

Causes of Haze Assessment (CoHA) Project: Alaska Applications



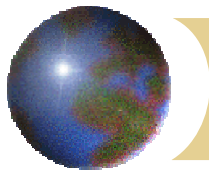
**Alaska Regional Haze Technical Analysis Meeting
Anchorage, AK – April 27, 2005**

Tom Moore, Technical Coordinator



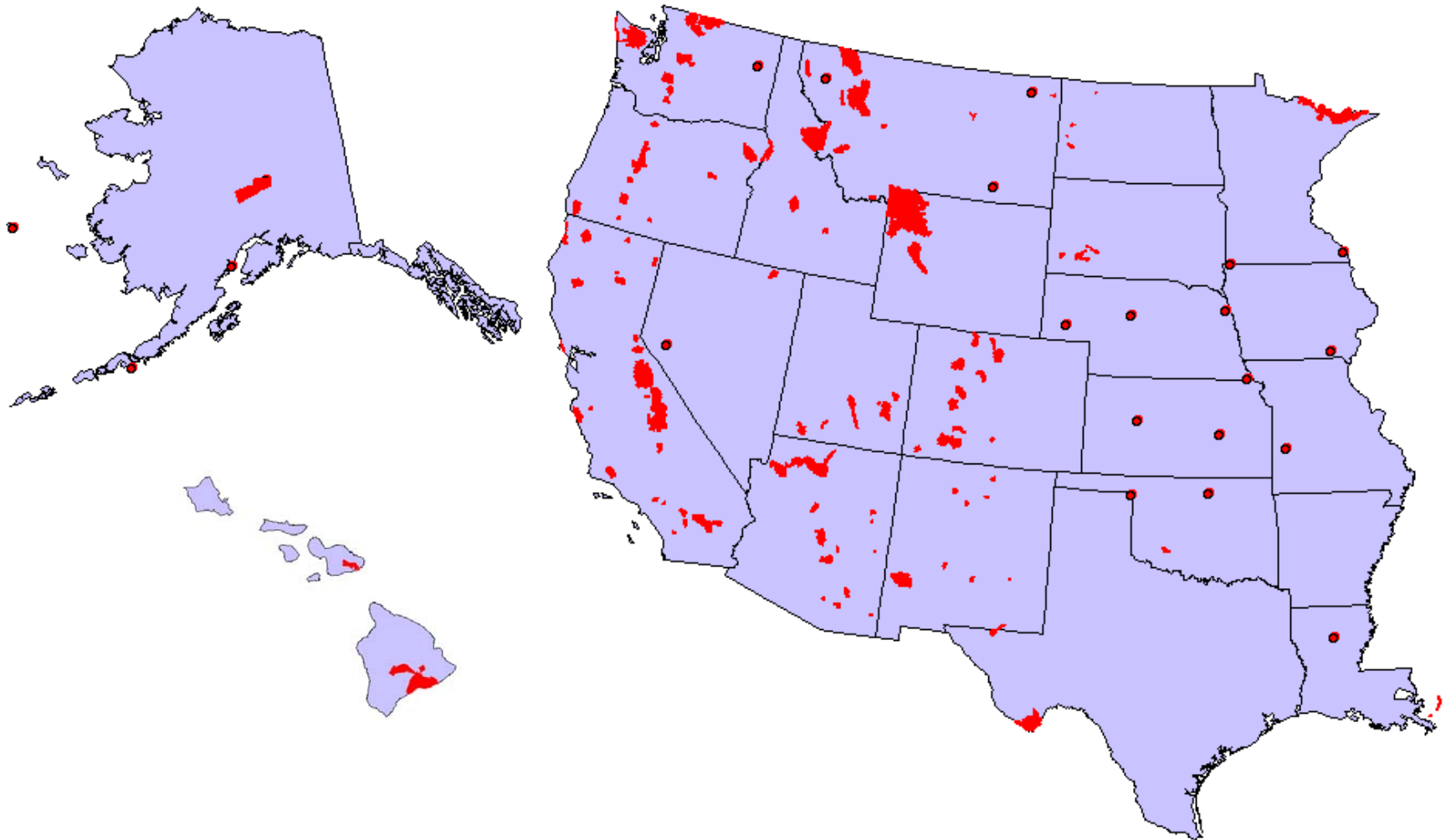
www.wrapair.org

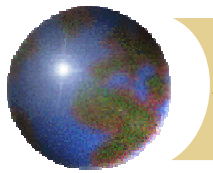
mooret@cira.colostate.edu



Causes of Haze Assessment Approach

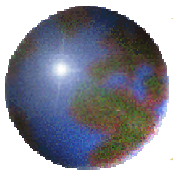
Determine monitored causes of haze at WRAP and CENRAP Class I areas, tribal and selected CENRAP IMPROVE protocol sites





Principal Inputs to CoHA Project

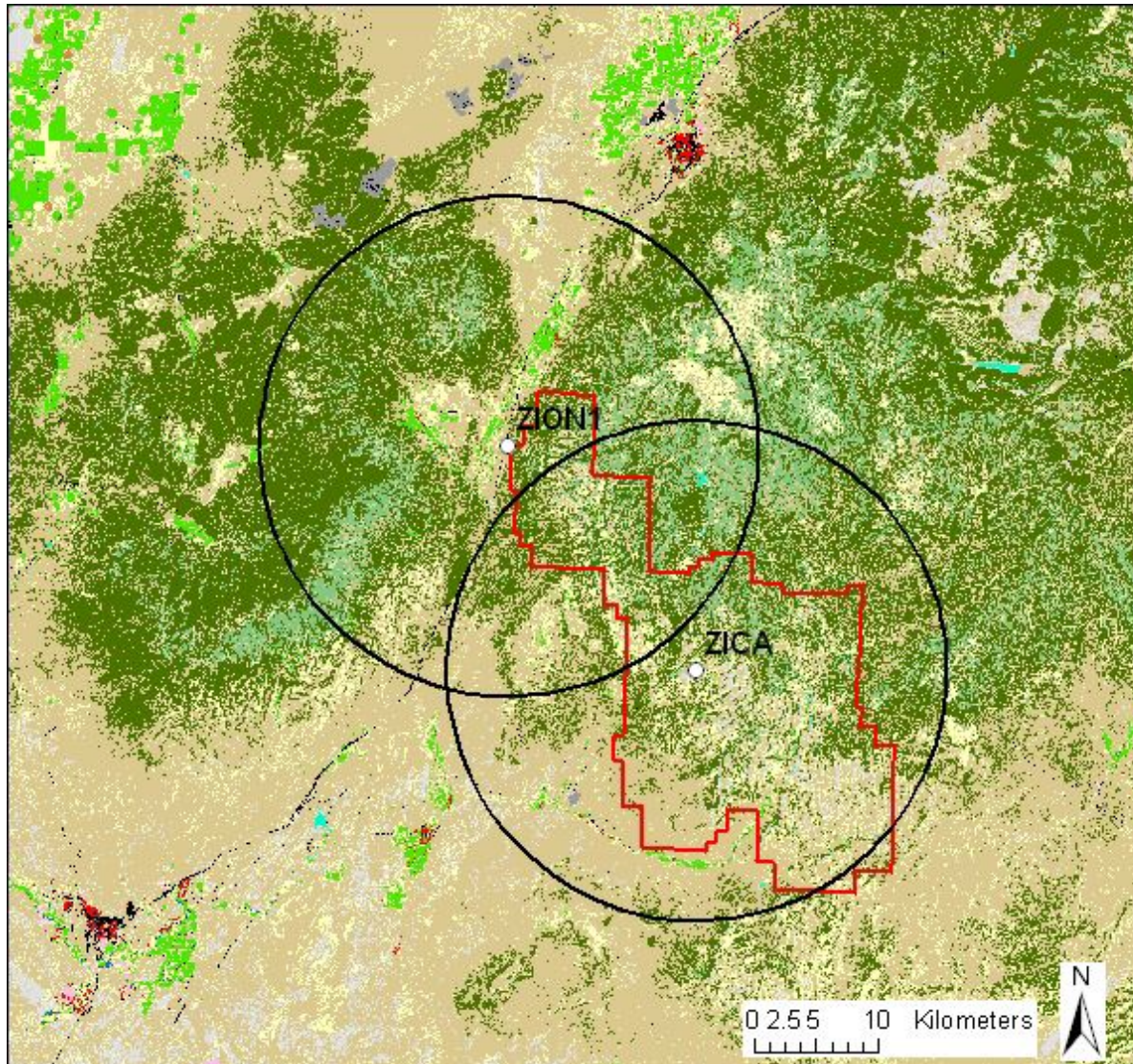
- **Interagency Monitoring of PROtected Visual Environments (IMPROVE) program monitors:
 - Regional haze at locations representing all 156 visibility-protected federal class I areas
 - Additional IMPROVE “protocol” sites
 - Meteorological data from Park Service, Forest Service, state agencies
 - IMPROVE provides these measurements (\$0 from WRAP leveraging over \$3.5 million/year)**
- **Assemble, distribute and prepare summary report on all appropriate measurements – VIEWS, originally a WRAP-only web data base with analysis tools provides this (\$50k from WRAP leverages \$200k from other RPOs)**
- **CoHA objective is to assess the causes of haze by analyzing ambient data**



CoHA Project - Overview of Past Years' Accomplishments

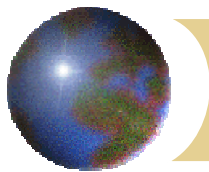
- **COHA web site summaries for every WRAP class I area**
 - Maps of NO_x, SO₂ & fire emissions within 20km of each site
 - Maps showing terrain, land-use, & other air quality/meteorological monitoring within 20km
 - Descriptions of the local climatological & meteorological factors that effect air quality
 - Descriptions of the aerosol species contributions to overall & worst/best visibility
 - Maps summarizing air flow patterns for all days, best & worst haze days, & extremes of particle components (more than 6000 maps based on over 26,000 back-trajectories/site)
- **Support of Attribution of Haze Workgroup, Phase I Report**
 - Trajectory Regression Analysis to identify source regions for light extinction and sulfate for all monitoring sites with a year or more of data

10 km radius land use/land cover maps

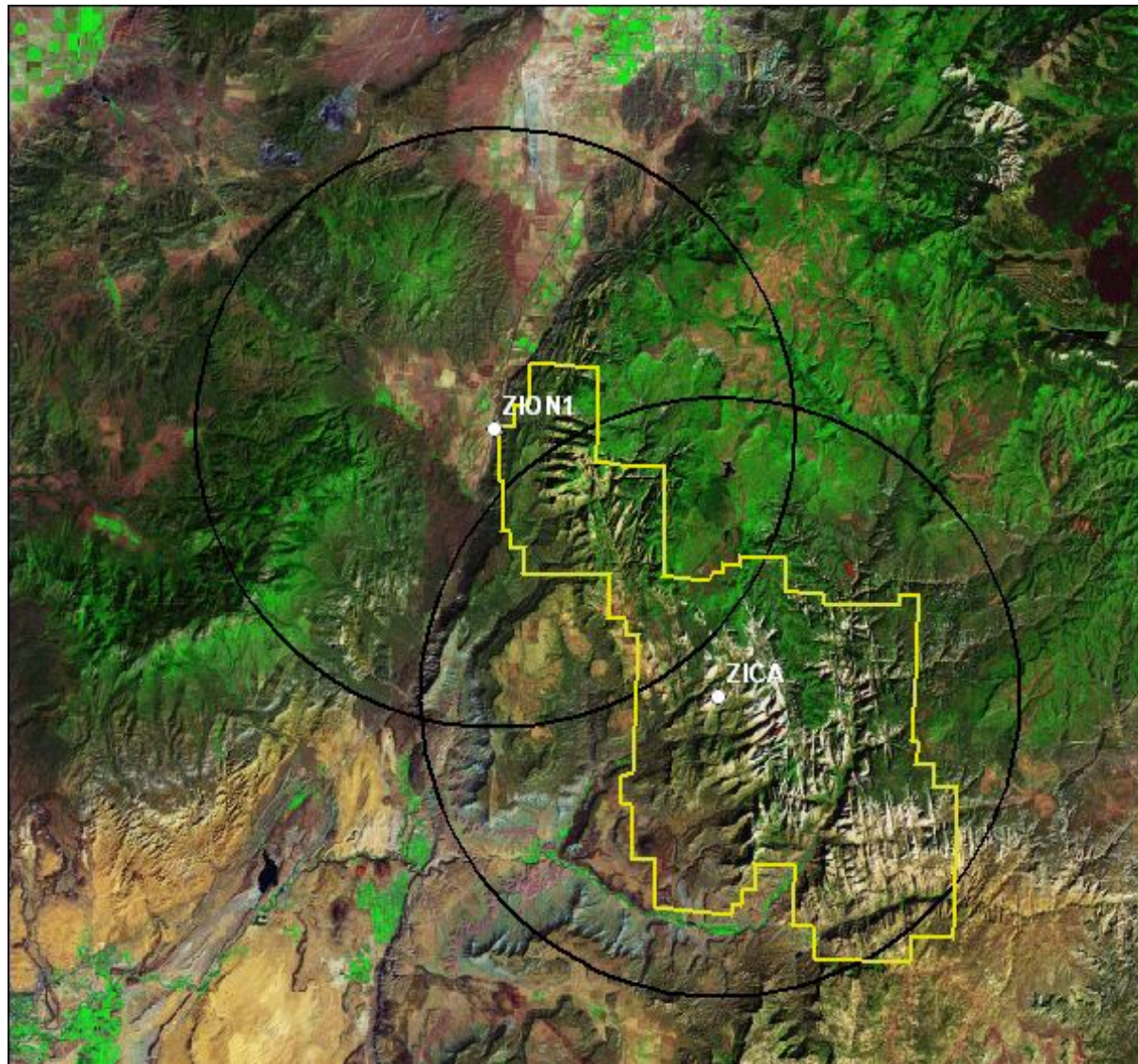


Legend

- IMPROVE sites
 - 20 km buffer around IMPROVE site
 - Class I boundary
- ### Land cover
- water
 - low intensity residential
 - high intensity residential
 - industrial
 - bare ground
 - mined areas
 - transitional
 - deciduous forest
 - evergreen forest
 - mixed forest
 - shrubland
 - grasslands
 - pasture, hay
 - row crops
 - small grains
 - fallow
 - urban, recreational grass
 - woody wetlands

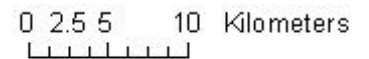


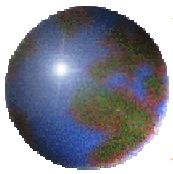
10 km radius terrain maps



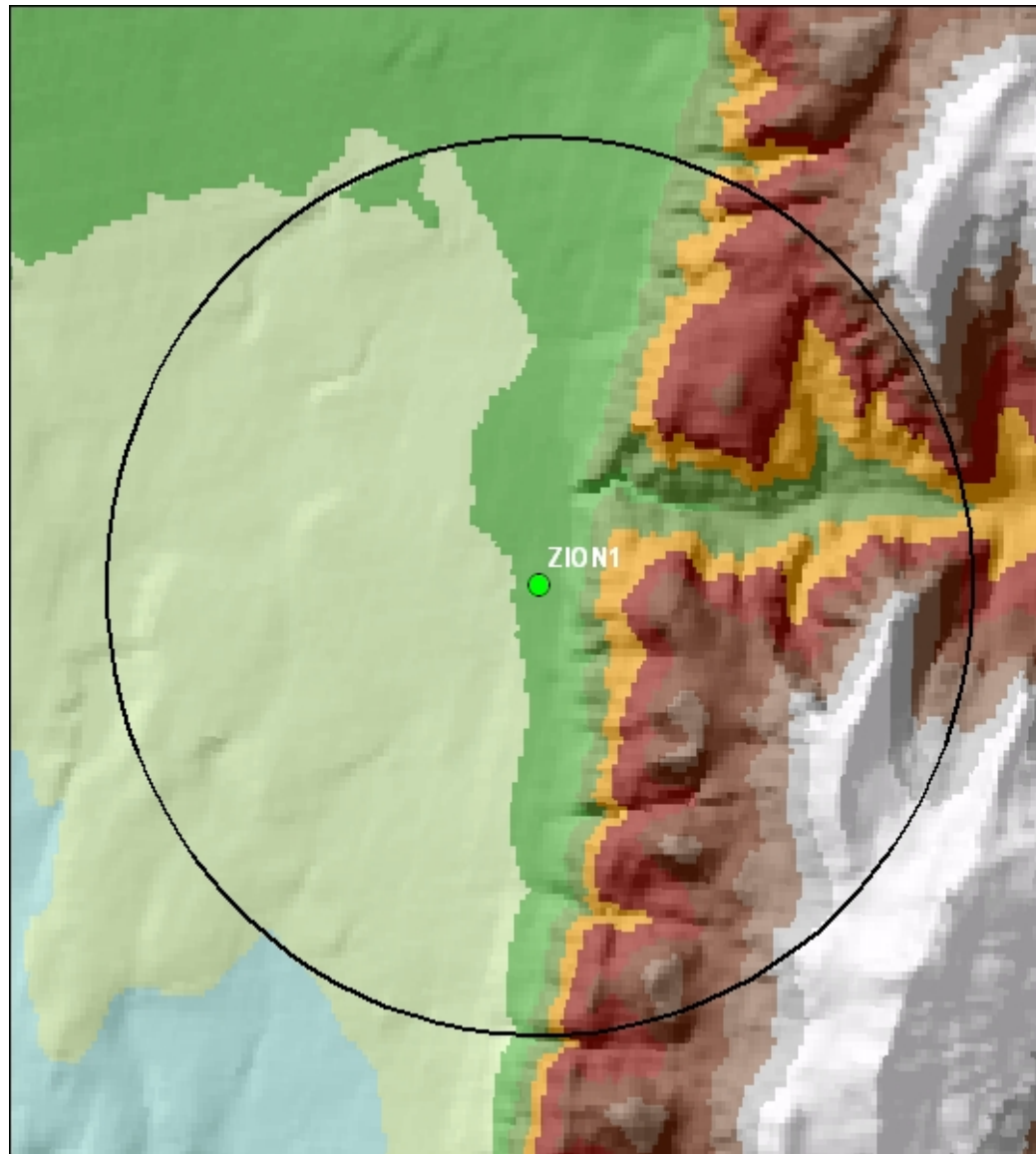
Legend

- IMPROVE site
- Class I boundary
- 20 km buffer around IMPROVE site





1 km radius terrain maps



Legend

- IMPROVE site
- 2km buffer around site

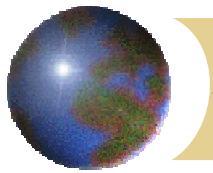
Elevation (m)

Value

- 586 - 1,500
- 1,500 - 1,550
- 1,550 - 1,600
- 1,600 - 1,650
- 1,650 - 1,700
- 1,700 - 1,750
- 1,750 - 1,800
- 1,800 - 1,850
- 1,850 - 1,900
- 1,900 - 1,950

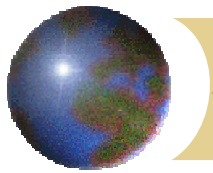


0 500 1,000 2,000 Meters



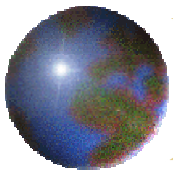
Causes of Haze Assessment – 2005 Plan

- ❖ **Task Overviews (planned completion date)**
 - ❖ **Complete trajectory regression analysis support of the Attribution of Haze Phase I report – (12/04)**
 - ❖ **Trends analysis of extinction & aerosol components – (6/05)**
 - ❖ **Assess meteorological representativeness of 2002 (modeling base year) compared to 2000 through 2004 (RH baseline period) – (8/05)**
 - ❖ **Continue case-study analysis of worst case days – (on-going)**
 - ❖ **Evaluate winds used in back-trajectory analysis – (9/05)**
 - ❖ **Communicate results via COHA web-site and WRAP (especially AoH) meeting participation – (on-going)**



Causes of Haze Assessment – 2005 Plan

- ❖ **Trends analysis (complete by 6/05)**
 - ❖ **Perform trends analysis of reconstructed extinction and major aerosol components for sites with 10 years of data, 1994 to 2003 (29 sites)**
 - ❖ **Identify the direction, magnitude, and level of statistical significance of all trends**
 - ❖ **Plot individual site trends and produce summary maps**
 - ❖ **Prepare descriptions of trends and explanations where possible and document in a new Trends section of the COHA web-site**



Trend Analysis for 20% Worst Days in WRAP

MEVE1

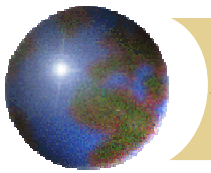
Site	S	Nitrate	OC	EC	Soil	CM	Bep
1994	0.40	0.17	1.01	0.15	1.12	7.64	23.21
1995	0.49	0.16	0.80	0.19	0.81	5.32	23.78
1996	0.38	0.22	1.31	0.27	2.39	4.55	24.11
1997	0.42	0.14	0.72	0.15	1.23	6.36	21.69
1998	0.48	0.15	1.15	0.22	1.15	4.07	24.90
1999	0.36	0.18	1.10	0.23	2.95	16.73	31.49
2000	0.33	0.24	2.24	0.37	1.73	5.98	31.61
2001	0.35	0.25	0.72	0.13	1.65	5.66	20.97
2002	0.26	0.43	1.67	0.22	3.93	15.27	34.66
2003	0.31	0.35	2.90	0.34	3.73	20.59	45.15
Slope	-0.017	0.020	0.130	0.015	0.194	0.954	1.566
S-Value	-29	27	15	13	25	13	25
P-Value	0.005	0.008	0.108	0.146	0.014	0.146	0.014

PEFO1

Site	S	Nitrate	OC	EC	Soil	CM	Bep
1994	0.41	0.20	0.98	0.33	1.14	6.55	23.79
1995	0.53	0.18	1.20	0.34	1.11	4.38	25.87
1996	0.49	0.23	1.09	0.28	1.17	6.77	25.06
1997	0.41	0.24	0.99	0.30	1.91	8.57	26.01
1998	0.58	0.20	1.58	0.34	0.89	4.67	29.10
1999	0.33	0.24	1.60	0.37	1.75	9.41	28.65
2000	0.36	0.32	1.45	0.29	1.52	8.33	27.70
2001	0.38	0.25	0.91	0.25	1.65	6.53	22.29
2002	0.40	0.44	4.95	0.61	2.79	15.84	55.78
2003	0.39	0.31	1.88	0.32	2.99	25.60	41.45
Slope	-0.007	0.017	0.100	0.002	0.181	1.161	1.075
S-Value	-13	29	19	1	25	23	21
P-Value	0.146	0.005	0.054	0.500	0.014	0.023	0.036

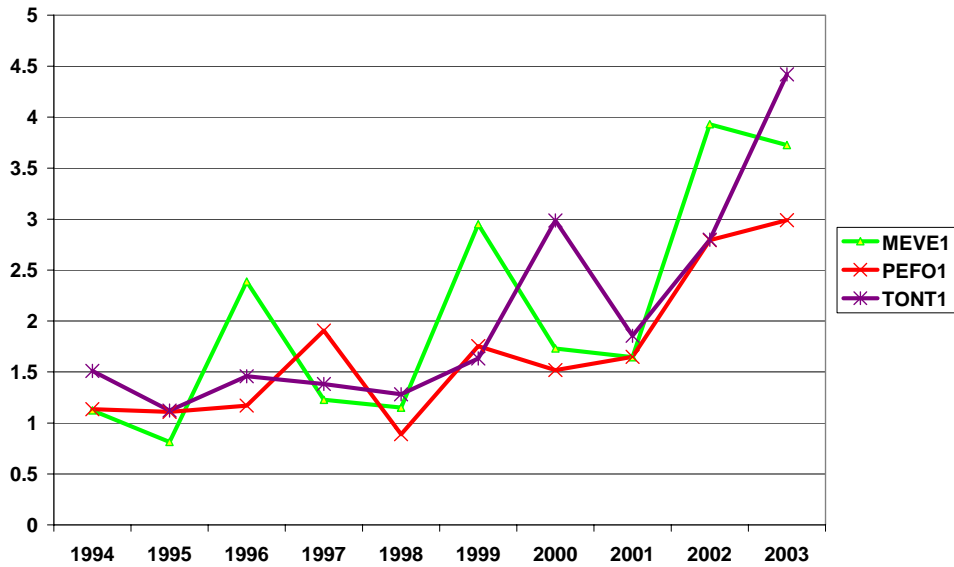
TONT1

Site	S	Nitrate	OC	EC	Soil	CM	Bep
1994	0.47	0.24	1.50	0.34	1.51	7.65	28.74
1995	0.55	0.16	1.85	0.45	1.12	10.10	34.55
1996	0.56	0.33	1.48	0.34	1.46	13.92	33.22
1997	0.59	0.30	1.27	0.26	1.38	10.79	30.59
1998	0.59	0.36	1.66	0.39	1.28	9.74	34.07
1999	0.35	0.44	2.36	0.46	1.63	12.74	37.17
2000	0.45	0.66	1.69	0.25	2.99	14.42	35.85
2001	0.41	0.45	1.52	0.32	1.86	12.85	32.32
2002	0.48	0.51	1.92	0.33	2.80	11.70	36.34
2003	0.41	0.66	2.01	0.31	4.42	18.44	40.93
Slope	-0.013	0.047	0.052	-0.004	0.223	0.661	0.798
S-Value	-13	35	17	-13	27	23	23
P-Value	0.146	0.000	0.078	0.146	0.008	0.023	0.023

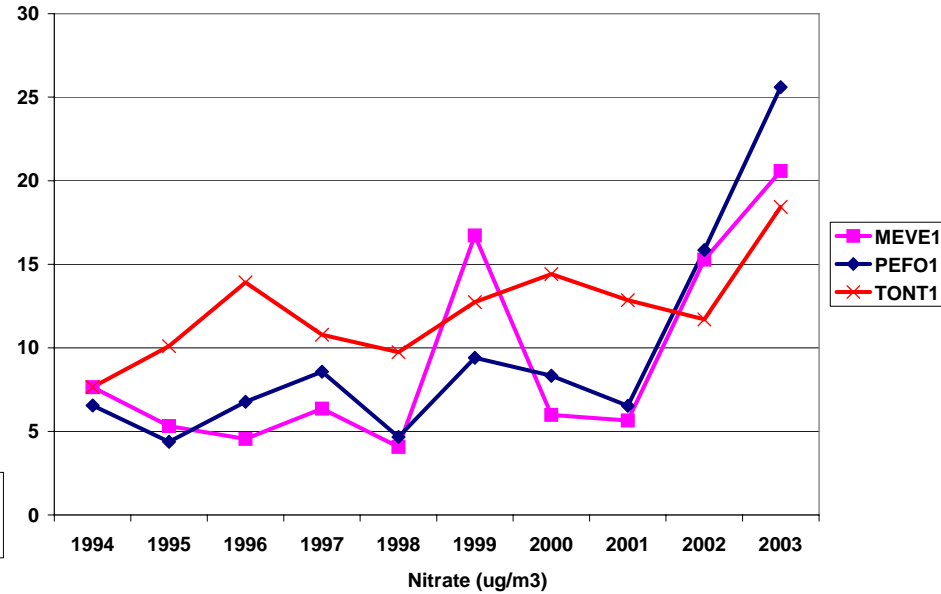


Time Series Analysis for 20% Worst Days in WRAP

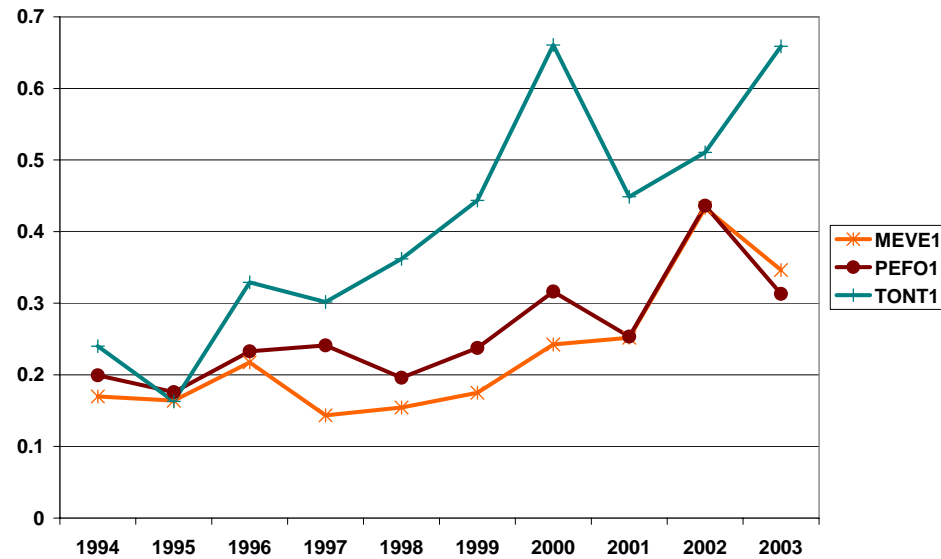
Soil (ug/m3)

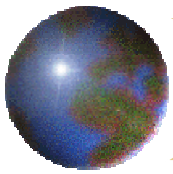


CM (ug/m3)



Nitrate (ug/m3)

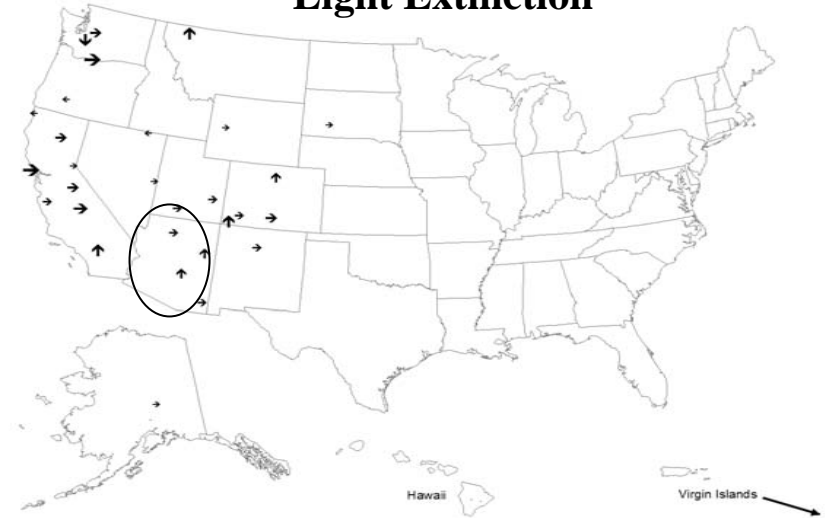




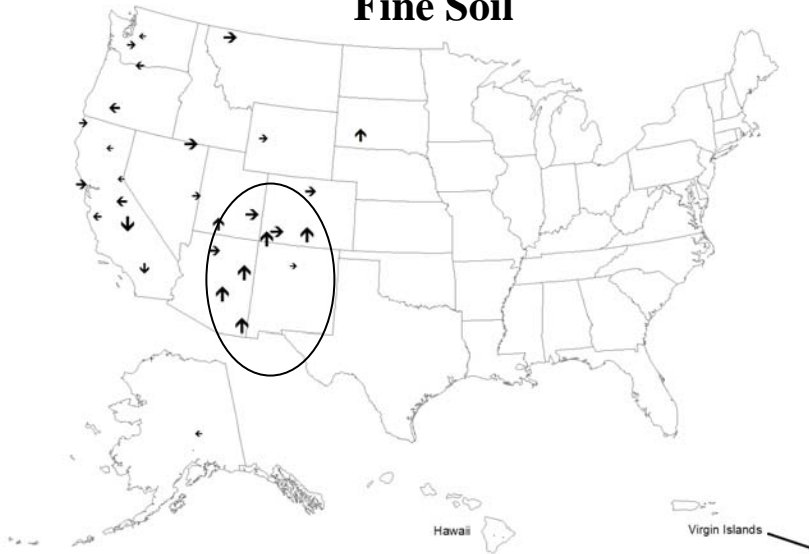
Trend Analysis for 20% Worst Days in WRAP Sites with More Than 10 Years of Data (1994-2003)

- ↑ Increase – statistically significant ($P < 0.05$)
- ↓ Decrease - statistically significant ($P < 0.05$)
- Increase - statistically insignificant
- ← Decrease - statistically insignificant
- * Size of the arrow is in proportion to the change rate (slope, unit/year)

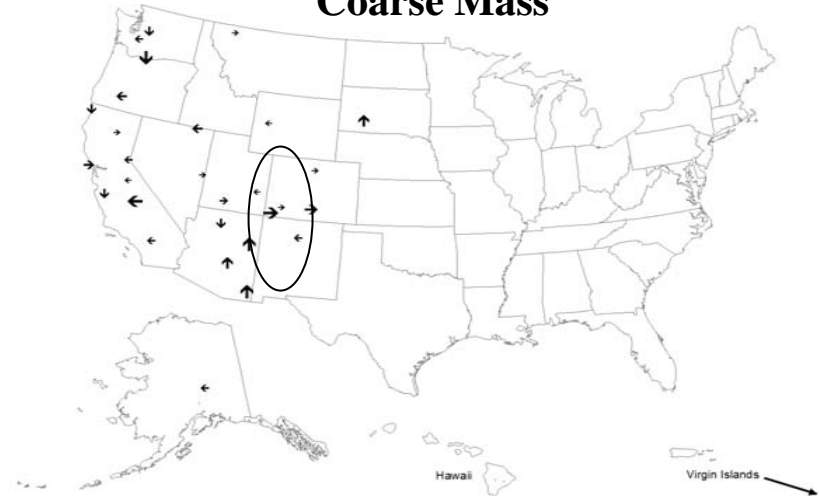
Light Extinction

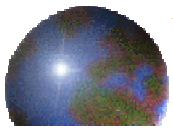


Fine Soil



Coarse Mass



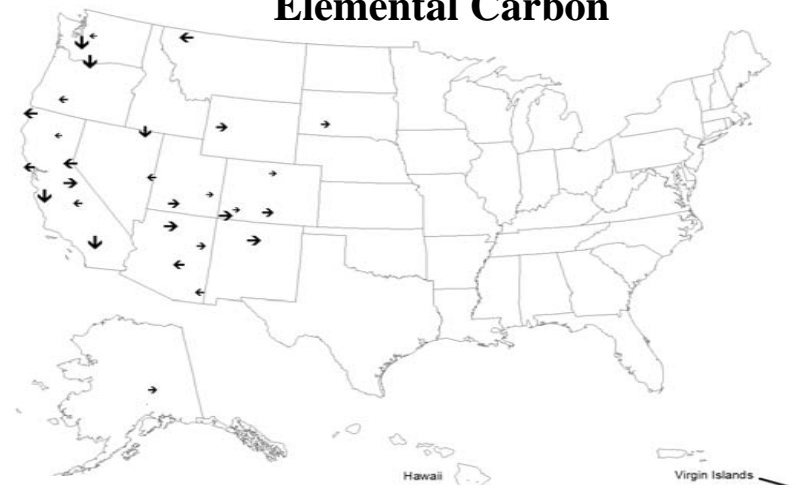


Trend Analysis for 20% Worst Days in WRAP Sites with More Than 10 Years of Data (1994-2003) - continued

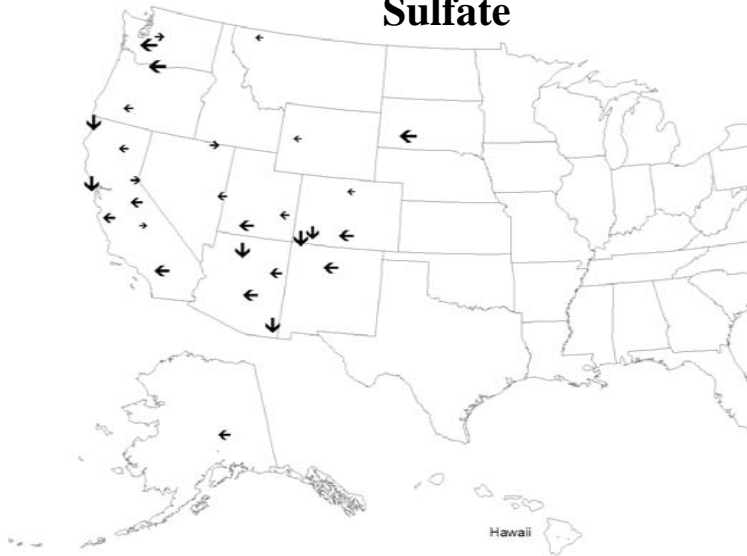
Organic Carbon



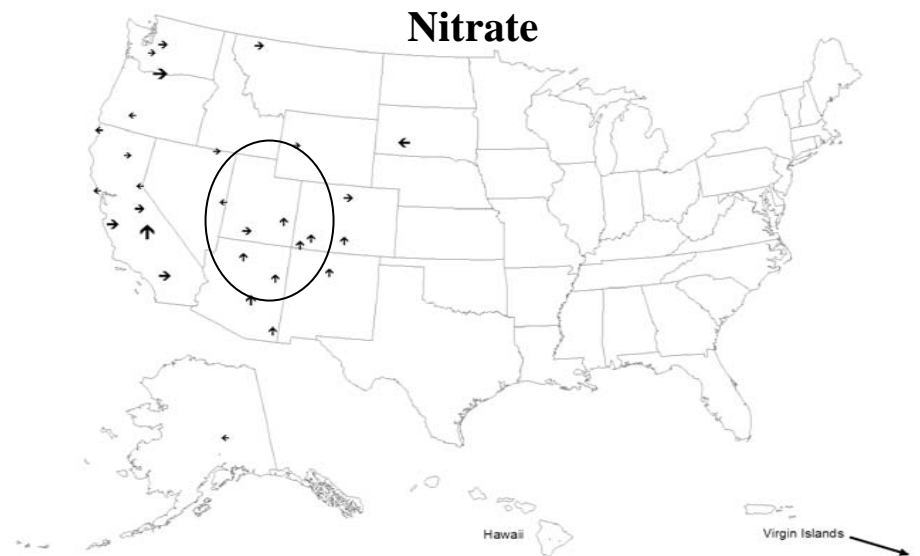
Elemental Carbon

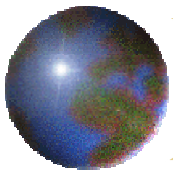


Sulfate



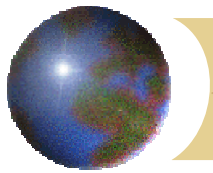
Nitrate





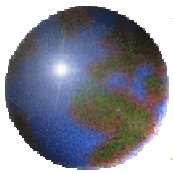
Meteorological & Emissions Descriptive Analysis

- ➊ **Archived monitoring network locations, climate, emissions, wildfires, census, political, physical, and image databases**
- ➋ **Information from these databases are helping us build conceptual models and answer descriptive analysis questions by visualizing data (e.g. map emissions densities)**
- ➌ **Assist us in the general and detailed description of the meteorological setting of each site**
- ➍ **Creating maps of emissions surrounding each site at two scales: 2 km and 20 km- Regional emission maps to be added**
- ➎ **Include table of surrounding point sources ranked by distance and emission rate**

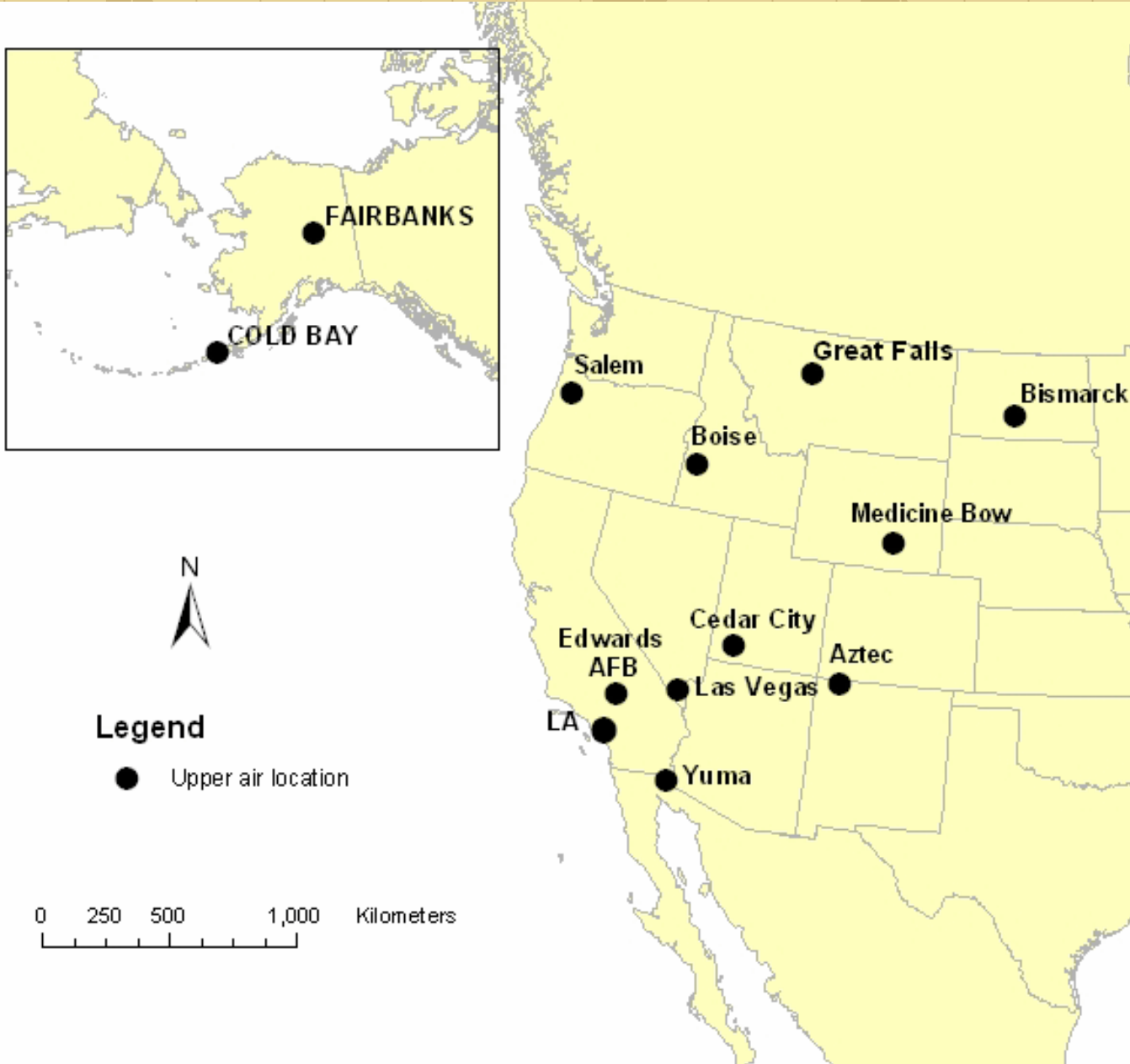


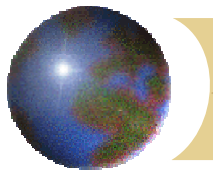
Causes of Haze Assessment – 2005 Plan

- **Meteorological representativeness (complete by 8/05)**
 - **Generate 8-day back-trajectories of all WRAP IMPROVE aerosol monitoring sites (every 3 hrs, from 3 starting heights) for 2003 and 2004 to give 5 years of trajectories**
 - **Produce residence time maps for 2002 and the 5-year period (2000 – 2004), plus maps of ratios and of differences of 2002 and the 5-year period for each site for the warm and for the cold periods of the year (warm defined as April through September)**
 - **Interpret the maps for each monitoring site and document on the CoHA web site**



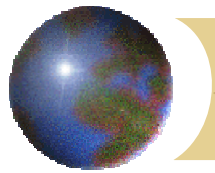
Candidate Upper Air Monitoring Sites for Checking Trajectory & MM5 Wind Fields





Causes of Haze Assessment – 2005 Plan

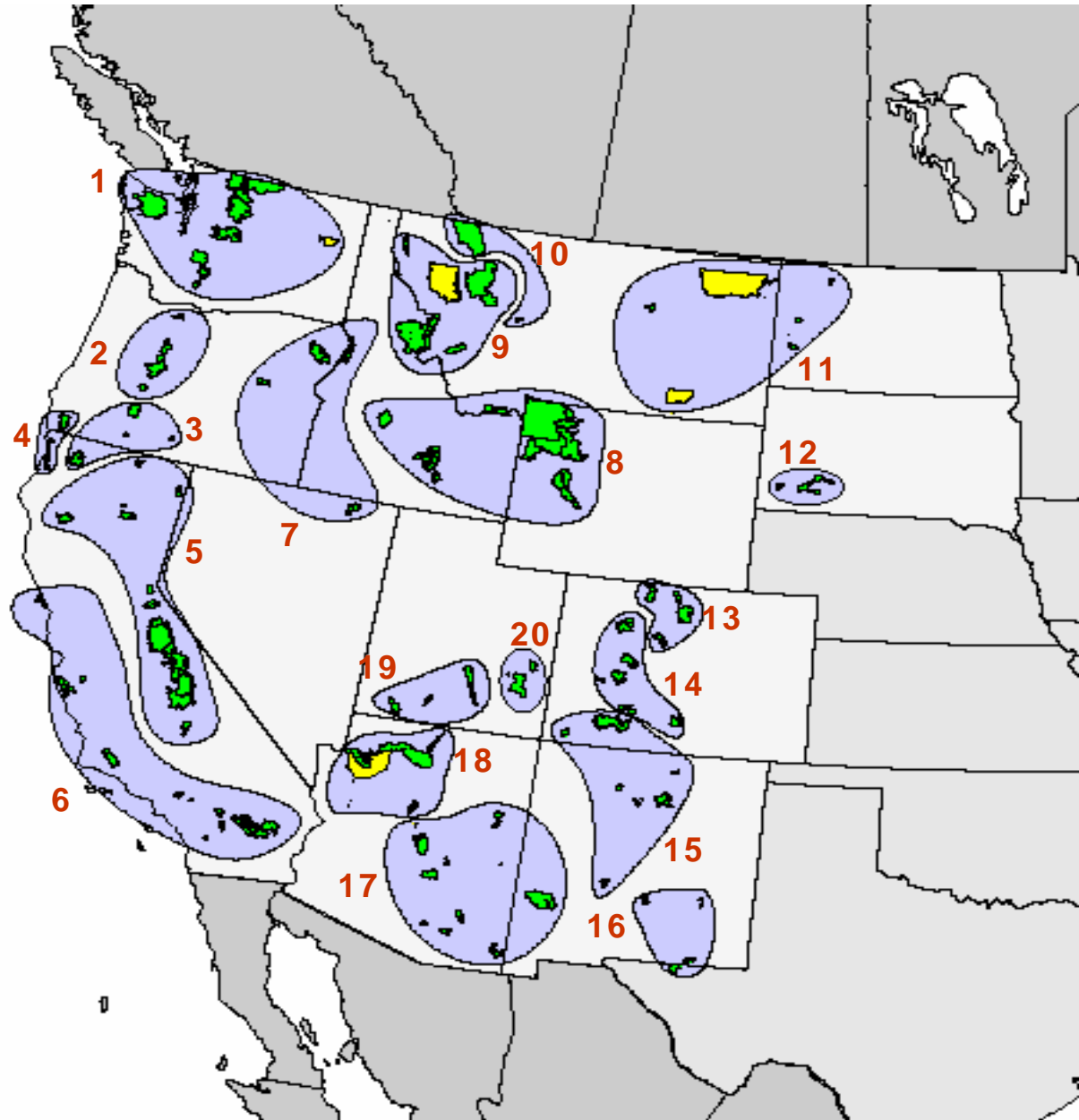
- ❖ **Continue case-study analysis of worst case days**
 - ❑ **Continue to do episode analysis (use of available data to understand extreme haze events)**
 - ❑ **Conduct PMF analysis on particle species data for groups of sites to statistically identify common factors (interpreted as effective source profiles)**
 - **Assess the contributions, frequency, seasonality, etc of PMF factors to worst haze days for all WRAP sites**
 - **Associate factors with transport pathways using trajectory analysis**
 - **Document in a new PMF section of the COHA website – (complete by 11/05)**

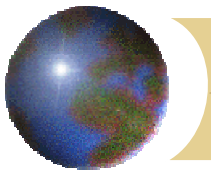


Site groupings from the TSSA attribution analysis in the Phase I AoH Report

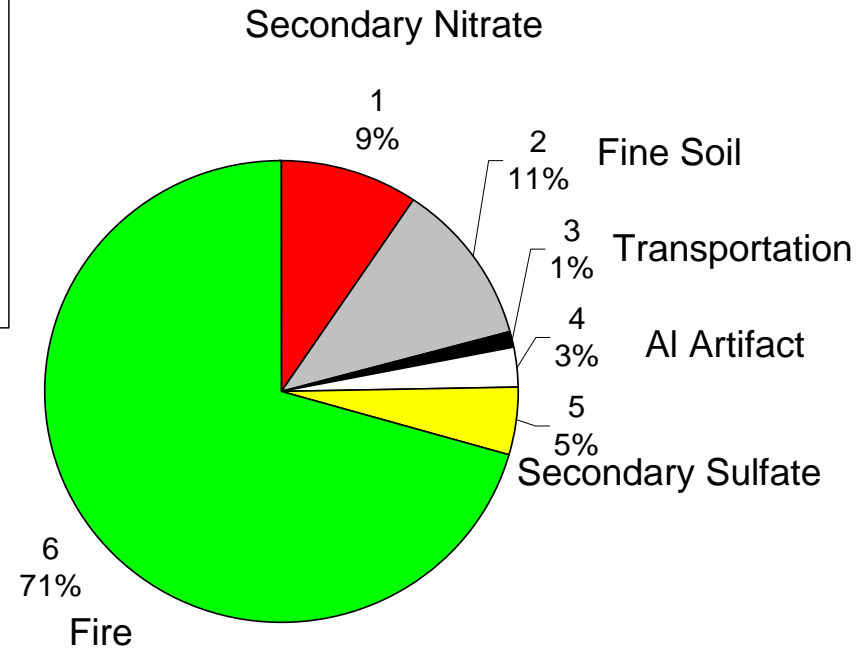
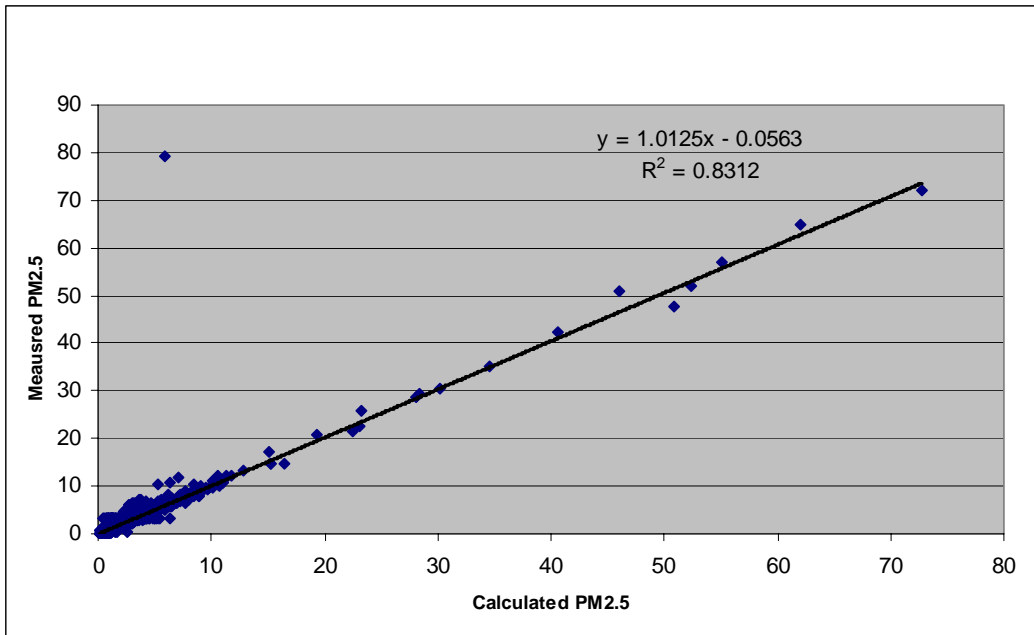
Will test use of these groups plus Alaska and Hawaii groups

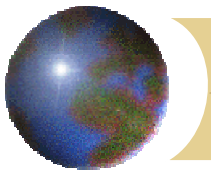
- **Plan is to run all data for group sites in a single PMF, then analyze the results separately for each site**
- **Comparisons of factors among sites in the groups and between different groups may help identify local, regional, and continental scale of factor influence**
- **Trajectory analysis may help identify source regions associated with various factors**



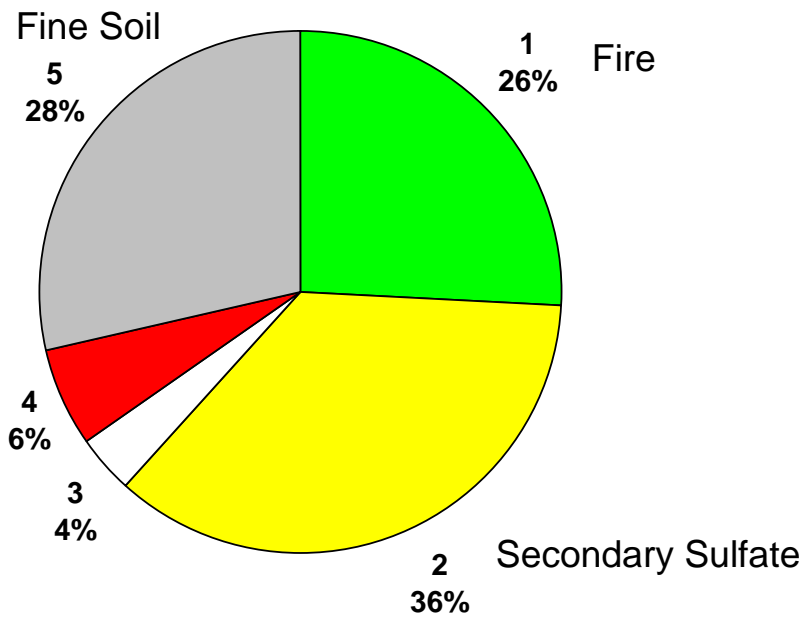
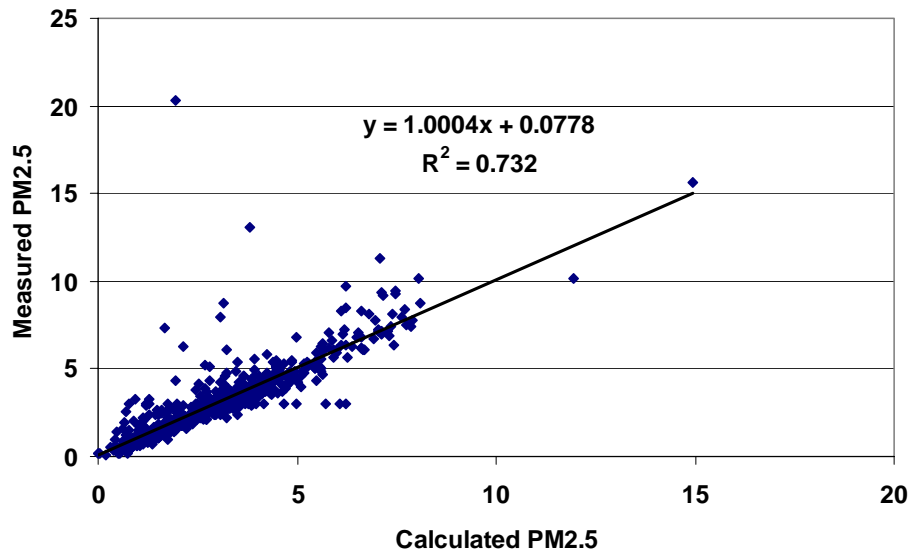


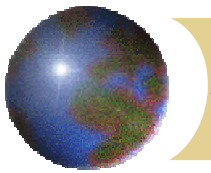
Crater Lake PMF Contributions From Source Factors (ug/m3)





Grand Canyon PMF Contributions From Source Factors (ug/m3)

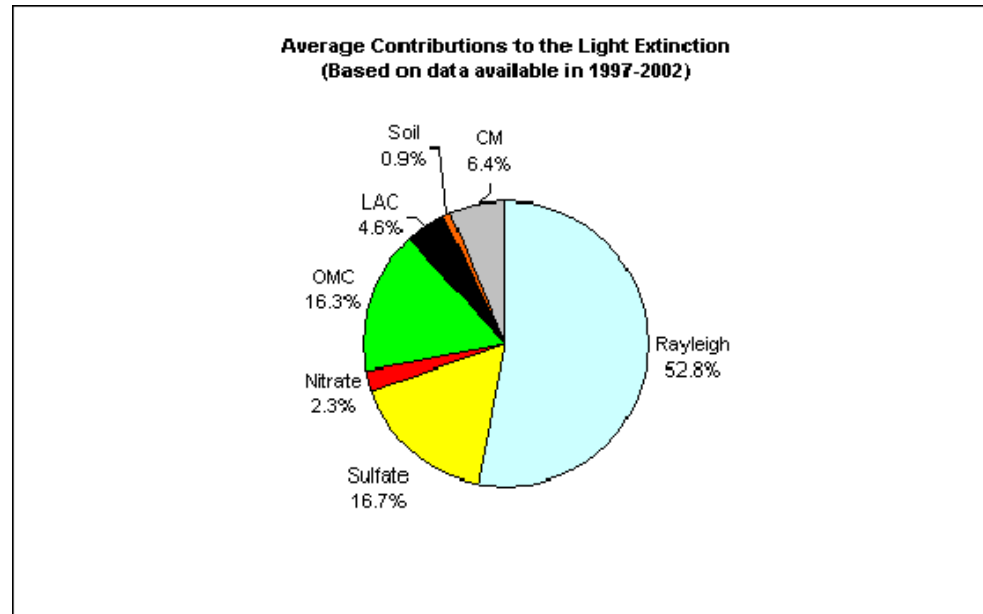


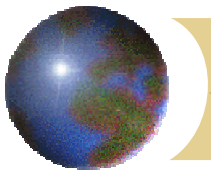


Denali NP Monitoring Results

DENA1 (Denali National Park, AK, Lat. 63.7233, Long. -148.9675, Alt. 658.2 m) 6 years aerosol data are available in Denali National Park during the sampling period of 1997 - 2002. As shown in Figure 1, the overall average total light extinction coefficient (Bext) is 18.9 Mm⁻¹ (Visual Range ~ 206 Km; Deciview ~ 6.4). The average PM_{2.5} mass concentration is 1.8 mg/m³. The overall aerosol light extinction is relative low in Denali National Park, and 52.8% of the light extinction is due to Rayleigh gas scattering. The average contributions of the major aerosol components to Denali National Park haze are particulate sulfate 16.7%, nitrate 2.3%, organic matter (OMC) 16.3%, elemental carbon (light absorbing carbon, LAC) 4.6%, fine soil 0.9% and coarse mass (CM) 6.4%.

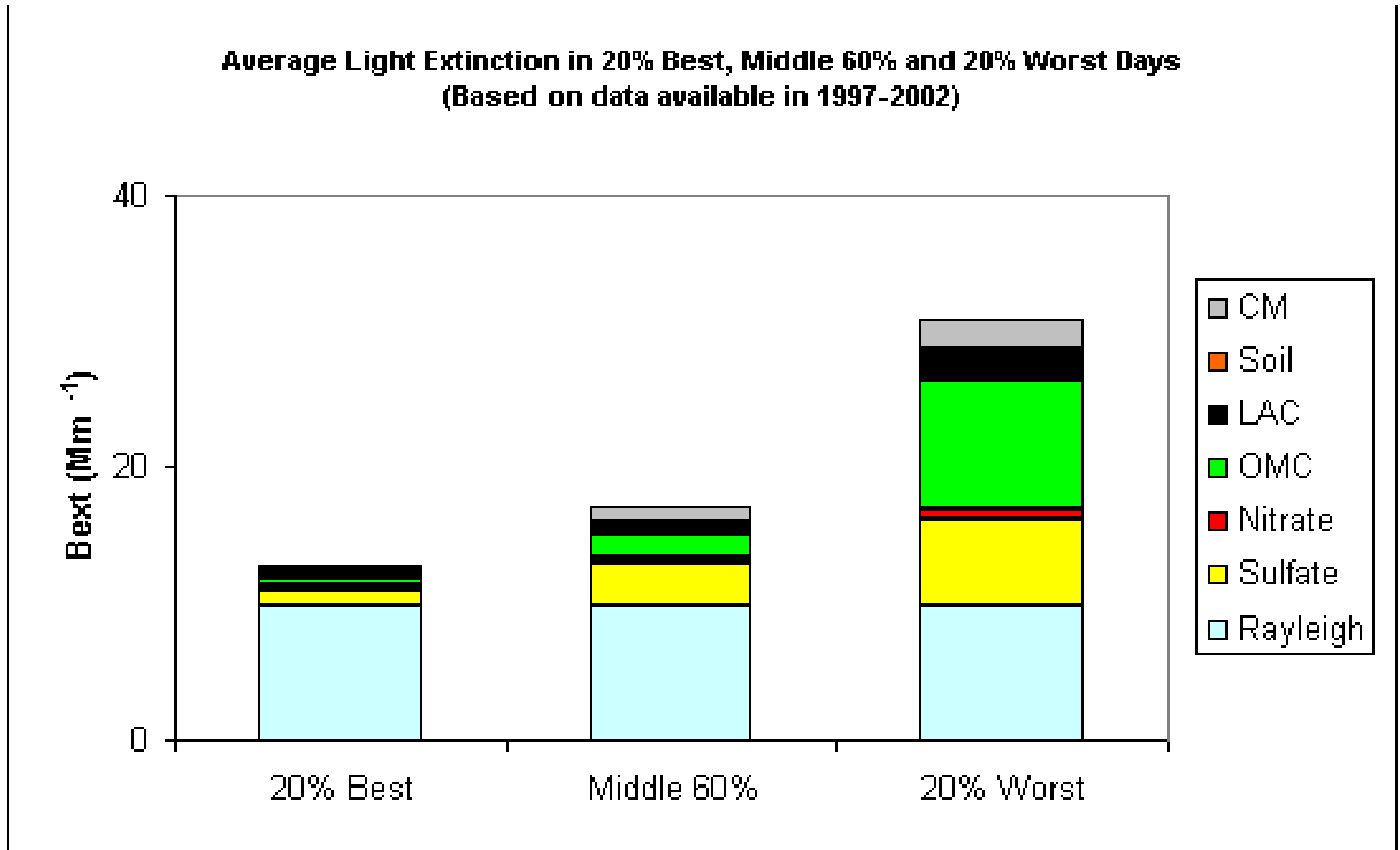
Bext = 18.9 Mm⁻¹

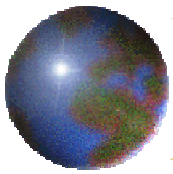




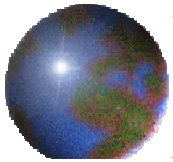
Denali NP Monitoring Results

1997-2002 average contributions of major aerosol chemical components to light extinction



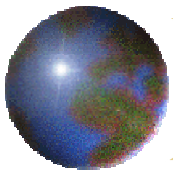


- ❖ **Source Regions** - the approach chosen to define source regions for the trajectory regression for the Causes of Haze Assessment is outlined below.
 - ❖ Divide the state containing the monitoring site into quadrants (i.e. NE, SE, SW, & NW) with the origin at the monitoring sites. This will provide the first 4 source regions.
 - ❖ For the states of Alaska & Hawaii divide the states into quadrants, and everything outside of the states into quadrants for a total of 8 source regions



Denali NP Trajectory Regression Analyses





Alaska Class I areas' Trajectory Regression Analysis Results

✚ Denali

✚ http://www.coha.dri.edu/web/state_analysis/Alaska/DENA1/DENA1_trajregress.html

✚ Simeonof

✚ http://www.coha.dri.edu/web/state_analysis/Alaska/SIME1/SIME1_trajregress_tables.html

✚ Tuxedni

✚ http://www.coha.dri.edu/web/state_analysis/Alaska/TUXE1/TUXE1_trajregress_tables.html