Resource Injury Indices

To quantify ozone exposure to plants, various indices other than the NAAQS primary and secondary standards are often used. These indices, defined below, take into account both peak ozone concentrations and cumulative exposure to ozone.

- W126 – A cumulative index that is calculated as the maximum 3-month sum of the 0800-2000 hourly average ozone concentrations during the EPA-designated ozone season, where a weighting function is used to give increasing significance (weights between 0 and 1) to concentrations of ozone greater than 0.04 ppm (40 ppb), and no weight to concentrations below 0.04 ppm (40 ppb). Units of this index are ppm-hr. EPA considered using the W126 metric for the secondary standard in its recent review of the ozone NAAQS. In its technical review, EPA recognized that the W126 was a more biologically relevant measure of ozone exposure to plants. NPS supported a secondary standard of 7-9 ppm-hr.
- SUM06 – A cumulative index that is calculated as the maximum 3-month sum of the 0800-2000 hourly average ozone concentrations during the ozone season that are equal to or greater than 0.06 ppm (60 ppb). The units of this index are ppm-hr. Several thresholds have been developed for SUM06 (Heck and Cowling, 1997[5]).

Table 10 displays the W126 and SUM06 thresholds for ozone effects to vegetation.

Table 11 presents the ozone exposure indices summary statistics for 2007. Summaries for POMS are included for reference only. Since portable sites are deployed for seasonal use, there may be significant biases in W126 and SUM06 exposure indices calculated from their data. These statistics were not calculated for sites that were operational for less than three months during the year. In 2007 these sites were Agate Fossil Beds and Olympic.

Figure 11 presents the 3-month maximum W126 exposure index. Figure 12 presents the annual 3-month maximum SUM06 exposure index for all network sites listed in Table 11. Index values are color-coded to represent three distinct levels of cumulative exposure. Data from portable sites (no color) are included for reference only.

Ozone effects depend not only on ozone exposure, but on other factors that may ameliorate or magnify the extent of ozone injury, including soil moisture, presence of other air pollutants, insects or diseases, and other environmental stresses. A high W126 exposure in a drought year, for example, may not result in vegetation injury because stomatal closure to prevent moisture loss will also prevent ozone uptake.

In 2006, assessments were completed to evaluate the potential for ozone injury to vegetation at many national park service units. The assessments are available at *http://www.nature.nps.gov/air/pubs/ecoeffects.cfm*. Information on ozone-sensitive plant species is available at *http://www.nature.nps.gov/air/pubs/pdf/baltfinalreport1.pdf*.

Table 10. W126 and SUM06 thresholds for ozone effects to vegetation (based on 3-month, 12-hour exposure)[5]

	W126	SUM06
Growth Reduction		
Tree seedlings - natural forest stands	7-13 ppm-hrs	10-15 ppm-hrs
Tree seedlings/saplings - plantations	9-14 ppm-hrs	12-16 ppm-hrs
Visible Foliar Injury		
Plants in natural ecosystems	5-9 ppm-hrs	8-12 ppm-hrs

Table 11. 2007 Summary of indices for resource injury (W126 and SUM06).

National Park Unit	Site Name	O_3% Valid	W126[a] (ppm-hr)	SUM06[b] (ppm-hr)
Sites operated by the National Park Service				
Badlands	Visitor Center	99.8	5.9	4.5
Big Bend	K-Bar Ranch Road	98.8	17.5	17.3
Canyonlands	Island in the Sky	97.2	27.9	33.0
Chiricahua	Entrance Station	97.1	18.4	20.8
Craters of the Moon	Visitor Center	60.4	14.7	10.7
Death Valley	Park Village	97.3	51.4	80.0
Denali	Headquarters	97.3	4.0	0.0
Glacier	West Glacier Horse Stables	96.2	0.9	0.0
Grand Canyon	The Abyss	97.6	32.7	48.4
Great Basin	Maintenance Yard	96.6	27.8	34.3
Great Smoky Mountains	Clingmans Dome	95.6	53.4	79.9
Great Smoky Mountains	Cove Mountain	99.6	45.6	65.9
Great Smoky Mountains	Look Rock	99.7	42.9	61.9
Joshua Tree	Black Rock	95.5	88.2	119.0
Joshua Tree	Cottonwood Canyon	77.0	30.0	41.1
Lassen Volcanic	Manzanita Lake Fire Station	99.7	18.9	23.5
Mammoth Cave	Houchin Meadow	99.3	25.1	35.0
Mesa Verde	Resource Management Area	98.5	25.9	32.0
Mount Rainier	Tahoma Woods	97.0	1.9	1.6
North Cascades	Marblemount Ranger Station	98.7	1.2	0.2
Petrified Forest	South Entrance	86.6	19.9	25.3
Pinnacles	SW of East Entrance Station	99.7	15.5	20.6
Rocky Mountain	Long's Peak	96.7	25.7	31.4
Sequoia and Kings Canyon	Ash Mountain	69.0	75.5	111.2
Sequoia and Kings Canyon	Lower Kaweah	99.6	75.6	102.2
Shenandoah	Big Meadows	96.2	25.1	39.2
Voyageurs	Sullivan Bay	94.9	7.8	5.3
Yellowstone	Water Tank	96.7	13.7	11.9
Yosemite	Turtleback Dome	96.6	44.4	67.0
Zion	Dalton's Wash	92.0	24.5	34.9
Sites operated by cooperating state agencies				
Acadia	Cadillac Mountain	99.3	14.5	16.2
Acadia	McFarland Hill	99.5	10.9	10.9
Cape Cod	Cape Cod	94.1	17.4	20.6
Chamizal	Chamizal	99.0	14.2	17.2
Congaree	Congaree Bluff	93.0	10.1	13.3
Cowpens	State Monitor	98.9	8.7	9.1
Great Smoky Mountains	Cades Cove	99.2	15.5	22.2
Great Smoky Mountains	Purchase Knob	94.4	26.9	36.6
Mount Rainier	Jackson Visitor's Center	86.9	4.6	3.9
Saguaro	Pima County	98.4	19.9	24.5
Theodore Roosevelt	Painted Canyon Visitor Center	96.8	5.9	3.4
Wind Cave	Visitor Center	99.8	9.7	8.8

Table 11. 2007 Summary of indices for resource injury (W126 and SUM06) (continued).

National Park Unit	Site Name	O_3% Valid	W126[a] (ppm-hr)	SUM06[b] (ppm-hr)
Nearby sites operated by other agencies				
Alabama-Coushatta	CASTNet site	65.9	3.8	2.9
Appalachian Trail	Mount Greylock Summit	96.6	24.0	31.3
Blue Ridge Parkway	7510 Blue Ridge Parkway	89.8	10.5	13.8
Blue Ridge Parkway	Barnet Knob Firetower Road	92.2	21.2	34.4
Blue Ridge Parkway	Frying Pan Mountain	92.3	32.2	52.4
Blue Ridge Parkway	Route 191	99.7	14.7	18.8
Blue Ridge Parkway	Ranger Station	97.5	8.1	8.9
Blue Ridge Parkway	Vinton Elementary	99.7	15.8	19.4
Boston Harbor Islands	Former Nike Missile Site	29.2	3.2	2.1
Cuyahoga Valley	800 Patterson	99.8	23.9	31.5
Everglades	Cutler Road	98.8	12.2	11.1
George Washington Pkwy	Alexandria Health	100.0	19.0	24.0
Guilford Courthouse	Mendenhall Middle School	92.8	25.9	37.1
Indiana Dunes	Ammunition Bunker	91.2	13.4	17.2
Indiana Dunes	Gas Station	90.5	6.2	6.2
Indiana Dunes	Water Treatment Plant	97.1	14.9	19.9
Mississippi	Anoka County Airport	99.2	9.6	10.9
Mississippi	Somerset Town Hall	99.1	9.8	10.0
Mississippi	Washington County	98.0	10.0	10.8
Mount Baker	Mount Baker	94.4	0.9	0.0
Petroglyph	Westside Taylor Ranch	99.7	18.5	25.4
Rock Creek	Achbold Parkway	97.8	17.2	22.4
Saratoga	Stillwater	98.6	13.1	15.0
Saugus Iron Works	Lynn Water Treatment	97.5	12.0	13.7
Portable ozone monitoring systems				
Abraham Lincoln Birthplace	Visitor Center	98.4	12.1	14.8
Assateague Island	Maintenance Area	90.5	15.5	20.0
Carlsbad Caverns	Maintenance Area	82.7	11.0	9.0
Colorado	Maintenance Yard	91.8	9.1	9.2
Cumberland Gap	Hensley Settlement	99.3	37.8	52.1
Dinosaur	West Entrance Housing	99.9	12.2	7.4
Joshua Tree	Pinto Wells	94.6	33.6	51.1
Mojave	Kelso Mountains	82.2	50.4	75.6
Natchez Trace Parkway	Dancy Ranger Station	100.0	8.6	10.0
Padre Island	Malaquite Visitor Center	88.6	13.4	19.6
Yosemite	School Yard	98.2	7.3	6.1

[a] W126 exposure index represents 0800-2000 hourly ozone concentrations where each concentration is weighted by a function that gives greater emphasis to the higher hourly concentrations while still including the lower ones. The value reported here represents a three-month maximum value during the ozone season. Units are ppm-hr. For more information on the W126 exposure index go to *http://www.nature.nps.gov/air/maps/AirAtlas/docs/air_quality_glossary.pdf*.

[b] SUM06 exposure index represents the 0800-2000 hourly ozone concentrations equaling or exceeding 0.06 ppm. The value reported here represents a three-month maximum value during the ozone season. Units are ppm-hr.

Operating agency key: plain text = site operated by the National Park Service; *italics* = site operated by a state agency; underline = site operated by the National Park Service, but consisting of non-EPA certified portable instrumentation

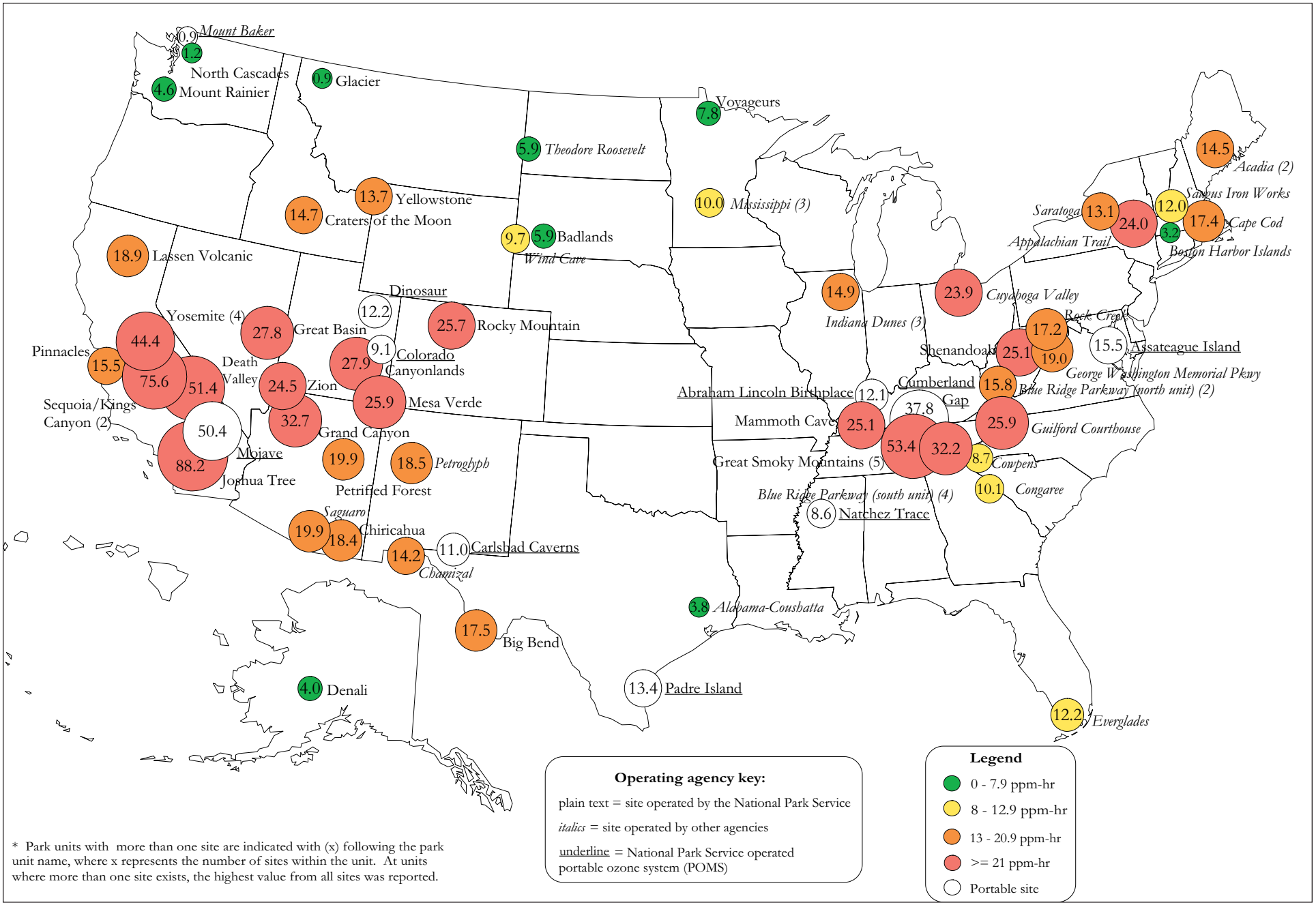

Figure 11. 2007 3-month maximum W126 exposure index during the ozone season (0800-2000 hourly concentrations).

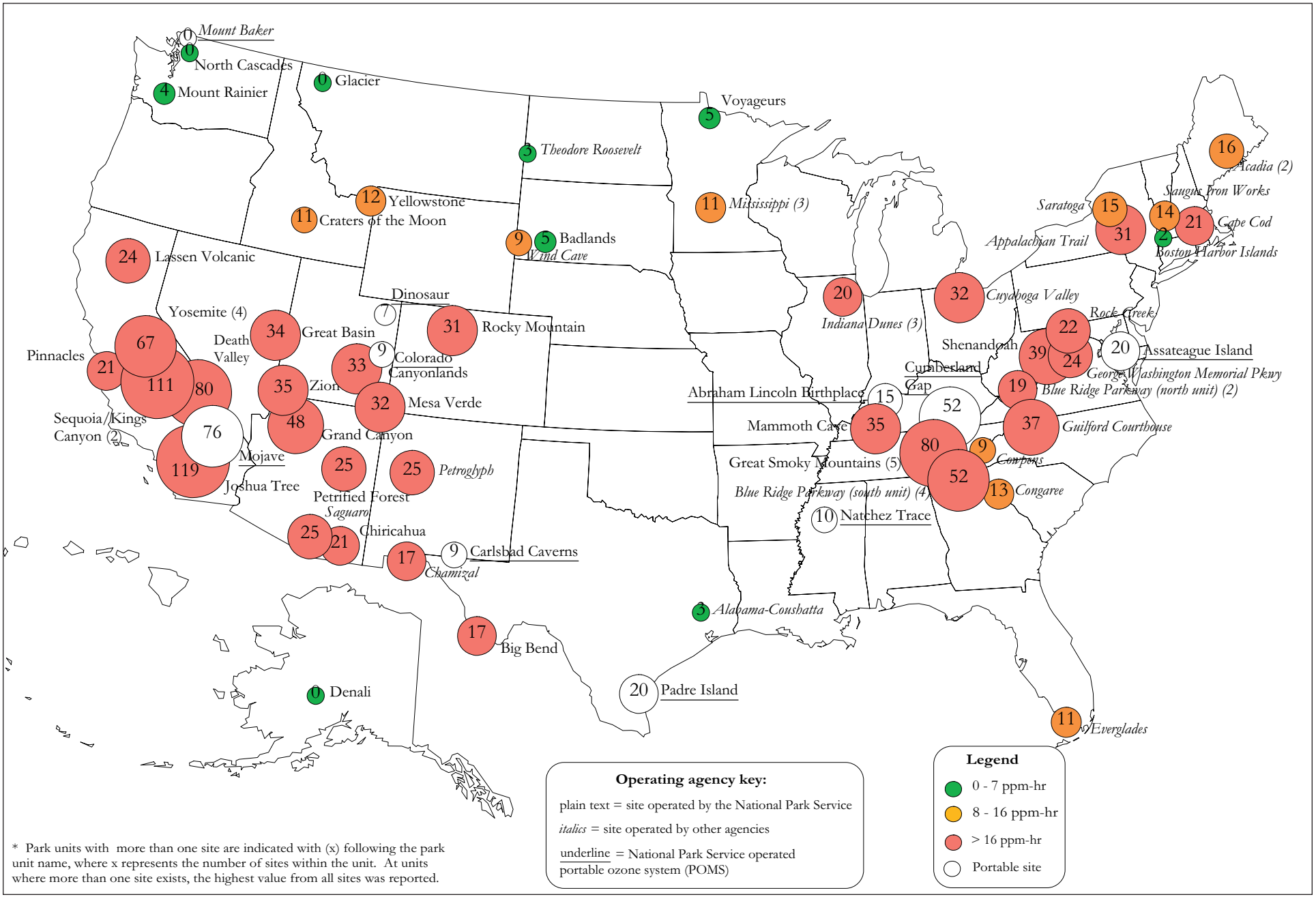

Figure 12. 2007 3-month maximum SUM06 exposure index during the ozone season (0800-2000 hourly concentrations).