Particulate Matter (PM2.5) Concentrations in Western Montana During the Wildfires of 2000

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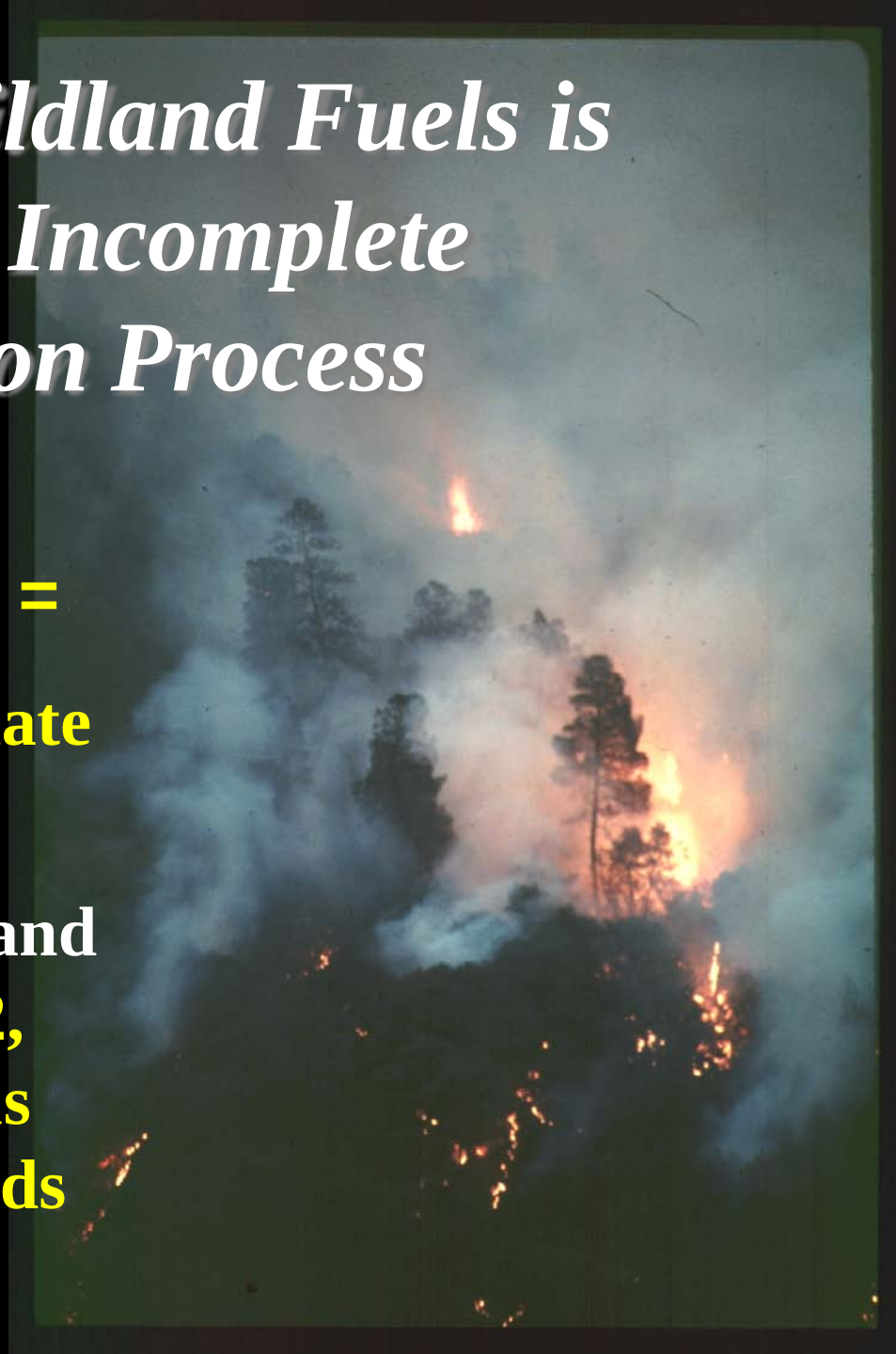
Complete Combustion of Wood

$$4(C_6H_9O_4) + \text{heat} + 25(O_2) = 24(CO_2) + 18(H_2O)$$

The only products of complete combustion are carbon dioxide and water, with about 1.8 tons of CO_2 being produced per ton of fuel consumed.

Burning of Wildland Fuels is Always An Incomplete Combustion Process



Woody Fuels + Heat + O_2 =

What you can see – particulate matter and water droplets

What you can't see – gases and organic vapors such as CO2, CO, CH4, C2H2, C2H3, plus hundreds of other compounds

CO2 accounts for about 90% of the gases produced, and the remaining gases which have been measured away from the immediate vicinity of the fire, have not been found to be in concentrations high enough to be in violation of EPA standards.

Particulate Matter is the emission of primary concern from wildland burning.

- **EFPM2.5 ~10 – 100 lbs/ton (30 typical)**
- **Adverse health effects**
- **Visibility impairment**
- **Criteria pollutant**

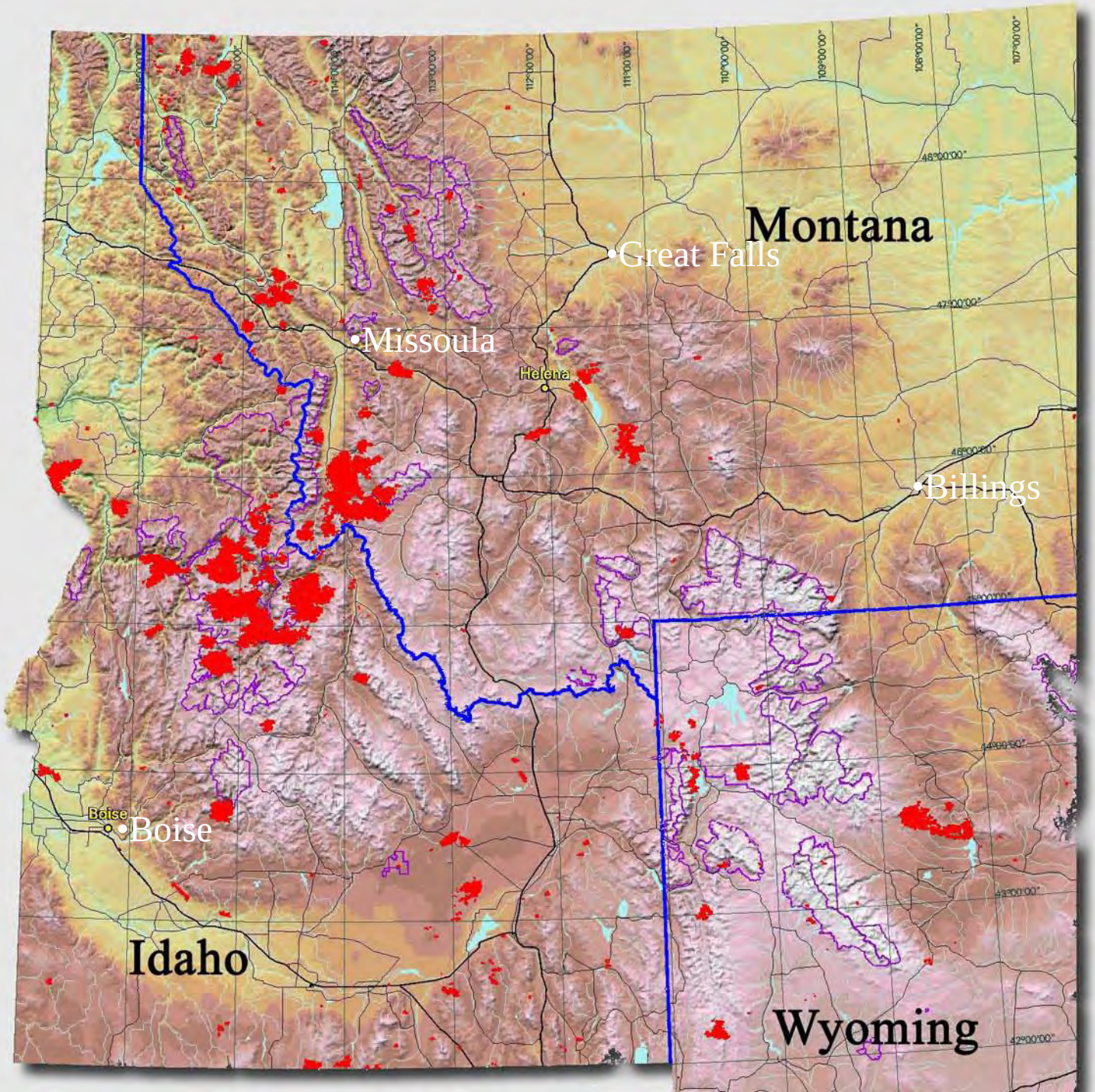
Measurement Objectives

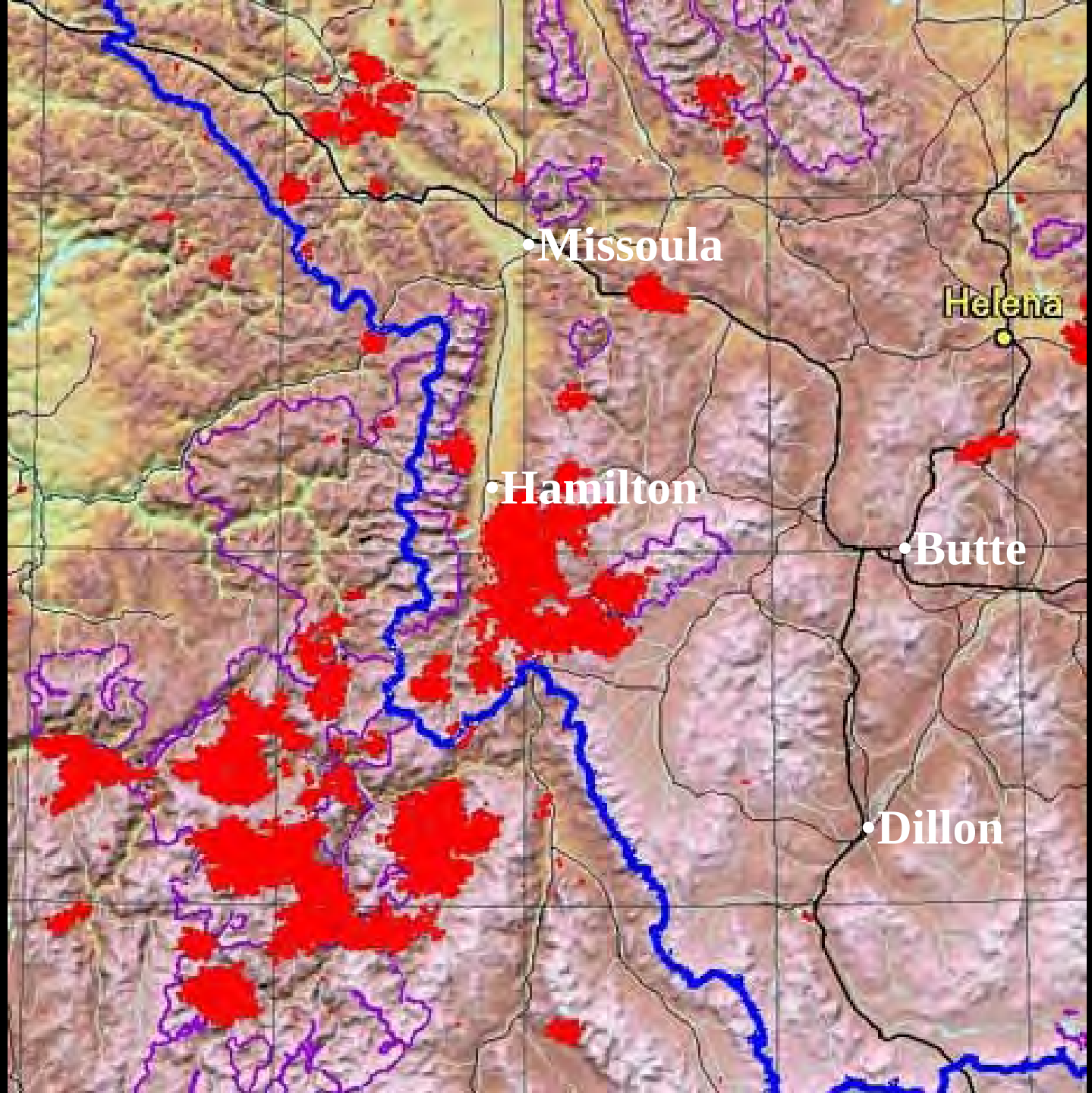
- USFS Region 1 air quality specialists and Fire Lab researchers wanted to make regional measurements of particulate matter in smoke from the 2000 wildfires to:
  - provide an historical record
  - provide information to help verify smoke dispersion models
  - provide information to examine tradeoffs between wildfire and prescribed fire

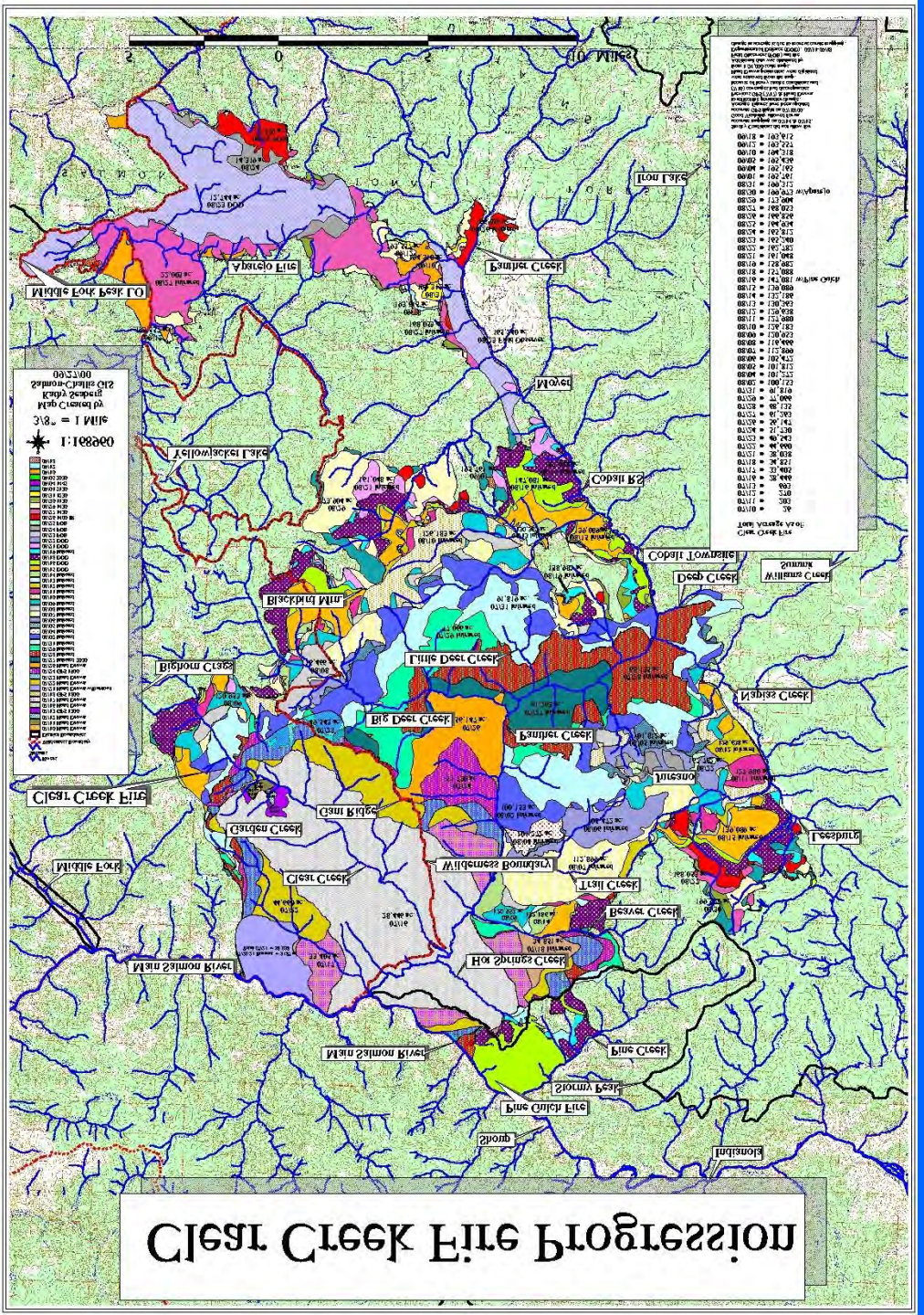
Where, What, and When

- **Measurements were made in Western Montana – primarily in Missoula and the Bitterroot Valley**
- **Parameters Measured**
  - **back scatter measured with a integrating nephelometer (per meter)**
    - **local particulate matter calculated from Bscat (ug/m^3)**
  - **GPS**
    - **longitude (decimal degrees)**
    - **latitude (decimal degrees)**
    - **altitude (feet)**
    - **time**
  - **temperature (degrees C)**
  - **relative humidity (%)**
  - **pressure (PSI)**
- **Data recorded at 10 second intervals**
- **20 Days of Measurements**
  - **Aug 12 to 25, Aug 27 to 30, Sept 01, 07**

E107
BRONCO


Montana
Great Falls
Missoula
Helena
Billings
Boise
Boise
Idaho
Wyoming


•Missoula
Helena
•Hamilton
•Butte
•Dillon



Clear Creek Fire, located in Western Central Idaho influenced air quality in the Bitterroot Valley, and burned about 210,00 acres over a period of about 2 months

Air Quality
Southwestern Montana
August 12, 2000

- Cities

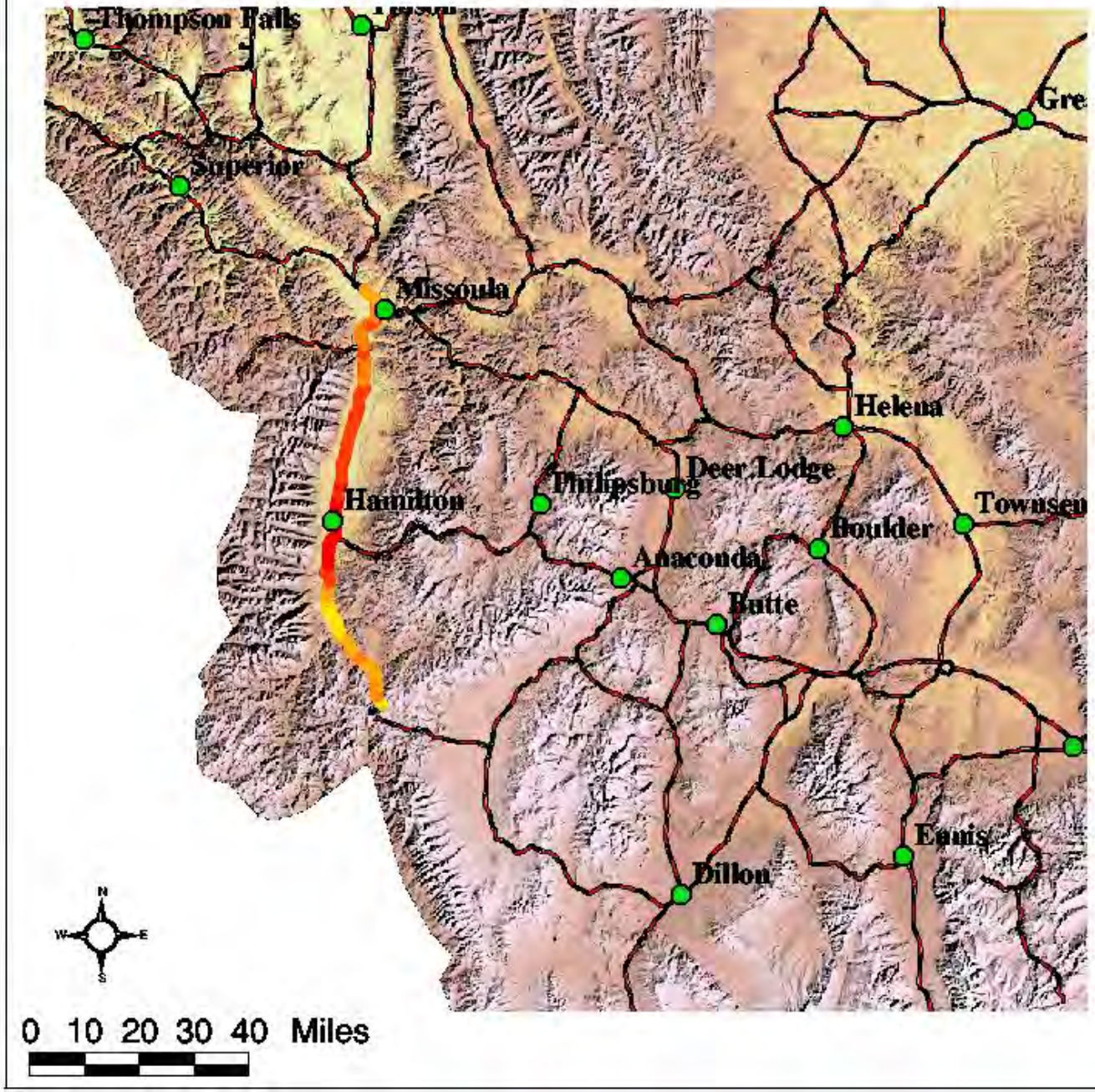
Measurement of PM (ug/m^3), 812

- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650
- Interstate/State Highways

INTERPRETATION*
Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

* As developed by Montana Department of Environmental Quality, Summer 2000.



Air Quality
Southwestern Montana
August 14, 2000

- Cities

Measurement of PM (ug/m^3), 814

- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650
- Interstate/State Highways

INTERPRETATION*
Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

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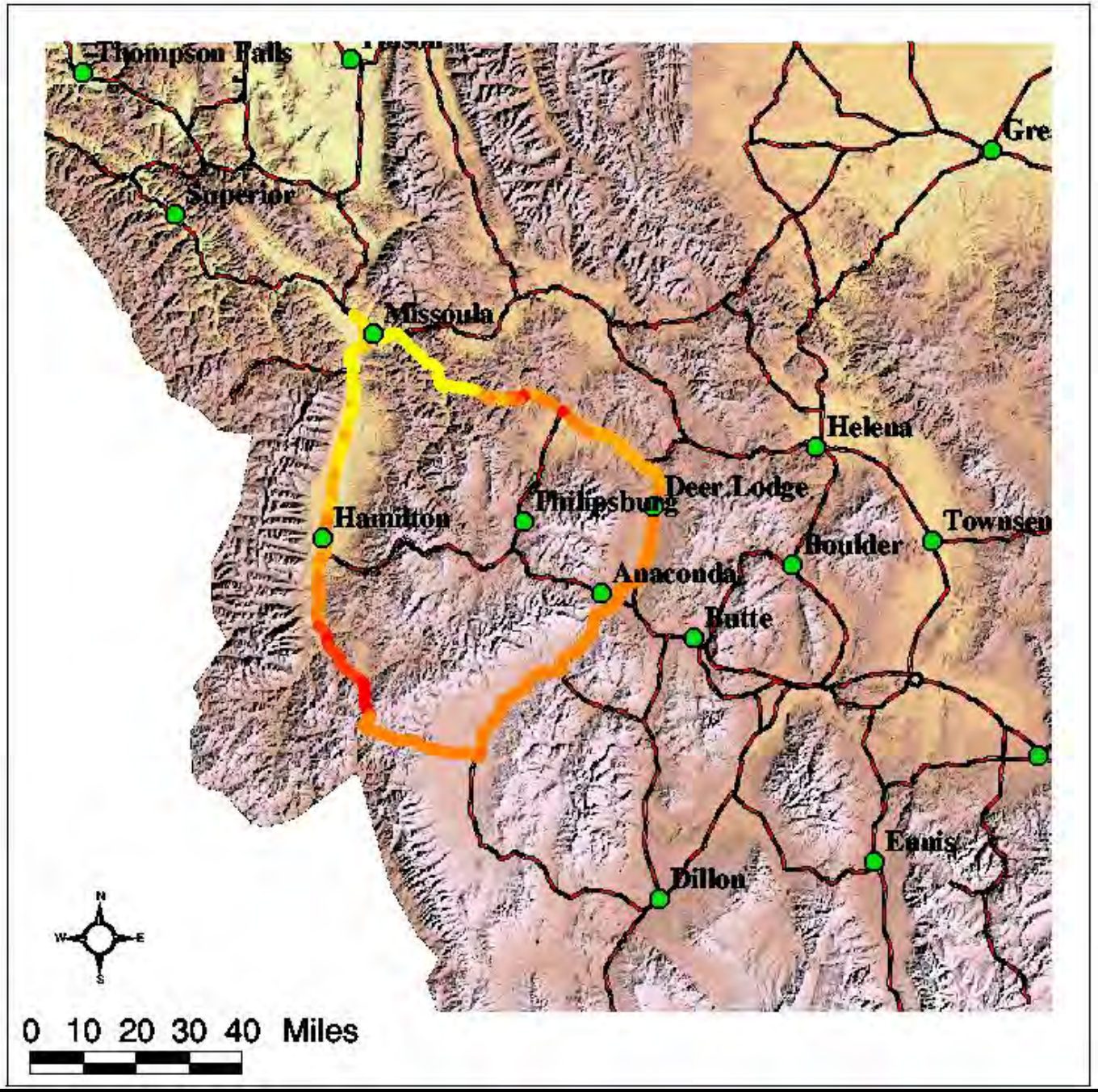


Air Quality
Southwestern Montana
August 15, 2000

- Cities

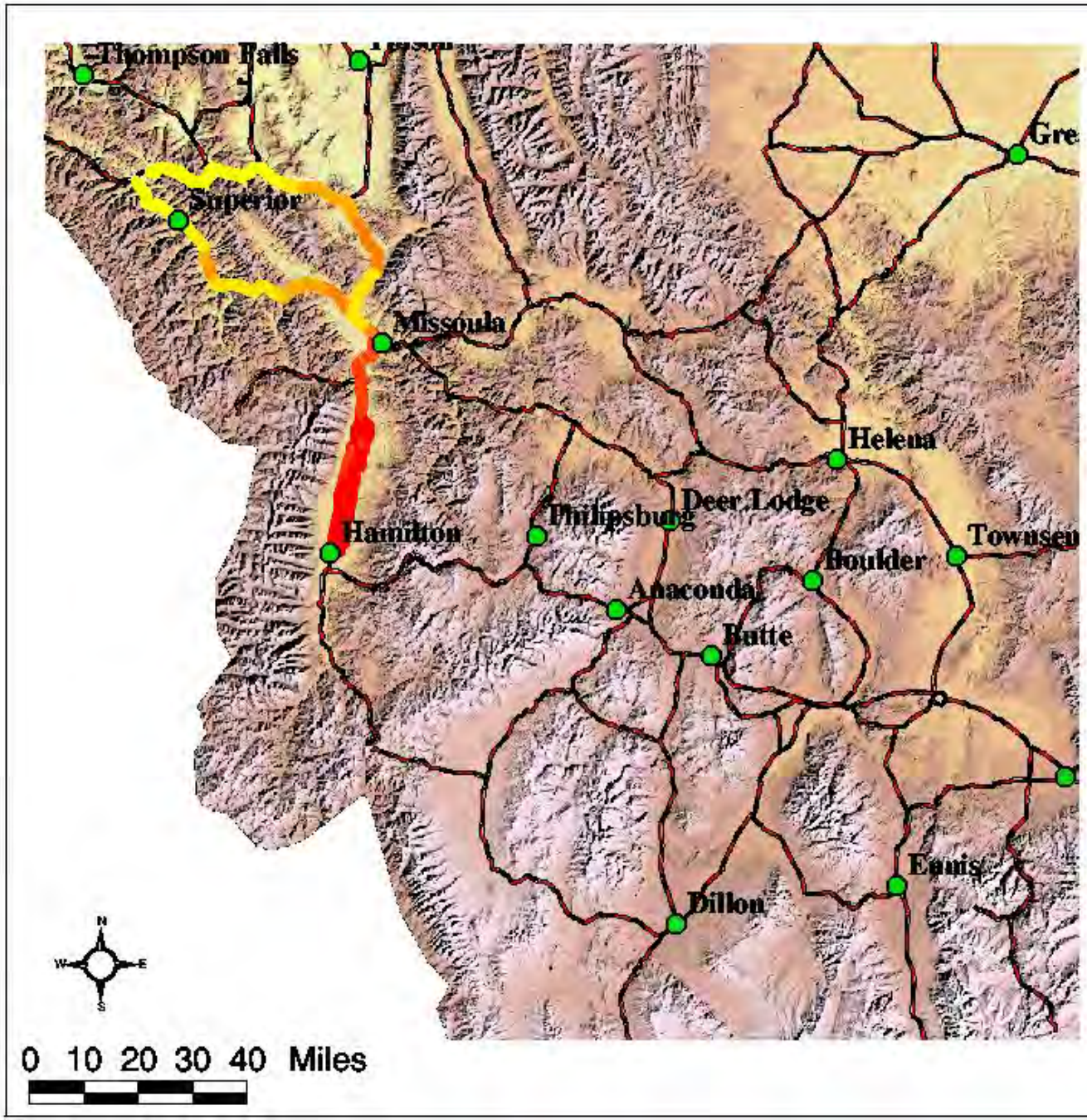
Measurement of PM (ug/m^3), 815

- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650
- Interstate/State Highways

INTERPRETATION*
Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

* As developed by Montana Department of Environmental Quality, Summer 2000.



Air Quality
Southwestern Montana
August 17, 2000

Cities

Measurement of PM (ug/m^3), 817

- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650

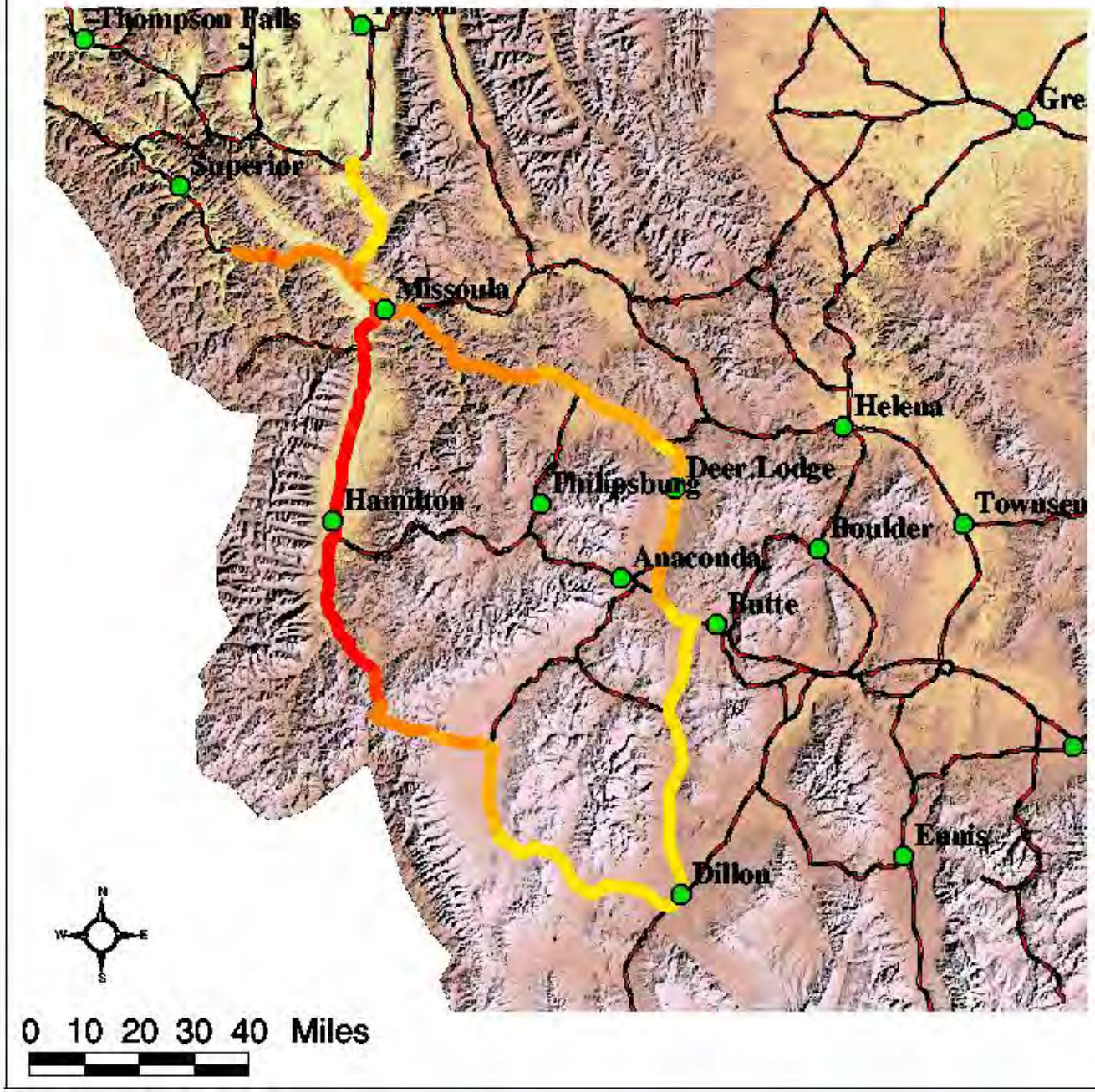
Interstate/State Highways

INTERPRETATION*

Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

* As developed by Montana Department of Environmental Quality, Summer 2000.



Air Quality
Southwestern Montana
August 18, 2000

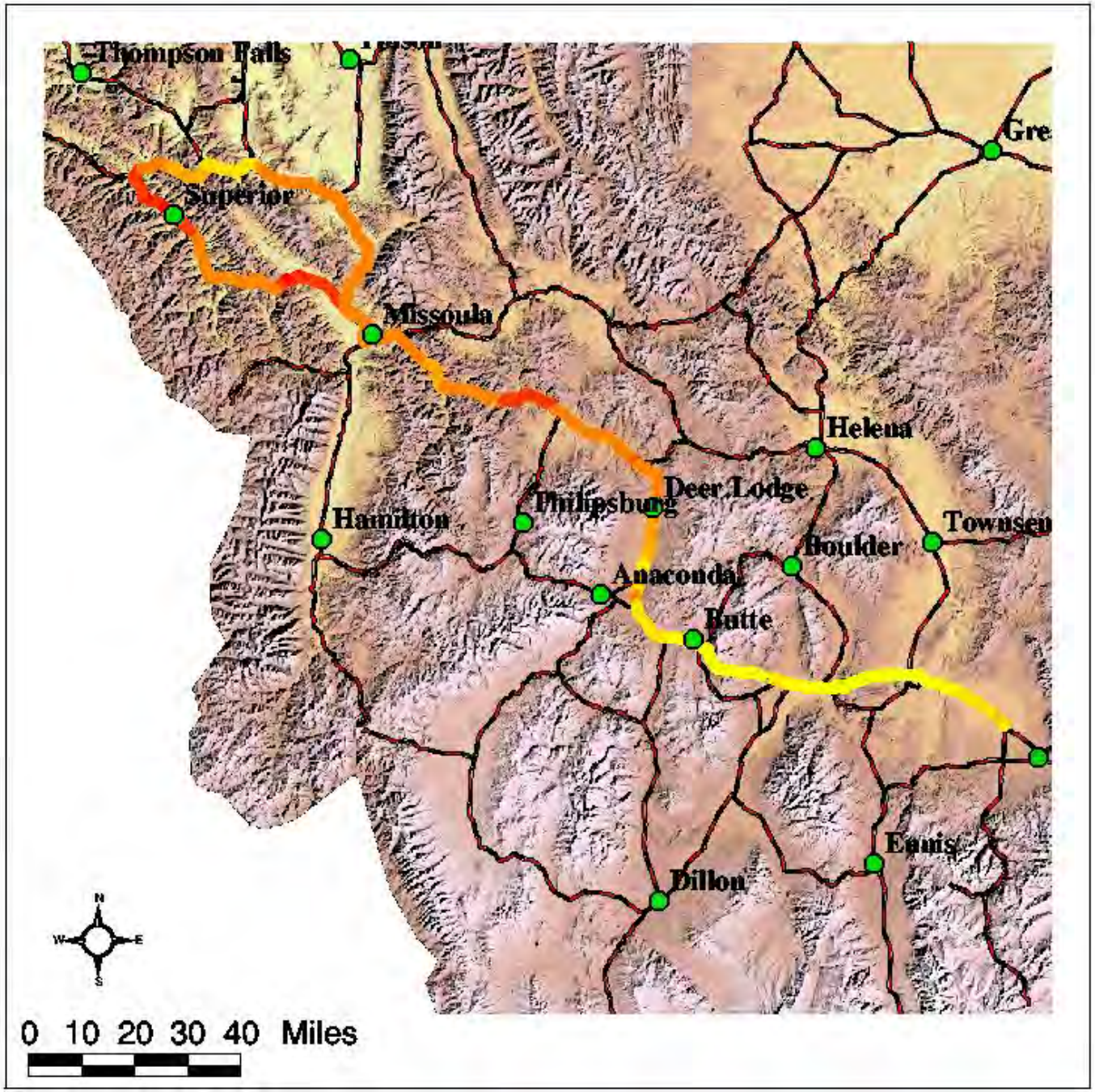
Cities
Measurement of PM (ug/m^3), 818
- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650

Interstate/State Highways

INTERPRETATION*
Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

* As developed by Montana Department of Environmental Quality, Summer 2000.



Air Quality
Southwestern Montana
August 20, 2000

- Cities

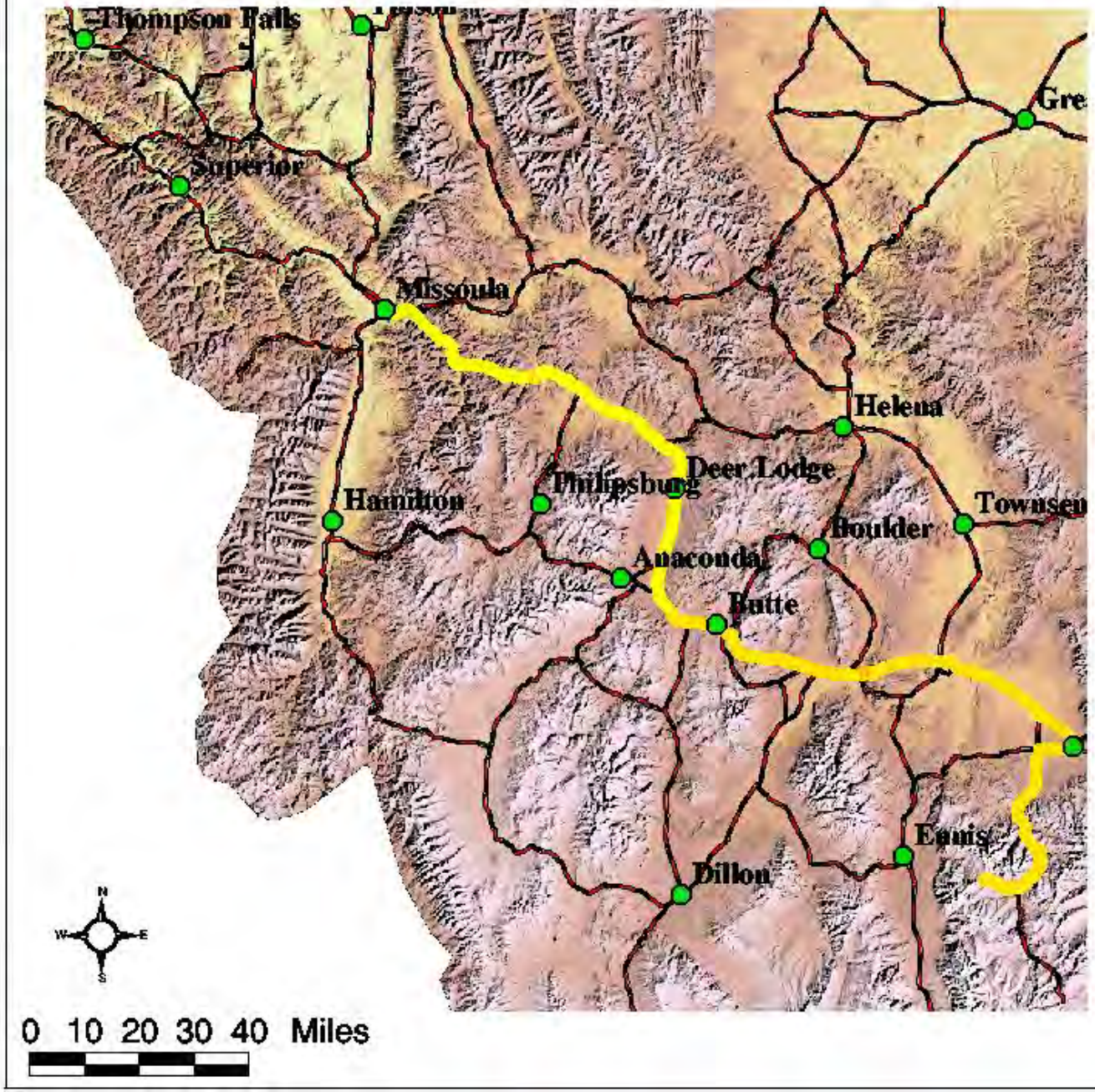
Measurement of PM (ug/m^3), 820

- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650
- Interstate/State Highways

INTERPRETATION*
Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

* As developed by Montana Department of Environmental Quality, Summer 2000.



Air Quality
Southwestern Montana
August 22, 2000

Cities

Measurement of PM (ug/m^3), 822

- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650

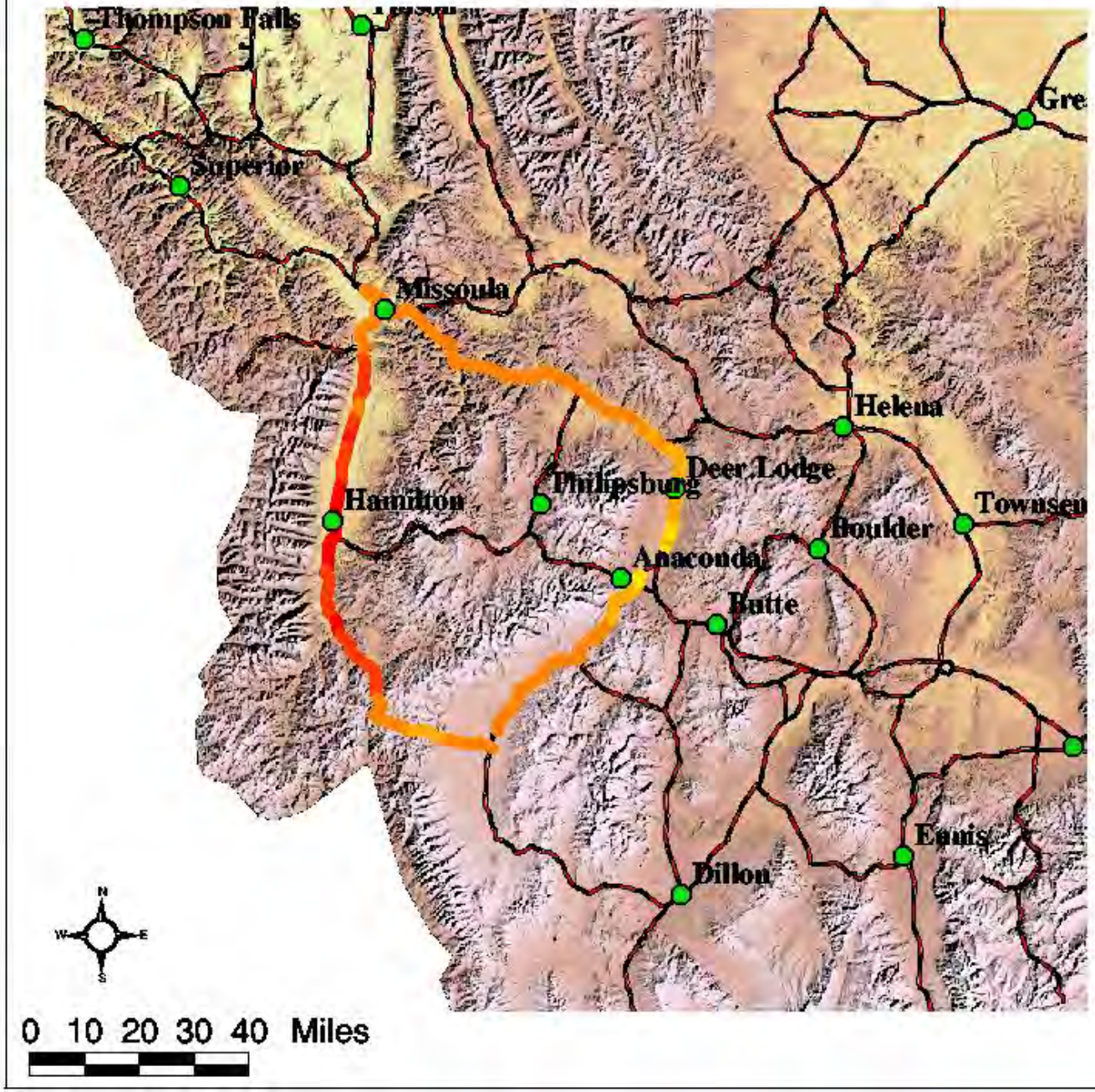
Interstate/State Highways

INTERPRETATION*

Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

* As developed by Montana Department of Environmental Quality, Summer 2000.



Air Quality
Southwestern Montana
August 30, 2000

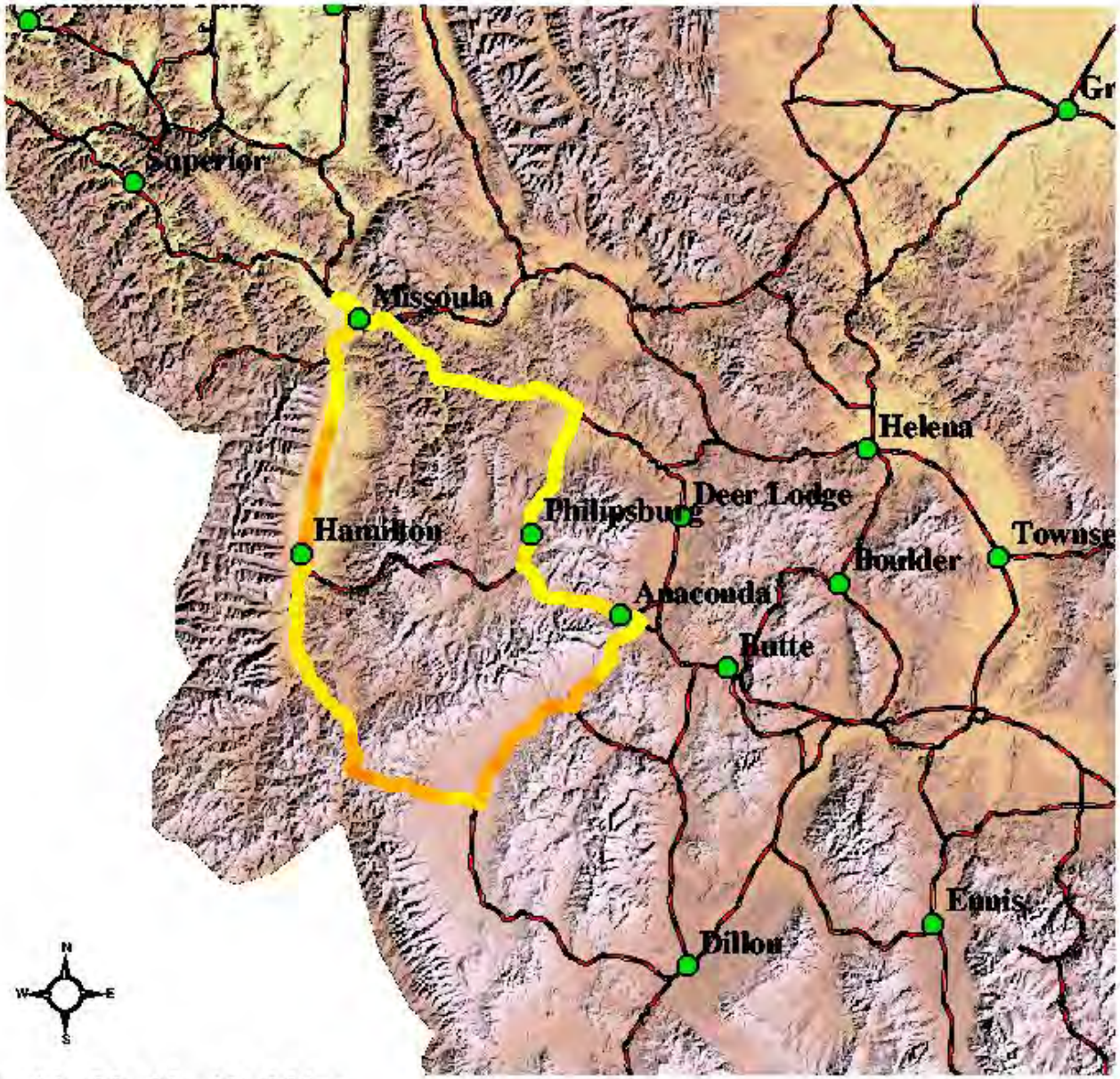
Cities
Measurement of PM (ug/m^3), 830
- 0 - 15.4
- 15.5 - 40.4
- 40.5 - 65.4
- 65.5 - 150.4
- 150.5 - 250.4
- 250.5 - 650

Interstate/State Highways

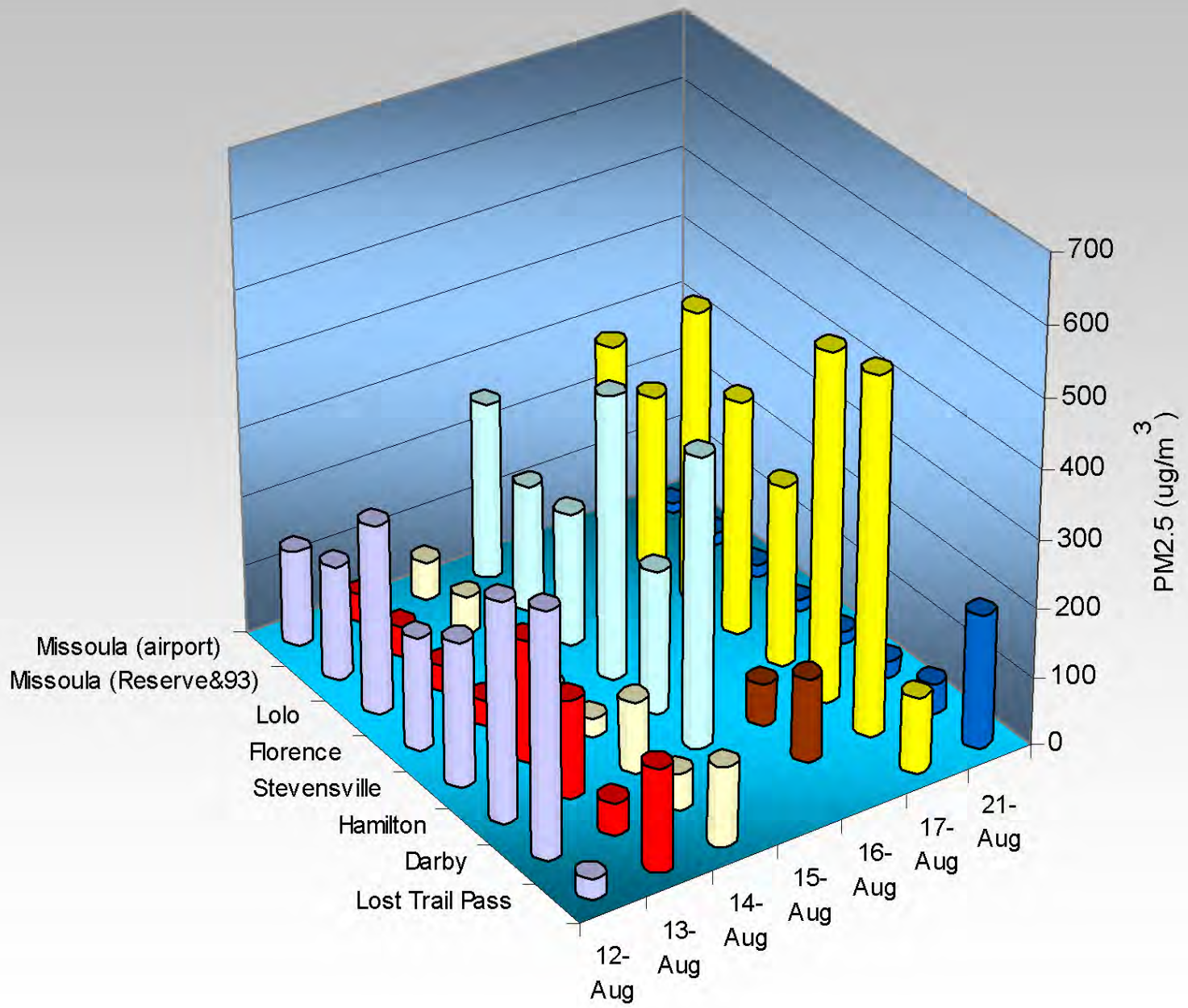
INTERPRETATION*
Air Quality Measurements

0 - 15.4	Good
15.5 - 40.4	Moderate
40.5 - 65.4	Unhealthy for some
65.5 - 150.4	Unhealthy
150.5 - 250.4	Very unhealthy
> 250.4	Hazardous

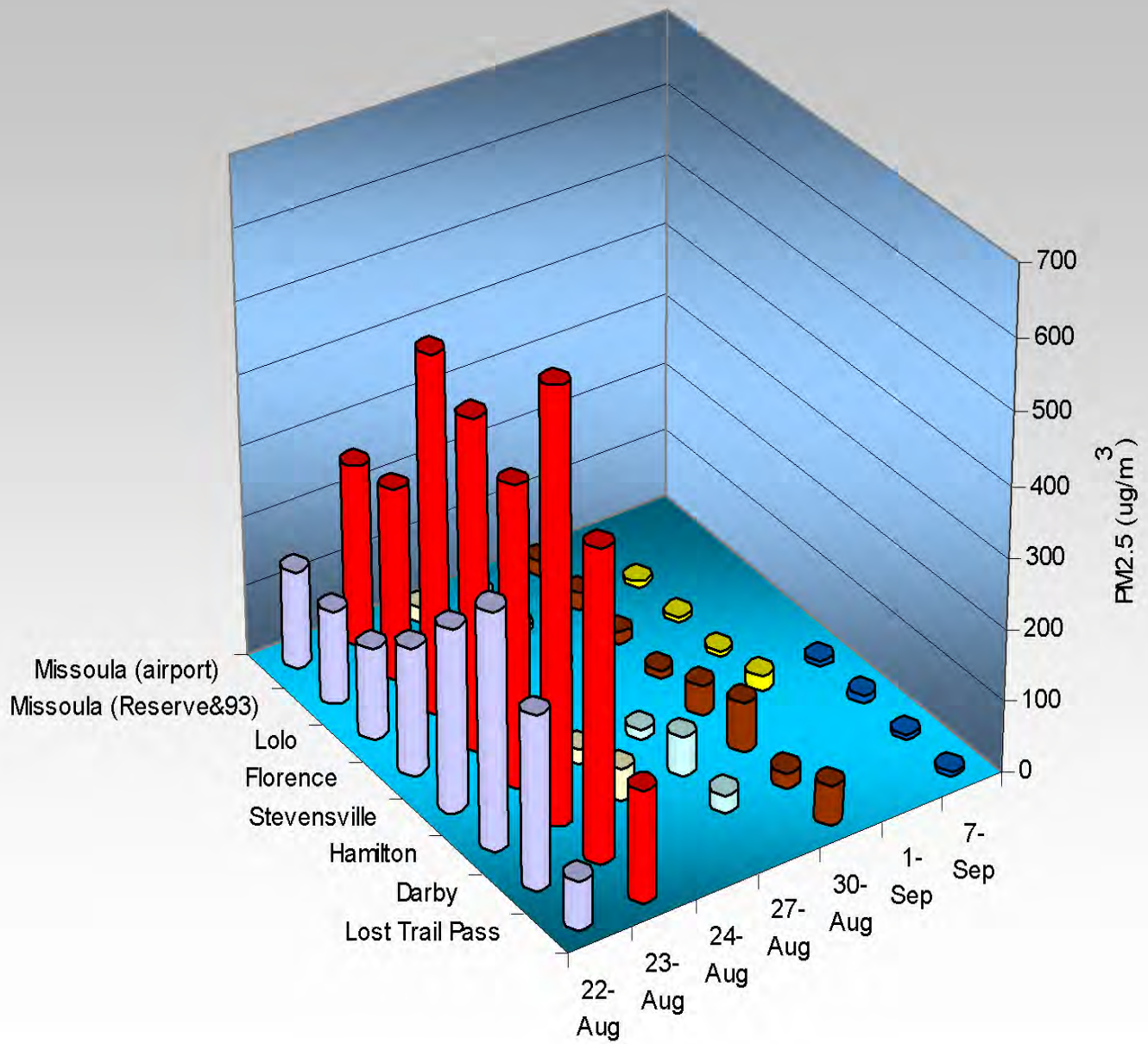
* As developed by Montana Department of Environmental Quality, Summer 2000.



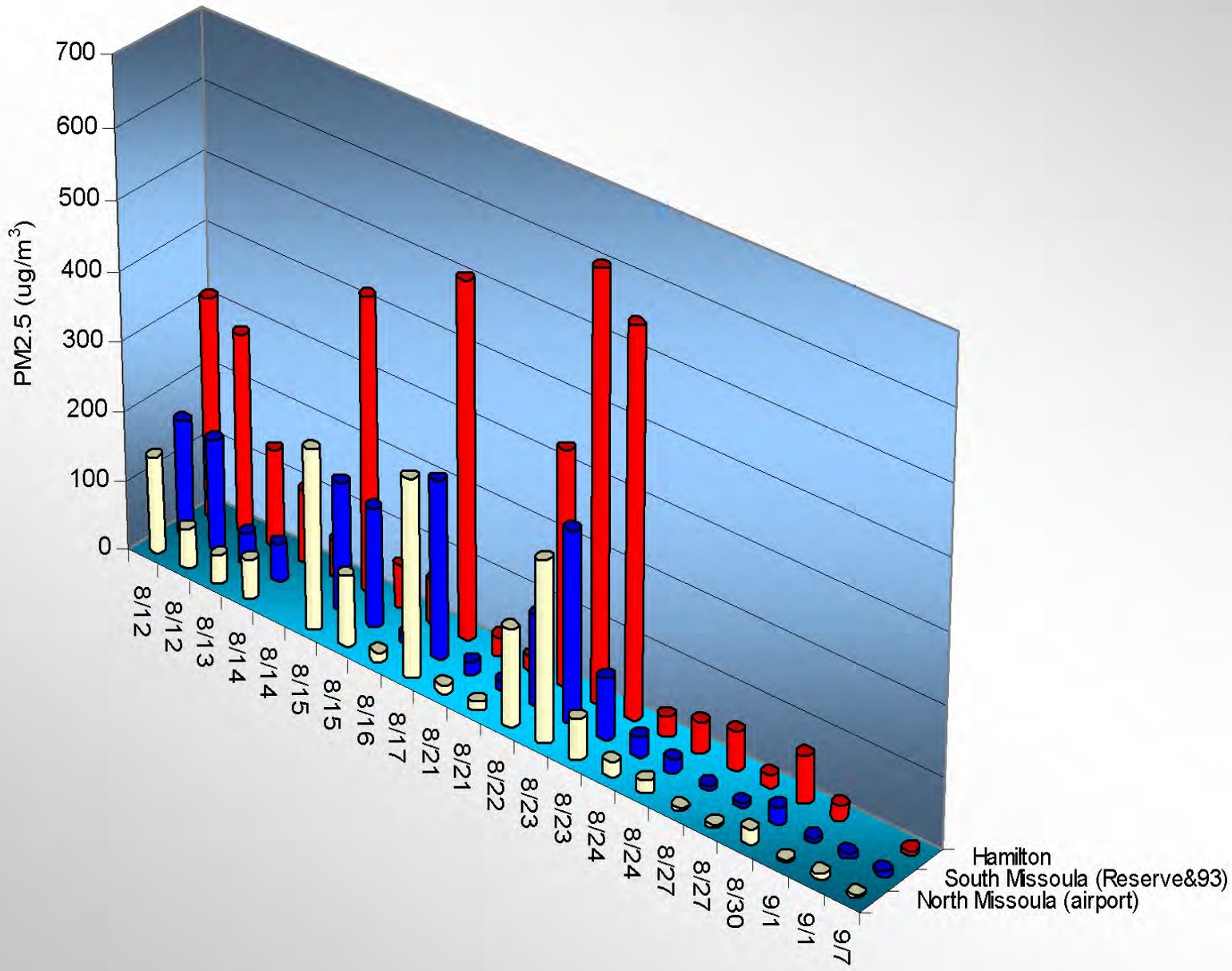
PM2.5 Missoula & Bitterroot Valley –Aug. 12 to Aug. 21



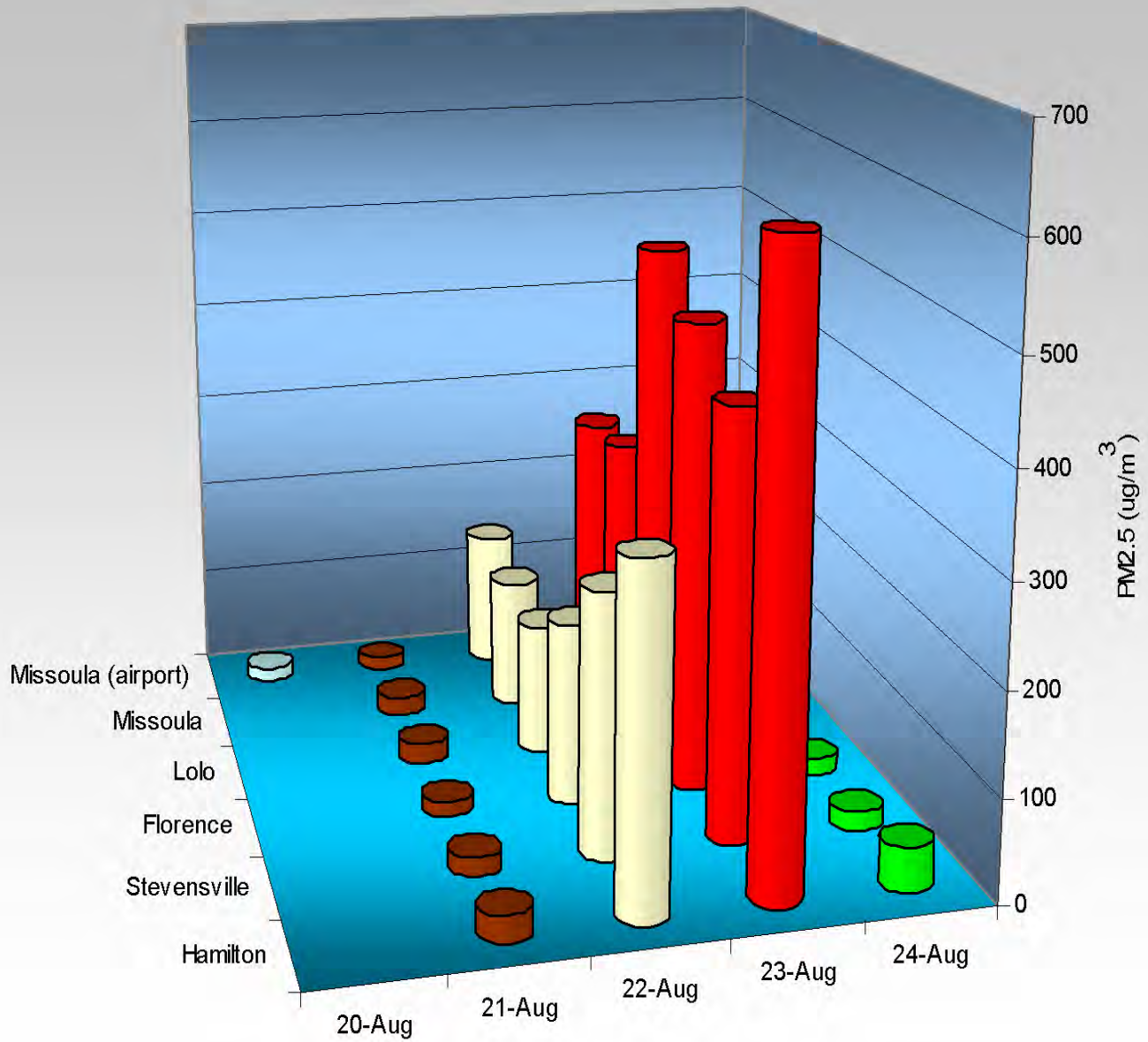
PM2.5 Missoula & Bitterroot Valley – Aug. 22 to Sept. 7

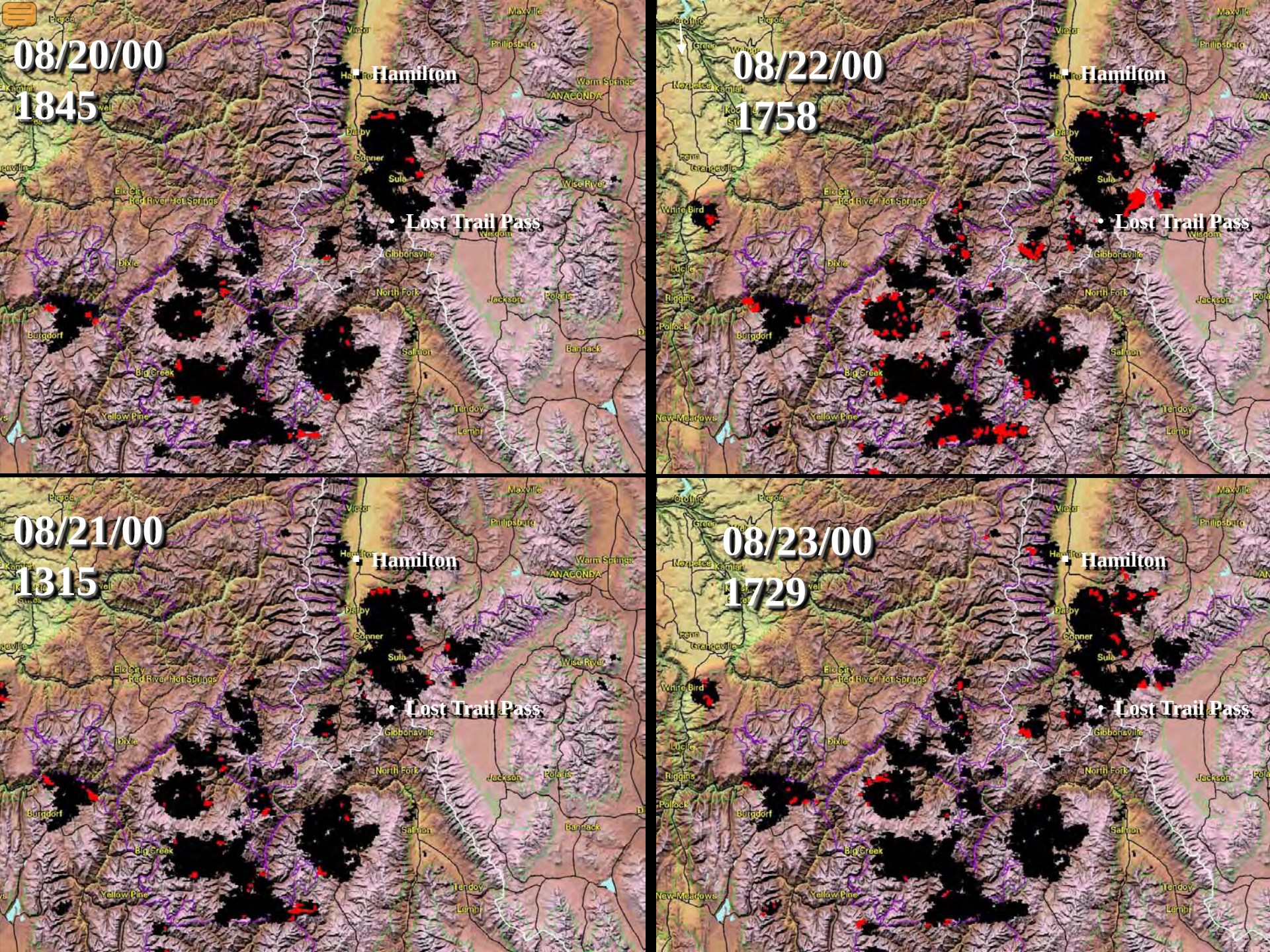


Missoula & Hamilton Estimated PM2.5

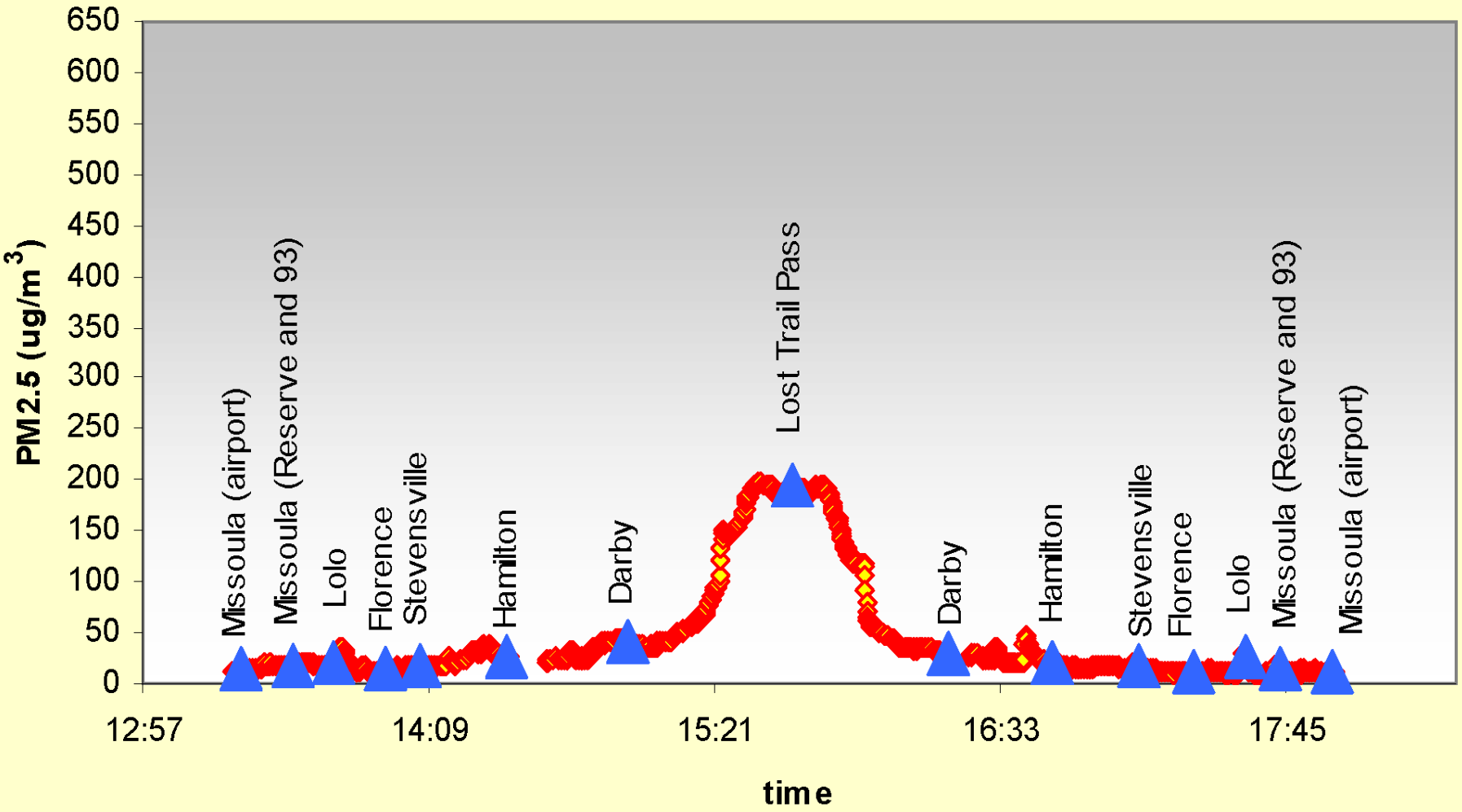


PM2.5 Missoula & Bitterroot Valley – Aug. 20 to Aug. 24

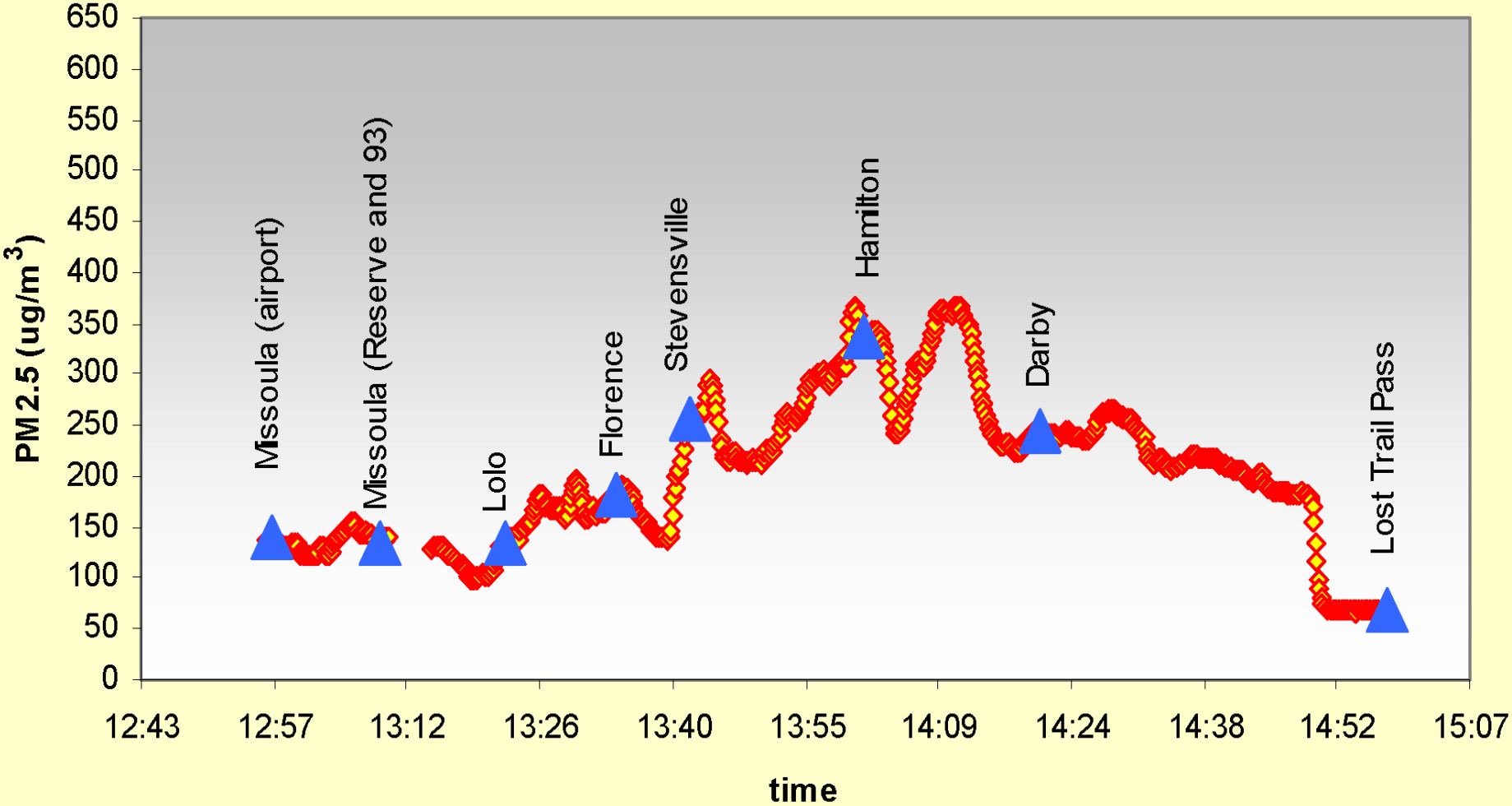



08/20/00
1845
Hamilton
Lost Trail Pass
08/22/00
1758
Hamilton
Lost Trail Pass
08/21/00
1315
Hamilton
Lost Trail Pass
08/23/00
1729
Hamilton
Lost Trail Pass
Pierce
Maxville
Victor
Philipsburg
Warm Springs
ANACONDA
Darby
Conner
Sula
Wise River
Elk City
Red River Hot Springs
Dixie
Gibbonsville
North Fork
Jackson
Polaris
Burgdorf
Salmon
Bannack
Big Creek
Yellow Pine
Tendoy
Lemhi
Grangeville
White Bird
Lucile
Riggins
Pollock
New Meadows

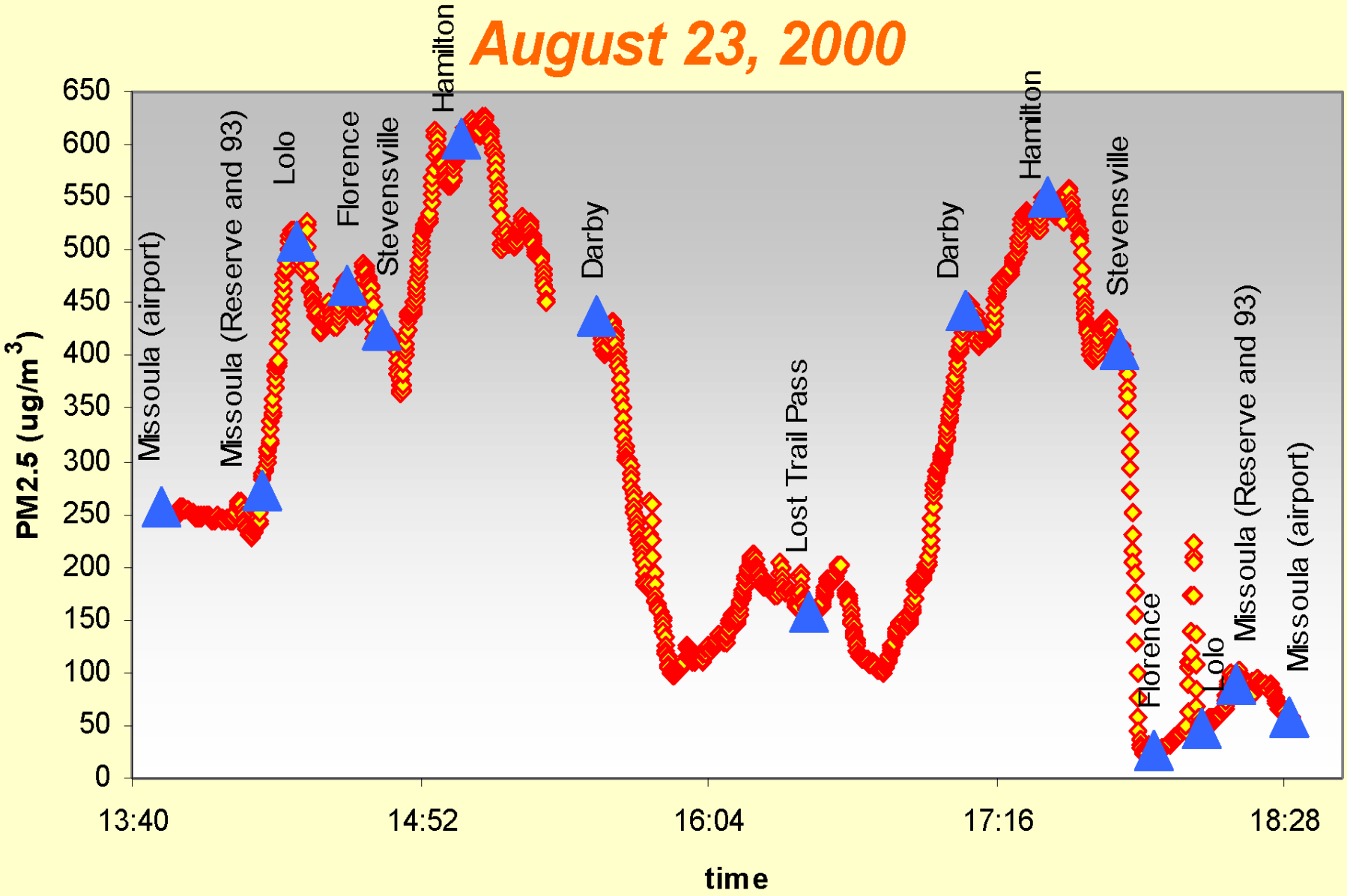
PM2.5 - Missoula & Bitterroot Valley
August 21, 2000



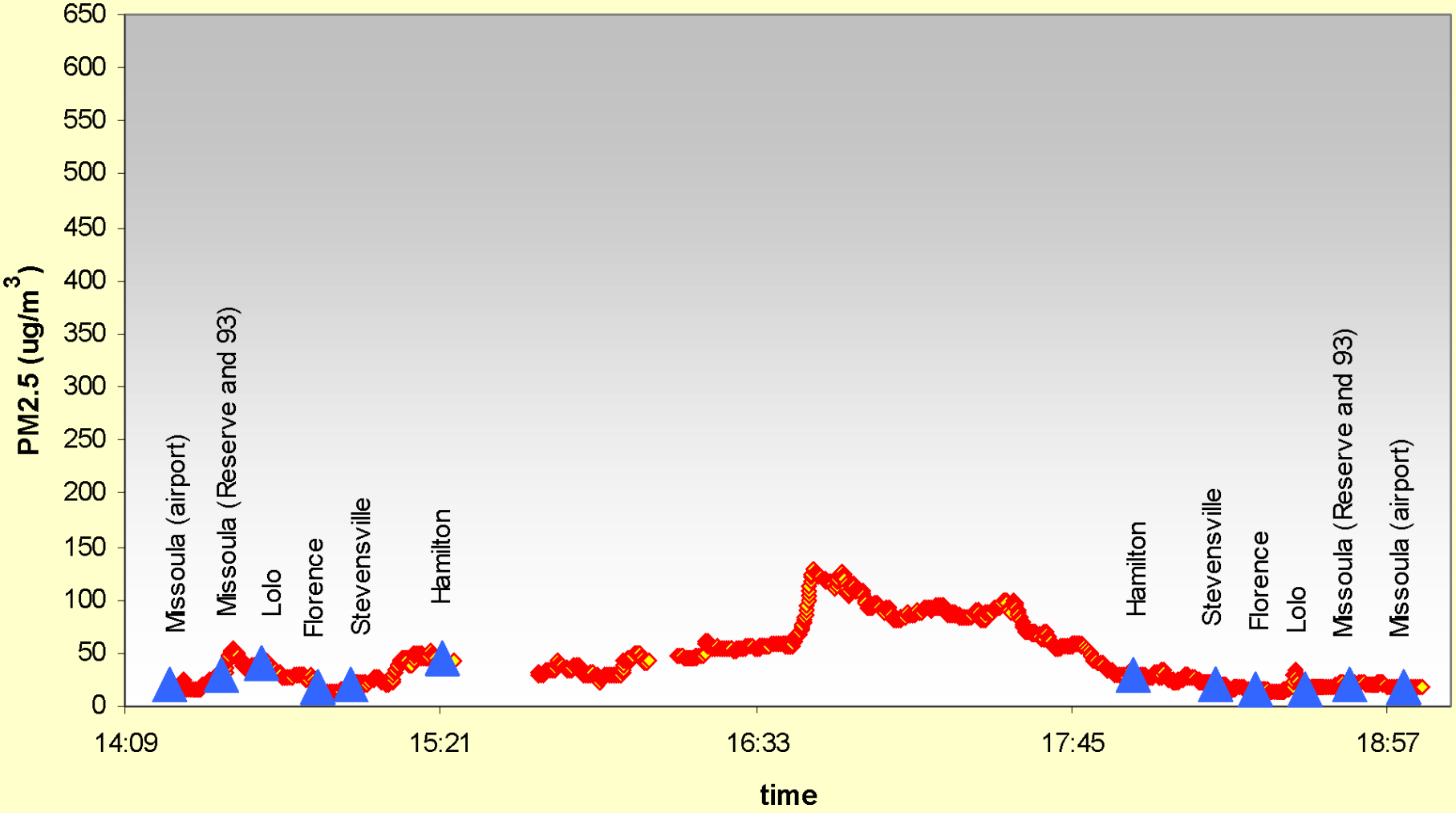
PM2.5 - Missoula & Bitterroot Valley
August 22, 2000



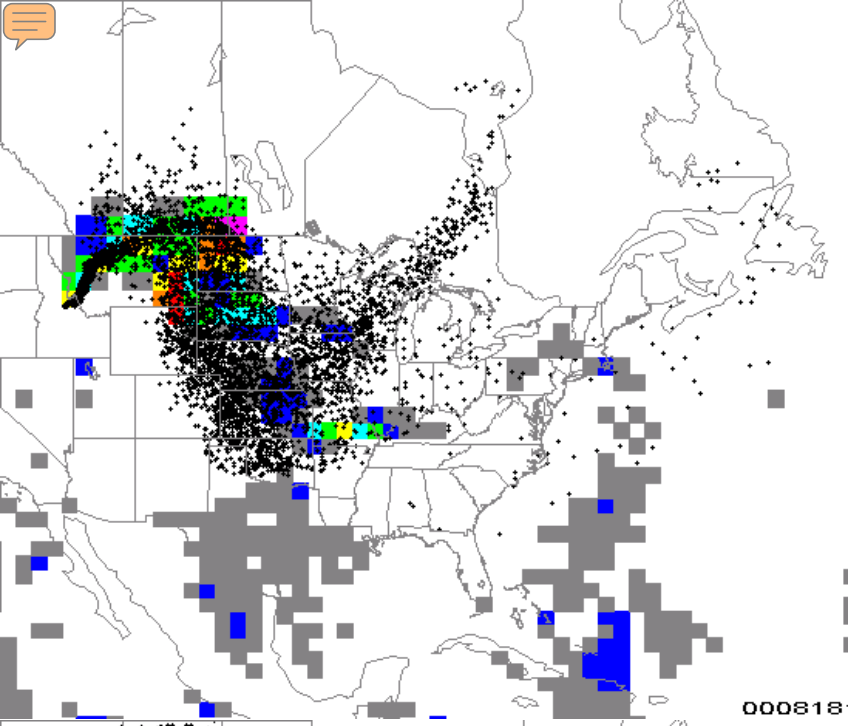
PM2.5 - Missoula & Bitterroot Valley
August 23, 2000



PM2.5 - Missoula & Bitterroot Valley
August 24, 2000



During peak burning periods most of the smoke is lofted into the transport winds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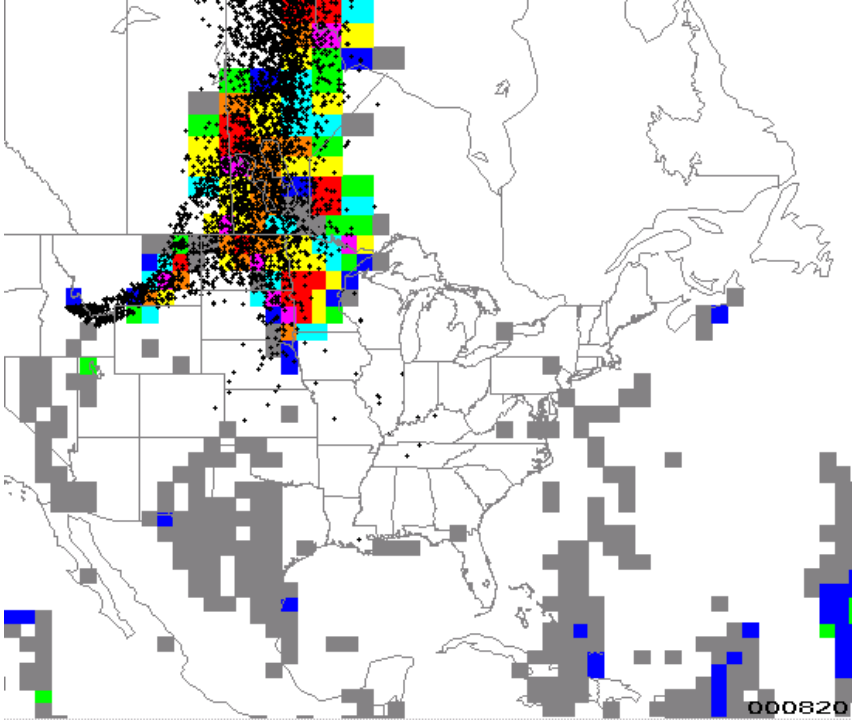
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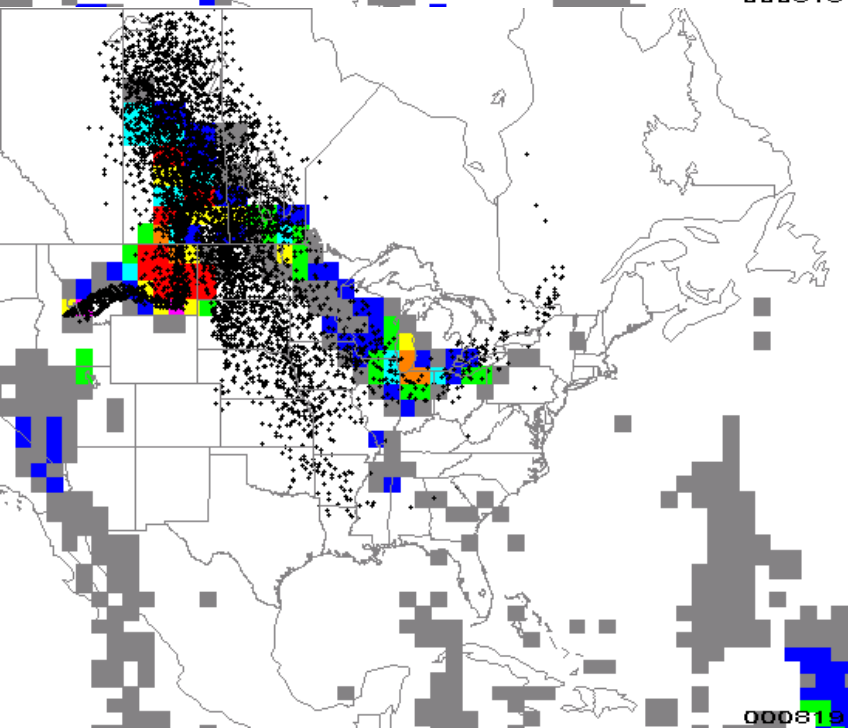
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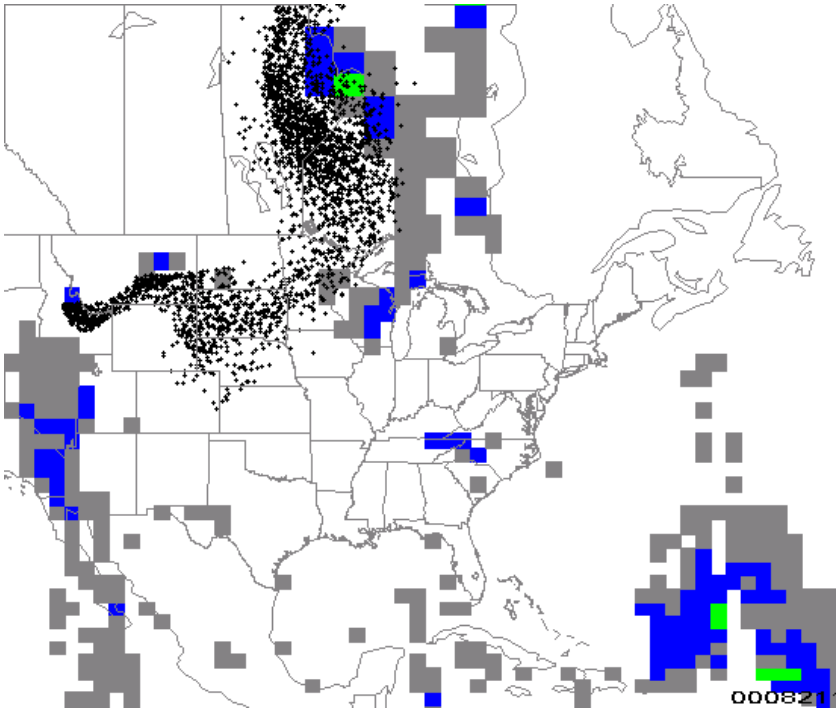
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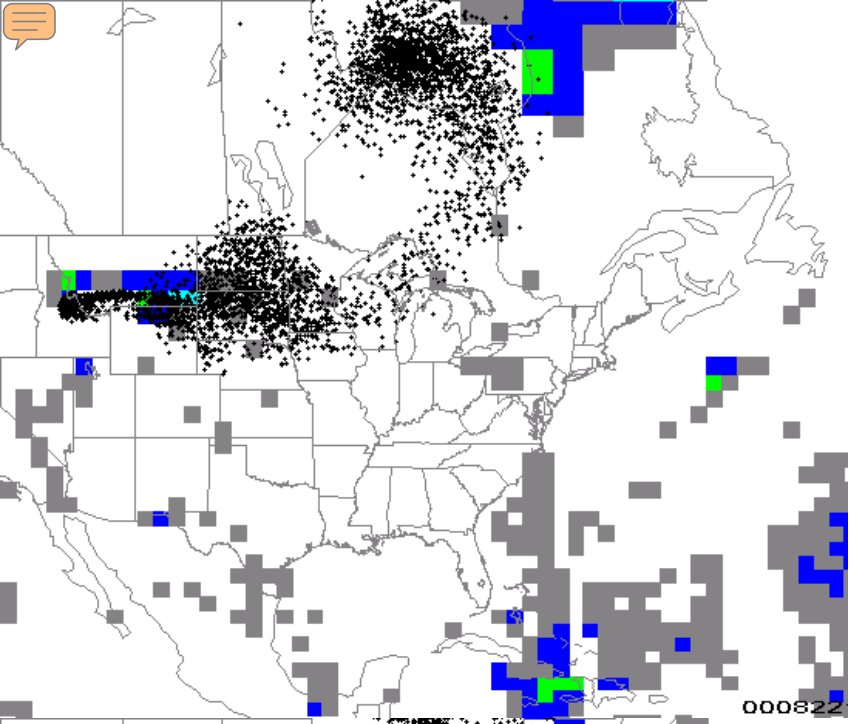
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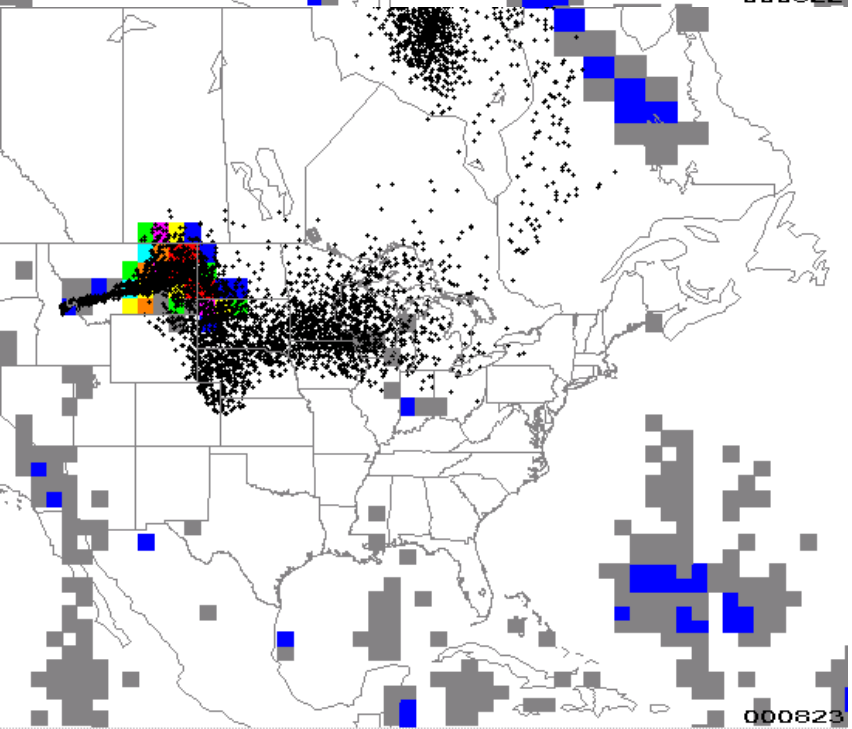
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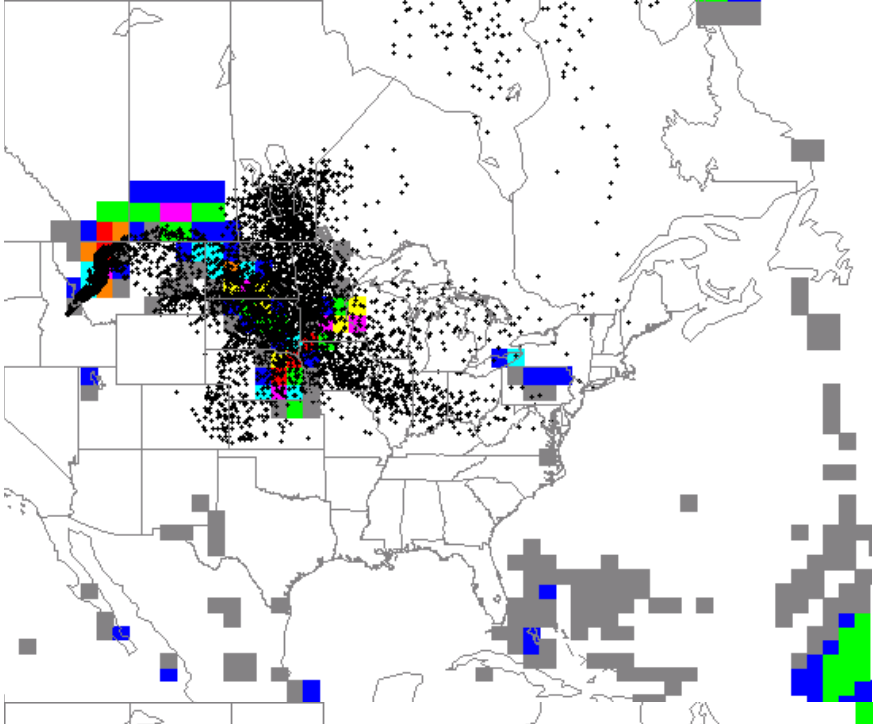

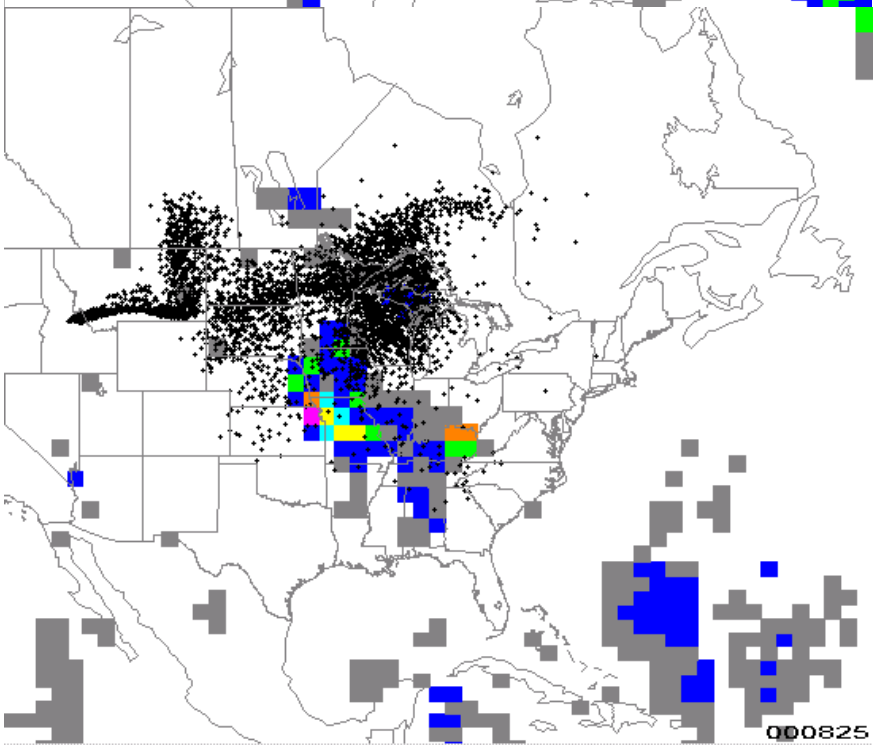
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Flight Path McCall to Missoula 9/9/94 ~ 17:45 to 19:30

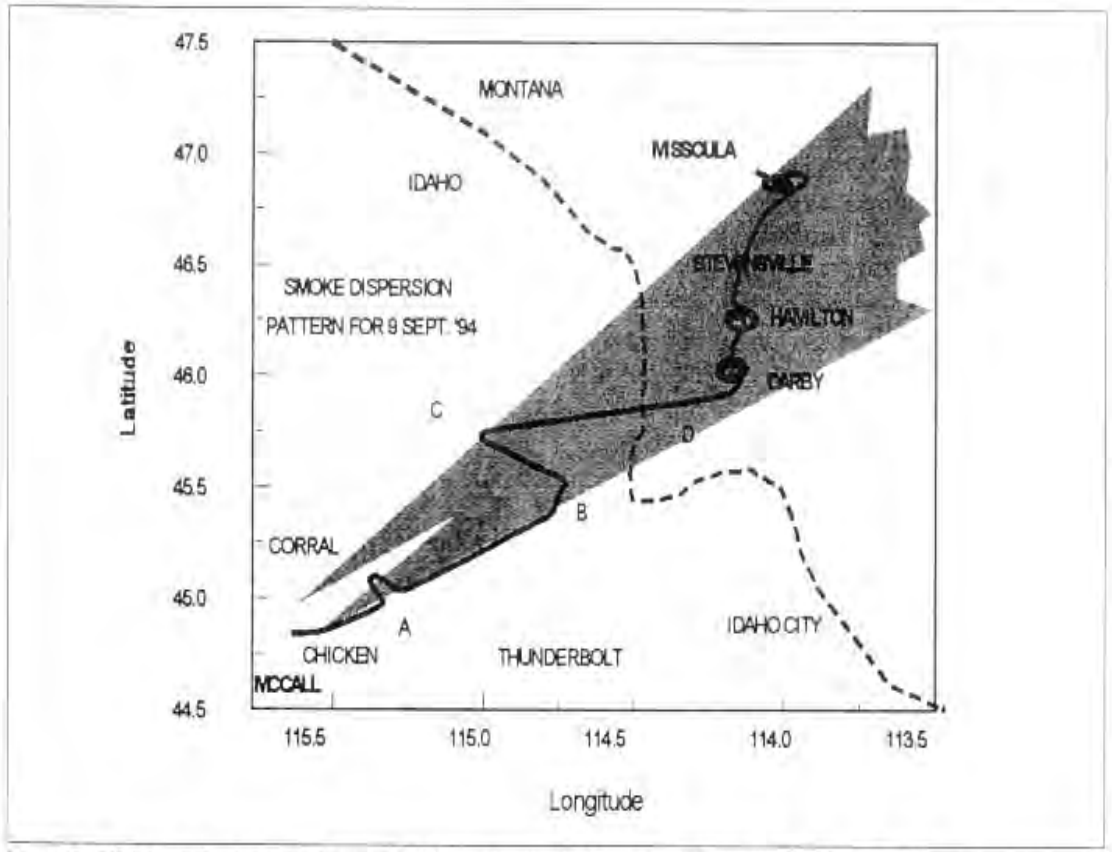


Figure 5. *Flight path for the research mission of September 9, 1994 from near McCall, ID, to Missoula, MT, crisscrossing plumes of the Chicken and Corral/Blackwell fires.*

<u>PM2.5 concentrations</u>

Darby:

120 *u*g/m^3

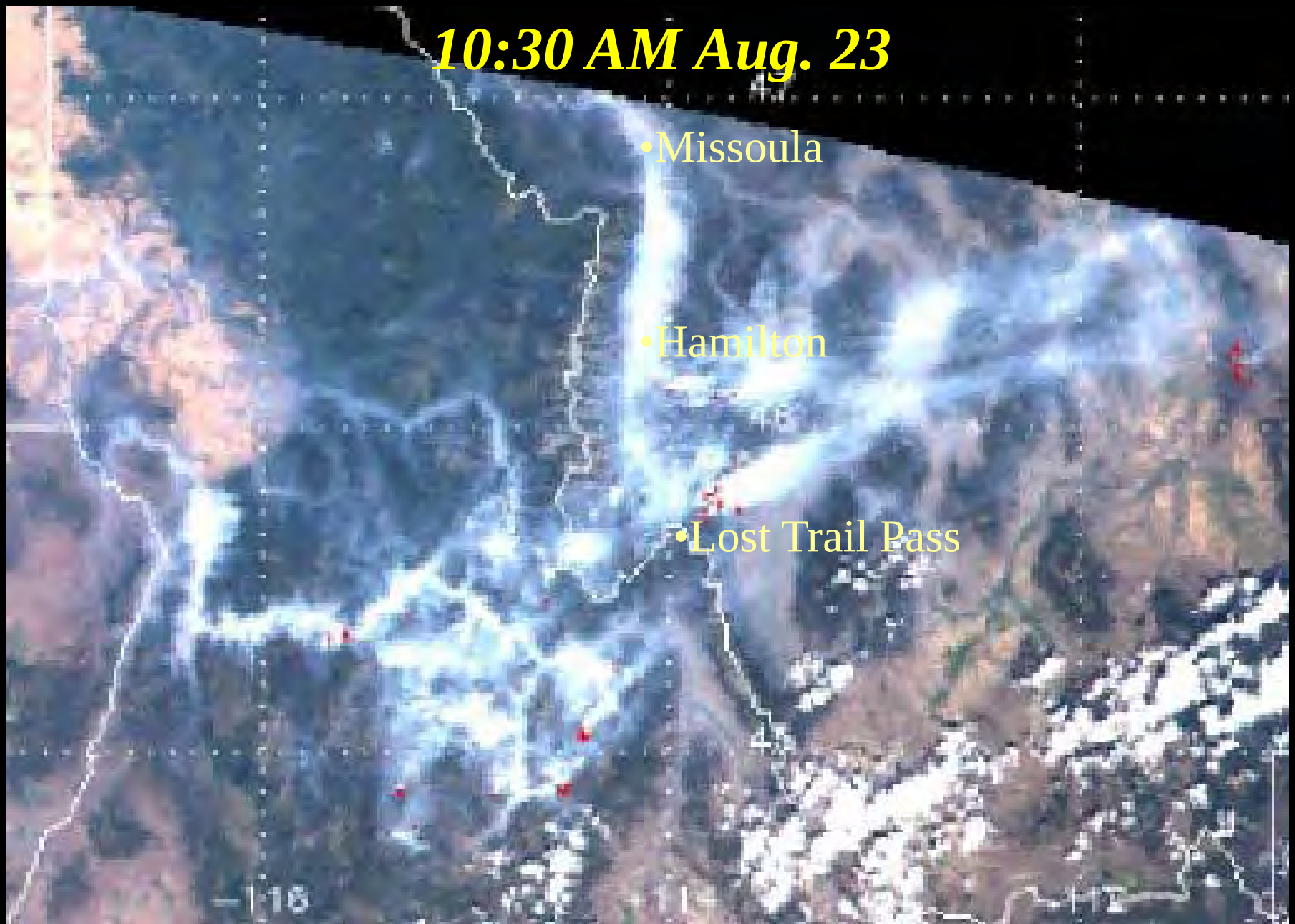
Hamilton:

80 *u*g/m^3

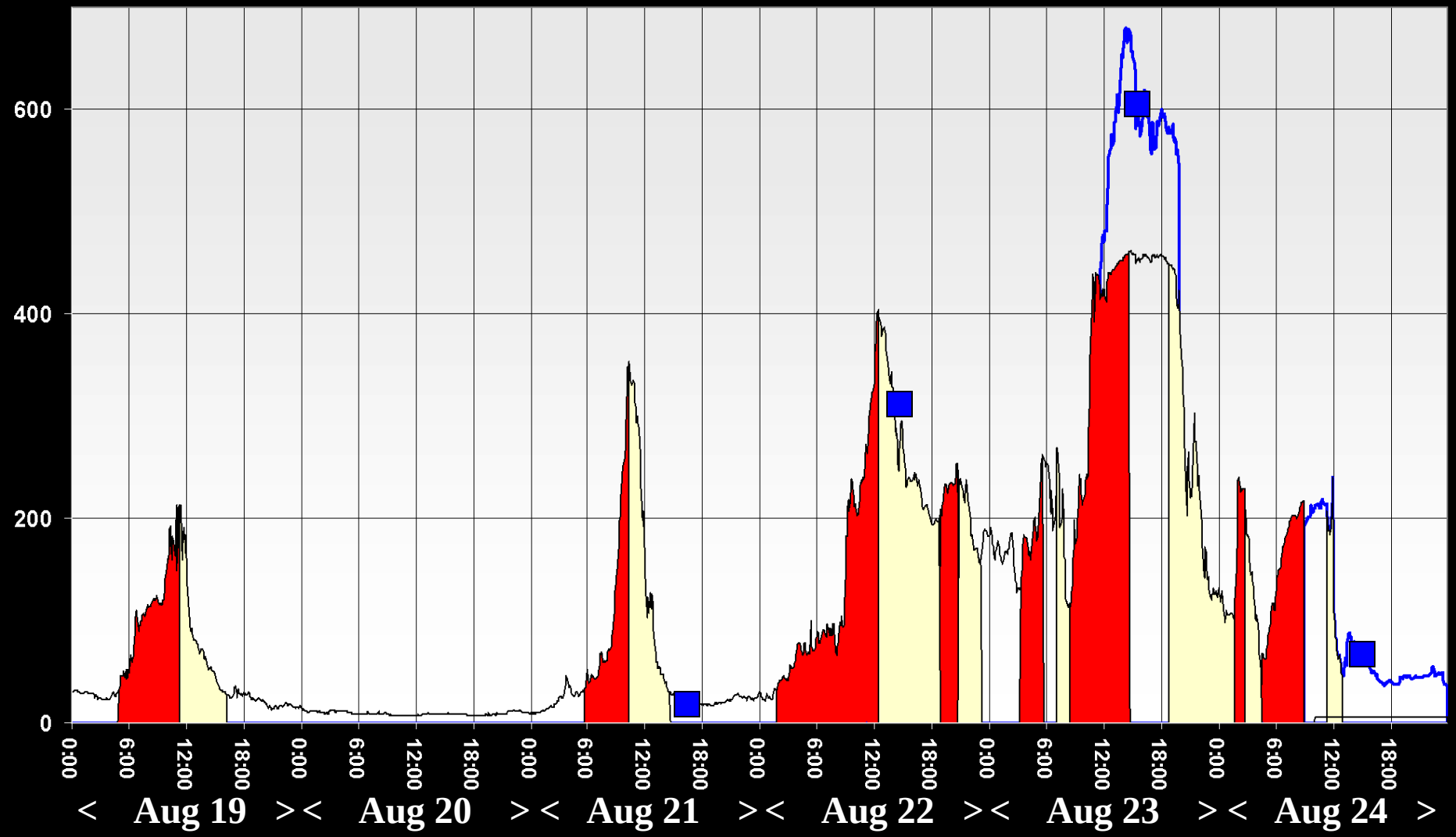
Missoula:

50 *u*g/m^3

MODIS image taken at approximately 10:30 AM Aug. 23



Hamilton MT - PM2.5 Concentration, Aug 19 to Aug 25



Important Observations on the 2k Wildfires in Western Montana

- Within 100 miles of the source, PM2.5 short term concentrations in the range of 100 to 600 ug/m^3 can be expected
- In valley situations, buildup will likely occur during the night, with some clearing in the afternoon
- Duration of high smoke concentrations may last for several weeks
- For shorter periods, areas several hundred miles downwind can be significantly impacted

What to expect in the upcoming years

An increase in prescribed burning - - prescribed burning programs currently substitute for only about 10% of the fires that occur naturally in an ecosystem

More large wildfire events, as prescribed fires will not likely be able to treat all of the high risk acres

An Increase in Smoke

1992 - Maraba, BZ. > 3500 ppm