Natural Haze Levels II: Application of the New IMPROVE Algorithm to Natural Species Concentrations Estimates

Final Report by the

Natural Haze Levels II Committee to the

RPO Monitoring/Data Analysis Workgroup

Note: This presentation contains substantial additional information in the notes section of PowerPoint that can be seen in the bottom panel of the “Normal” view mode, and can be printed by selecting “Notes Pages” from the “Print what” selection of the “Print” menu (go to “Files” on the top tool bar and select “Print”). You can also use “Preview” for the “Notes Pages” to more easily read the notes on your computer monitor.

These notes were prepared

1. to aid those hearing the presentation by relieving them of the burden of taking as many notes;
2. to allow those who haven’t heard the presentation to understand it by providing the additional information that is spoken during presentations; and
3. to provide a more complete documentation of the natural haze levels II approach for anyone who may want to understand it

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Overall Goal

- Estimate 20% best and 20% worst natural haze levels for visibility-protected class I areas using the new IMPROVE algorithm for estimating light extinction from aerosol species concentrations.
  - Needed for Regional Haze Rule (RHR) rate of progress glide slopes where the new IMPROVE algorithm is used to characterize current haze levels
  - Should minimize the technical problems identified in the RHR default natural haze levels that were developed using the original IMPROVE algorithm

Default Natural Haze Levels Approach

- Typical haze level estimates for East and West
  - Typical light extinction by applying the original IMPROVE algorithm to Trijonis natural species concentration estimates for East and West
  - Convert to haze index (deciview units)
- 20% best and 20% worst haze estimate for East and West
  - Best = typical – 1.28(standard deviation)
  - Worst = typical + 1.28(standard deviation)
  - Standard deviation is 3dv for the East and 2dv for the West (corresponds to the 10^{th} and 90^{th} percentile)

Criticism of the Default Approach

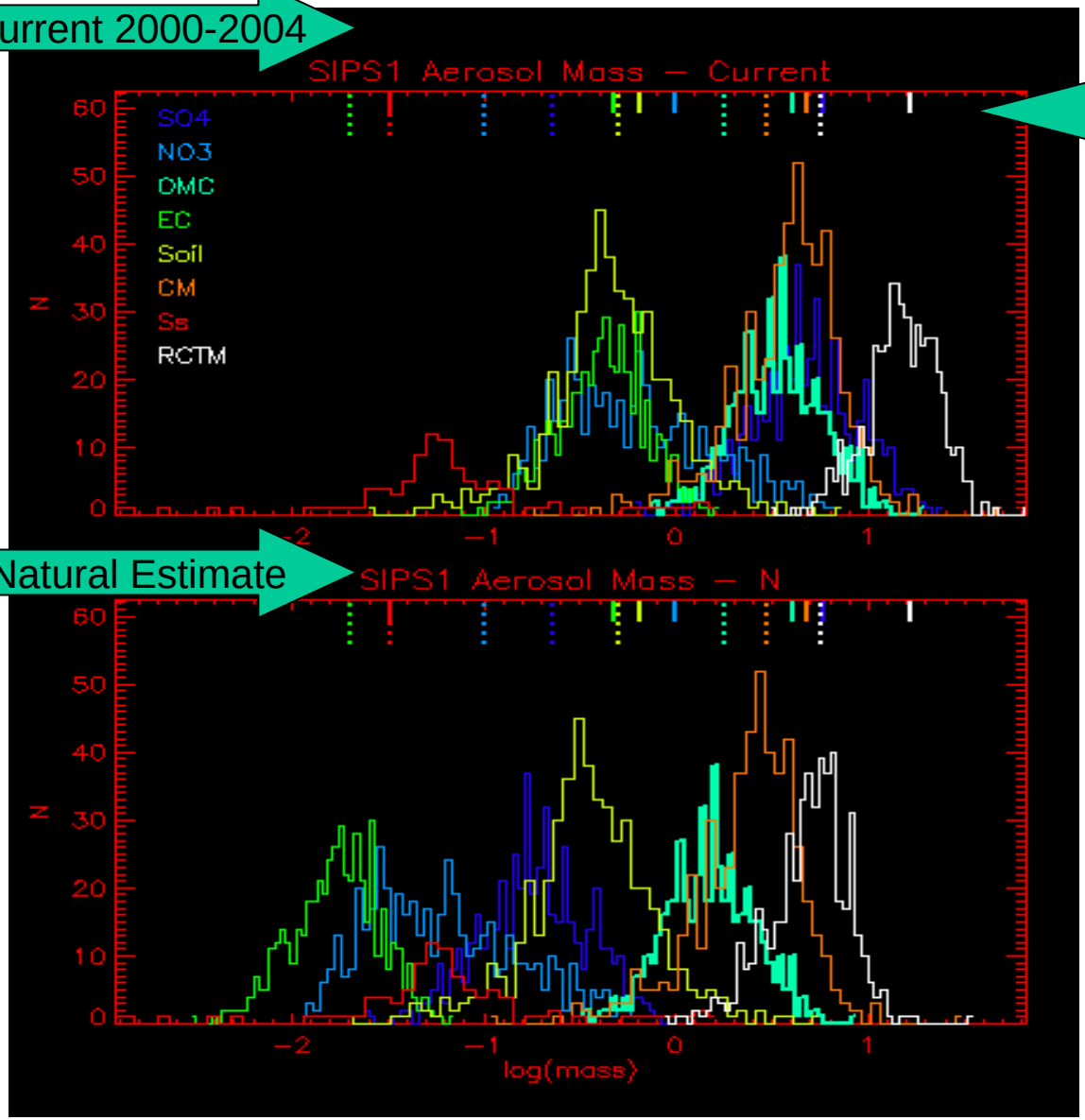
- Limitations of the original IMPROVE algorithm
  - Biased light extinction estimates at the extremes
  - Uses an outdated organic compound mass to carbon mass ratio
  - No sea salt (important at a few sites)
  - Rayleigh scattering of $10Mm^{-1}$ used for all site
- Flawed assumptions used to estimate 20% best and worst conditions
  - Haze index for natural conditions are not likely to be normally distributed due to inclusion of Rayleigh scattering
  - 10^{th} and 90^{th} percentiles don't correspond to the best and worst conditions if the distribution were normal

Natural Haze Levels II Approach

- Adjust each of the measured major species concentrations to the Trijonis natural concentration estimates
  - Multiply each species concentration at a site by the site-specific ratio of the (Trijonis natural estimate) divided by the (annual mean concentration) for the species for the 5 year baseline period
  - If the annual mean concentration for a species is smaller than the Trijonis natural estimate, make no adjustment
  - Current sea salt levels are taken to be natural levels
- Apply the new IMPROVE algorithm to the Trijonis-adjusted species concentrations at each site to produce a distribution of natural light extinction values
- Convert to deciview and calculate the mean of the 20% best and 20% worst haze levels

Trijonis-Adjusted Specie Frequency Distributions

Current 2000-2004

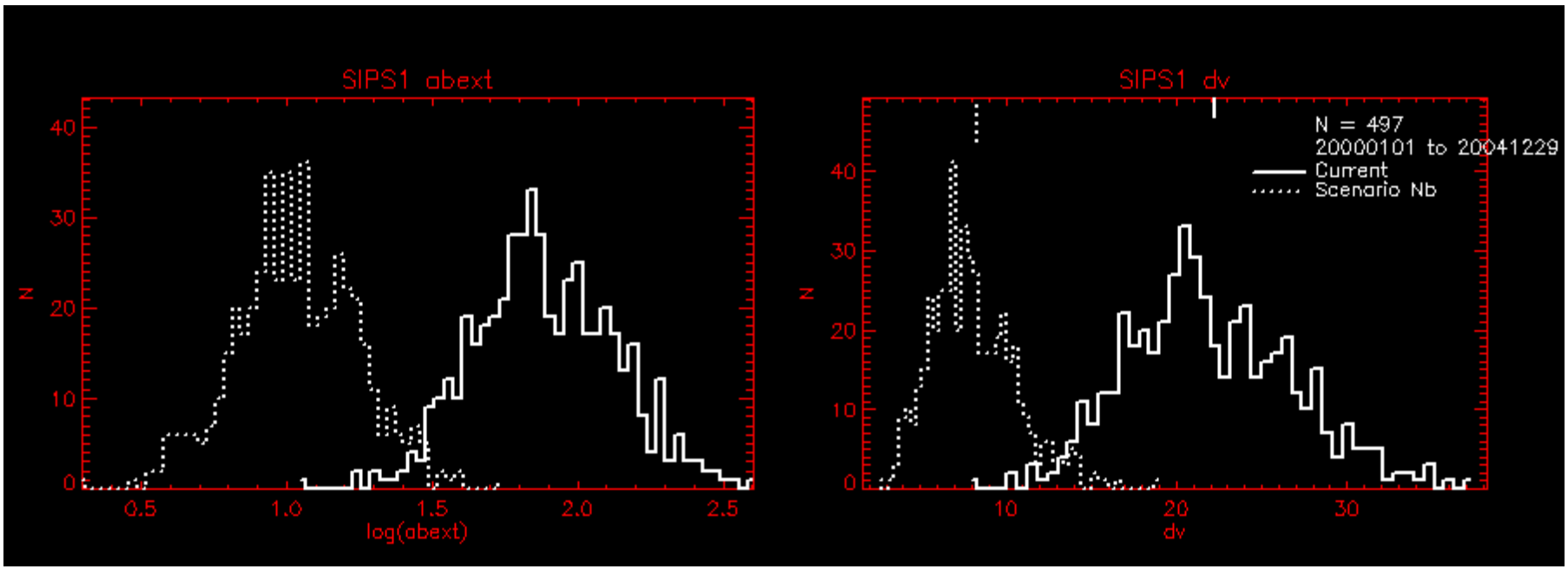


Hanging bars
Solid - current mean
Dashed - natural estimate mean

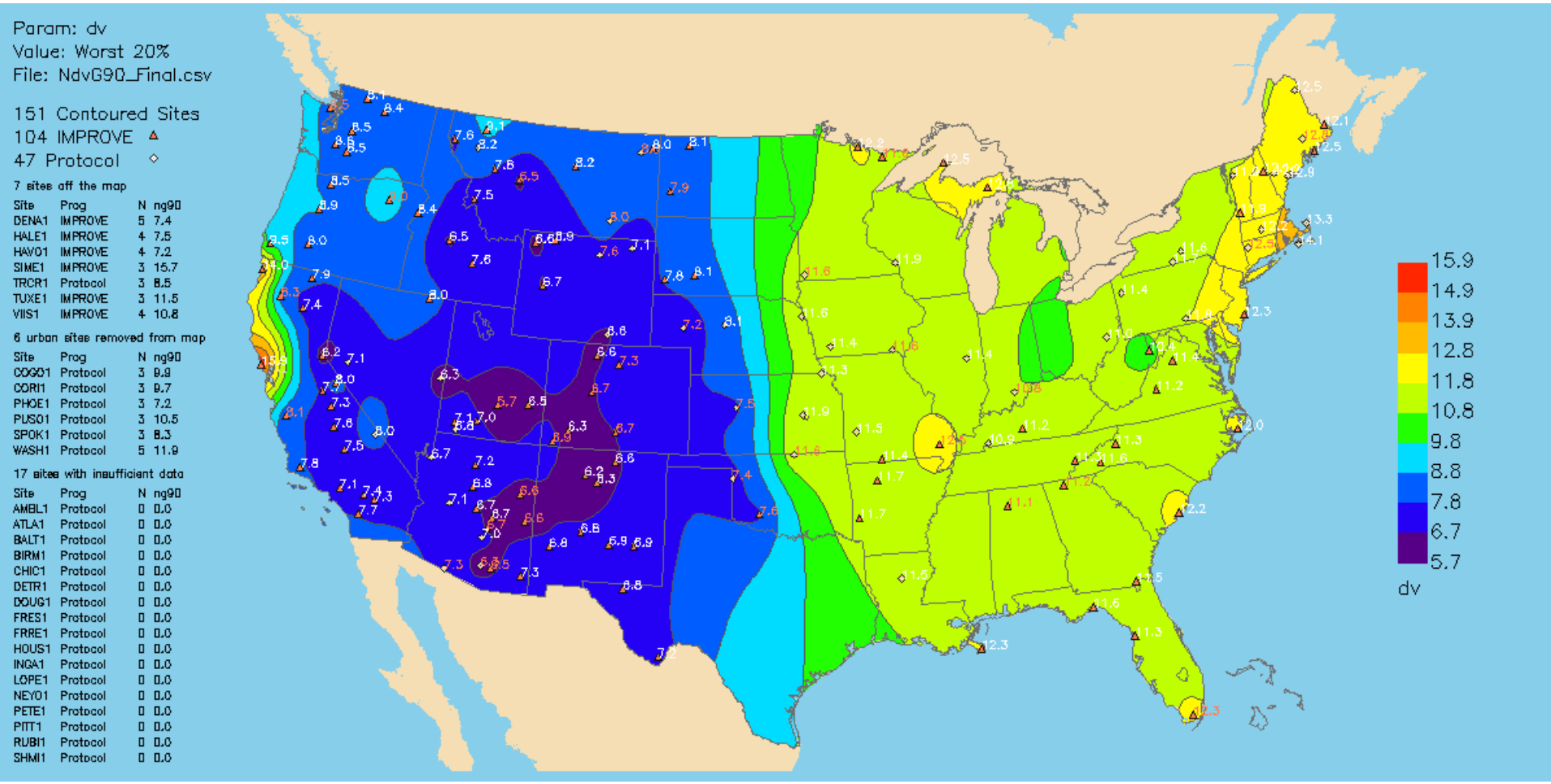
- Sipsey Alabama
- Each aerosol species mass concentration frequency distribution scaled to estimated natural mass concentrations
- If current species mean is less than natural estimate, the that species is not scaled
- Geometric shape of species distributions is unchanged

Current and Natural Haze Frequency Distributions

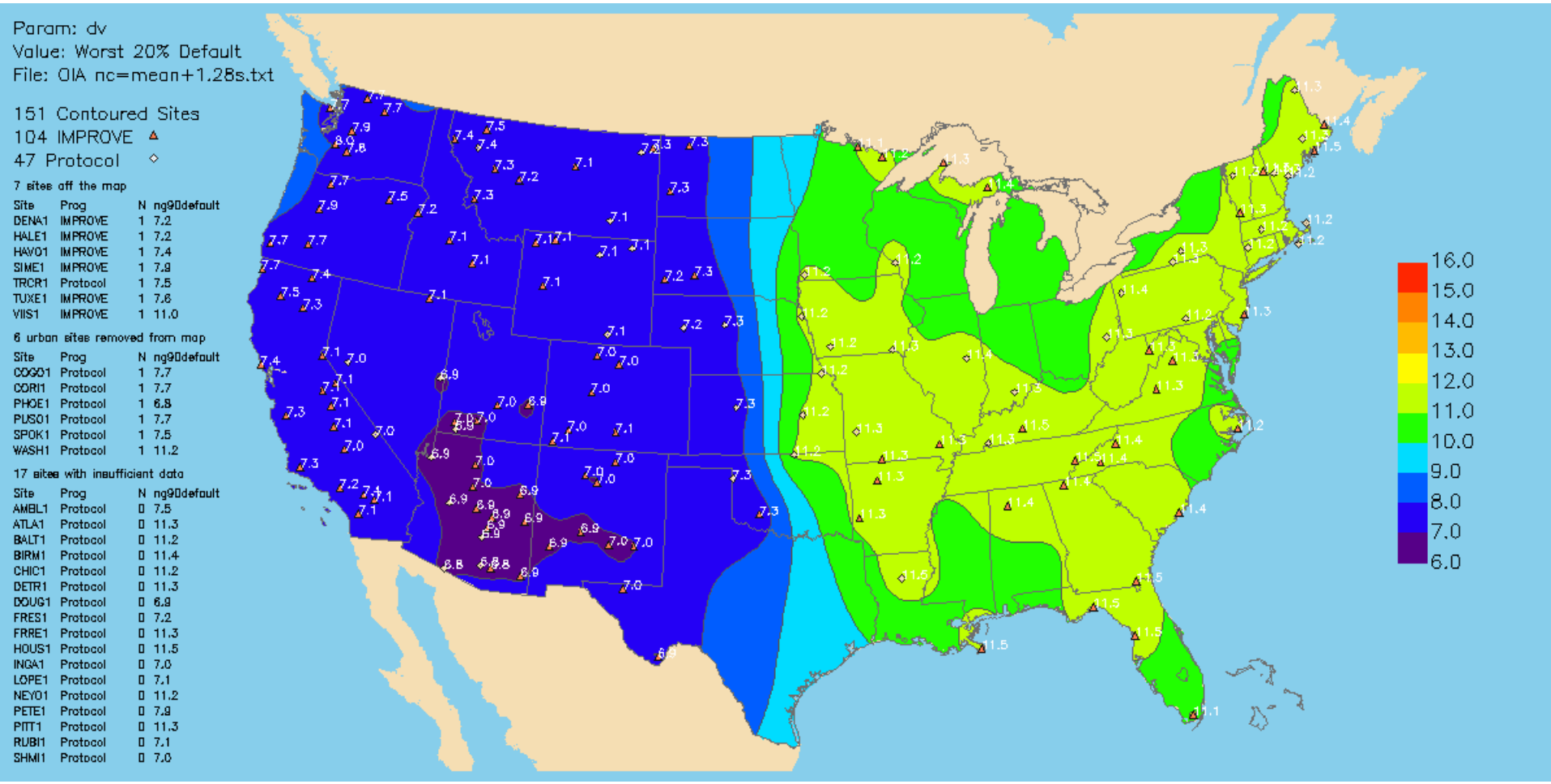
- Sipsey Alabama
- Natural scenario joint distribution shape is derived from scaling current aerosol species mass concentrations to natural condition estimates
- Allows estimation of best and worst 20% dv or aerosol species extinction



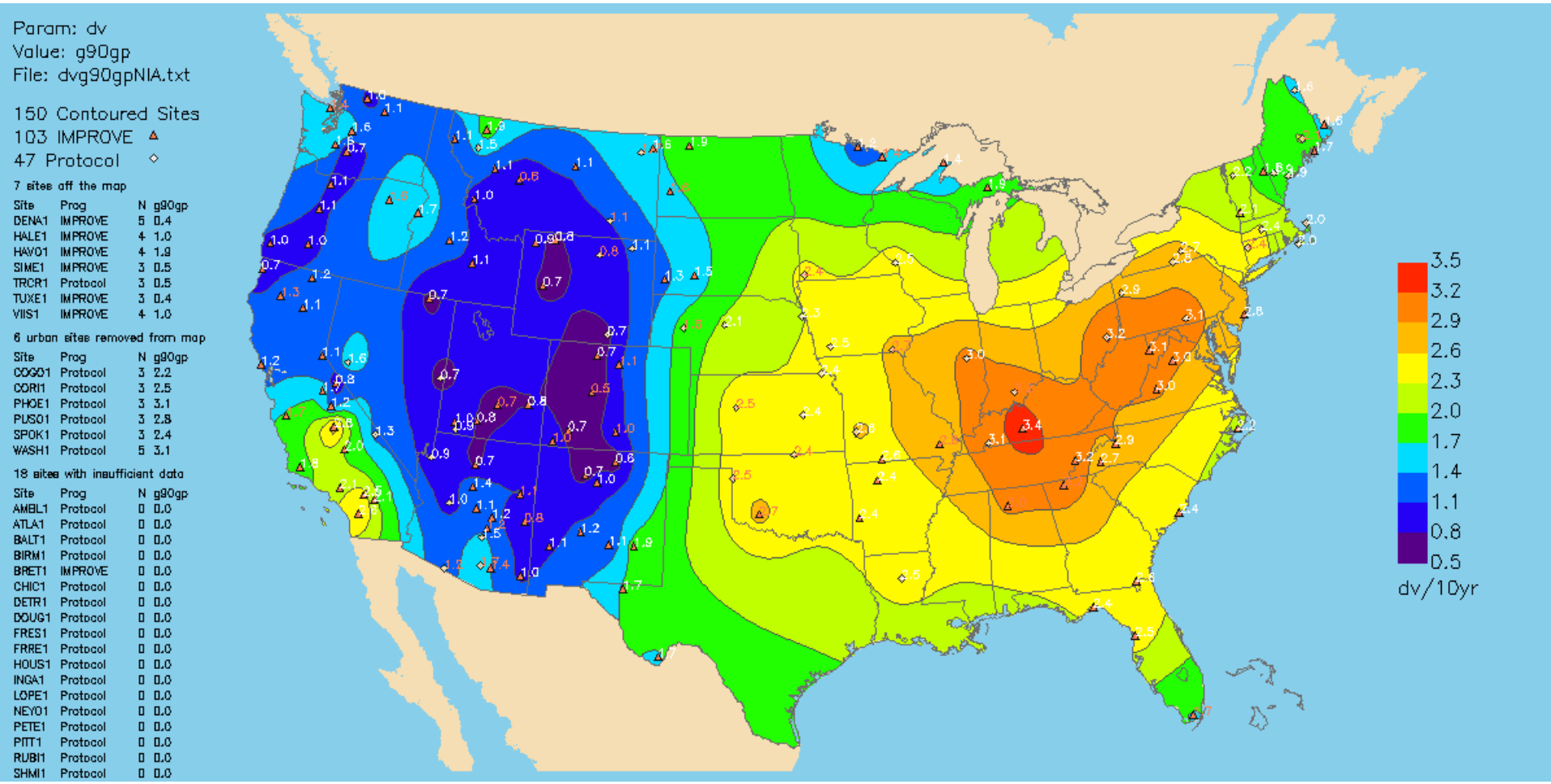
Natural Haze Levels II



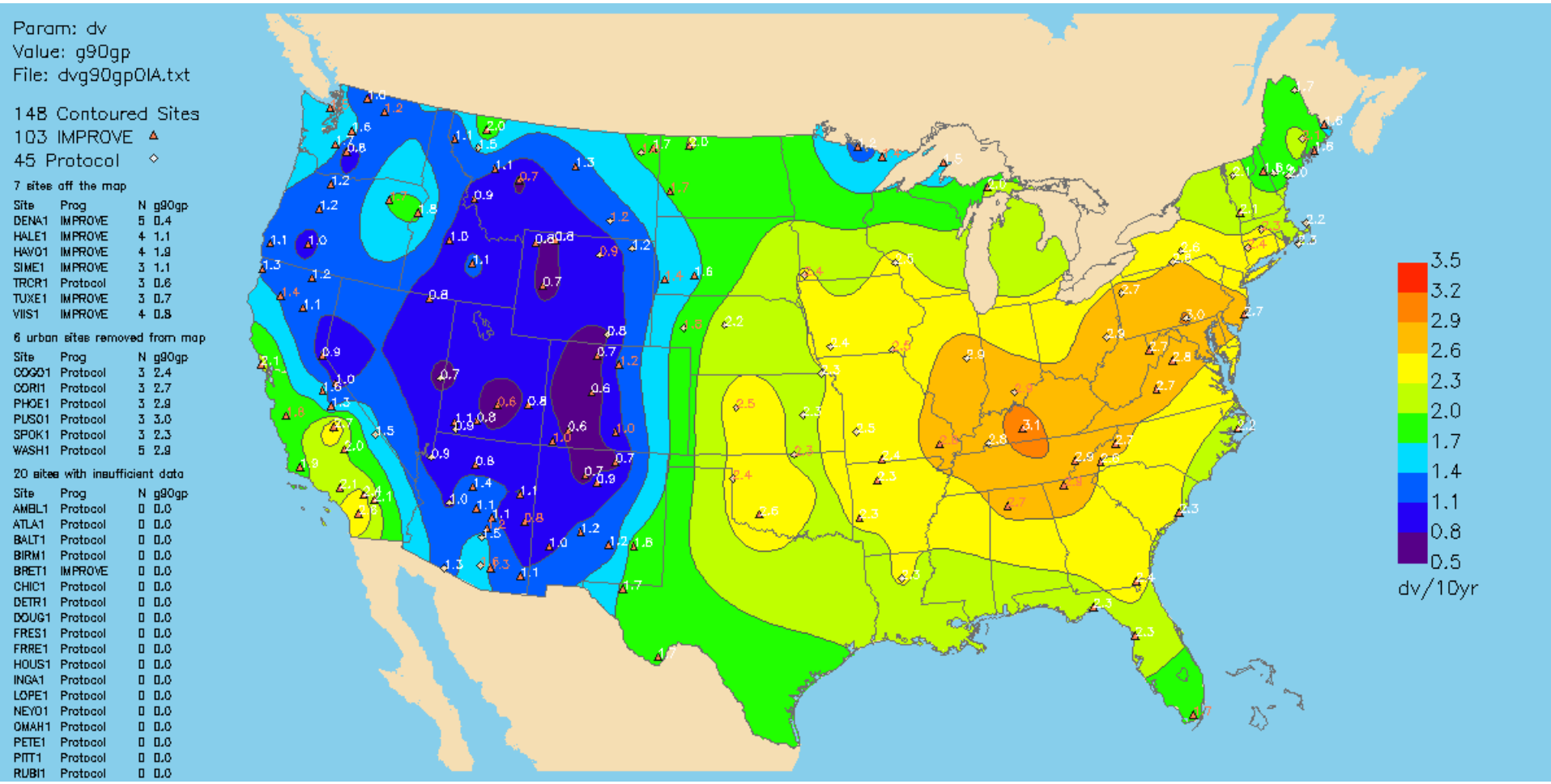
Default Natural Haze Levels



Natural Haze Levels II, 10-Year Rate of Progress Glide Path



Default Natural Haze Levels, 10-Year Rate of Progress Glide Path



Status and Next Steps

- This presentation is the final report of the Natural Haze Levels II Committee of the RPO Monitoring/Data Analysis Workgroup
- Review comments received by August 25, 2006 will be considered in preparation of the RPO Monitoring/Data Analysis Workgroup approved approach
- Workgroup approved approach is forwarded to the RPOs for their consideration by August 31, 2006
- This presentation, including the natural haze estimates and any modifications will be made available on VIEWS

Appendix

- Tables of Natural Haze Level II Estimates for all IMPROVE Sites by RPO and State

CENRAP

Site	Name	State	Complete Years	Worst Haze Natural II (dv)	Worst Haze Baseline (dv)	10-year Glide Slope (dv)	Class I Area(s)
CACR1	Caney Creek	Arkansas	3	11.7	26.4	2.4	Caney Creek
UPBU1	Upper Buffalo Wilderness	Arkansas	5	11.7	26.3	2.4	Upper Buffalo
BRET1	Breton*	Louisiana	4	12.3	0.0	0.0	Breton
BOWA1	Boundary Waters Canoe Area	Minnesota	2	11.6	20.0	1.4	Boundary Waters Canoe Area
VOYA2	Voyageurs NP #2	Minnesota	5	12.2	19.3	1.2	Voyageurs
HEGL1	Hercules-Glades	Missouri	3	11.4	26.7	2.6	Hercules-Glade
MING1	Mingo	Missouri	1	12.5	29.5	2.8	Mingo
WIMO1	Wichita Mountains	Oklahoma	3	7.6	23.8	2.7	Wichita Mountains
BIBE1	Big Bend NP	Texas	4	7.2	17.3	1.7	Big Bend
GUMO1	Guadalupe Mountains NP	Texas	5	6.8	17.2	1.7	Guadalupe Mountains; Carlsbad Caverns

MANE-VU & Midwest RPO

Site	Name	State	Complete Years	Worst Haze Natural II (dv)	Worst Haze Baseline (dv)	10-year Glide Slope (dv)	Class I Area(s)
ACAD1	Acadia NP	Maine	5	12.5	22.9	1.7	Acadia
MOOS1	Moosehorn NWR	Maine	5	12.1	21.7	1.6	Moosehorn; Roosevelt Campobello
GRGU1	Great Gulf Wilderness	New Hampshire	4	12.1	22.8	1.8	Great Gulf; Presidential Range-Dry River
BRIG1	Brigantine NWR	New Jersey	5	12.3	29.0	2.8	Brigantine
LYBR1	Lye Brook Wilderness	Vermont	5	11.9	24.4	2.1	Lye Brook
ISLE1	Isle Royale NP	Michigan	5	12.5	20.7	1.4	Isle Royale
SENE1	Seney	Michigan	5	12.8	24.2	1.9	Seney

VISTAS + VI

Site	Name	State	Complete Years	Worst Haze Natural II (dv)	Worst Haze Baseline (dv)	10-year Glide Slope (dv)	Class I Area(s)
SIPS1	Sipsy Wilderness	Alabama	4	11.1	29.0	3.0	Sipsey
CHAS1	Chassahowitzka NWR	Florida	3	11.3	26.1	2.5	Chassahowitzka
EVER1	Everglades NP	Florida	4	12.3	22.3	1.7	Everglades
SAMA1	St. Marks	Florida	2	11.6	26.0	2.4	Saint Marks
COHU1	Cohutta	Georgia	2	11.2	30.3	3.2	Cohutta
OKEF1	Okefenokee NWR	Georgia	5	11.5	27.1	2.6	Okefenokee; Wolf Island
MACA1	Mammoth Cave NP	Kentucky	5	11.2	31.4	3.4	Mammoth Cave
LIGO1	Linville Gorge	North Carolina	4	11.3	28.8	2.9	Linville Gorge
SHRO1	Shining Rock Wilderness	North Carolina	2	11.6	27.9	2.7	Shining Rock
SWAN1	Swanquarter	North Carolina	2	12.0	25.5	2.2	Swanquarter
ROMA1	Cape Romain NWR	South Carolina	5	12.2	26.5	2.4	Cape Romain
GRSM1	Great Smoky Mountains NP	Tennessee	5	11.3	30.3	3.2	Great Smoky Mountains; Joyce Kilmer-Slickrock
JARI1	James River Face Wilderness	Virginia	4	11.2	29.1	3.0	James River Face
SHEN1	Shenandoah NP	Virginia	5	11.4	29.3	3.0	Shenandoah
DOSO1	Dolly Sods Wilderness	West Virginia	5	10.4	29.0	3.1	Dolly Sods; Otter Creek
VIIS1	Virgin Islands NP	Virgin Islands	4	10.8	17.0	1.0	Virgin Islands

WRAP

Site	Name	State	Complete Years	Worst Haze Natural II (dv)	Worst Haze Baseline (dv)	10-year Glide Slope (dv)	Class I Area(s)
DENA1	Denali NP	Alaska	5	7.4	9.9	0.4	Denali
SIME1	Simeonof	Alaska	3	15.7	18.6	0.5	Simeonof
TUXE1	Tuxedni	Alaska	3	11.5	14.1	0.4	Tuxedni
BALD1	Mount Baldy	Arizona	2	6.6	11.5	0.8	Mount Baldy
CHIR1	Chiricahua NM	Arizona	5	7.3	13.4	1.0	Chiricahua NM; Chiricahua W; Galiuro
GRCA2	Hance Camp at Grand Canyon NP	Arizona	4	7.2	11.7	0.7	Grand Canyon
IKBA1	Ike's Backbone	Arizona	4	6.7	13.3	1.1	Mazatzal; Pine Mountain
PEFO1	Petrified Forest NP	Arizona	5	6.6	13.2	1.1	Petrified Forest
SAGU1	Saguaro NM	Arizona	3	6.5	14.8	1.4	Saguaro
SIAN1	Sierra Ancha	Arizona	4	6.7	13.7	1.2	Sierra Ancha
SYCA1	Sycamore Canyon	Arizona	4	6.8	15.3	1.4	Sycamore Canyon
TONT1	Tonto NM	Arizona	3	6.7	13.9	1.2	Superstition

WRAP

Site	Name	State	Complete Years	Worst Haze Natural II (dv)	Worst Haze Baseline (dv)	10-year Glide Slope (dv)	Class I Area(s)
AGTI1	Agua Tibia	California	4	7.7	23.5	2.6	Agua Tibia
BLIS1	Bliss SP (TRPA)	California	4	6.2	12.6	1.1	Desolation; Mokelumne
DOME1	Dome Lands Wilderness	California	4	7.5	19.4	2.0	Dome Land
HOOV1	Hoover	California	3	8.0	12.9	0.8	Hoover
JOSH1	Joshua Tree NP	California	4	7.3	19.6	2.1	Joshua Tree
KAIS1	Kaiser	California	2	7.3	14.8	1.2	Ansel Adams; Kaiser; John Muir
LABE1	Lava Beds NM	California	4	7.9	15.1	1.2	Lava Beds; South Warner
LAVO1	Lassen Volcanic NP	California	5	7.4	14.1	1.1	Lassen Volcanic; Caribou; Thousand Lakes; Caribou; Thousand Lakes
PINN1	Pinnacles NM	California	4	8.1	18.5	1.7	Pinnacles; Ventana
PORE1	Point Reyes National Seashore	California	3	15.9	22.8	1.2	Point Reyes
RAFA1	San Rafael	California	2	7.8	18.9	1.8	San Rafael
REDW1	Redwood NP	California	5	14.0	18.5	0.7	Redwood
SAGA1	San Gabriel	California	3	7.1	19.9	2.1	San Gabriel; Cucamonga
SAGO1	San Gorgonio Wilderness	California	4	7.4	22.2	2.5	San Gorgonio; San Jacinto
SEQU1	Sequoia NP	California	3	7.6	24.6	2.8	Sequoia; Kings Canyon
TRIN1	Trinity	California	3	8.3	16.3	1.3	Marble Mountain; Yolla Bolly-Middle Eel
YOSE1	Yosemite NP	California	5	7.7	17.6	1.7	Yosemite; Emigrant

WRAP

Site	Name	State	Complete Years	Worst Haze Natural II (dv)	Worst Haze Baseline (dv)	10-year Glide Slope (dv)	Class I Area(s)
GRSA1	Great Sand Dunes NM	Colorado	5	6.7	12.8	1.0	Great Sand Dunes
MEVE1	Mesa Verde NP	Colorado	5	6.9	13.0	1.0	Mesa Verde
MOZI1	Mount Zirkel Wilderness	Colorado	4	6.6	10.5	0.7	Mount Zirkel; Rawah
ROMO1	Rocky Mountain NP	Colorado	5	7.3	13.8	1.1	Rocky Mountain
WEMI1	Weminuche Wilderness	Colorado	4	6.3	10.3	0.7	La Garita; Black Canyon of the Gunnison; Weminuche
WHRI1	White River NF	Colorado	4	6.7	9.6	0.5	Flat Tops; Maroon Bells-Snowmass; West Elk; Eagles Nest
HALE1	Haleakala NP	Hawaii	4	7.5	13.3	1.0	Haleakala
HAVO1	Hawaii Volcanoes NP	Hawaii	4	7.2	18.9	1.9	Hawaii Volcanoes
CRMO1	Craters of the Moon NM	Idaho	4	7.6	14.0	1.1	Craters of the Moon
SAWT1	Sawtooth NF	Idaho	4	6.5	13.8	1.2	Sawtooth
CABI1	Cabinet Mountains	Montana	4	7.6	14.1	1.1	Cabinet Mountains
GAMO1	Gates of the Mountains	Montana	4	6.5	11.3	0.8	Gates of the Mountains
GLAC1	Glacier NP	Montana	3	9.1	20.5	1.9	Glacier
MELA1	Medicine Lake	Montana	5	8.0	17.7	1.6	Medicine Lake
MONT1	Monture	Montana	4	7.8	14.5	1.1	Bob Marshall; Mission Mountains; Scapegoat
SULA1	Sula Peak	Montana	4	7.5	13.4	1.0	Selway-Bitterroot; Anaconda-Pintler
ULBE1	UL Bend	Montana	4	8.2	15.1	1.1	UL Bend

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JARB1	Jarbidge Wilderness	Nevada	4	8.0	12.1	0.7	Jarbidge
BAND1	Bandelier NM	New Mexico	5	6.3	12.2	1.0	Bandelier
BOAP1	Bosque del Apache	New Mexico	3	6.8	13.8	1.2	Bosque del Apache
GICL1	Gila Wilderness	New Mexico	4	6.8	13.1	1.1	Gila
SACR1	Salt Creek	New Mexico	4	6.9	18.0	1.9	Salt Creek
SAPE1	San Pedro Parks	New Mexico	4	6.2	10.2	0.7	San Pedro Parks
WHIT1	White Mountain	New Mexico	3	6.9	13.7	1.1	White Mountain
WHPE1	Wheeler Peak	New Mexico	3	6.6	10.4	0.6	Wheeler Peak; Pecos
LOST1	Lostwood	North Dakota	5	8.1	19.6	1.9	Lostwood
THRO1	Theodore Roosevelt	North Dakota	4	7.9	17.7	1.6	Theodore Roosevelt
CRLA1	Crater Lake NP	Oregon	3	8.0	13.7	1.0	Gearhart Mountain; Crater Lake; Diamond Peak; Mountain Lakes
HECA1	Hells Canyon	Oregon	3	8.4	18.6	1.7	Hells Canyon
KALM1	Kalmiopsis	Oregon	4	9.5	15.5	1.0	Kalmiopsis
MOHO1	Mount Hood	Oregon	4	8.5	14.9	1.1	Mount Hood
STAR1	Starkey	Oregon	4	9.0	18.6	1.6	Eagle Cap; Strawberry Mountain
THSI1	Three Sisters Wilderness	Oregon	5	8.9	15.3	1.1	Three Sisters; Mount Jefferson; Mount Washington

WRAP

Site	Name	State	Complete Years	Worst Haze Natural II (dv)	Worst Haze Baseline (dv)	10-year Glide Slope (dv)	Class I Area(s)
BADL1	Badlands NP	South Dakota	5	8.1	17.1	1.5	Badlands
WICA1	Wind Cave	South Dakota	5	7.8	15.8	1.3	Wind Cave
BRCA1	Bryce Canyon NP	Utah	5	7.0	11.6	0.8	Bryce Canyon
CANY1	Canyonlands NP	Utah	5	6.5	11.2	0.8	Canyonlands; Arches
CAPI1	Capitol Reef NP	Utah	2	5.7	10.0	0.7	Capitol Reef
ZION1	Zion	Utah	3	7.1	13.2	1.0	Zion
MORA1	Mount Rainier NP	Washington	4	8.6	18.2	1.6	Mount Rainier
NOCA1	North Cascades	Washington	2	8.1	14.0	1.0	North Cascades; Glacier Peak
OLYM1	Olympic	Washington	3	8.5	16.7	1.4	Olympic
PASA1	Pasayten	Washington	4	8.4	15.2	1.1	Pasayten
SNPA1	Snoqualmie Pass	Washington	4	8.5	17.8	1.6	Alpine Lakes
WHPA1	White Pass	Washington	4	8.5	12.8	0.7	Mount Adams; Goat Rocks
BRID1	Bridger Wilderness	Wyoming	5	6.7	11.1	0.7	Bridger; Fitzpatrick
NOAB1	North Absaroka	Wyoming	3	6.9	11.5	0.8	North Absaroka; Washakie
YELL2	Yellowstone NP 2	Wyoming	5	6.6	11.8	0.9	Yellowstone; Red Rock Lakes; Grand Teton; Teton