
Ozone NAAQS Secondary Standard

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Secondary Standard

Provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, buildings, and ecosystems



Source: NASA (2011).

O₃ Secondary Standard

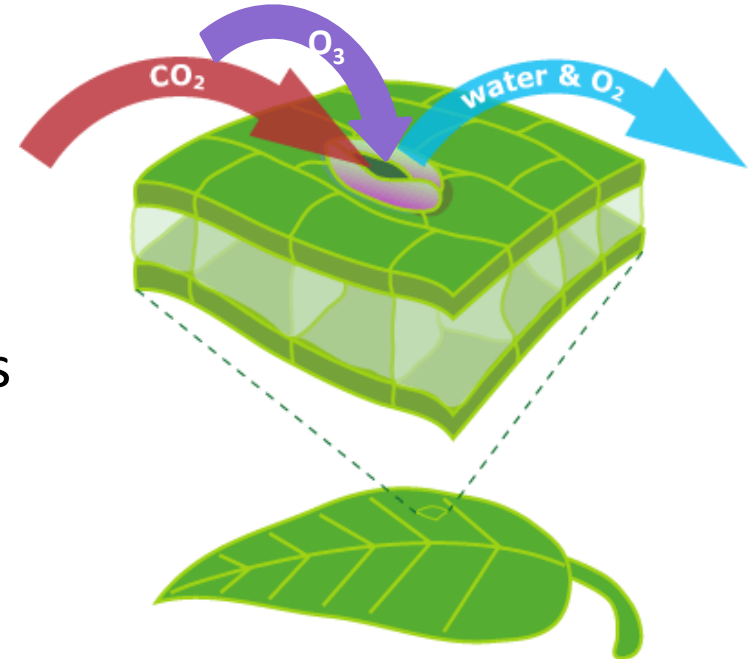
- Welfare Effects
 - Visible foliar injury, tree/crop growth, ecosystem services
- Form
 - Biologically-based form
- Level
 - Estimated welfare risks at different O₃ exposure levels
- Current review proposal



Source: NASA (2011).

O₃ Welfare Effects – Visible Foliar Injury

- O₃ enters leaves through stomata during normal gas exchange
- Once inside, O₃ (or its secondary products) can cause several symptoms
 - Open top chamber (OTC) studies
 - Chlorosis, necrosis, flecks, stipples, bronzing, reddening
 - Almost impossible to tell whether foliar chlorosis or necrosis in the field is caused by ozone, normal senescence, or other stressors



Source: University of California Museum of Paleontology's Understanding Evolution (<http://evolution.berkeley.edu>).



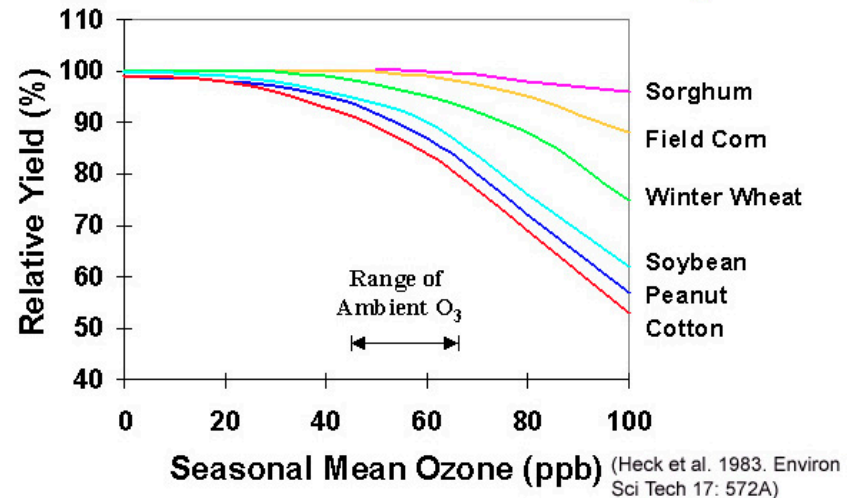
Source: NASA (2011).

O₃ Welfare Effects – Vegetation Growth

- O₃ can also inhibit growth
 - Inhibition of photosynthesis
 - Allocation of energy to repair away from growth
- Field research to measure effects of seasonal O₃ exposure on crop yield has been in progress for >40 yrs
 - Field OTC studies
 - Most extensive dataset from five sites assessed as part of the National Crop Loss Assessment Network (NCLAN) between 1980-1987



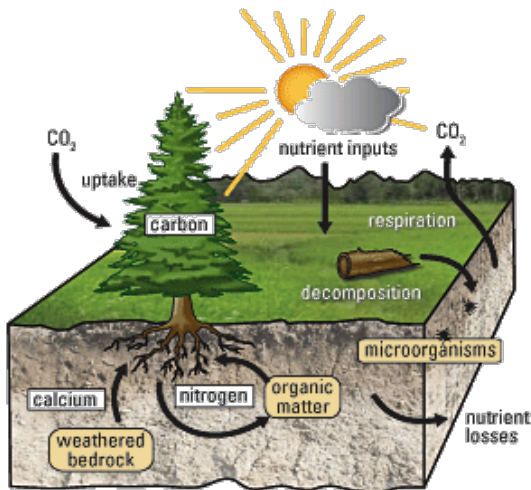
Source: NASA (2011).



O₃ Welfare Effects – Ecosystem Services

Public benefits received from the resources and processes that are supplied by ecosystems

- Provisioning: crops, timber
- Regulating: carbon sequestration, climate control
- Cultural: recreation, aesthetics
- Supporting: nutrient cycling



Source: USGS (2009).



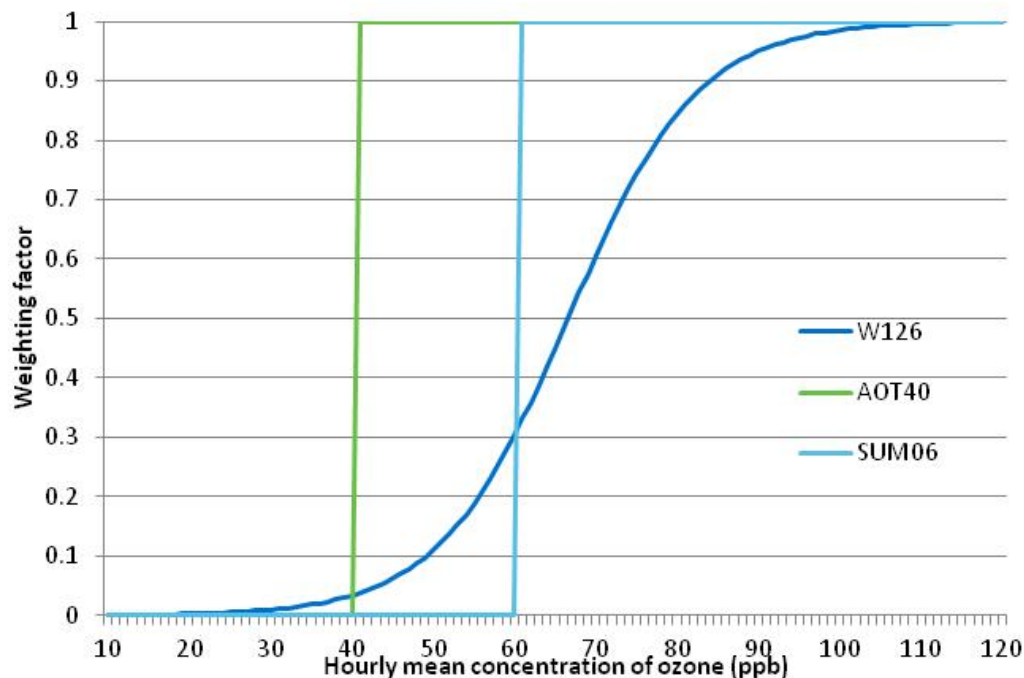
Source: USDA.gov.

Biologically-Based O₃ Secondary Standard Form

- Account for cumulative impact of repeated peak and mid-level O₃ exposure
 - Over growing season (consecutive 3 months)
 - Over diurnal window (8 am – 8 pm)
 - Give greatest weight to higher ozone exposure
- Better at relating O₃ exposure to plant growth response
 - Indices that weight peak concentrations using a sigmoidal (or discrete 0-1) weighting scheme and accumulate exceedances over a threshold concentration give a better fit to crop yield data than do indices that use mean concentrations over a growing season or peak values alone (based on NCLAN data)
- Challenges
 - Species sensitivity
 - Parameters that influence the stomatal O₃ flux (*e.g.*, soil moisture, vapor pressure deficit, temperature)

Biologically-Based O₃ Secondary Standard Form

No one concentration-weighted exposure index best accounts for the complex relationship between O₃ concentrations and plant responses across a wide range of species



Weighting factors for AOT40, SUM06, and W126

$$\text{AOT40 (ppbh)} = \sum_{i=1}^n [C_{\text{O}_3} - 40]_i \quad \text{for } C_{\text{O}_3} \geq 40 \text{ ppb,}$$

$$\text{SUM06 (ppbh)} = \sum_{i=1}^n [C_{\text{O}_3}]_i \quad \text{for } C_{\text{O}_3} \geq 60 \text{ ppb,}$$

$$\text{W126 (ppbh)} = \sum_{i=1}^n C_i * w_i \quad \text{where } w_i = 1 / [1 + 4403 * \exp(-0.126 * C_i)]$$

Biologically-Based O₃ Secondary Standard Form

- EPA considered a distinct, cumulative, seasonal secondary standard in the last two reviews (first SUM06, then W126)
- However, based on considerable overlap between both standard form options in air quality analyses, EPA set the secondary standard identical to the primary standard
- Uncertainty remained in last review as to whether an 8-hour average form would, in practice, provide sufficient protection for vegetation

Final Rule	Indicator	Averaging Time	Level (ppm)	Form
1971 (36 FR 8186)	Total photochemical oxidants	1 hour	0.08	Not to be exceeded more than one hour per year
1979 (44 FR 8202)	O ₃	1 hour	0.12	Attainment is defined when the expected number of days per calendar year, with maximum hourly average concentration greater than 0.12 ppm, is equal to or less than 1
1993 (58 FR 13008)	The US EPA decided that revisions to the standards were not warranted at the time			
1997 (62 FR 38856)	O ₃	8 hours	0.08	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
2008 (73 FR 16483)	O ₃	8 hours	0.075	Form of the standards remained unchanged relative to the 1997 standard

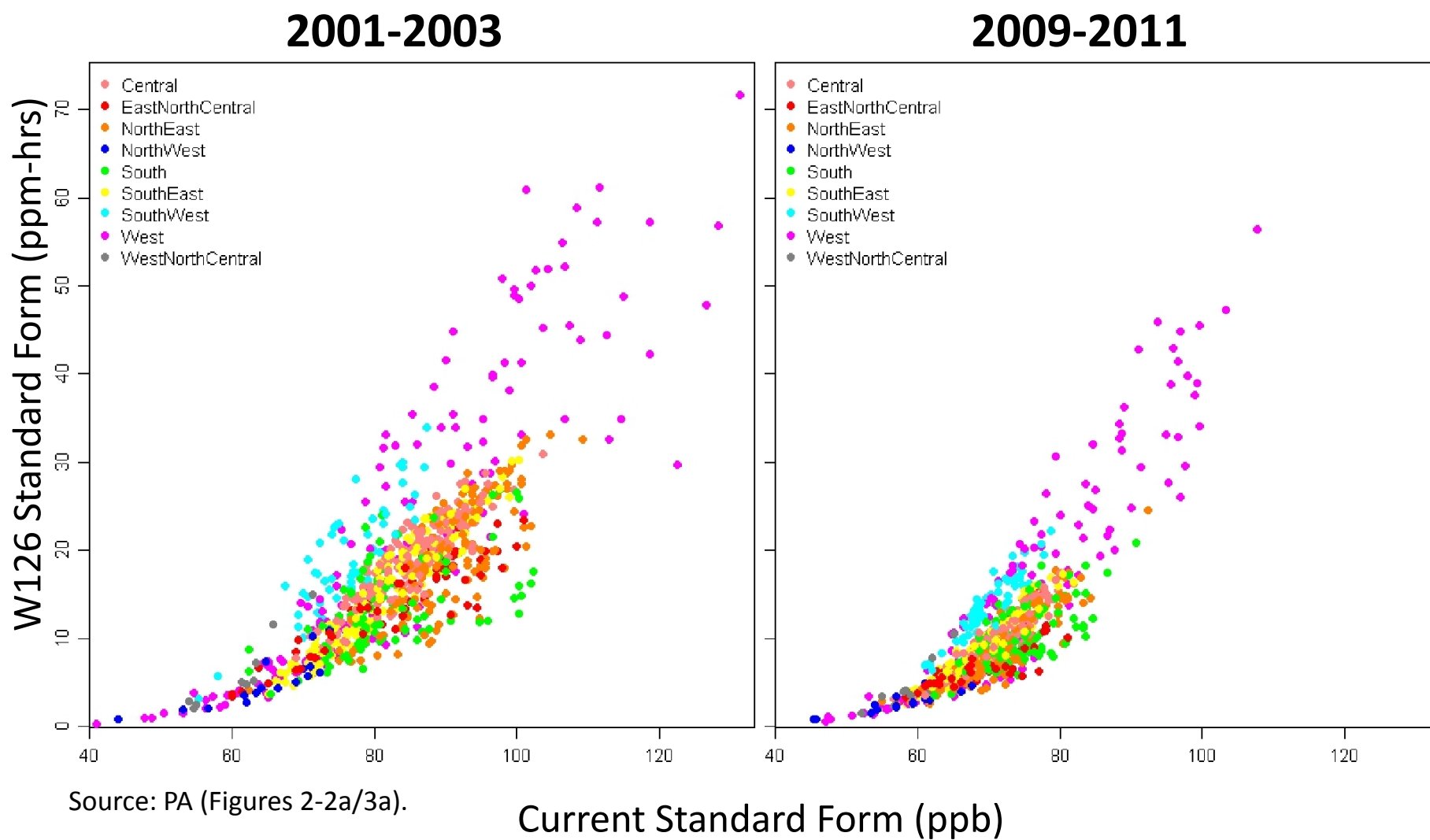
Current Review Proposal

- Welfare Risk and Exposure Assessment (WREA)
 - EPA concludes that air quality analyses **support retaining the current form**
 - EPA concludes that welfare risk analyses **support lowering the current level**
- Proposed Rule (PR)
 - Retain current form (identical to the primary standard)
 - Lower to a level set within a range between 0.065-0.070 ppm
 - Estimated to provide air quality, in terms of 3-year average W126 index values, of $\leq 13-17$ ppm-hours

O₃ Secondary Form

- EPA evaluated the relationship between O₃ concentrations measured in:
 - **Current form:** 3-year average of the annual 4th highest daily maximum 8-hour concentrations (in ppb)
 - **W126 form:** 3-year average of the annual maximum 3-months' sum of weighted daytime (8 AM – 8 PM) concentrations (ppm-hours)

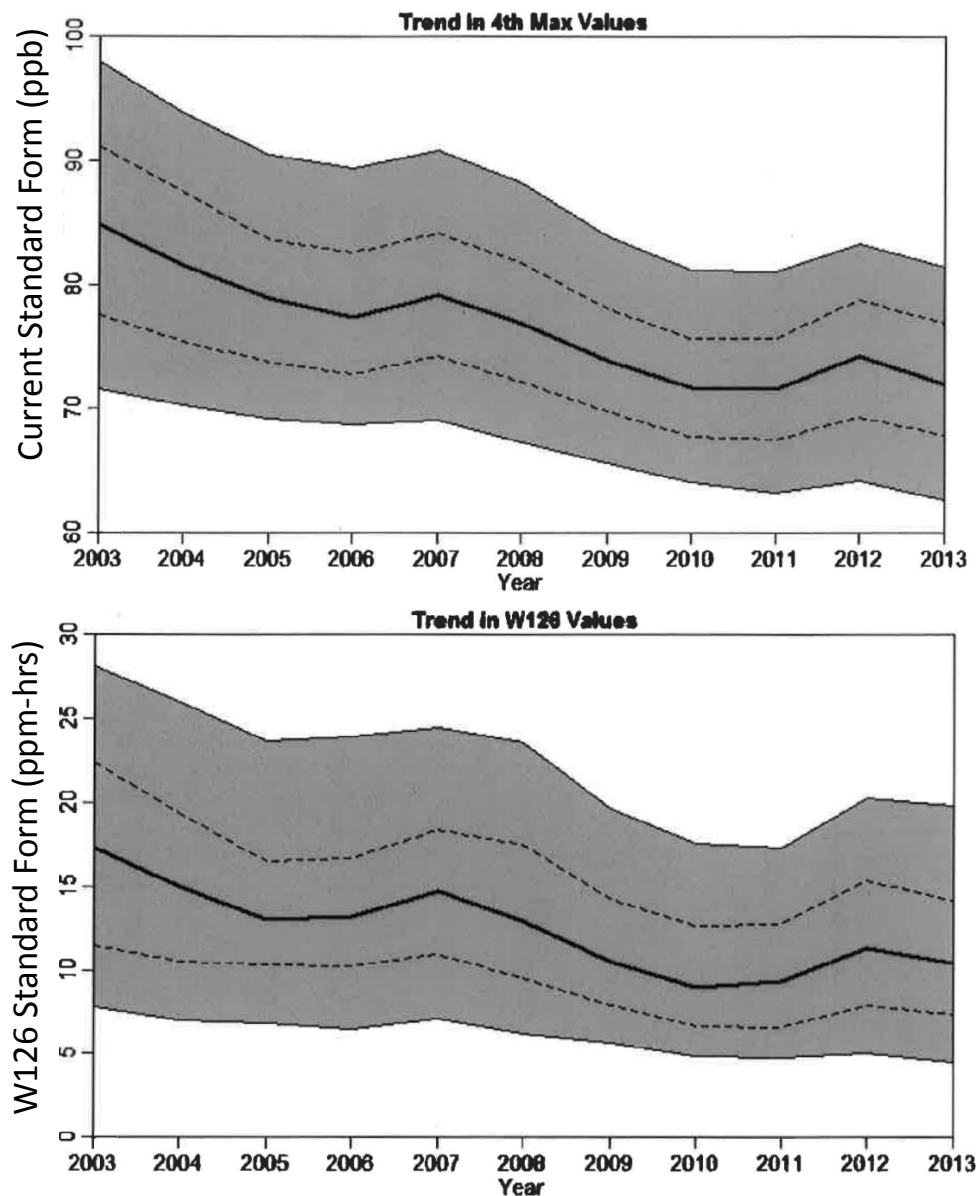
O₃ Secondary Form – Air Quality Analyses



Source: PA (Figures 2-2a/3a).

Current Standard Form (ppb)

O₃ Secondary Form – Air Quality Analyses



Source: Wells (2014, Figures 6-7).

O₃ Secondary Form – Air Quality Analyses

Based on these analyses, EPA states in the PR:

- “The 4th high metric and a three-year average W126 metric are highly correlated, as are the relative changes in these two metrics over the past decades.” (FR/Vol. 79, No. 242, p. 75346)
- “If the EPA were to establish a distinct secondary standard, there would be unique implementation issues to consider. These could include issues related to, but not limited to, PSD [prevention of significant deterioration] implementation, nonattainment area classification thresholds, attainment planning, and conformity demonstrations.” (FR/Vol. 79, No. 242, p. 75374-75375)

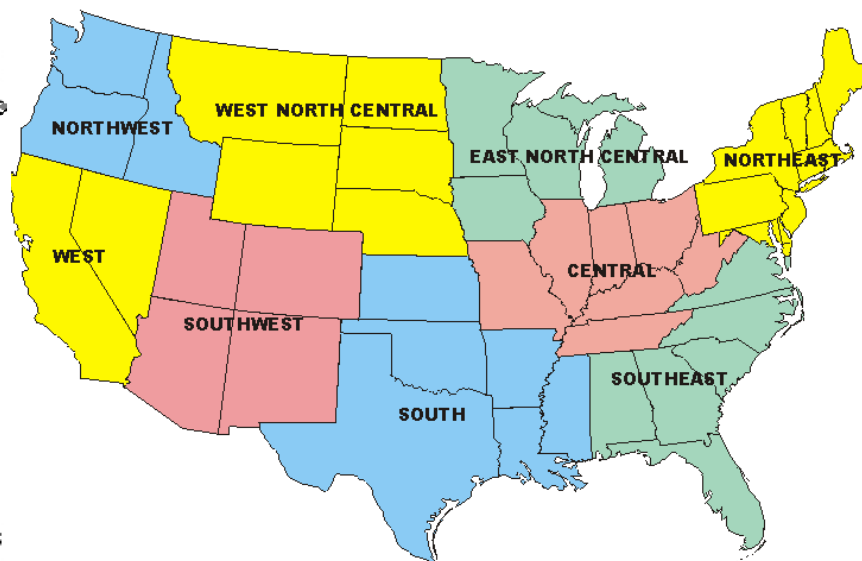
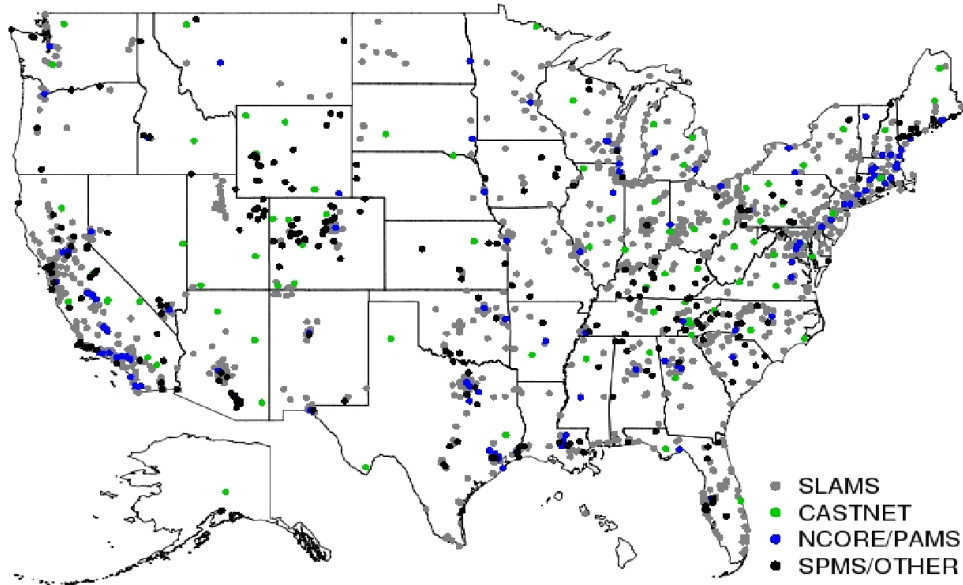
O₃ Secondary Form – Summary

- EPA's analyses demonstrate that the current standard form can serve as an effective surrogate for an alternative cumulative standard form (W126) in providing air quality that protects welfare
- EPA is correct in recognizing that a distinct secondary standard would result in unique implementation and programmatic challenges. These need to be better understood before a distinct secondary standard is considered
- **EPA is justified in proposing to retain the current form**

O₃ Secondary Level

- In the WREA, welfare risks were evaluated for:
 - Recent ambient air quality (2006-2008)
 - Just meet the existing standard (75 ppb)
 - W126 levels of 15, 11, and 7 ppm-hrs
- In the PR, EPA concludes that W126 levels in range from 13-17 ppm-hrs would provide requisite welfare protection (FR/Vol. 79, No. 242, p. 75237)
 - Air quality analyses
 - Relative Biomass Loss (crops, trees)
 - Visible Foliar Injury
 - Ecosystem Services

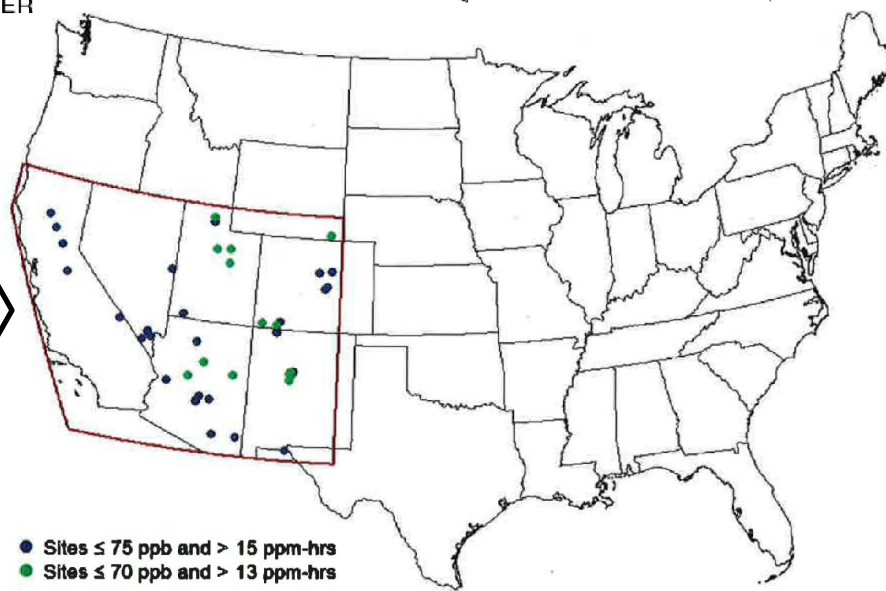
O₃ Secondary Level – Air Quality Analyses



- SLAMS
- CASTNET
- NCORE/PAMS
- SPMS/OTHER

4 th Max. Level (ppm)	Total Monitors	W126 Level (ppm-hrs)		
		> 13	> 15	> 17
0.075	907	75	35	15
0.070	614	16	4	0
0.065	296	0	0	0

Source: Wells (2014).



- Sites ≤ 75 ppb and > 15 ppm-hrs
- Sites ≤ 70 ppb and > 13 ppm-hrs

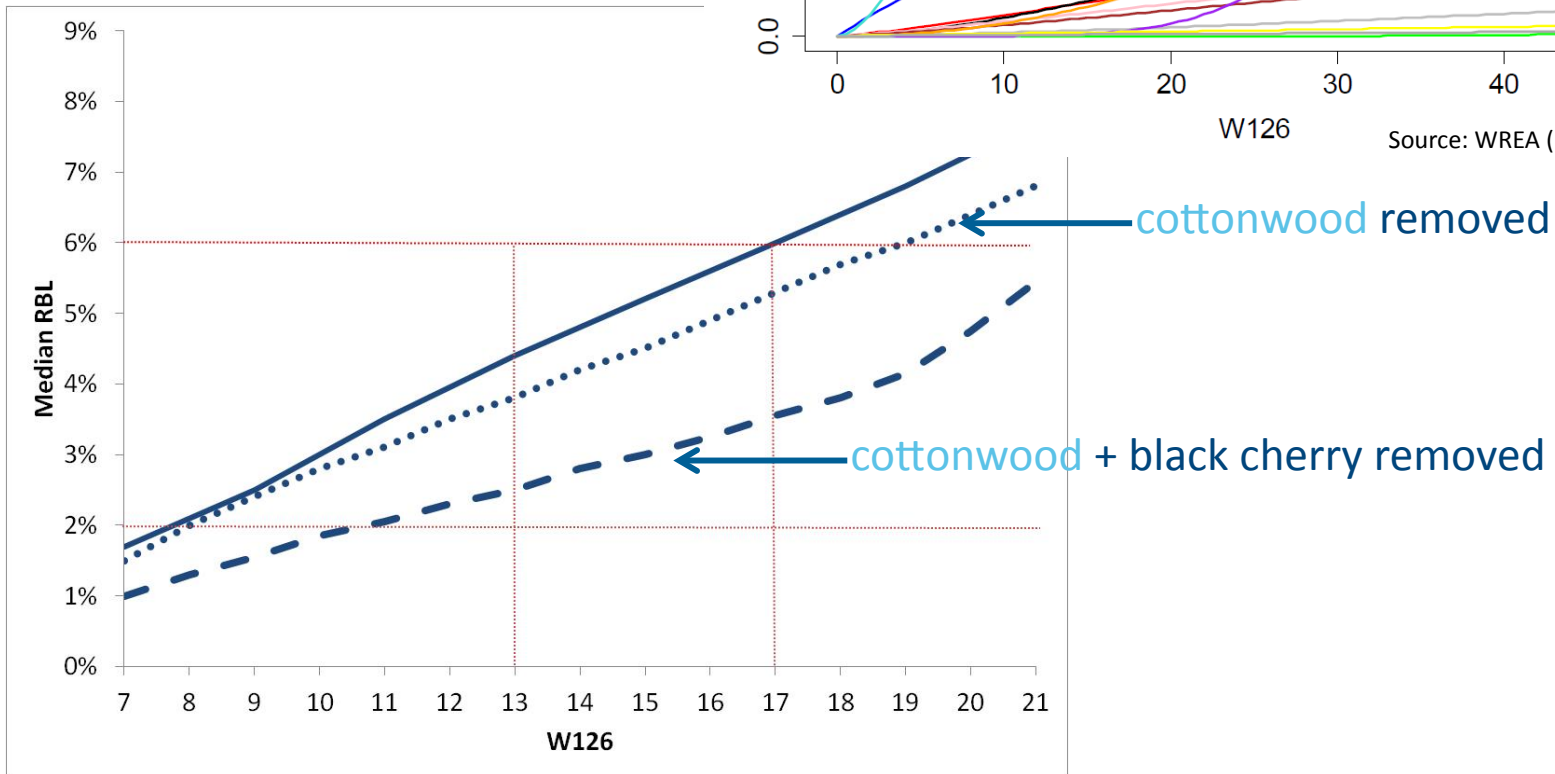
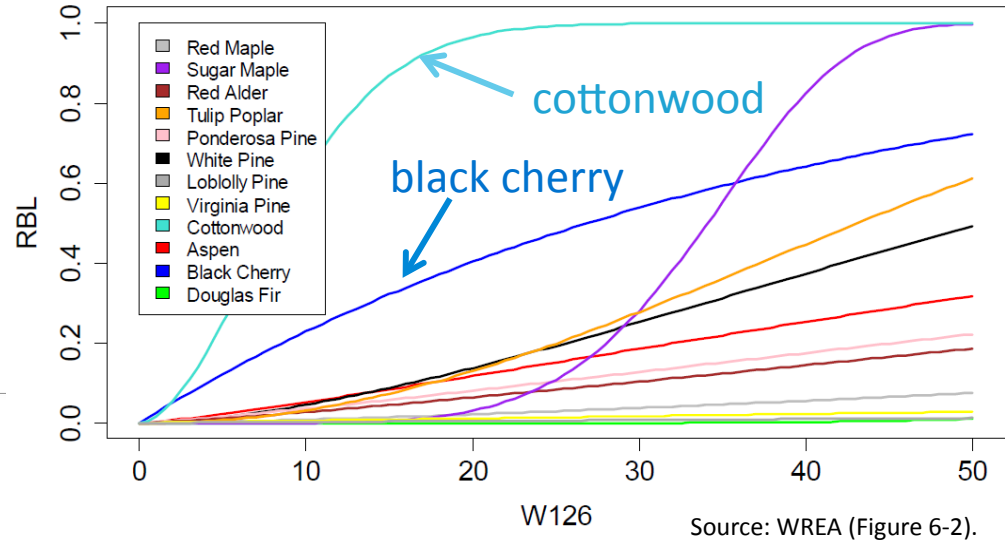
O₃ Secondary Level – Air Quality Analyses

- EPA recognizes several uncertainties associated with the W126 estimates in the SW and W climate regions
 - “W126 index values estimated in the rural areas in the West, Northwest, Southwest, and West North Central with few or no monitors...are more uncertain than those estimated for areas with denser monitoring” (FR/Vol. 79, No. 242, p. 75323)
 - “O₃ concentrations in certain high-elevation sites in the western United States can be substantially impacted by a combination of non-local sources like international transport, stratospheric O₃ , and O₃ originating from wildfires” (FR/Vol. 79, No. 242, p. 75323)
 - W126 index values are uncertain in areas with non-average climate conditions, characterized by drought and/or low soil moisture (*i.e.*, conditions that cause some plants to progressively close their stomata, thereby limiting air movement into the foliage reducing O₃ exposure)
- In light of the uncertainties associated with the few predicted exceedances in the SW and W, just meeting the current standard, is already predicted to result in W126 levels in the proposed range (*i.e.*, 13-17 ppm-hrs)

O₃ Secondary Level – Biomass Loss

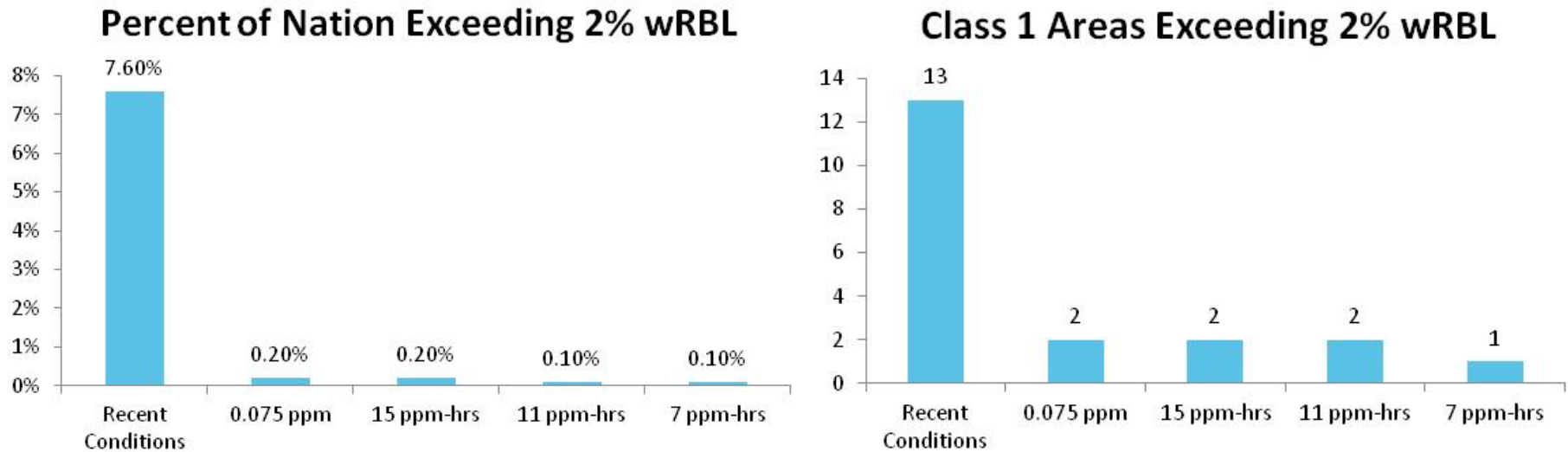
- Substantial uncertainties
 - Limited dataset (12 species, 52 studies; 51 studies conducted in 1989-1992)
 - High inter-species variability
 - Potential outlier studies (Eastern Cottonwood, Black Cherry)
 - Seedling-to-adult extrapolation: data only available for 6 species, shown to result in over- and underestimations
 - Two additional FACE studies (Aspen, Soybean), conducted using only two exposure levels well outside the proposed range (13-17 ppm-hrs) – ambient (3-4 ppm-hrs) and elevated (28-46 ppm-hrs)
 - Arbitrary RBL threshold
- Recognized by EPA
 - CASAC stated that the cottonwood data received too much emphasis. EPA revised its RBL analyses in the final WREA and PR with respect to cottonwood (and black cherry)
 - EPA acknowledged in the PR that CASAC has not provided a scientific rationale for its recommended RBL thresholds (FR/Vol. 79, No. 242, p. 75343). EPA revised its RBL analyses by considering an arbitrary range from 2-6% tree RBL, rather than an arbitrary 2% tree RBL

O₃ Secondary Level – Biomass Loss



O₃ Secondary Level – Biomass Loss

- Substantial reductions in tree RBL and crop RYL predicted when going from recent conditions to just meeting the current standard (*i.e.*, corresponding to W126 levels of ~15 ppm-hrs)
- Predicted additional reductions in RBL at lower W126 levels (<15 ppm-hrs) are small and uncertain



145 Class 1 Areas Included in Analysis

O₃ Secondary Level – Foliar Injury

- Substantial uncertainties
 - Highly variable (year-to-year, site-to-site, intra-species, and inter-species)
 - Difficult to relate to effects on individual plant growth
 - To the extent visible foliar injury causes growth impacts, those would already be evaluated in the RBL analyses
- Recognized by EPA
 - “We take note of the appreciable variability in this endpoint...which poses challenges to giving it primary emphasis in identifying potential alternative standard levels” (PA, p. 6-65)
 - “O₃ is not a good predictor of the presence or absence of foliar injury” (WREA, p. 7-63)



Source: NASA (2011).



O₃ Secondary Level – Foliar Injury

Screening-level assessment of Visible Foliar Injury in National Parks

- When adjusted to just meet the existing standard, none of the 214 parks evaluated would exceed the 10.46 ppm-hrs benchmark identified by EPA

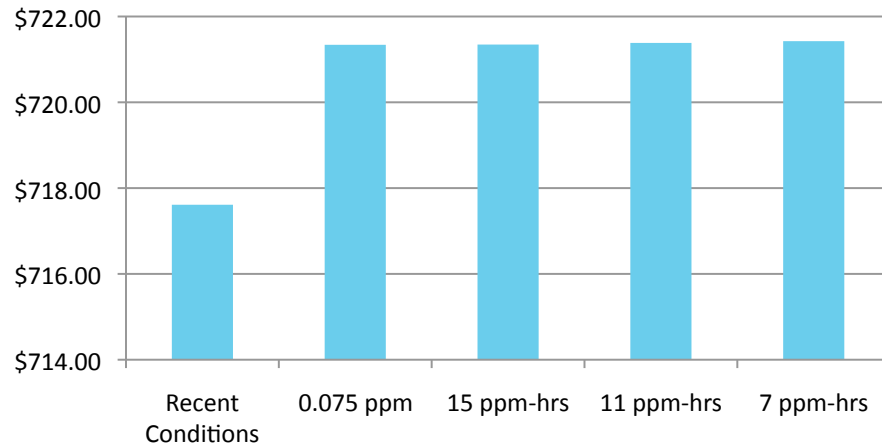


Source: WREA Appendix 7A (Figure 7A-6).

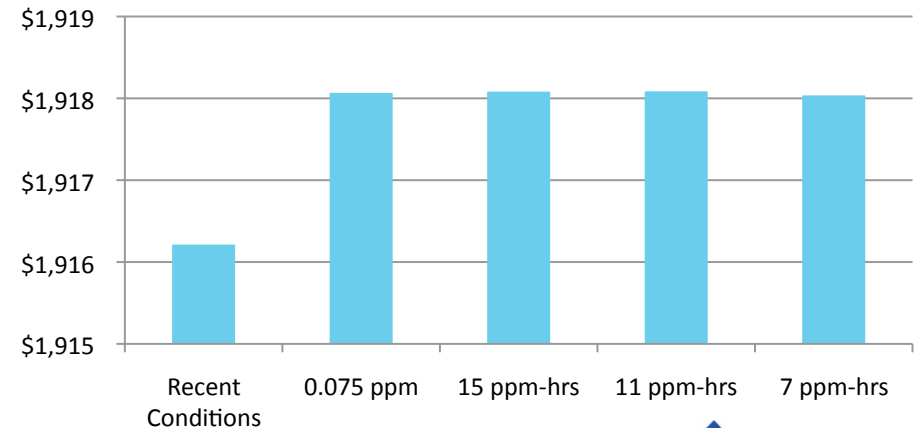
O₃ Secondary Level – Ecosystem Services

- “Economic welfare impacts resulting from just meeting the existing and alternative standards were largely similar between the forestry and agricultural sectors.” (FR/Vol. 79, No. 242, p. 75323)
- Predicted changes in carbon sequestration and air pollution removal were substantial when just meeting the current standard compared to recent conditions, with lower W126 levels showing only small and highly uncertain additional benefits

Forestry Consumer Surplus

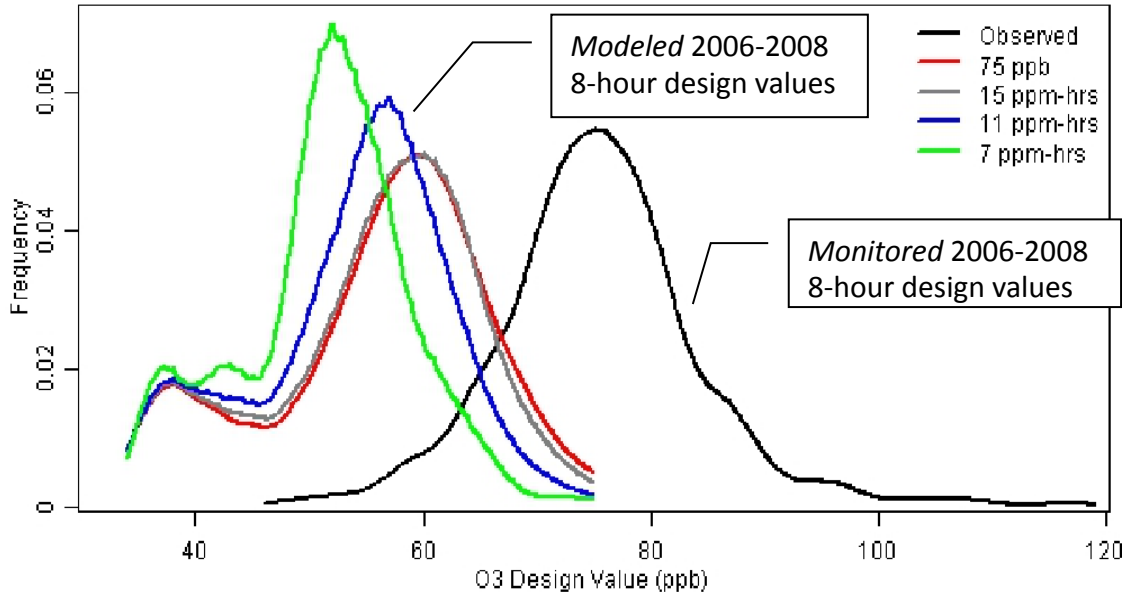


Agriculture Consumer Surplus



O₃ Secondary Level – Summary

- Meeting the current level is predicted to result in substantial reductions in O₃ exposure (W126 levels) and substantial welfare benefits
- Further level reductions result in marginal and highly uncertain incremental air quality and welfare benefits
- **Current review data and analyses do not support lowering the level**



Source: WREA (Figure 4-15).

Region	Highest W126 Value (ppm-hrs)	
	Monitored	Modeled (75 ppb adjustment)
Central	18.3	14.0
East North Central	13.8	6.4
Northeast	17.9	2.6
Northwest	6.6	3.8
Southeast	22.2	11.9
South	18.1	6.4
Southwest	24.3	17.7
West	48.6	18.9
West North Central	12.2	9.3

Source: WREA (Table 4-3).

O₃ Secondary – Conclusions

- **Form** – The current form of the O₃ secondary standard (identical to the primary form) is capable of providing welfare protection equivalent to a secondary standard in the W126 form
- **Level** – Lowering the level of the O₃ secondary standard is expected to provide marginal and highly uncertain welfare benefits beyond the substantial benefits predicted by just meeting the current standard level

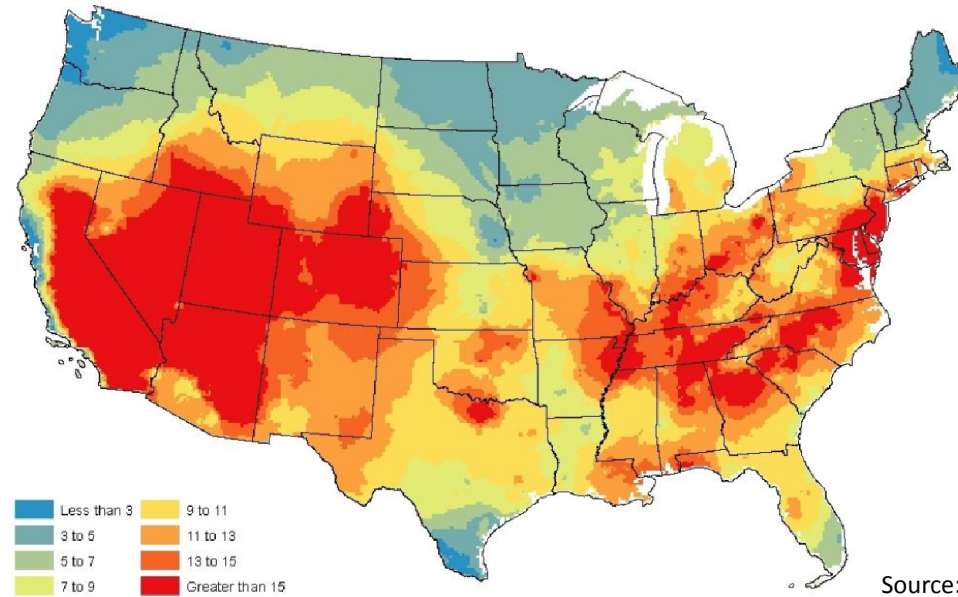
Questions?

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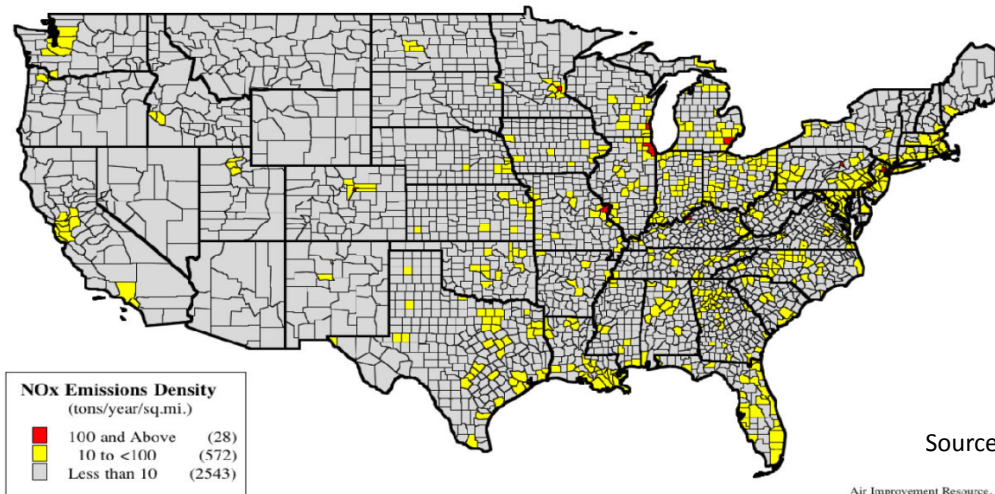
Back-up Slides

Background Contributions in W/SW Regions



Source: WREA (Figure 4-5).

National Surface of Observed 2006-2008 Average W126 Concentrations, in ppm-hrs



Source: Wolff et al. 2014 (Figure 6).

NO_x Emission Densities in 2011, by County

Air Improvement Resource, Inc.



Air Quality in Class I Areas

- EPA conducted an analysis to show that 22 Class I Areas have W126 levels ≥ 15 ppm-hrs, even though air quality met the current standard level (during one or more 3-year periods during 1998-2012)
- In 20 of these Class I areas, W126 levels ranged from 19-29 ppm-hrs (19 ppm-hrs estimated by EPA to correspond to median RBL of $\geq 6\%$ which CASAC deemed “unacceptably high”)
- EPA relies on this analysis to conclude, in the PR, that attainment of the current standard does not adequately protect against potential tree growth impacts in Class I areas
 - Due to the long range transport of ozone and ozone precursors to Class I areas from upwind non-attainment areas, it is not appropriate for EPA to evaluate the level of protection offered by the current primary ozone standard under current conditions.
 - When these upwind areas make emissions reductions to attain the current standard, downwind areas will see improvements in air quality and decreasing W126 levels. As a result, EPA's W126 estimates for Class I areas were overestimated.
 - Using the 2025 baseline inventory adjusted to meet a primary standard of 75 ppb, ESS and ENVIRON show that all Class I areas identified by EPA as attaining a standard of 75 ppb but exceeding a W126 of 15 ppm-hours have a W126 below 13 ppm-hours
 - This analysis should not be considered justification for lowering the standard level.

Summary of RBL Analyses

Analyses	Recent Conditions	Adjustment			
		Existing Standard (75 ppb)	15 ppm-hrs	11 ppm-hrs	7 ppm-hrs
National-scale RBL Analysis (see WREA, Table 6-25; excluding cottonwood)	Percent of Total Covered Area Exceeding 2% wRBL = 7.6%	Percent of Total Covered Area Exceeding 2% wRBL = 0.2%	Percent of Total Covered Area Exceeding 2% wRBL = 0.2%	Percent of Total Covered Area Exceeding 2% wRBL = 0.1%	Percent of Total Covered Area Exceeding 2% wRBL = < 0.1%
Class I Area RBL Analysis (see WREA, Table 6-26; excluding cottonwood)	Number of Class I Areas Exceeding 2% wRBL = 13	Number of Class I Areas Exceeding 2% wRBL = 2	Number of Class I Areas Exceeding 2% wRBL = 2	Number of Class I Areas Exceeding 2% wRBL = 2	Number of Class I Areas Exceeding 2% wRBL = 1
County Analysis (see WREA, Table 6-7; excluding Cottonwood and Black Cherry)	Percentage of Counties with median RBL Exceeding 2% = 0.21%	Percentage of Counties with median RBL Exceeding 2% = 0.012%	Percentage of Counties with median RBL Exceeding 2% = 0.006%	Percentage of Counties with median RBL Exceeding 2% = 0.002%	Percentage of Counties with median RBL Exceeding 2% = 0.001%
Provisioning – Timber Production (see WREA, Table 6-9)	N/A	Range RYL = 0-3.25%	Range RYL = 0-3.25%	Range RYL = 0-2.79%	Range RYL = 0-2.0%
Provisioning – Agricultural Harvest (see PA Table 6-4)	N/A	Mean yield loss Corn = < 5% Soybean = < 5%	Mean yield loss Corn = < 5% Soybean = < 5%	Mean yield loss Corn = < 5% Soybean = < 5%	Mean yield loss Corn = < 5% Soybean = < 5%
Relative Crop Yield Loss for 10 species (see WREA, Table 6F-2)	N/A	N/A	Median species Relative Crop Yield Loss = 3.9%	Median species Relative Crop Yield Loss = 2.0%	Median species Relative Crop Yield Loss = 0.8%