and finally small macrolichens. Decrease in biomass/diversity of crustose lichens, especially fertile individuals. ☞ Increasing biomass and diversity of nutrient loving lichens when pollution contains nitrogen compounds. ☞ Effects are visible in coniferous forests first. ☞ Lichens become dwarfed, shubby, compact, discolored, bleached, parasitized, hypersorediate or isidiate, and may be overgrown by other lichens or green algae. Growth slows and the number of new individuals decreases. ☞ Biodiversity is affected sooner than total biomass.

improve our understanding of the range of air pollution effects on lichens, urban lichen surveys were conducted in Bend, Eugene, Salem, Albany, Springfield, Corvallis and Portland for comparison to the National Forest surveys. These sites tend to be intermediate in air quality to the urban and National Forest study sites. An illustrated, comprehensive field guide to lichens will soon be released which will contain air pollution sensitivity ratings for Pacific Northwest lichens.

The lichen monitoring program and reports are designed to allow Forest managers to fulfill legal and ecosystem management responsibilities by:

- ☞ Identifying air quality trends on National Forests due to regional pollution
- ☞ Evaluating the intensity and geographical extent of specific pollutants on the National Forests
- ☞ Improving the quality of data provided to air regulators when reviewing new and existing permits for air pollution sources, and
- ☞ Allowing forest managers to identify forest health problems caused by on or off-forest air pollution sources.

Annual reports and current maps will be available each year in late Spring beginning



Figure 16 — Some species of lichen in PNW are sensitive to Air Pollution and are being considered for use as bio-indicators for Ozone impact.

in 1997.

The air program does not stand alone! Lichen surveys for air quality monitoring purposes are producing much needed habitat and distribution information about ecologically important, as well as rare, lichens. The lichen biomonitoring documentation system links with other mapping and vegetation databases so that

What Do We Do With Our Monitoring Results?

The Air program uses many avenues to protect wilderness ecosystems and scenic quality including, establishing strong ties with air regulatory agencies and the companies and industries

regulated, cultivating relationships with environmental stakeholders, and information sharing so affected parties understand

Applying The Guidelines

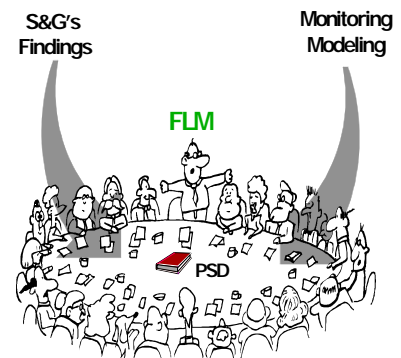


Figure 17 — We work with air regulators and owners of industrial plants that create air pollution, to find ways to reduce emissions and to determine what, if any, the current and future impacts of air pollution might be on National Forest ecosystems.

our goals. Strong ties are also forged with research to insure the best science is used when decisions are made through the regulatory process. The primary regulatory process that enables us to affect local air pollution decisions is called PSD or Prevention of Significant Deterioration. This Federal Clean Air Act program is intended to restrict or slow the growth of air pollution increases around sensitive areas, such as wilderness, while still allowing for economic growth. The PSD program is administered by the States but Federal Land Managers participate by advising whether the new pollution

source could cause an impact to resources we manage (figure 17). To receive a permit to operate, a pollution source must demonstrate a number of things including that they will neither cause nor contribute to adverse impacts to AQRV's in any Class I area. There are of course, economic costs associated with PSD decisions which sometimes create difficult decisions. As a result, diplomacy, persistence and timing are also key elements of the Forest Service role in the PSD process.

We must present highly defensible scientific data if

are to effect decisions on whether to permit, or not permit, air pollution sources. Conducting and sponsoring both monitoring and research are the best way we can collect the needed data. The courts have held that the data do not have to be absolute. In the case of visibility impairment, reasonable attribution to a source has been held sufficient to support a regulatory decision to require installation of appropriate emission control technology in efforts to reduce the impacts on Class I Wilderness.

Success Stories

One goal of PSD is to limit emission increases that could adversely effect Class I wilderness. A second goal is to learn more about the current condition and air pollution sensitivity of Air Quality Related Values and to mitigate any current effects. In this context PSD is an opportunity.

An accurate accounting of emission accomplishment is a bit difficult--it would be presumptuous for us to take credit for all emission reductions or limitations that have occurred. We are a participant in a process with many players each of which presents an issue or point of view that on any given application could influence the outcome in subtle ways. In a few cases our interaction

in the process can be directly tied to decreases or restricting increases. In one case 12,000 tons/year of a proposed nitrogen dioxide increase was disallowed because of potential adverse effects to wilderness lakes. In another, 15,000 tons/year of sulfur dioxide was reduced. In this latter case, other factors played a role as well--negotiations are ongoing between federal land management agencies, the facility owners and regulatory agencies to bring about further reductions.

Most often, we have been successful in negotiating permits that require monitoring. The list of accomplishments here is lengthy--much of the monitoring discussed

elsewhere in this report, visibility monitoring in the CRGNSA, lake and snow monitoring in Goat Rocks wilderness, and ozone work in Glacier Peak wilderness for example, are funded by private industry through PSD permit monitoring requirements. The National Park Service is also a cooperator in these activities and are managing monitors close to National Parks. In most of these cases we were co-participants in the negotiations which preceded these permit agreements.

Impacts of Air Pollution from National Forests on urban areas

The Air program frequently provides assistance in evaluating the effects of emissions from forest management activities. The most frequent situation involves smoke emissions from prescribed fire and wildfire, which involves model development, emission tracking, and working with air regulators during development and review of state & federal air quality rules. Other projects we have assisted with the Personal Use Firewood Program EA, Columbia River Basin and investigation of dust emissions from mine tailings piles on the Wenatchee NF. In addition, a significant portion of staff time is spent developing information with, and for, the regulatory community to insure communication and understanding of the need for, and use of, prescribed fire.

Prescribed Fire and Air Quality

Over the last two years, the Air program has worked with State and Federal air regulatory agencies to determine how the Forest Service could reach goals: 1) for improved ecosystem health via increased use of prescribed fire, 2) for visibility protection in Class I areas, 3) and for protection of human health from effects of smoke.

The issues were addressed, and the resolutions documented, in a Memorandum Of Understanding (MOU) between the USDA Forest Service, BLM, Oregon Department of Forestry, and Oregon Department of Environmental Quality. This MOU was the first time air regulatory agencies (ODEQ and EPA) formally recognized the benefit of increasing the use of prescribed fire in an effort to reduce the impact of emissions from wildfire.

In Theory, No Net Increase In Emissions Over Time

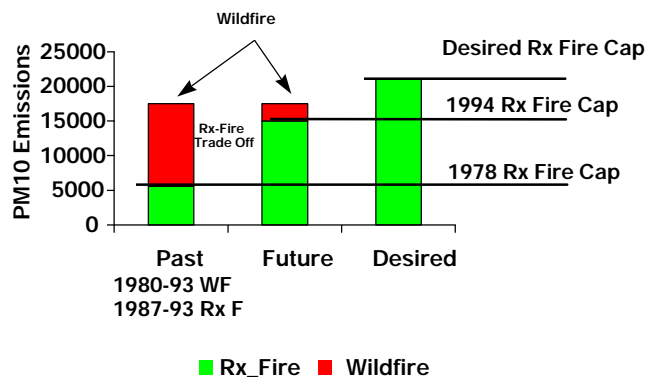


Figure 18 — Oregon Department of Environmental Quality modified the 1978 cap for prescribed fire emissions to include emissions from wildfire. The objective was to allow the Forest Service to increase the use of prescribed fire in hopes of reducing emissions from wildfires, and therefore have a **no-net-increase** in total emissions (smoke) coming from National Forests.

Negotiations with air and prescribed fire (see regulatory agencies resulted in the initiation of two studies:

- To model the tradeoffs of emissions between wildfire and prescribed fire (see Figure 18) (Schaaf 1996), and
- To model the difference in impacts on human health standards and visibility between wildfire

Even though this study indicates we can expect total emissions to increase in the foreseeable future, the impacts on the federal health standards from prescribed fire are negligible compared to wildfire impacts.

and prescribed fire (see Figures 19 & 20) (Earth Tech. 1996).

The first study looked at the 1.2 million acres in the Grande-Ronde River basin in NE Oregon. The results demonstrated that wildfire emissions

could be reduced by increasing the use of prescribed fire. However, total emissions (wildfire plus prescribed fire) would go up for the foreseeable future (50-80 years). The primary reason emissions go up is increased fuel loading caused by fire exclusion for the last 70 years, which is the result of our wildfire suppression efforts. Once the backlog of fuel buildup has been reduced to historic levels, the total emissions coming from the Grande-Ronde river basin comes back down to current levels.

This was documented in a study done in the Columbia River Basin (CRB) as part of the Interior CRB Ecosystem Management Project. Although this study clearly demonstrates that there would/could be widespread impacts to air quality from an increased use of prescribed fire in the CRB, these impacts would be at a low level, compared to wildfire.

Wildfires can be expected to continue to regularly violate health standards (figures 19 & 21), and significantly impact visibility in Class I Wildernesses.

Conversely, prescribed fire does not violate health standards off public land when executed properly (figure 20), although there can be impacts to visibility. Although violations of health standards from wildfire are infrequent in a particular area, they occur on a regular basis on a Statewide, or regional basis. Whereas impacts from prescribed fire emissions, if

Impacts of Emissions From Wildfires

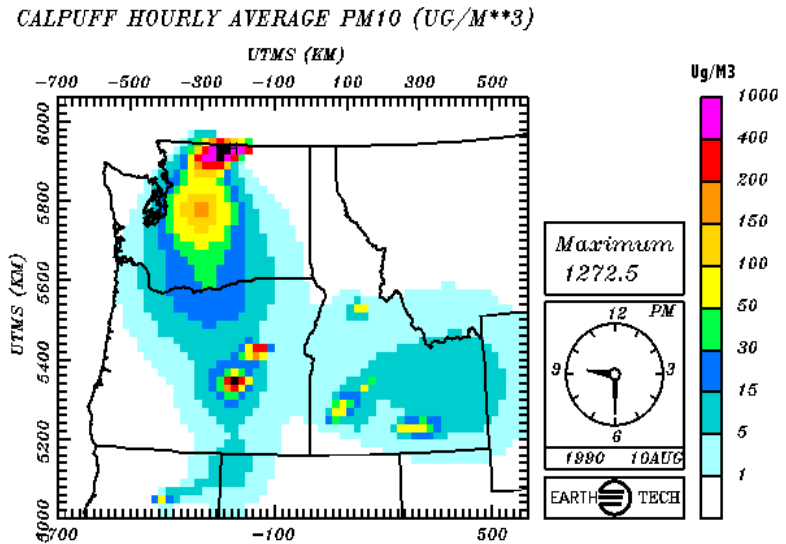


Figure 19 — A snapshot of modeling results showing the impacts of emissions from wildfires. The modeling was done for a 8 day period where 171,180 acres were burned. Meteorological data, the number of acres burned per day, and the location of wildfires modeled were based on the 8 day period Aug 6-13, 1990. The Federal health standard for smoke (PM10) is 150 Ug/M3. The modeling shows what we experienced, showing large areas where the federal health standard was breached.

Impacts of Emissions From Prescribed Fire

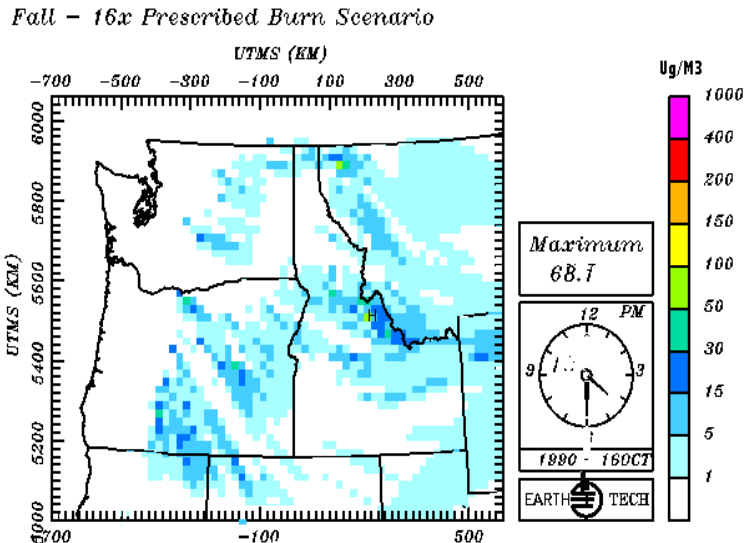


Figure 20 — This is a snapshot of the modeling done for prescribed fire. The modeling was done for a 6 day period where 222,128 acres were burned in 2,448 units (60% in Ponderosa Pine, 25% in Shrub, 15% in Mixed Conifer vegetation types). Meteorological data were obtained for the 6 day period Oct 14-19, 1990. The location of the 2,448 units were randomly selected based on a weighting scheme that recognized vegetation types and type of burns, such as underburns, Piles, and broadcast burning. The Federal health standard for smoke (PM10) is 150 Ug/M3. The modeling shows what we experienced, showing large areas of impact but the health standards are not breached.



Figure 21 — PM10 filter taken in Wenatchee, WA during impacts of emissions from a wildfire. Since the filter was clogged, the data was not included in the States emission database. The filter clogged @ 300+ Ug/m3.

managed properly, will not violate health standards.

To help Forest Managers determine likely impacts on air quality, we developed a model that can be used at the

local level to disclose downwind impacts on health standards and visibility. The model can be used in local NEPA analysis. It uses local meteorology, fuels, and terrain data to make

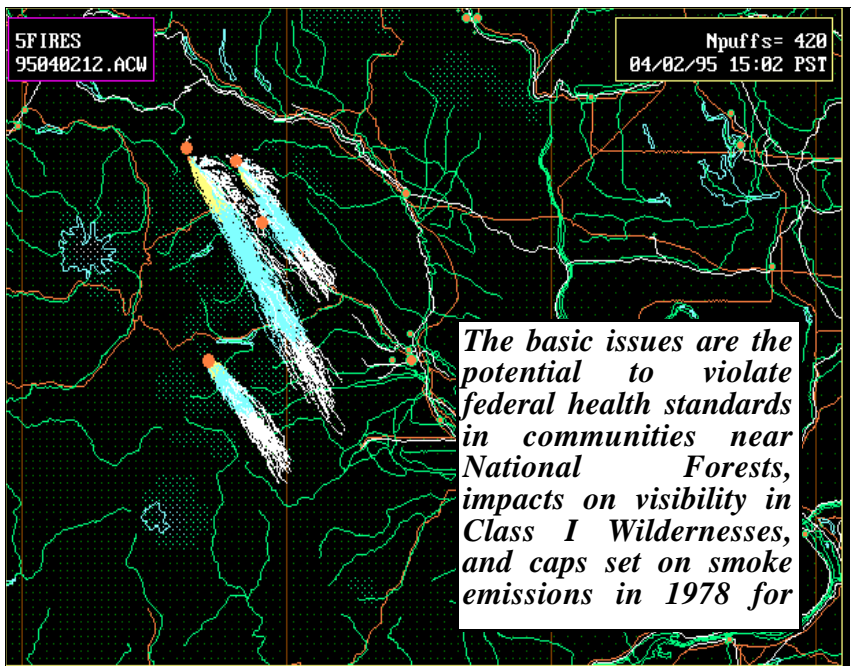


Figure 22 — One of the outputs from a new model being made available to Forest managers, that can be used to display potential down wind impacts from prescribed fire emissions. The name is NFSPUFF, which was jointly developed between Fire management and the Air resource program.

Holden Mine Site

A large, inactive mine site is located on the Wenatchee National Forest at Holden village, 12 miles up Railroad Creek from Lake Chelan. Mining operations beginning in 1938 and ending in 1957 processed about 10 million tons of ore extracting copper, zinc, gold, and silver. Three large tailing piles, encompassing approximately 80-90 acres remain at the site. Due to the proximity of the tailing piles to Railroad Creek and the village (population approximately 500 during the summer months) the EPA requested the site be studied for possible inclusion on the National Priorities List (Superfund). The possibility that blowing dust from the tailing piles could contain hazardous amounts of arsenic, lead, and/or other compounds needed to be investigated. During the summer of 1994, 7 high-volume air samplers and a meteorological site were operated for a period of 24-hours, twice a week for 2 months. The air samplers collected particulate matter which was then analyzed for 24 separate compounds. The results of the analysis are complete but EPA is currently prevented from making additions to the National Priorities List so a conclusion on whether the tailings are causing an air quality hazard has not been made.



The road to the future will continue to challenge us, but with a clear vision and hard work, we will be successful in protecting the public's National treasures from adverse impacts of air pollutants for our grandchildren .



“We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect.”

Aldo Leopold (1886–1948), U.S. forester. Quoted in: Stewart L. Udall, *The Quiet Crisis*, ch. 14 (1963).

