

Trends in Visibility 2002-2008



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Lynsey Parker, Till Stoeckenius
ENVIRON International Corp.

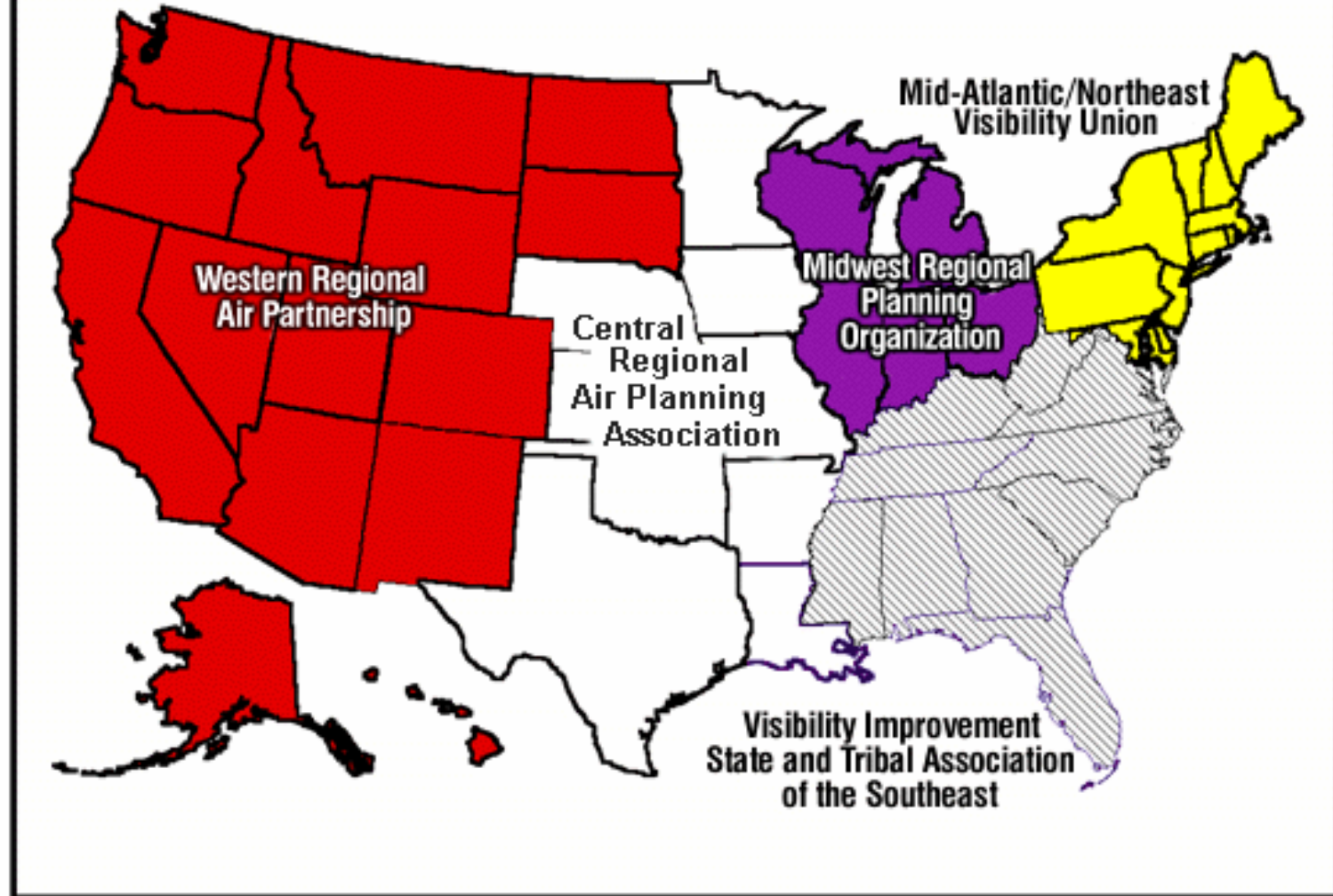
&

Gregory Stella
Alpine Geophysics, LLC

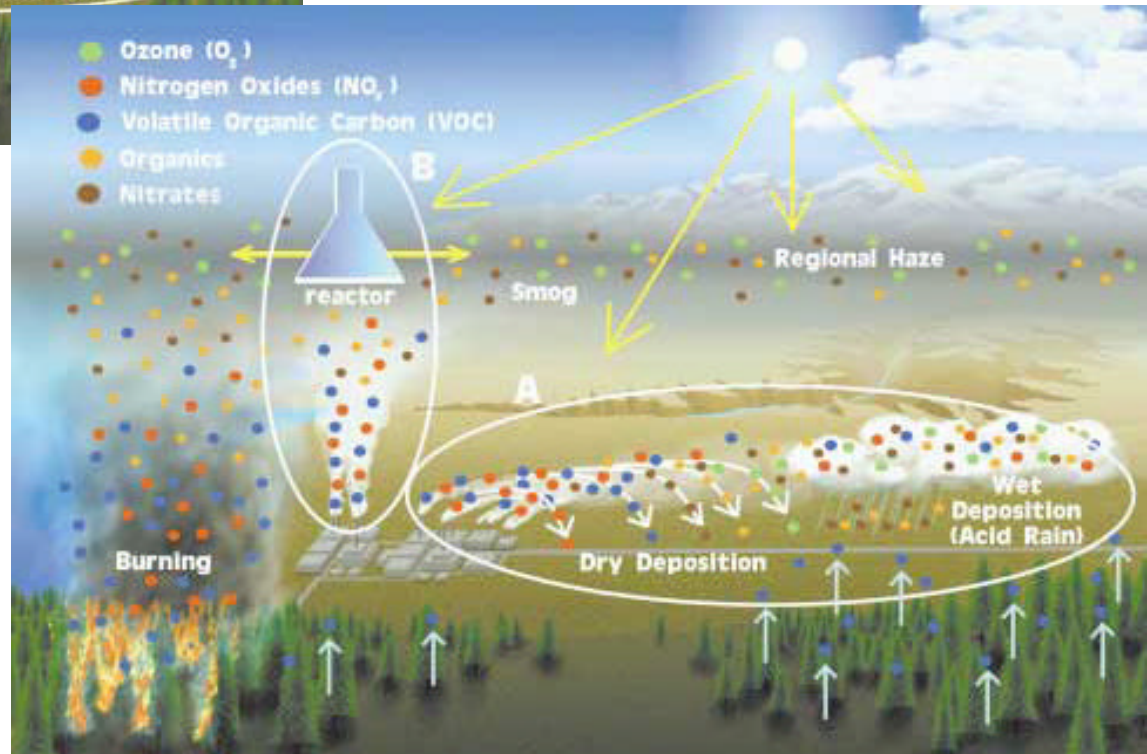
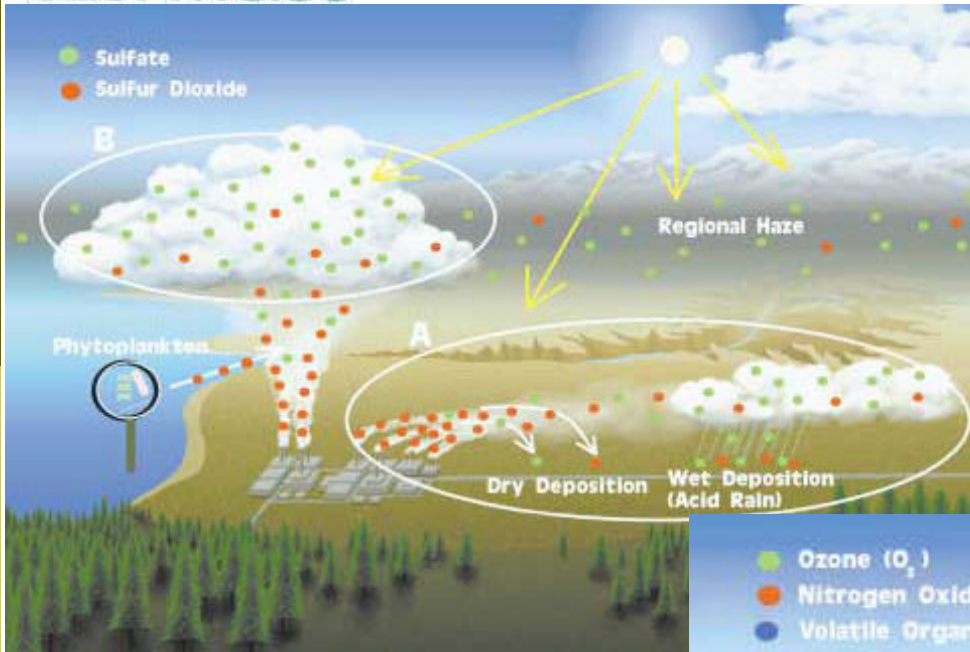
Scope

- Compute, summarize and display visibility trends for the continental U.S. for the period 2002 – 2008
- Create a spreadsheet database of average visibility on 20% best and worst visibility days in each year at each monitoring site for additional analyses

Regional Planning Organizations



Visibility Impairment

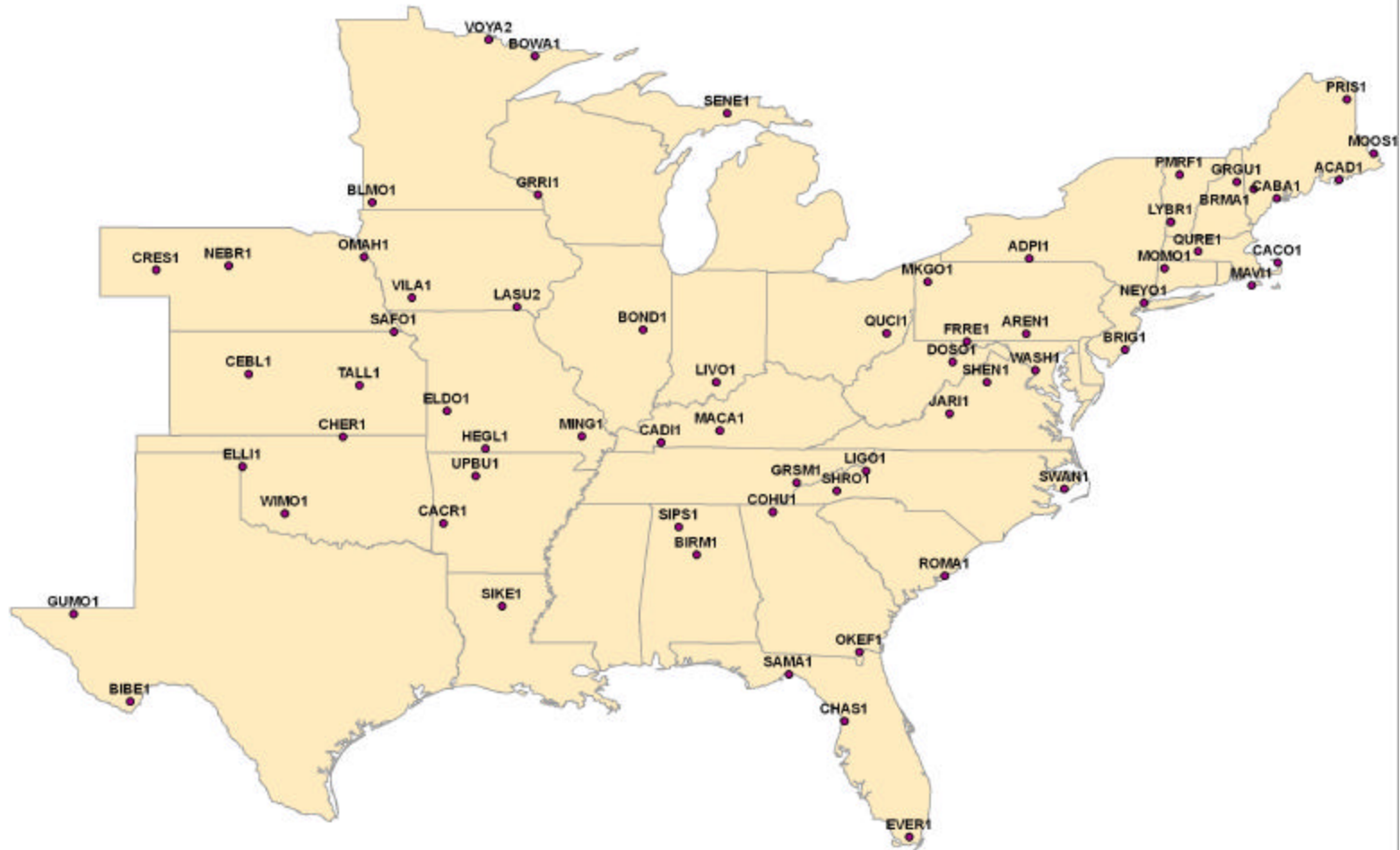


Source: Malm, 1999: *Introduction to Visibility*, Colorado State Univ., ISSN 0737-5352-40, May.

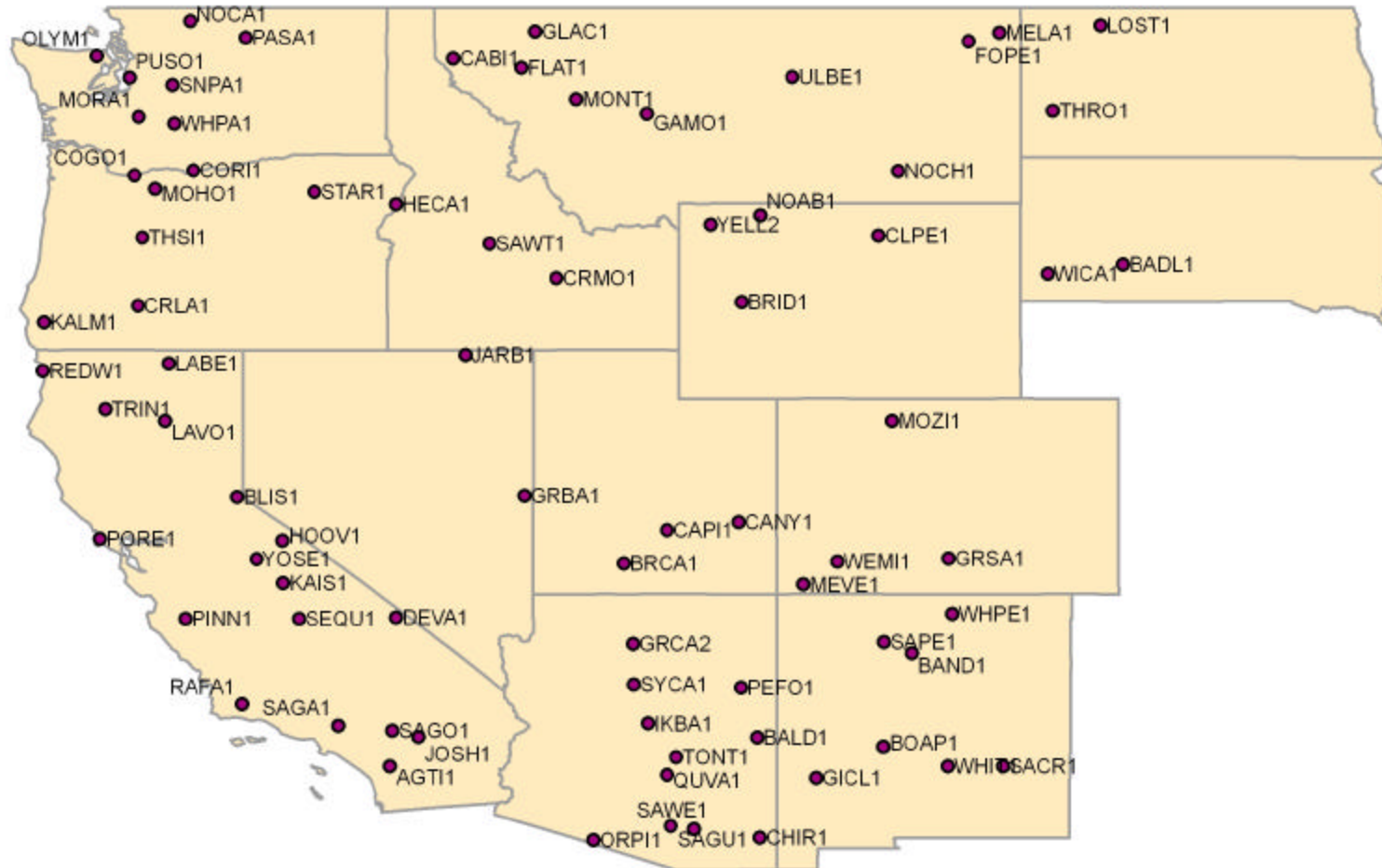
Data Sources

- Aerosol concentration data from IMPROVE monitoring sites
- Compute visibility in terms of deciview (dv) values using “new IMPROVE” equation
 - dv function of concentrations and relative humidity
 - Downloaded dv data from Visibility Information Exchange Web System (2.0) (<http://views.cira.colostate.edu>)
 - Dataset: IMPROVE Aerosol, RHR (New Equation), with substituted data (Dataset Code= IMPRHR2)
- Annual summary statistics as per Regional Haze Rule
 - Average over 20% **best** visibility days
 - Average over 20% **worst** visibility days

IMPROVE Sites – Eastern U.S.



IMPROVE Sites – Western U.S.

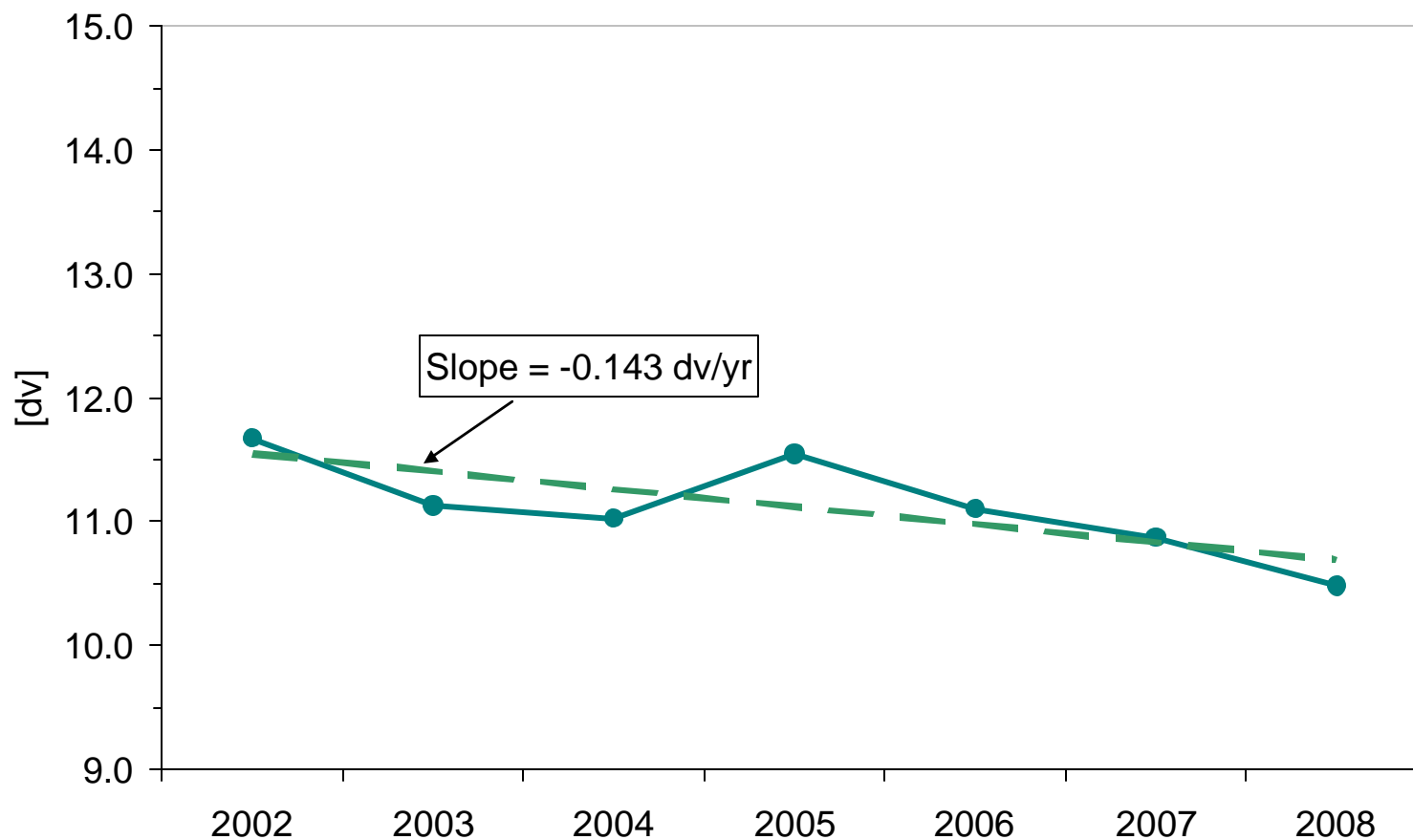


Trend Calculation Assumptions

- ❑ A 7-year (2002 – 2008) trend period was selected for this analysis because the IMPROVE network was significantly expanded in 2002
- ❑ Data from a monitoring site was only included if valid values were available in at least six out of the 7 years 2002-2008
 - Missing years were filled by linear interpolation for years with data in both previous and following years, and filled with adjacent year values otherwise
- ❑ For all sites and all years, a minimum of 16 days of dv values are included in the 20% best/worst annual averages. Since the IMPROVE measurements are made every 3 days, this corresponds to a minimum 2/3 completeness in all cases
 - Note: most years and sites are 100% complete

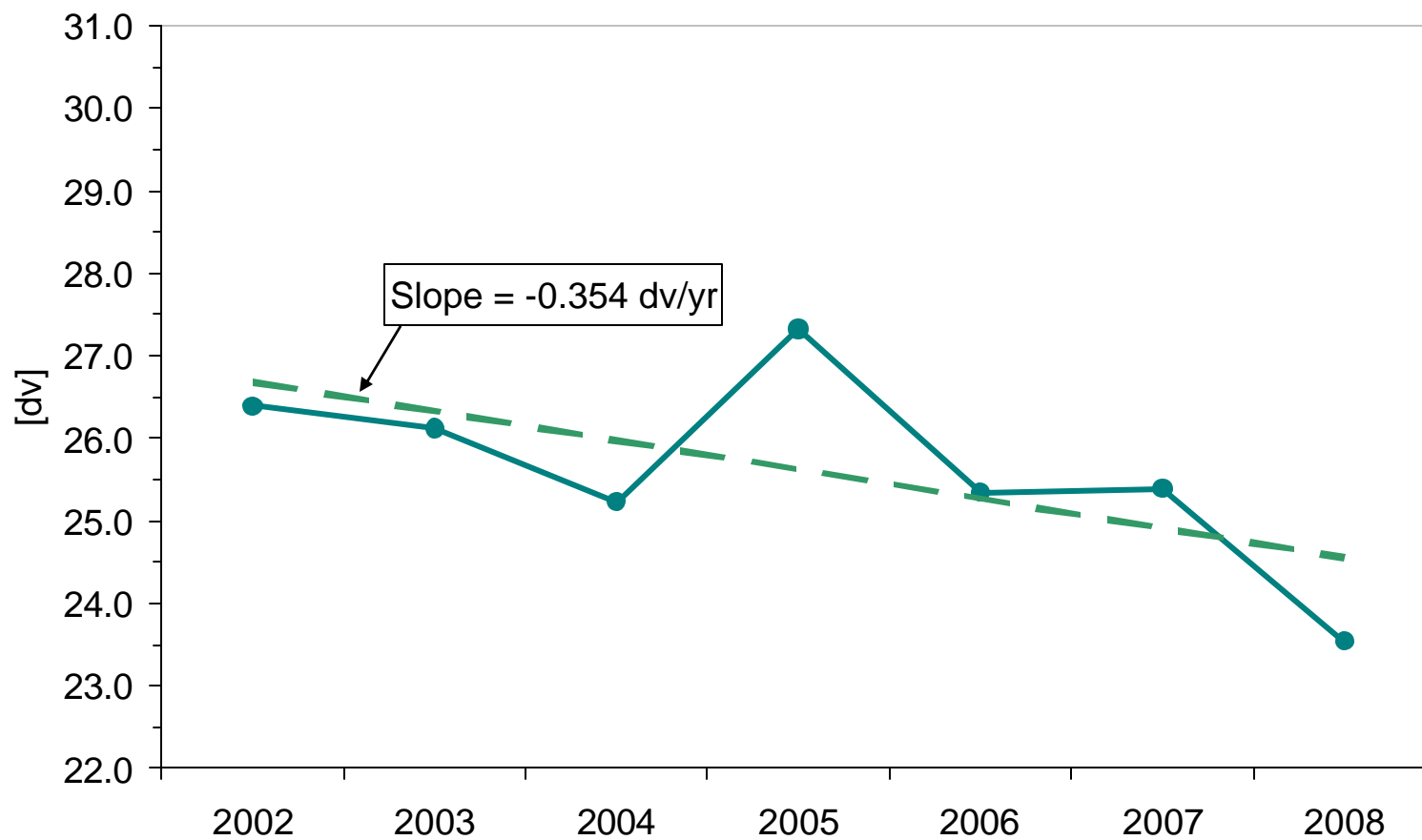
Trends Averaged over Eastern U.S. Sites: Best Visibility Days

**Avg. Over 20% Best Visibility Days
All East and Midwest IMPROVE Sites**



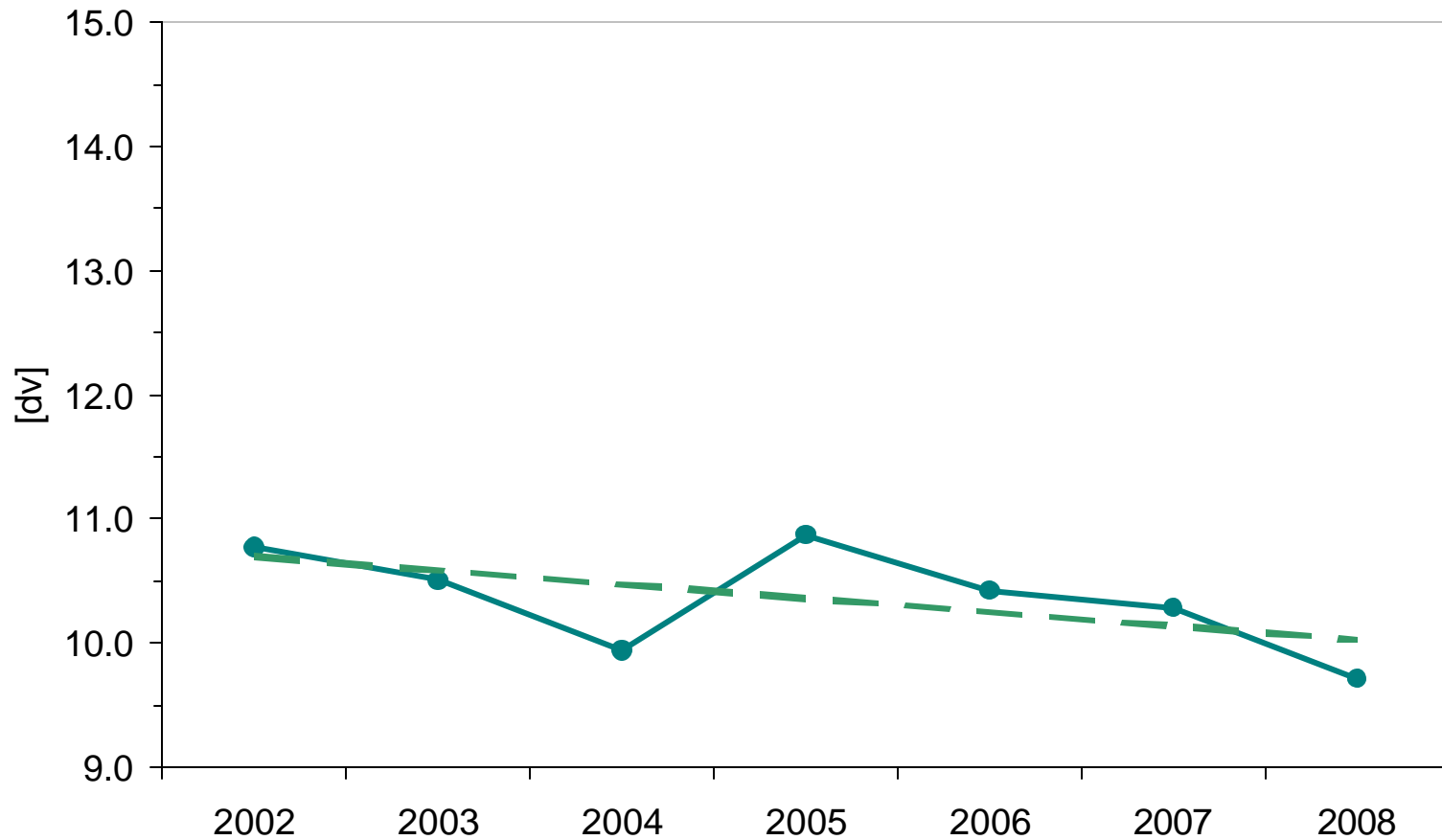
Trends Averaged over Eastern U.S. Sites: Worst Visibility Days

**Avg. Over 20% Worst Visibility Days
All East and Midwest IMPROVE Sites**



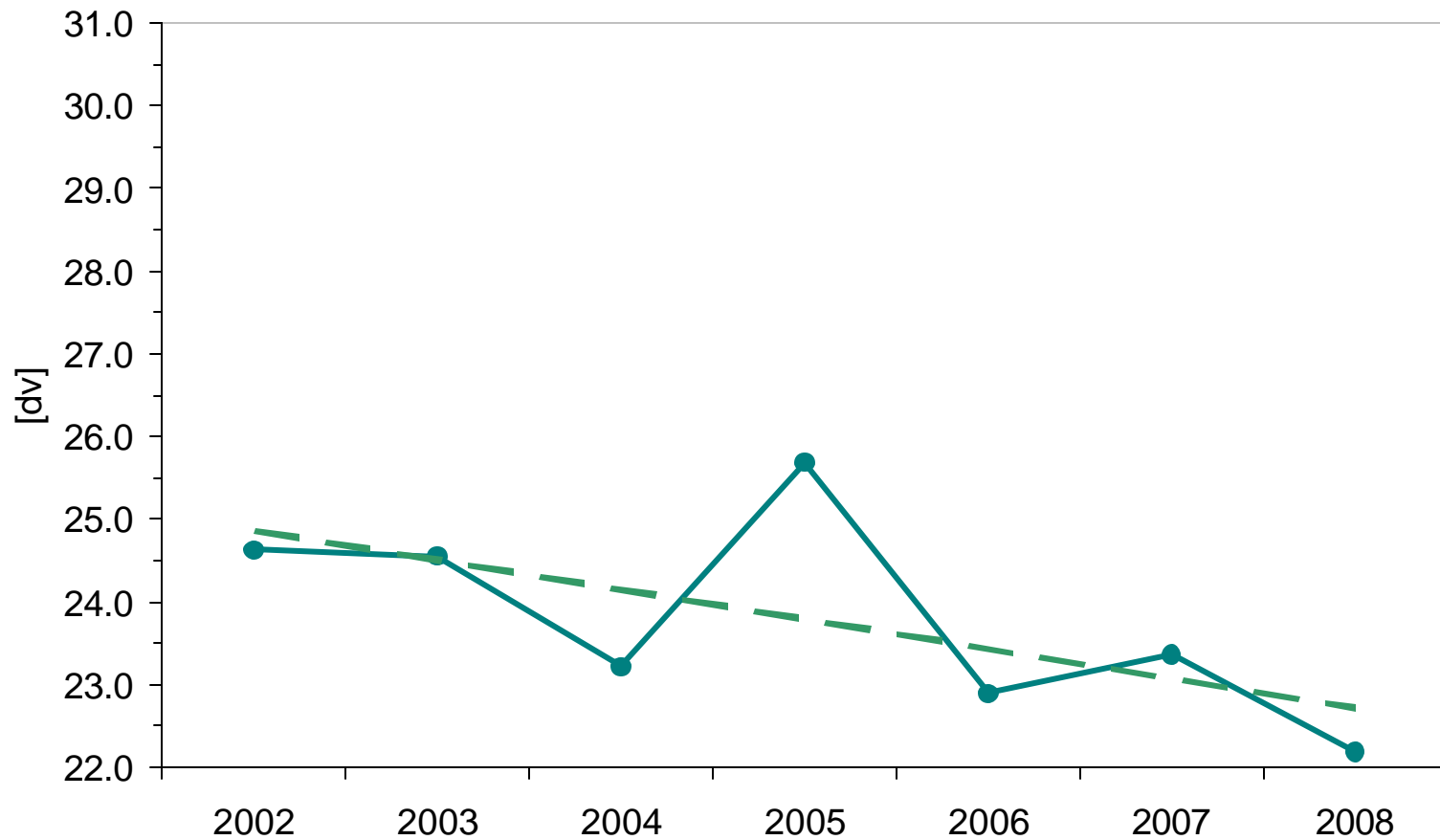
Trends Averaged over CENRAP Sites: Best Visibility Days

**Avg. Over 20% Best Visibility Days
CENRAP**



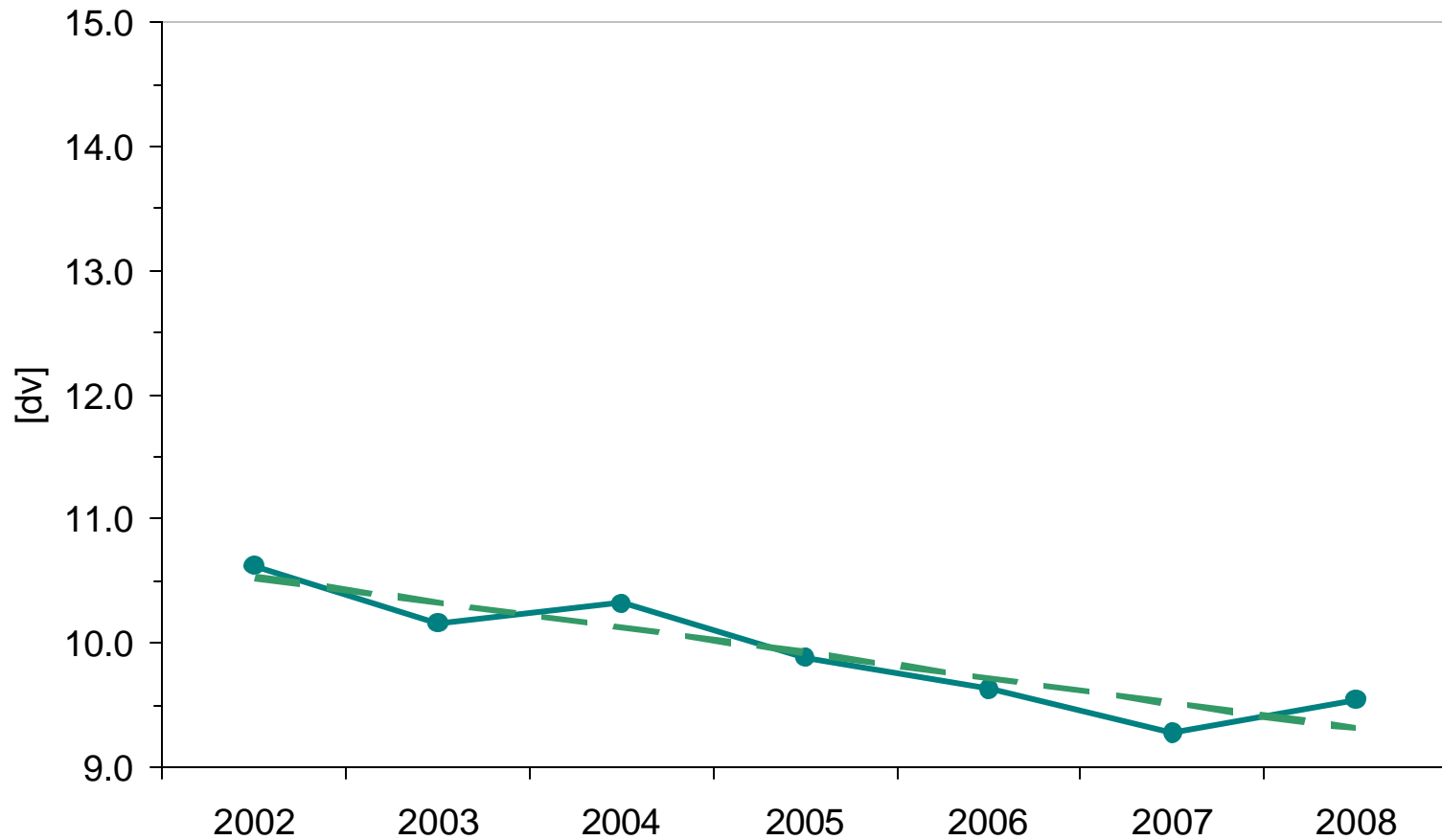
Trends Averaged over CENRAP Sites: Worst Visibility Days

**Avg. Over 20% Worst Visibility Days
CENRAP**



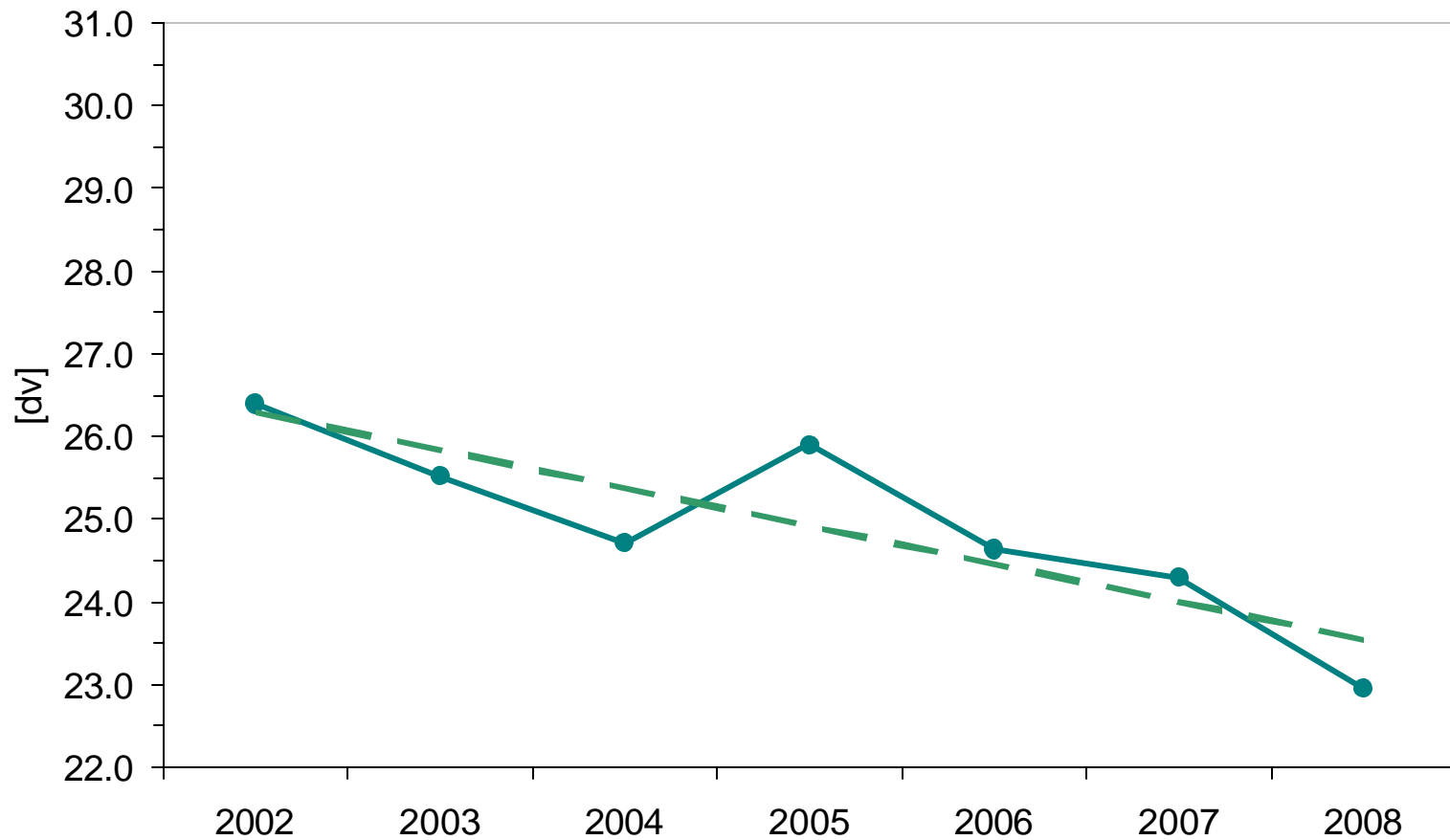
Trends Averaged over MANE-VU Sites: Best Visibility Days

**Avg. Over 20% Best Visibility Days
MANE-VU**



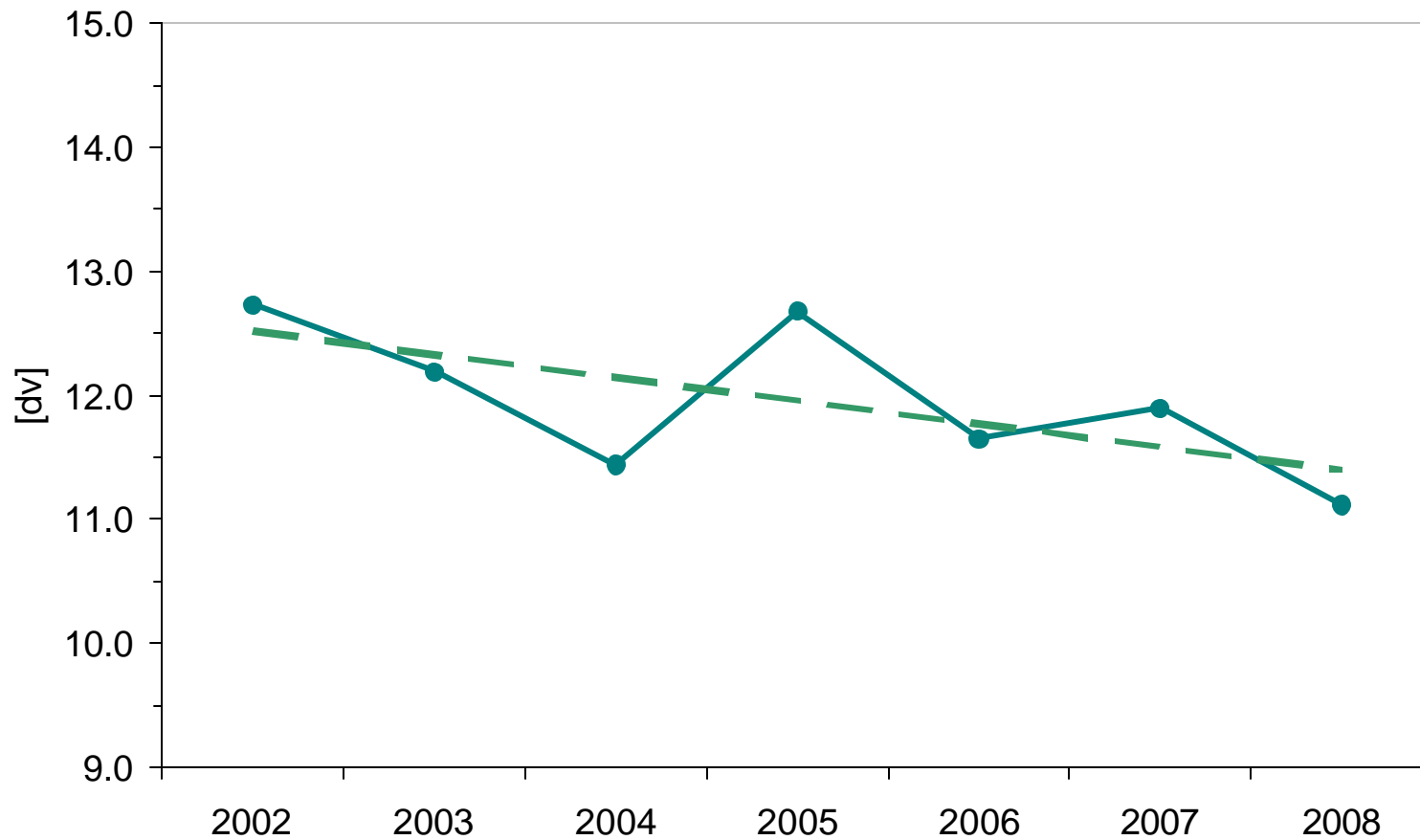
Trends Averaged over MANE-VU Sites: Worst Visibility Days

**Avg. Over 20% Worst Visibility Days
MANE-VU**



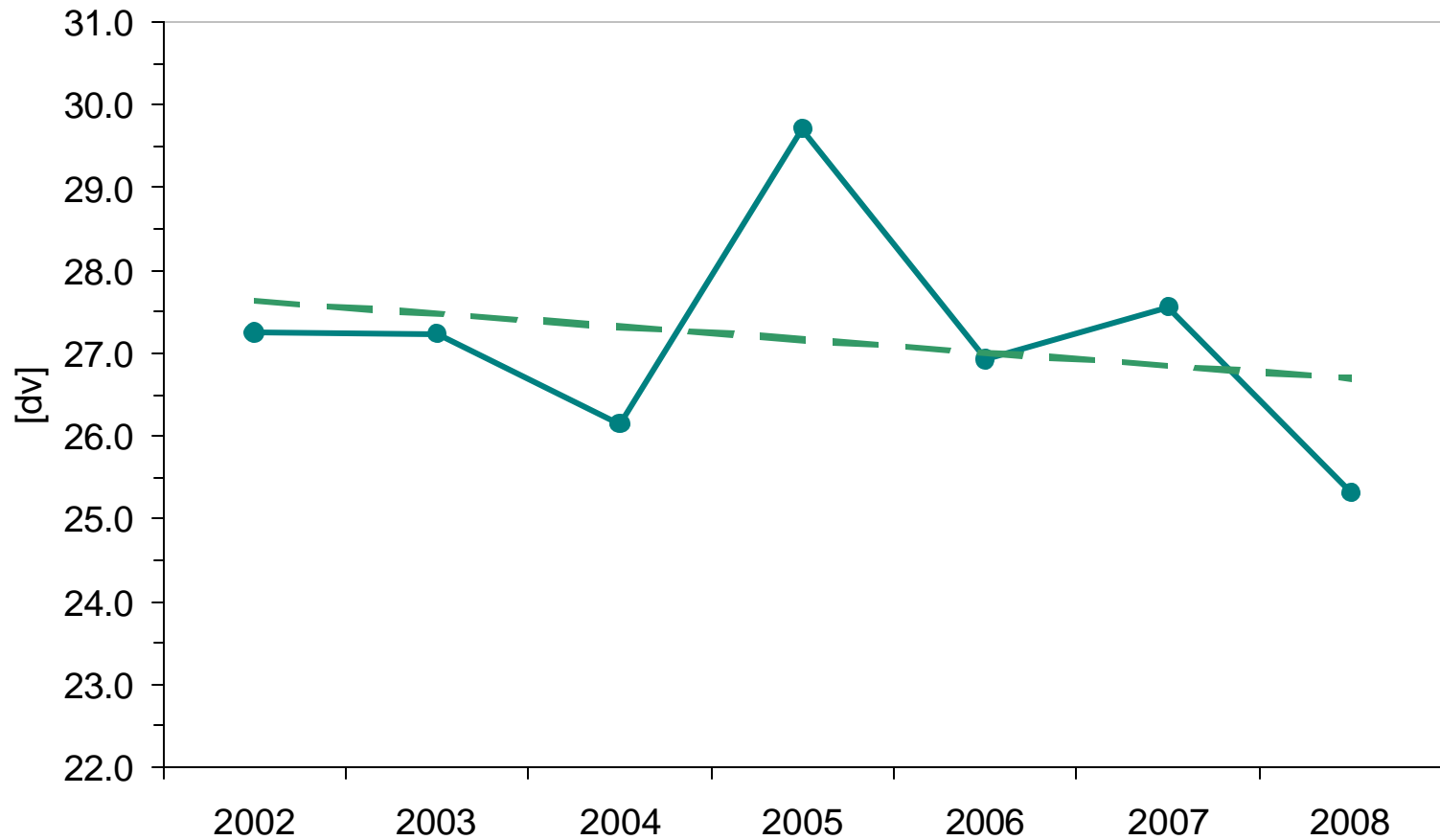
Trends Averaged over Midwest RPO Sites: Best Visibility Days

**Avg. Over 20% Best Visibility Days
Midwest RPO**



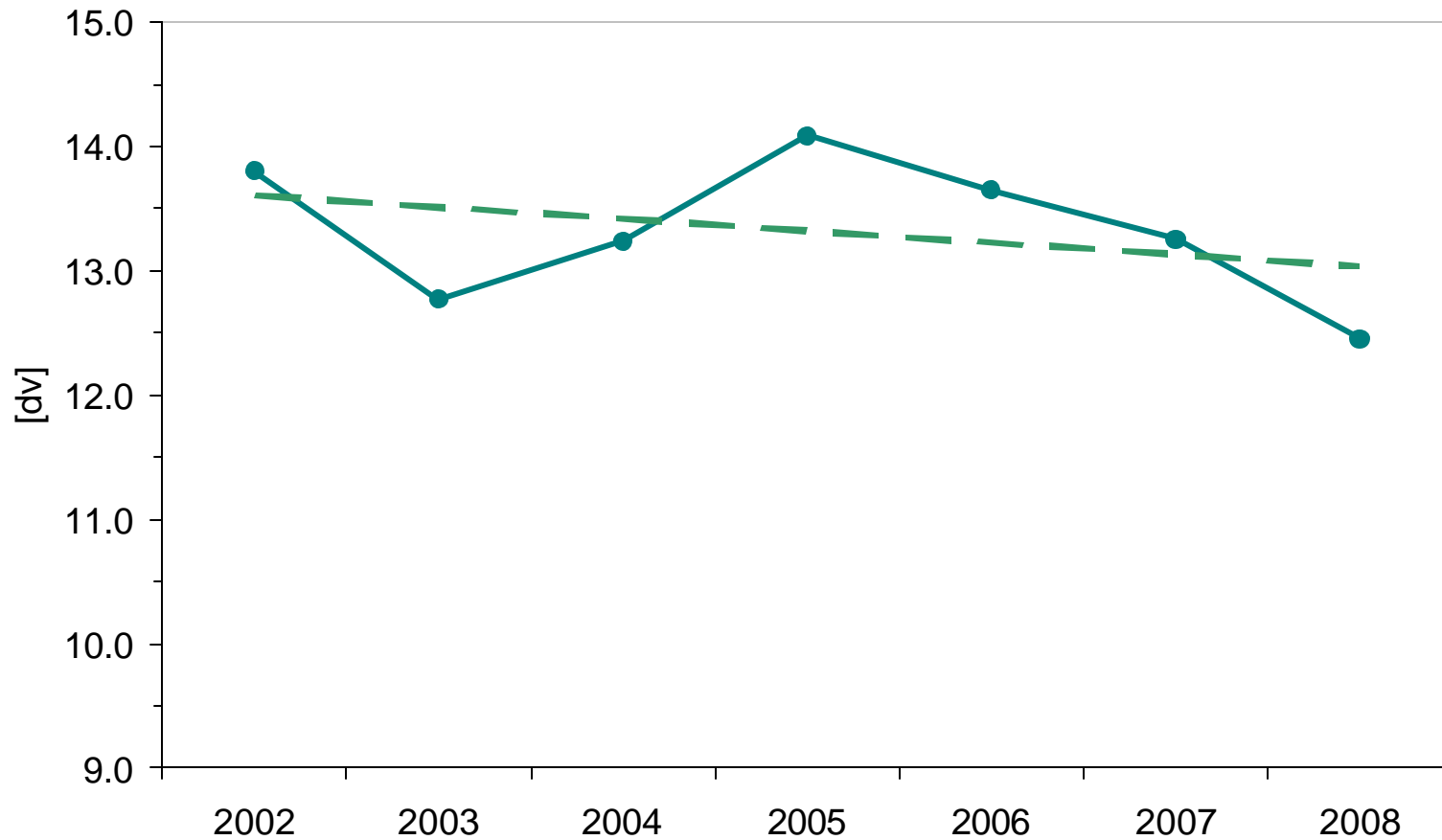
Trends Averaged over Midwest RPO Sites: Worst Visibility Days

**Avg. Over 20% Worst Visibility Days
Midwest RPO**



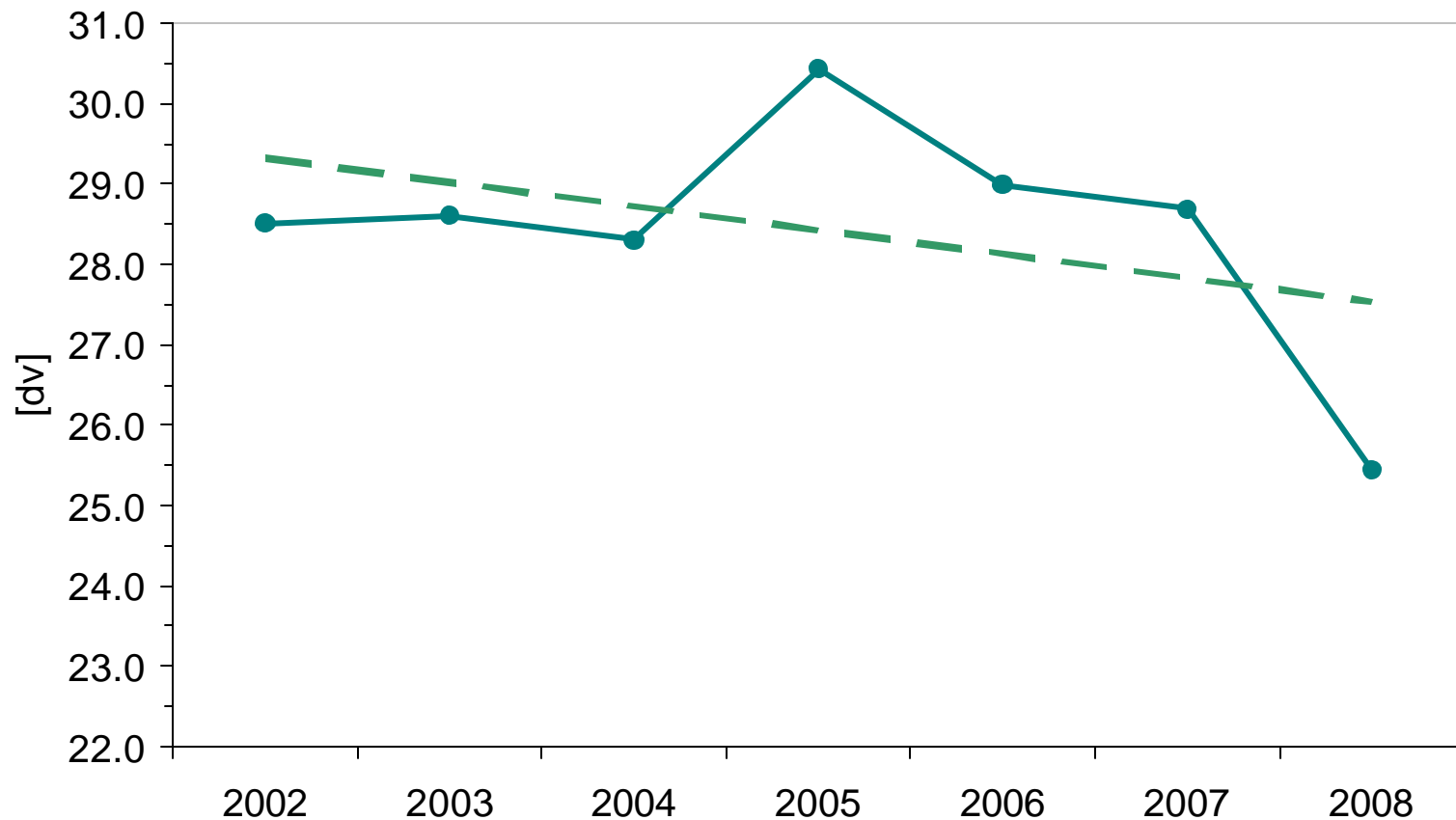
Trends Averaged over VISTAS Sites: Best Visibility Days

**Avg. Over 20% Best Visibility Days
VISTAS**



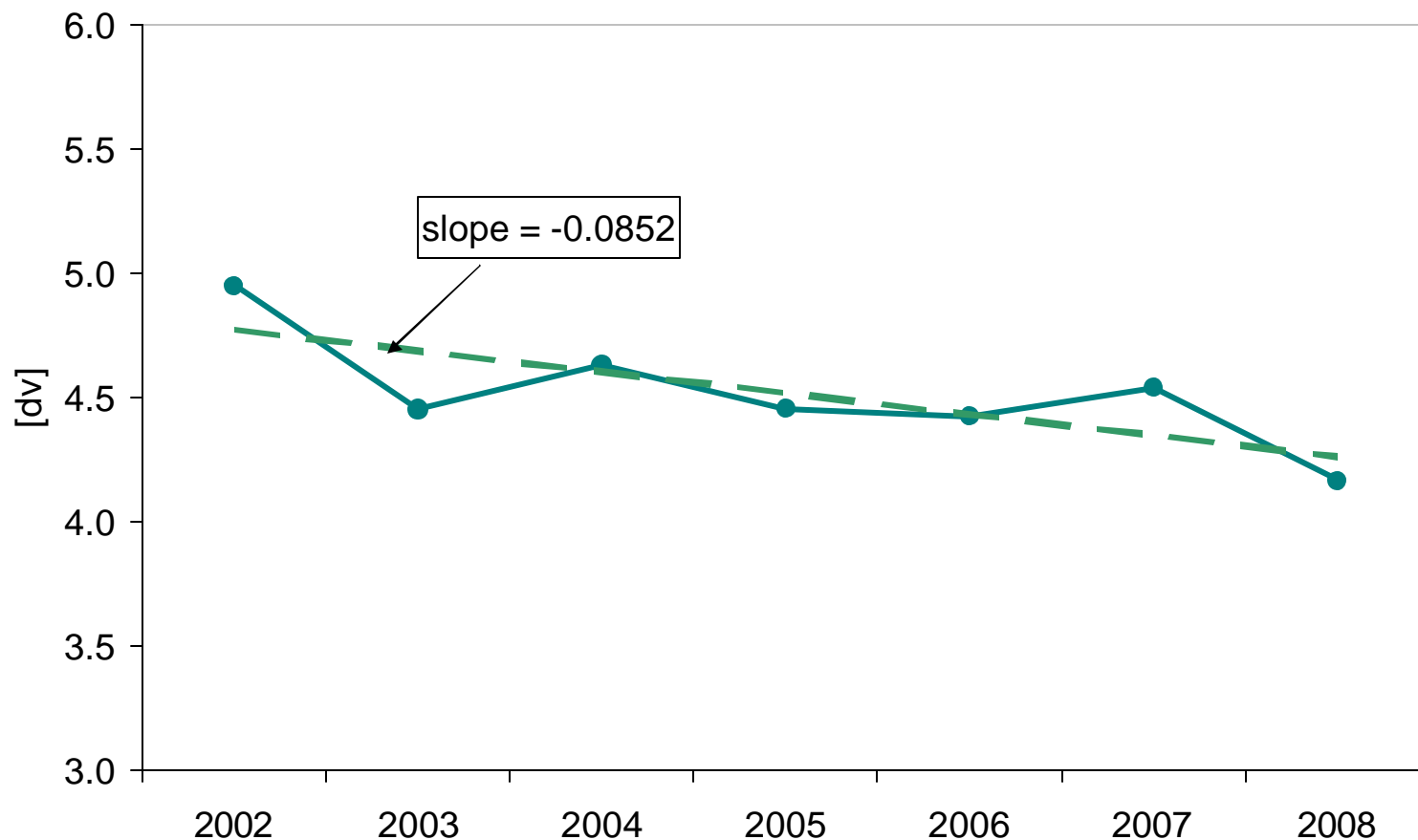
Trends Averaged over VISTAS Sites: Worst Visibility Days

**Avg. Over 20% Worst Visibility Days
VISTAS**



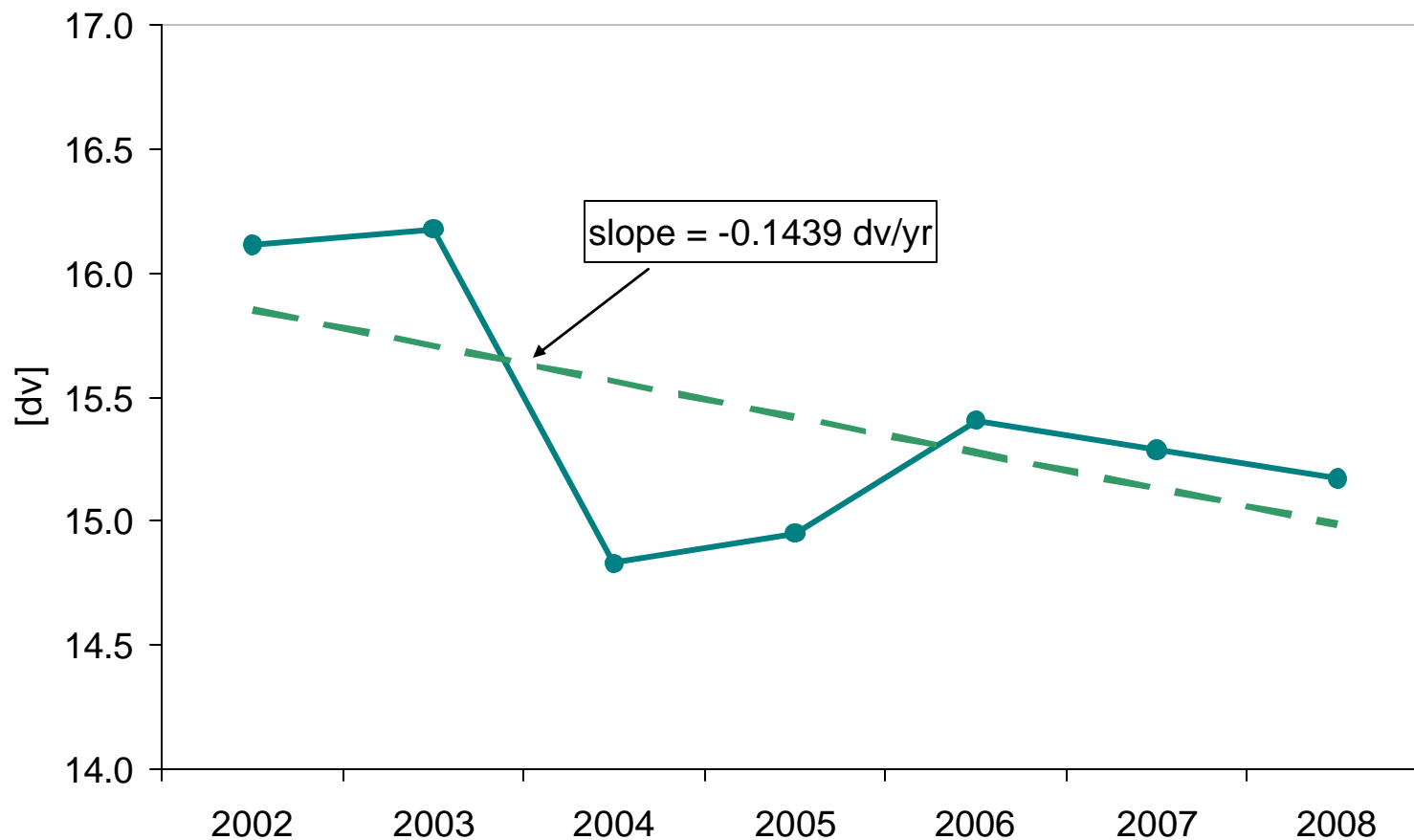
Trends Averaged over WRAP/Western U.S. Sites: Best Visibility Days

Avg. Over 20% Best Visibility Days
WRAP IMPROVE Sites



Trends Averaged over WRAP/Western U.S. Sites: Worst Visibility Days

**Avg. Over 20% Worst Visibility Days
WRAP IMPROVE Sites**



Average Trends

	20% Worst days (dv/year)	20% Best days (dv/year)
CENRAP Sites Average	-0.36	-0.11
MANE-VU Sites Average	-0.46	-0.20
Midwest RPO Sites Average	-0.16	-0.19
VISTAS Sites Average	-0.30	-0.10
Eastern Sites Average	-0.35	-0.14
WRAP/Western Sites Average	-0.14	-0.09

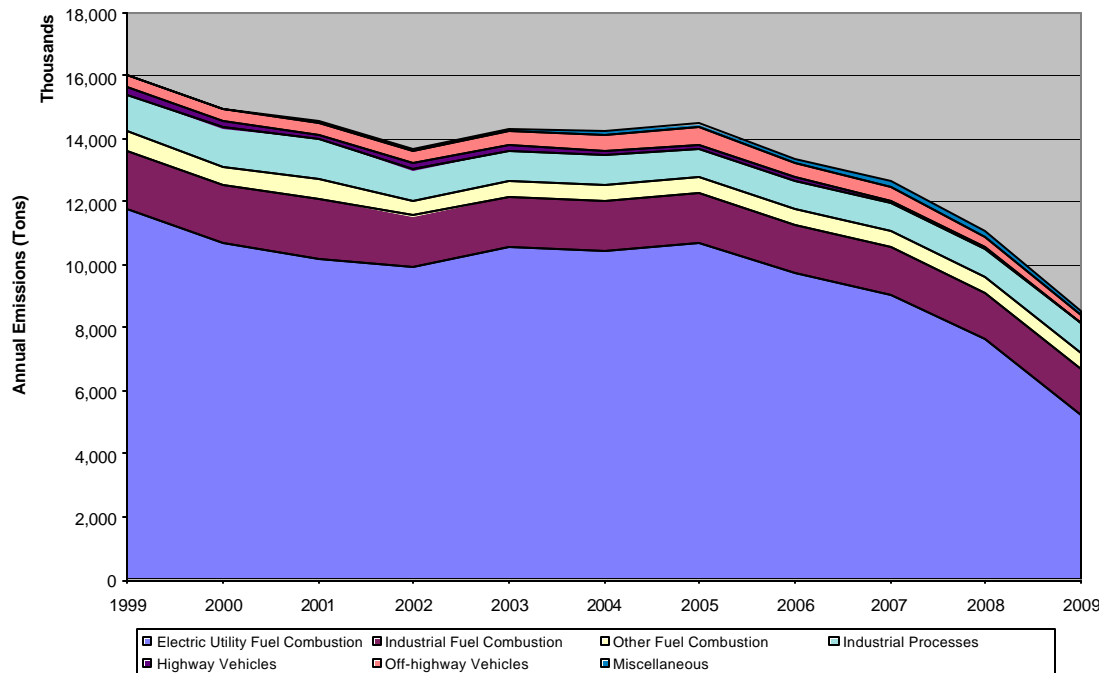
Visibility Changes: 2002 - 2008

	20% Worst days	20% Best days
CENRAP Sites Average	10.1%	7.3%
MANE-VU Sites Average	12.2%	13.5%
Midwest RPO Sites Average	3.9%	10.4%
VISTAS Sites Average	7.1%	4.9%
Eastern Sites Average	9.3%	8.7%
WRAP/Western Sites Average	12.5%	6.4%

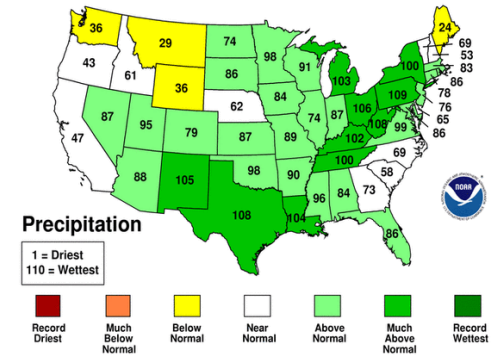
- Percent reduction in dv 2002 – 2008 based on linear least squares trend averaged over all trends sites in region
- Positive value indicates percent improvement

Emissions & Meteorology Impact

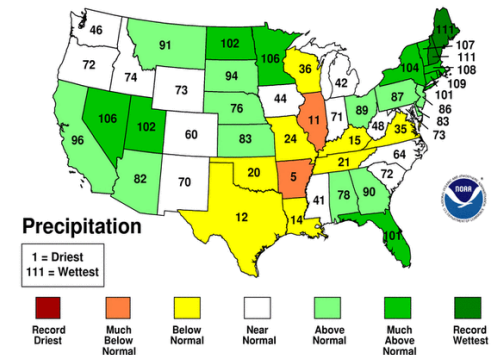
- Visibility degradation “bump” in 2005 for eastern States correlates to documented increase in SO₂ emissions between 2004 and 2005 as well as movement from wet to dry regime during same period



January-December 2004 Statewide Ranks
National Climatic Data Center/NESDIS/NOAA

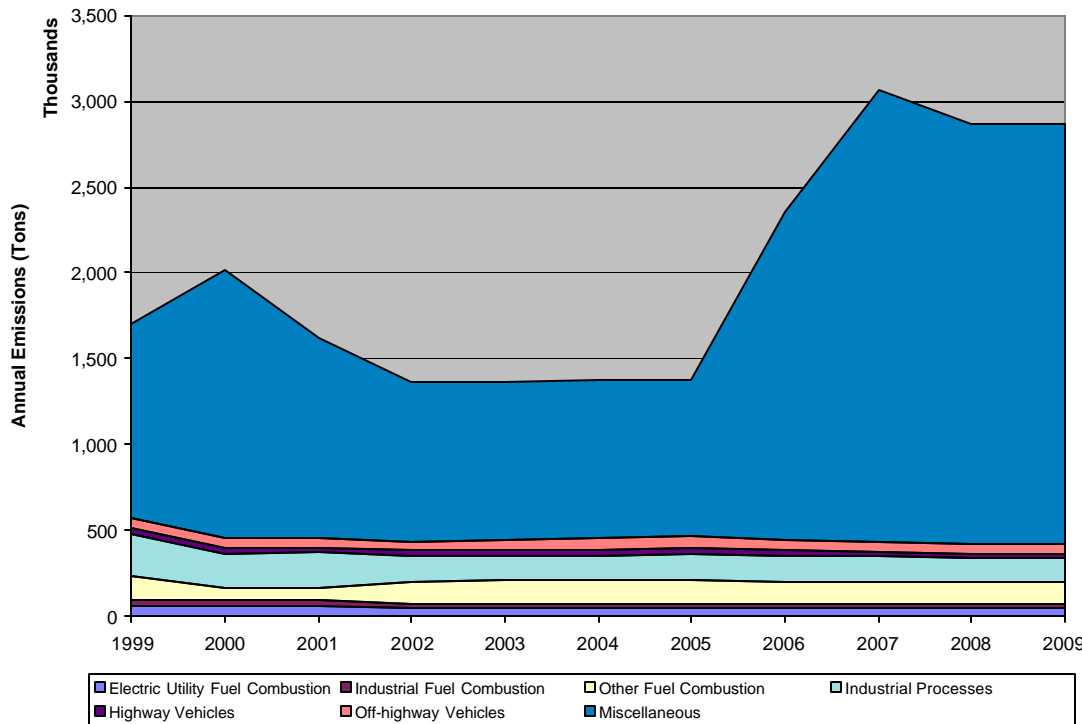


Statewide Ranks Jan-Dec 2005
National Climatic Data Center/NESDIS/NOAA



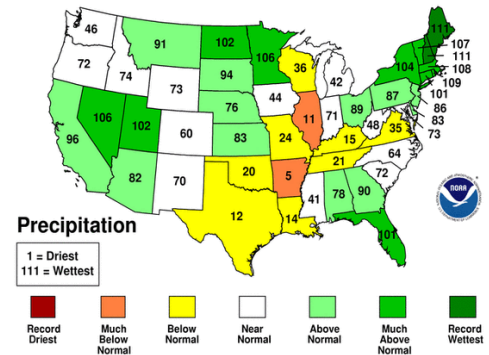
Emissions & Meteorology Impact

- Similarly in the western States, visibility degradation in 2005-2007 timeframe correlates to significant increase in wildfire emissions (PM_{2.5} shown) during the period as well as movement from wet to dry regime



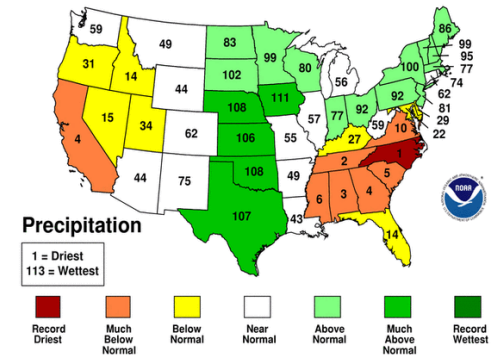
Statewide Ranks Jan-Dec 2005

National Climatic Data Center/NESDIS/NOAA



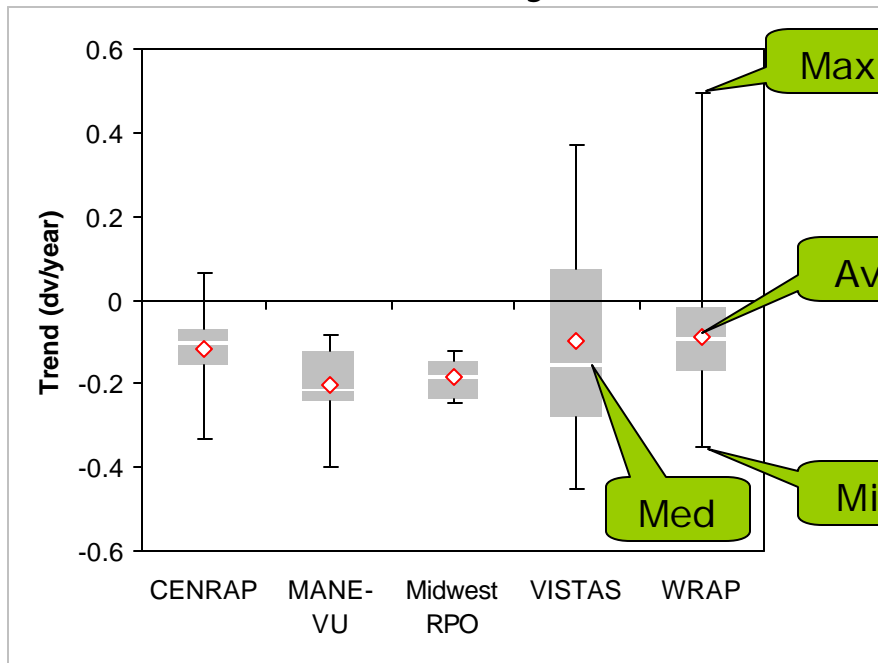
Statewide Ranks Jan-Dec 2007

National Climatic Data Center/NESDIS/NOAA

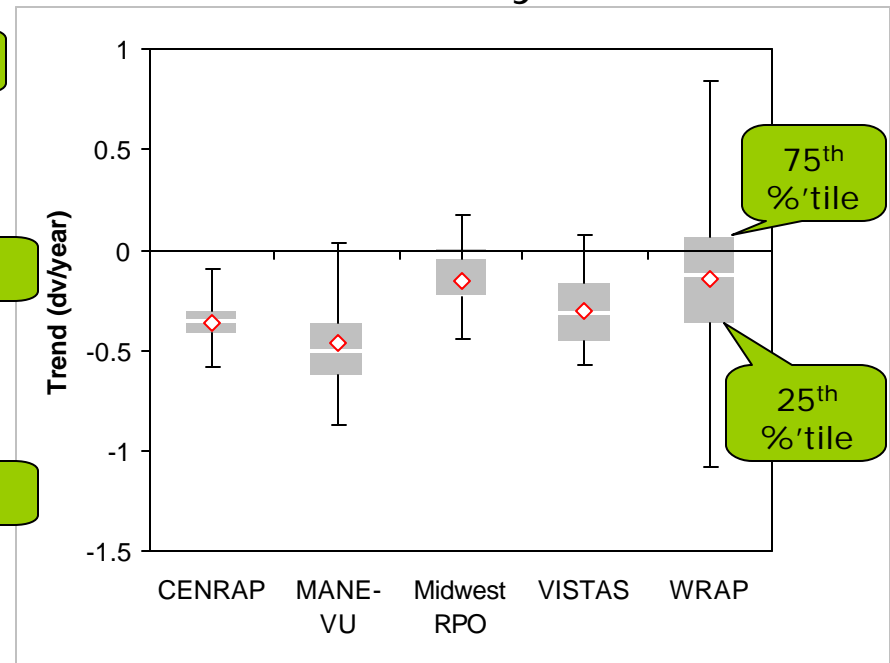


Individual Site Trends: 2002-2008

20% Best Days



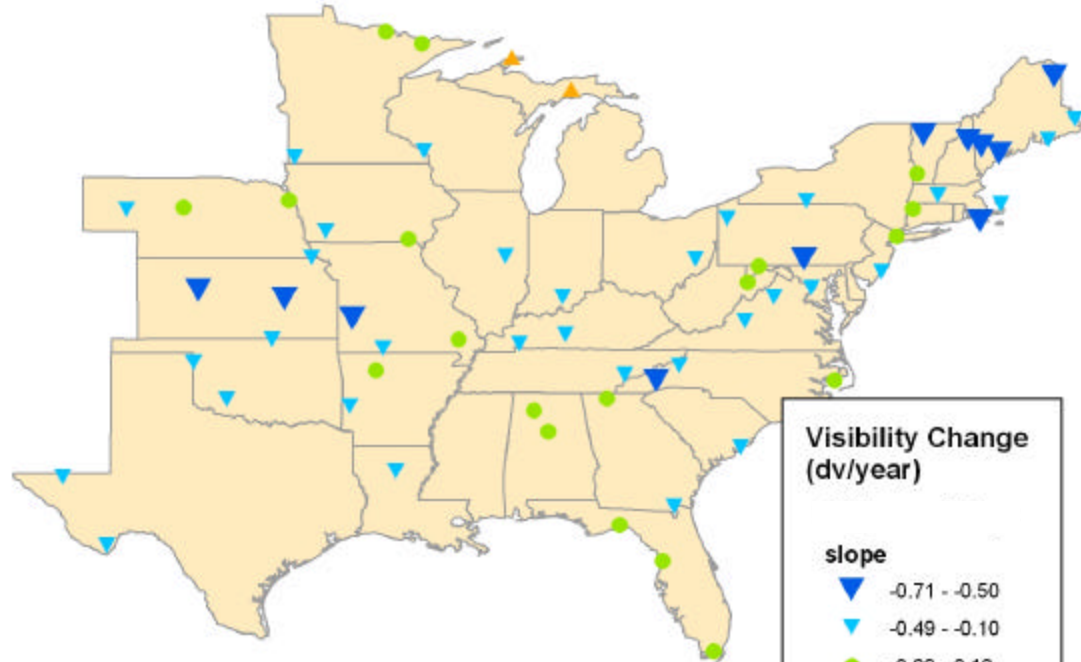
20% Worst Days



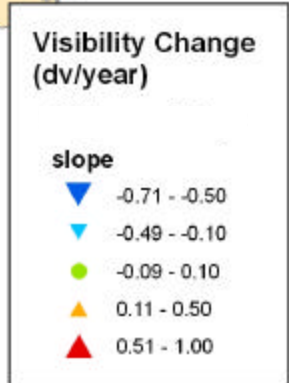
ENVIRON
Visibility Trends
1999 - 2008



20% Best Vis. Days

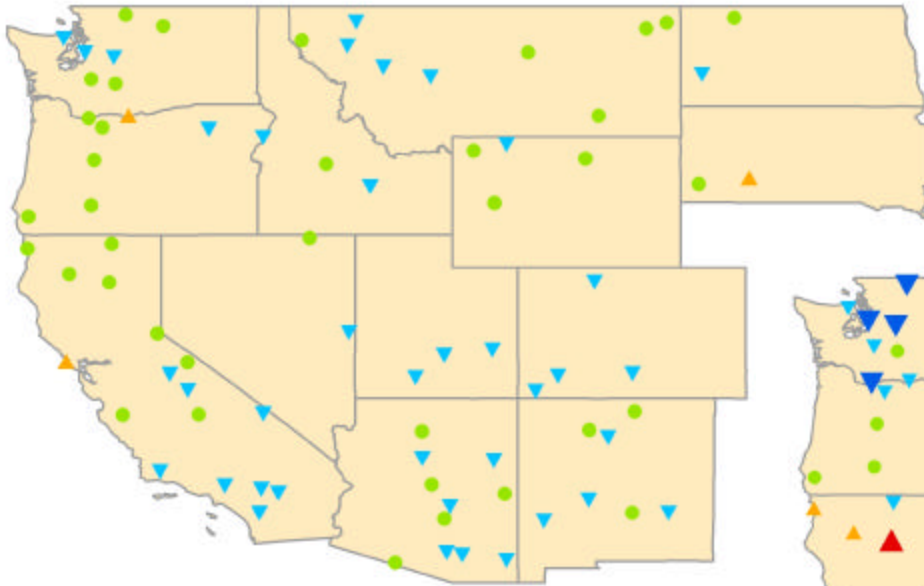


20% Worst Vis. Days

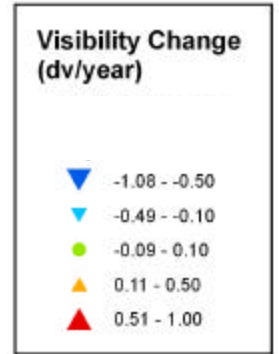
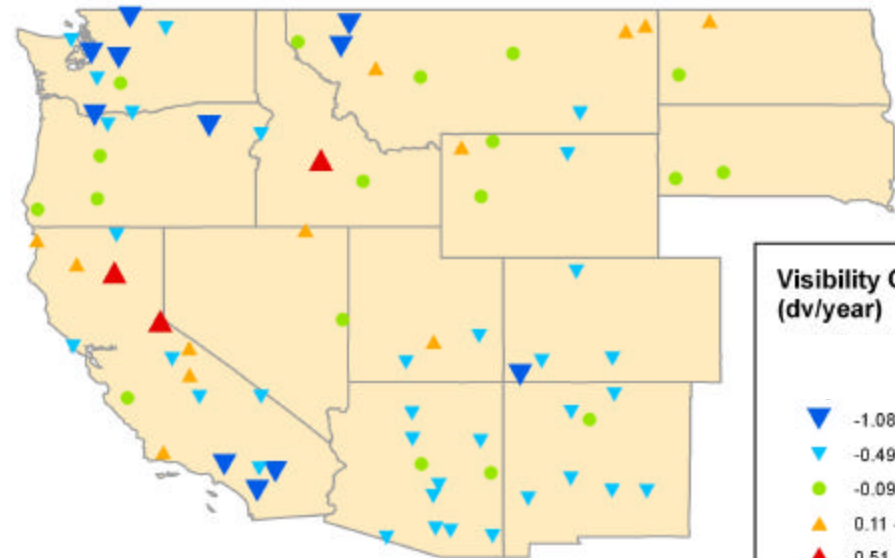


Note: Trends shown are over either 1999-2008 or 2002-2008 depending on data availability

ENVIRON
Visibility Trends
2002 - 2008



20% Best Vis. Days



Note: Trends at individual sites may be strongly impacted by wildfire events

20% Worst Vis. Days

Conclusions

- Average and median trends are negative (improving visibility) in all RPOs
- At least $\frac{3}{4}$ of all sites have negative trends except VISTAS (20% best days) and WRAP (20% worst days)