WESTERN REGIONAL AIR PARTNERSHIP
NATURAL CONDITIONS
STATUS SUMMARY AND RECOMMENDATIONS REPORT

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6/25/2013

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1.0 INTRODUCTION

The concept of "Natural Conditions" in regional haze represents the long term goal of improving visual conditions in our national parks and wilderness areas. In regulatory context, section 169A of the Clean Air Act (CAA), established in the 1977 Amendments, set forth a national goal for visibility which is the ''prevention of any future, and the remedying of any existing, impairment of visibility in Federal Class I areas (CIAs) which impairment results from manmade air pollution.''[1] In 1999, EPA promulgated the Regional Haze Rule (RHR),[2] which included requirements that each state develop and submit State Implementation Plans (SIPs) to address regional haze in Federal CIAs by establishing goals that provide for "reasonable progress" towards achieving natural visibility conditions by the year 2064.

The first RHR SIPs were due by December 17, 2007, and were required to address reasonable progress towards an initial 2018 planning milestone towards the long-term Natural Conditions goal at each state's CIAs. EPA provided the concept of a linear, or uniform, rate of reasonable progress between the 2000-2004 baseline period and the nominal Natural Conditions goal year of 2064.[3] Each state will be required to submit a revised regional haze implementation plan by July 31, 2018 and every 10 years thereafter, defining and defending new interim amounts of reasonable progress toward natural visibility goals, adjusting the end year as needed along the way.

An important consideration for defining interim reasonable progress goals towards Natural Conditions is establishing what the long-term Natural Conditions goals are. Formally, as specified in the CAA, Natural Conditions represent the visibility conditions that would be experienced in the absence of human-caused impairment. In practical terms, establishing long-term "Natural Condition" goals is complicated by several factors, including the following:

1. Natural Conditions cannot be directly measured.

2. Human-caused impairment is an ambiguous concept, as human activity can affect emissions from sources such as windblown dust and wildfires, and human activity profoundly affects all natural systems and their emissions.[4]

3. Naturally occurring visibility impairment is not constant, and can vary daily, seasonally and from year to year. This can depend on things such as wildfire activity, meteorology, global warming, etc.

[1] See Section 169a of the 1977 CAA Amendments

[2] See CFR 40 Part 51 Regional Haze Regulations; Final Rule, July 1, 1999 sections 308 and 309

[3] Note that States can extend the period of time needed to achieve Natural Conditions, beyond the nominal 2064 in the RHR, defining and defending new interim amounts of reasonable progress, and adjusting the 2064 end year as needed (see CFR Section 51.308).

[4] The current era is referred to as the "Anthropocene", which is an informal geologic chronological term that serves to mark the evidence and extent of human activities that have had a significant global impact on the Earth's ecosystems.

4. Some human-caused impairment is caused by uncontrollable sources such as international transport of emissions, making the Natural Conditions goal as defined in the CAA effectively unattainable.

The RHR formally requires each state provide an adequate estimate of natural visibility conditions for best and worst visibility days in each CIA within the state. In recognizing the complexity of the issue of estimating natural visibility goals, the EPA committed to developing technical guidance on estimating natural visibility conditions.[5] To this end, the EPA published the *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule* in September 2003, which offered as a starting point a "default" natural visibility target for each Class I area. Default conditions were based on broad regional estimates, with expectations these estimates would be refined over time.[6] One such refinement was the Natural Conditions II estimates[7] that were used by most states in developing their original RHR SIPs. These revised estimates were based on the same EPA default mass estimates, but included updates in methodology that addressed some criticisms regarding the calculation of extinction from the default mass values.

With each 10-year SIP revision, there is an opportunity for states to further refine Natural Conditions estimates. This document provides a summary of the progression and current status of these estimates, including the original EPA default estimates and the revised Natural Conditions II estimates. Also summarized here are considerations and recommendations for future Natural Condition refinements, and some recommended adjustments to regional haze management strategies. Much of the documentation referenced in this report regarding methodologies, critical reviews, and current science related to Natural Conditions has been assembled and archived in an online repository maintained by the WRAP.[8]

[5] CFR 40 Part 51 states, "The EPA understands that estimating natural visibility conditions can involve many technically complex issues. The EPA is committed to working with the States, tribes, and FLMs on this issue to develop technical guidance on estimating natural visibility conditions."

[6] CFR 40 Part 51 states, "The EPA is committed to working with the States, tribes, and FLMs on this issue to develop technical guidance on estimating natural visibility conditions. The EPA expects that these estimates may be refined over time."

[7] See Copeland's 2008 *Regional Haze Rule Natural Level Estimates Using the Revised IMPROVE Aerosol Reconstructed Light Extinction Algorithm*.

[8] WRAP's archived repository of Natural Conditions information, projects and references is available at http://www.wrapair.org/forums/aamrf/projects/NCB/index.html.

2.0 EPA DEFAULT NATURAL CONDITIONS

The EPA's 2003 Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule offered a "default" natural visibility target in deciviews for each Class I area.[9] The default measurements were a crude first estimate based on broad regional mass concentration estimates. The guidance stated that these initial Natural Conditions estimates were anticipated to be adequate to satisfy the requirements of the regional haze rule as a starting point for the initial SIPs.[10] While a useful starting point, these estimates have been widely reviewed and criticized. Described here is a general description of the methodology applied for the default estimates, and a summary of some of the criticisms, assumptions and limitations that were inherent in these first estimates.

2.1 METHODOLOGY

The starting point for the EPA default Natural Conditions were estimates of natural background mass concentrations for the PM species that contribute to haze, as developed in 1990 by Trijonis for the National Acid Precipitation Assessment Program (NAPAP).[11] These estimates were applied broadly as characterizing conditions east of the Mississippi (including the Virgin Islands) and west of the Mississippi (including Alaska and Hawaii). Extinction was estimated from these mass concentrations as follows:

1. Total extinction was estimated from mass concentrations using the original IMPROVE algorithm, different from the revised IMPROVE algorithm used by all states in their baseline RHR SIPs.

2. Calculated total extinction values were converted to deciview units.

3. To estimate the 20% best and worst days, a normal distribution centered on the deciview approximations was assumed, with assumed standard deviations based on data distributions at pristine locations applied separately for the eastern and western regions.

4. From the normal distributions, the 10^{th} and 90^{th} percentile values were used to estimate averages for the 20% best and worst days.

Figure 1 presents a contour map showing the distribution of Natural Conditions for the default numbers. Constant mass values were used on each side of the Mississippi, but variability

[9] EPA's September 2003 *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule* is available at www.epa.gov/ttnamti1/files/ambient/visible/natural.pdf.

[10] CFR 40 Part 51 states "The EPA supports use of these estimating techniques as a valid starting point because they rely on peer-reviewed estimates of the natural composition of fine particle mass and analysis of data from the IMPROVE program's well established approach, refined over the past 10 years or more, for calculating light extinction from monitored PM constituents."

[11] See Appendix A (*Characterization of Natural Background Aerosol Concentrations*) by J.C. Trijonis in NAPAP's 1990 *Acidic Deposition: State of Science and Technology. Report 24. Visibility: Existing and Historical Conditions – Causes and Effects*.

is introduced through use of CIA specific relative humidity factors in the IMPROVE extinction calculation algorithm to account for the growth of some particle species as relative humidity increases.

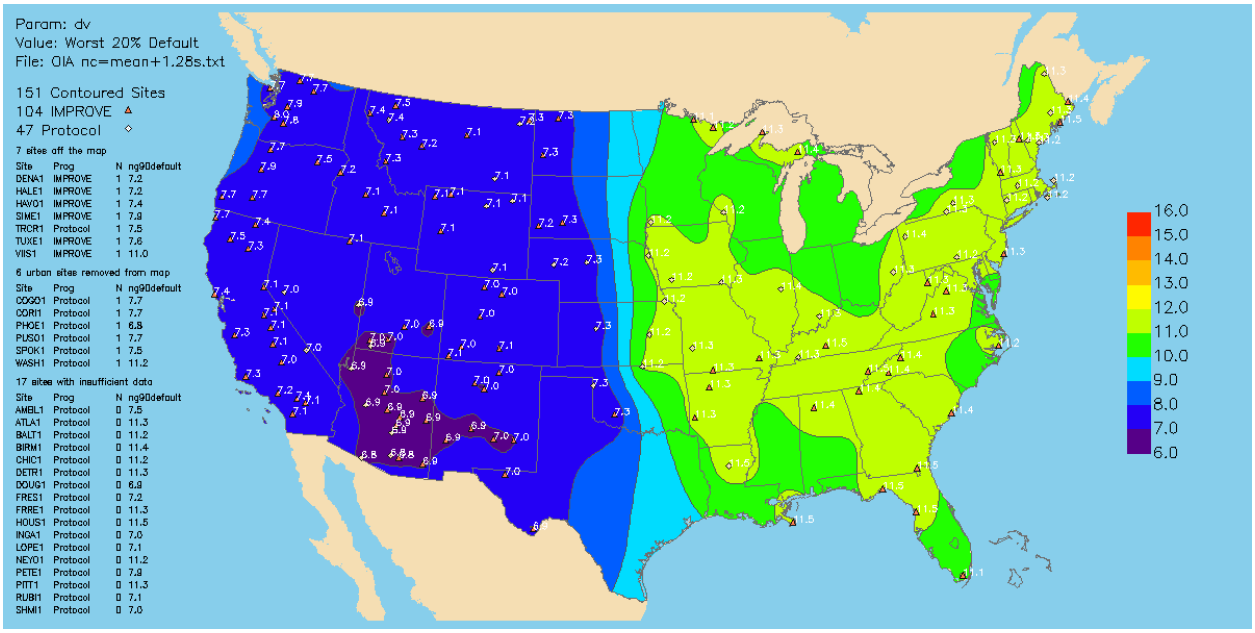

Figure 1. Contour Map Depicting EPA Default Natural Condition Calculations (from Pitchford et al., 2006).

2.2 CRITICISMS, ASSUMPTIONS, AND LIMITATIONS

In proposing the default conditions, the EPA noted that these were crude first estimates, with the expectation that the estimates would be refined over time. Numerous critical reviews have pointed out the shortcomings of these first default estimates offered by the EPA.[12] Some of the criticisms, assumptions, and limitations that have been identified are listed below:

- The default estimates used mass estimates as a starting point (the Trijonis estimates) originally published in 1990 that were based on the limited information available at the time, and included large error factors.

- The Trijonis mass estimates were applied as broad regional constants for only two regions: eastern states including one tier west of the Mississippi, and western states which also included Alaska and Hawaii, except where the measured average was already less than the estimated default. In these cases, actual measured values were used in place of the default estimates. Besides the lack in spatial variability, criticisms of this application have included the following:

[12] See, for example, EPRI's 2004 *Recommended Refinements to EPA's Guidance for Estimating Natural Conditions and Tracking Progress Under the Regional Haze Rule* and Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions* (full references in bibliography).

- The estimates do not include temporal variability which may be affected by local meteorological conditions and episodic events such as wildfires, dust transport, and volcanic activity.

- Applying these estimates as constants for each region does not account for the variability that was implied when Trijonis proposed these numbers as a "mean" rather than a "constant".[13]

- The western Trijonis mass numbers were originally proposed as representative of the mountain/desert areas of the western United States. This characterization excludes some of the western United States where the number were applied, including the non-mountain/desert regions (e.g., western coastal areas), and any non-contiguous areas (e.g., Alaska and Hawaii).

- The mass estimates do not account for uncontrollable background conditions that are outside of federal and state jurisdictions, including transported anthropogenic emissions from international sources, as well as natural sources such as wildfire events and volcanic emissions.

- The procedure to estimate the 20% best and worst day calculations from the deciview estimates was also noted to have some flaws, including the following:

  - The estimate assumed a normal distribution of deciviews, and assumed a constant east or west standard deviation. Actual distributions for each CIA will have some degree of spatial and temporal variability, and EPRI notes that studies have shown visibility measurements do not tend to follow a normal distribution.[14]

  - Assuming a normal distribution, the selection of the 10th and 90th percentile values are not statistically representative of the 20% best and worst day averages.

- Extinction was calculated from the mass estimates using the original IMPROVE algorithm, which has since been updated to reflect current science, with additions such as the contribution of extinction from a sea salt surrogate, and improvements upon some of the biases in the original equation.

- It has also been noted that the default calculations offered by the EPA used RH factors from CIA centroids, while IMPROVE calculations are intended to use RH factors from the actual IMPROVE monitor location.

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[13] A draft report by David Halliday, PhD at TCEQ, proposed accepting measured conditions as default if they were already within the error bounds of the default measurements (see Halliday's 2007 report, *Estimating Natural Conditions Based on the Revised IMPROVE Algorithm* at http://www.tceq.texas.gov/assets/public/implementation/air/sip/bart/haze_sip-est.natural_conditions.pdf).

[14] EPRI's 2004 *Recommended Refinements to EPA's Guidance for Estimating Natural Conditions and Tracking Progress Under the Regional Haze Rule* cites an STI study (Ryan, 2004) showing that reconstructed visibility data (in deciviews) does not follow a normal distribution.

3.0 NATURAL CONDITIONS II

Between the publication of the EPA's *Guidance for Estimating Natural Visibility Conditions*, and the submission of the original RHR SIPs, revisions were offered to address some of the limitations inherent in the default estimates. These revisions were termed Natural Conditions II (NCII), and were adopted by most states for use in the first round of SIP submittals. NCII estimates used the same mass approximations used for the default measurements, but calculation methodology was revised as follow:

- Extinction calculations used a revised IMPROVE algorithm,[15] which addressed some of the limitations of the original IMPROVE algorithm.

- Site and species specific distributions from the current monitoring period were scaled and applied for the selection of best and worst days. This addressed some of the issues associated with the use of a normal distribution as used for the default estimates.

The methodology applied for these revised measurements is described briefly here, followed by a summary of some of the outstanding criticisms, assumptions and limitations.

3.1 METHODOLOGY

In 2006, a committee established by the five regional planning organizations developed methodology to address some of the issues identified for the EPA default estimates.[16] This included the use of the same Trijonis mass estimates, but with some modifications in the methodology used to determine Natural Condition visibility goals. Extinction was estimated from the Trijonis mass concentrations as follows:

1. For each regional haze species, the mass distributions as measured during the 2000-2004 baseline period were determined for each site. The distributions were preserved, but measurements were scaled so that the means matched Natural Condition estimates. If the species specific annual mean mass concentration was already less than the natural estimate, no scaling was applied to the distributions.

2. Total extinction was calculated from the mass distributions using a revised IMPROVE algorithm. The revised algorithm included the addition of a sea salt surrogate, which was not included in the original Trijonis mass numbers, so actual 2000-2004 sea salt measurements without adjustments were used to represent Natural Conditions on a site specific basis.

[15] The revised IMPROVE algorithm is described in detail in Hand's 2005 *Review of the IMPROVE Equation for Estimating Ambient Light Extinction Coefficients - Final Report* available at http://vista.cira.colostate.edu/improve/Publications/GrayLit/016_IMPROVEeqReview/IMPROVEeqReview.htm.

[16] See Copeland's 2008 *Regional Haze Rule Natural Level Estimates Using the Revised IMPROVE Aerosol Reconstructed Light Extinction Algorithm*.

3. From the species specific distributions, total extinction was calculated, and the resulting distribution was used to determine the 20% best and worst day averages. An advantage of using species specific distributions was the fact that an average for the 20% best and worst days could also be calculated by species. While not specifically required by the RHR, species specific Natural Conditions goals were referenced by most states in their initial SIPs for planning purposes.

Figure 2 presents a contour map showing the distribution of Natural Conditions for the NCII numbers. The distribution is similar to calculations for default measurements, as both methods use the constant mass values for the "east" and "west" regions of the states. More variability is introduced for the NCII numbers through the application of site specific distributions, sea salt measurements and relative humidity factors. The impact of including the site specific sea salt surrogate is dramatic at some of the coastal sites.

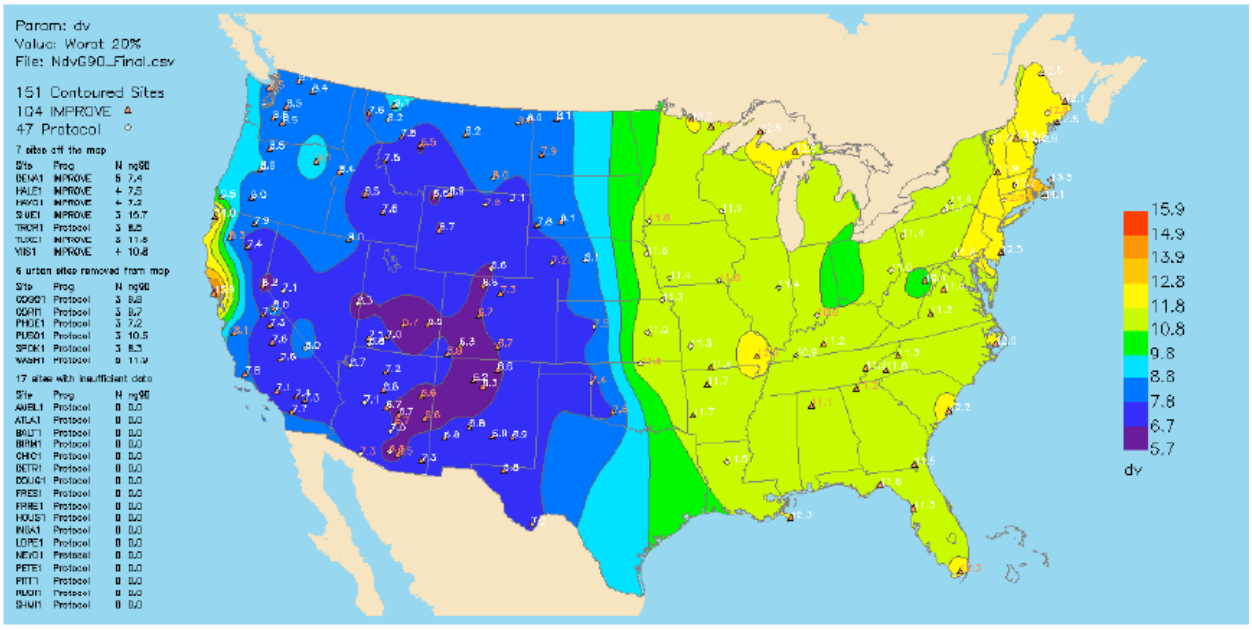

Figure 2. Contour Map Depicting NCII Natural Condition Calculations (from Pitchford et al., 2006).

3.2 CRITICISMS, ASSUMPTIONS AND LIMITATIONS

The NCII estimates addressed some of the major flaws in the default methodology, but were based on the same mass estimates as the default measurements, with some of the same limitations. Some of the outstanding criticisms, assumptions and limitations for these current estimates of Natural Conditions are listed below:

- The NCII estimates still rely on the same default mass concentrations as the basis for calculation. As described earlier, using these mass values as representative constants for the east and west regions severely limits the spatial and temporal representativeness of these estimates.

- The frequency distribution for each component under Natural Conditions is assumed to be the same as the average distribution that was measured between the years 2000 and 2004. Even with only natural impacts, this distribution would vary from year to year due to variables such as episodic events and changes in meteorology. Also, it is unknown to what extent the current distribution is driven by anthropogenic emissions.

- Extinction calculations rely on the IMPROVE algorithm, which was recently revised, but is still an approximation of the effects of aerosol concentrations on visibility with assumptions and limitations of its own.

4.0 CURRENT STATUS AND OPTIONS

The long term 60 year implementation period for RHR goals, with periodic SIP updates due every 10 years, provides an opportunity to continually review and revise the Natural Conditions estimates. Also, over the long term planning process, it is possible that regulatory policy and guidance language will continue to evolve and provide clarification regarding how visibility protection is best achieved.

This section explores some of the current options and input, including both refinements to current estimates, and ideas for policy level changes that would affect how visibility improvement is achieved. Items here include some of the topics of discussion from a recent WESTAR meeting, where RHR concepts were discussed,[17] and references to several publications and reviews on the subject, many of which are available in an online repository archived by the WRAP.[18]

4.1 SCIENCE BASED ISSUES

The most relevant science-based issue is determining the conditions that most accurately reflect what would be measured in the absence of anthropogenic impacts. Implicit in this question are some policy level questions which are discussed in the next section. The default Natural Conditions and the updated Natural Conditions II estimates divide the county into only "east" and "west," but these estimates served as a useful starting point for regulatory purposes. The preamble to the 1999 rule stated that further refinement of the default estimate will need to take place in the future on a site-specific basis. The EPA further stated that the first estimates would likely not have a large impact on the first planning period, but would be more sensitive to refinements as the difference between current and Natural Conditions for each Class I area becomes smaller.[19] Also, Tombach showed through sensitivity studies that, in most cases, the initial direction of emission management strategies were not going to be influenced by small changes in our current ability to estimate Natural Conditions.[20]

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[17] The agenda for the May 22-23, 2013 WESTAR meeting is available here, http://www.westar.org/Docs/Business%20Meetings/Spring13/Spring13agenda.html.
At the meeting, topics of discussion included concepts specific to potential revisions to the RHR, including Natural Conditions consideration (see http://www.westar.org/Docs/Business%20Meetings/Spring13/04.1%20Regional%20Haze%20Recommendations.pdf.

[18] WRAP's archived repository of Natural Conditions information, projects and references is available at http://www.wrapair.org/forums/aamrf/projects/NCB/index.html.

[19] Section III-E of the preamble to CFR 40 Part 51 states "Because these values are expressed in regional terms only, further refinement of these estimates will need to take place in the future on a site-specific basis. However, because current conditions at most Class I areas with existing IMPROVE monitoring exceed the above estimates by at least several deciviews (with some of the more impaired Class I areas having values that exceed estimated Natural Conditions by 20 deciviews or more), EPA does not believe that such refined values are necessary for the initial 10-year program implementation period. As the difference between current and Natural Conditions for a particular Class I area becomes smaller, it will be important to develop more precise techniques for estimating Natural Conditions."

[20] See page 6-10 in Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions*.

Each 10-year SIP revision provides the opportunity to further refine the Natural Conditions estimates. For the next round of 2018 revisions, a great deal of new information has become available since the original Trijonis work as the science and understanding of visibility impairment has continued to evolve. Updated measurements will necessarily include factors such as better regional representativeness, and a more accurate representation of the physical composition of aerosol mass related to natural sources. Some of the options for refinements to the regional representativeness and refinements in estimates of the actual mass values used to represent each CIA are listed below.

4.1.1 Refinements to the Regions

One of the biggest limitations of the current estimates is the use of constant mass values which represent the variability of conditions throughout the United States as only two regions, east and west. Ideally, natural background would be estimated on a site-by-site basis, but it may be practical as refinements progress to focus on geographically similar regions. Tombach's report indicated that up to 15 geographically distinct regions are justified based on similar geographic, topographic, vegetative and meteorological traits which affect the characteristics of current PM species concentrations. Tombach's proposed regions are presented in Figure 3.[21]

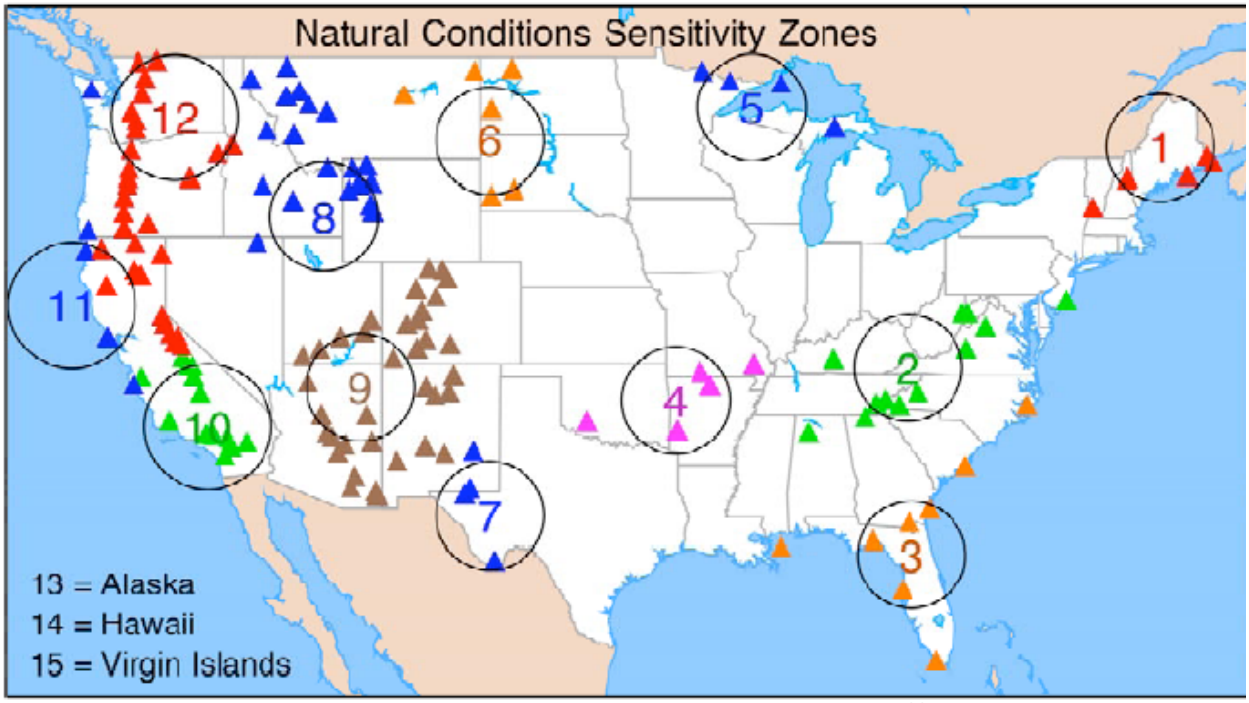

Figure 3. Map of Sensitivity Zones Showing Class I Area Groupings.[22]

[21] Page 7-6 of Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions* includes this map of proposed sensitivity regions, which include 13 in the contiguous US, Hawaii and Alaska.

[22] Figure from Page 7-6 of Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions*.

4.1.2 Attribution Using Current Measurements

Current monitored data can provide useful insight into refinements of the estimates of Natural Conditions. For the NCII estimates, measured sea salt concentrations were used with the assumption that current concentrations are completely derived from natural sources. Attribution for other measured species is more complicated because most current aerosol measurements come from a combination of natural and anthropogenic sources, requiring some sort of attribution analysis to estimate how much of each species is due to natural versus anthropogenic sources on a sample specific basis. The original Trijonis estimates were in part based on inferences regarding the natural fraction of monitoring data, with attribution based on information that was available at the time. Some of the tools available for quantifying the natural fraction of contribution to measured aerosol include the following:

- Carbon isotope dating (e.g., apportioning carbon sources by identifying the age of the measured carbon, which helps to distinguish between newer sources, such wood burning, and older sources such as fossil fuels)

- Application of PMF and CMB models (source apportionment models can apply factors that can work backward from measured data to identify likely source combinations)

- Evaluation of data on cleaner days (clean day measurements in an area may be an indicator of what conditions would be like without man-made emissions)

- Source attribution based on wind direction (identifying a transport patch backwards in time can help identify source regions for measurements)

A current literature review that involved assembling newer data from these and other types of attribution studies would help provide updated information on a finer regional scale for use in revised estimates.

4.1.3 Application of Transport and Diffusion Models

In addition to attribution analysis, transport and diffusion models continue to provide better estimates of current and projected conditions, especially as uncertainties in emissions inventories are reduced. Some examples of modeling approaches are listed below.

- Tombach cited estimates from simulations using GEOS-Chem, a global chemical transport model, which included estimates for natural sources, and transboundary transport from Canada, Mexico, and the rest of world.[23]

- Large scale regional modeling approaches were applied, as specified by the EPA, for the development of the original SIPs to estimate future progress towards interim 2018

[23] Page 7-4 of Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions* includes estimates of background and natural component concentrations from a GEOS-Chem global transport study by Park et a., 2006.

goals. As an example, work by the WRAP included substantial efforts to develop emissions inventories for natural source categories including biogenic emissions, wildland fire and windblown dust. These emissions were modeled along with boundary conditions, along with some projected reductions in anthropogenic emissions.[24] These same modeling approaches could be extended to project "background conditions" with no impact from controllable sources, and also "Natural Conditions" without any human-caused impairment. Using runs from the same modeling effort to project both interim and end points along the glide path would have the advantage of using consistent assumptions, such as natural emissions including emissions from episodic events like wildfires.

4.1.4 Refinements to Extinction Calculation Methodology

Refinements in any Natural Condition estimates are also subject to assumptions involved in calculations of visibility impairment from measured mass. The IMPROVE algorithm for estimating light extinction from mass concentrations was adopted by the EPA as basis for the regional haze metric used to track progress under the RHR. The algorithm estimates species specific light scattering and absorption efficiencies, and includes considerations for factors such as particle growth in different relative humidity environments.

Since its inception, the IMPROVE algorithm has been scrutinized carefully to assess deficiencies that could bias the implementation of the RHR. In 2005, a revised IMPROVE algorithm was proposed that addressed some of the deficiencies identified in the original algorithm, improving the performance of the new algorithm as compared to direct measurements of light scattering.[25] A number of assumptions still exist in the calculation, such as the use of climatological averages of monthly RH for each site, and some assumptions about aerosol composition. The recent revisions of the algorithm reflect the current science available, but continued application of extinction calculations over the long term RHR planning process will likely include continued assessments and improvements which may affect calculations of Natural Conditions.

4.2 POLICY BASED ISSUES

Over the course of promulgation of the RHR rule, the publishing of EPA guidance, and the first RHR SIP submittals, several policy level questions have been raised that may affect how a State is able to demonstrate reasonable progress. Questions have included issues such as how Natural Conditions are defined, how goals are set and how progress is measured. Some of these considerations are listed in this section.

[24] Descriptions of WRAP modeling and emissions inventory efforts for the initial RHR SIPS are available on the WRAP Technical Support System (TSS) project page http://vista.cira.colostate.edu/tss/.

[25] The revised IMPROVE algorithm is described in detail in Hand's 2005 *Review of the IMPROVE Equation for Estimating Ambient Light Extinction Coefficients - Final Report* available at http://vista.cira.colostate.edu/improve/Publications/GrayLit/016_IMPROVEeqReview/IMPROVEeqReview.htm.

4.2.1 Definitions of Natural vs. Man-Made

Natural Conditions are defined in the CAA as the visibility conditions that would be experienced in the absence of human-caused impairment. One issue is the fact non-human impairment is an ambiguous concept, as human activity can affect emissions that might otherwise be considered natural. These kinds of classifications are largely subjective, but the WRAP has made significant contributions towards providing policy level definitions of natural versus anthropogenic attributions for dust and fire. Examples of work to date include the following:

- For dust, the distinction between anthropogenic and natural emissions is complicated by issues such as deforestation, changing land use, climate change and drought condition impacts. For the initial SIPs, the WRAP sponsored a "definition of dust" project to help discern between the types of dust emissions.[26]

- Wildfires are another ambiguous category, because forest fires are important to the ecosystem, but management policies such as fire suppression and prescribed burns have human influenced implications on the size and scope of wildfires. The fire classification policy developed by WRAP created an operational policy level definition of fire activity as discretely natural or anthropogenic, which included allowing certain types of prescribed fires to be treated as natural.[27]

4.2.2 Episodic Variability in Natural Conditions

Refining estimates of Natural Conditions is also confounded by the fact that Natural Conditions are a moving target. It is important to consider how Natural Conditions can better reflect episodic events such as wildfires, dust storms, and volcanic emissions (in Hawaii), which are variable from year to year, but figure prominently in regional haze. For these types of events, EPA Guidance currently indicates that a state should submit a technical demonstration if it finds that unusual events (e.g., large wildfires) have affected visibility progress during a 5-year period.[28]

One example of treatment of episodic events involved the modeling scenarios used by the WRAP for use in the original WRAP state RHR SIPs. For fires, an average of fire emissions from the 2000-2004 baseline years was used as representative of fires in 2018. Modeling results were used in a relative sense, with the change in modeled results for the baseline and future years applied to scale the measured baseline results.[29] Using the same representation of episodic events

[26] The WRAP Definition of Dust project is report is available at http://www.wrapair.org/forums/dejf/documents/defdust/.

[27] The WRAP Policy for characterizing fire emissions is available at http://www.wrapair.org/forums/fejf/documents/nbtt/firepolicy.pdf.

[28] See page 1-8, Section 1.9 of EPA's September 2003 *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*.

[29] Descriptions of WRAP modeling efforts for the initial RHR SIPS are available on the WRAP Technical Support System (TSS) project page http://vista.cira.colostate.edu/tss/.

for both the beginning and interim points could be extended to 2064 Natural Conditions projections, and this could be updated with each SIP revision.

Another option proposed to represent the variability of Natural Conditions due to episodic events might be to incorporate some sort of range of Natural Conditions (e.g., using standard deviation or maximum and minimum values), based on the variability observed over time in the measured conditions. This would add the complication of developing a methodology that can measure progress towards a range of values.

4.2.3 Exclude Exceptional Events

An alternative approach to including some kind of average or other representation of episodic events in Natural Conditions estimates is excluding these events from current monitoring data. This is similar in concept to the treatment of "exceptional events" as applied for NAAQS exceedances for criteria pollutants. Some of the considerations for development of a RHR "Exceptional Events" procedure might include the following:

- Fire impacts are some of the most commonly occurring large source impacts. The organic carbon mass measured on most samples collected during the warm months in the West likely has a fraction related to wildfire. Since multiple aerosol species measurements are used to construct total extinction, excluding days with fire impacts would necessarily exclude some man-made pollution. Exclusion of only the part of a sample believed to be influenced by an exceptional event would require some methodology designed to attribute just part of a sample to an event.

- The RHR metrics are based on averages for the 20% best and worst days. Exclusions of all or part of a day from monitored data would affect the data completeness requirements for calculations of averages, and influence the distribution of these days.

4.2.4 Controllable vs. Uncontrollable Sources

As defined currently, the Natural Conditions goal may be unattainable due to human-caused impairments from pollutants emitted beyond United States borders and otherwise outside of State and Federal jurisdictions. Figure 4 presents a graphic from Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions*, which represents the portion of emissions that might be controllable. Within the anthropogenic portion of United States emissions, states may still not have direct control over emissions which are controlled at a federal level.

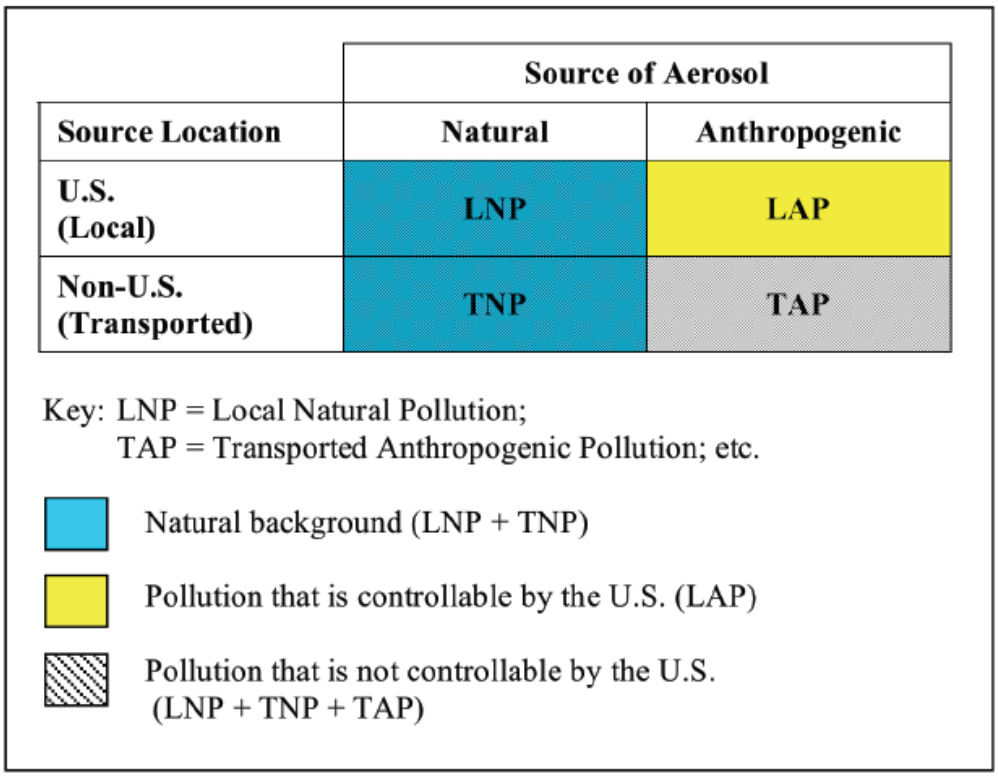

Figure 4. Schematic Representation of Background Aerosol and Their Amenability to U.S. Emission Control Actions.[30]

Policy questions have arisen around the idea of replacing an end goal of "Natural Conditions" with the concept of "background conditions," where background conditions would include estimates of uncontrollable sources such as international emissions. Tombach reported that global modeling suggests mean transported sulfate and nitrate concentrations are ~2-3 times the default concentrations.[31] For the initial SIPs, efforts were made to characterize boundary conditions for use in modeling interim projections.[32]

EPA guidance currently states that, if the state finds international emission sources are responsible for a substantial increase in emission in any Class I area or causing a deficiency in visibility progress, the state must submit a technical demonstration to the EPA in support of its findings.[33] If conditions degraded or failed to meet reasonable progress goals, the state would be required to analyze the cause of the shortfall, and address it as appropriate in future strategies.

[30] Figure from page 2-2 of Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions.*

[31] See page 7-5 of Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions.*

[32] Descriptions of WRAP modeling efforts for the initial RHR SIPS are available on the WRAP Technical Support System (TSS) project page http://vista.cira.colostate.edu/tss/.

[33] See page 1-8, Section 1.9 of EPA's September 2003 *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*.

4.2.5 Tracking Progress Using Species Specific Goals

Another issue related to tracking progress is the fact that progress is reported in terms of deciviews, which is a logarithmic transformation of the sum of contributions from individual species. In practice, most states applied an approach that included setting goals for each individual particulate component. The original default Natural Conditions included mass estimates for each species, but average extinction for the 20% best and worst days was only calculated for the deciview metric and not for individual species, so the concept of tracking progress on a species-specific basis was not included in the original guidance. With the NCII revisions,[34] species-specific goals became available and many States made use of these estimates for planning purposes. In light of this, updated guidance with suggested methodologies for tracking species specific-progress on a regionally consistent basis may be appropriate.

One complication of using this application to support progress towards Natural Conditions is the fact that the best and worst days are sorted according to worst visibility days, and not according to the light extinction from a specific species. Because of this, the maximum concentrations of a particular species may not frequently or necessarily occur on the haziest days, adding a complicating factor to the control strategies for specific species. Another issue is that the glide slope is defined as linear in terms of deciviews, but because deciviews are logarithmic transformation of extinction, this does not translate into linear species specific goals.

4.2.6 Tracking Progress Using Emissions Goals

Another option that has been proposed as an additional or alternative way to track progress is focusing on reductions in precursor emissions from controllable sources (e.g., non-international, anthropogenic sources). For most states, emission of SO_2 and NO_X contribute the largest amount of controllable emissions. Setting regional emission reduction targets (RERTS) would be consistent with recommendations of the Grand Canyon Visibility Transport Commission (GCVTC),[35] and consistent with emission milestones that are applied for Section 309 regulations.[36]

[34] See Copeland's 2008 *Regional Haze Rule Natural Level Estimates Using the Revised IMPROVE Aerosol Reconstructed Light Extinction Algorithm*.

[35] The June 1996 *Grand Canyon Visibility Transport Commission Report, Recommendations for Improving Western Vistas* Report is available at www.wrapair.org/WRAP/reports/GCVTCFinal.PDF.

[36] Section 51.309(d)(5)(ii) of the RHR includes requirements for 309 states to track mobile source emissions and Section 51.309(d)(4)(i) includes requirement to track annual SO_2 emissions milestones have been met as compared to SO_2 emissions milestones.

5.0 RECOMMENDATIONS

The long-term Natural Conditions goals of the RHR necessitate planning activities spanning many decades. As defined by the EPA, and given complexities such as uncontrollable sources, episodic natural events, and an otherwise changing natural environment, it appears that attaining "natural" visibility conditions may be an unachievable goal. In fact, using current estimates, SIP projections showed that Natural Conditions will not be attained for most CIAs by 2064. An advantage of the existing framework is that it offers some flexibility, with the expectation that Natural Condition estimates be refined over time.[37] Some issues with the default estimates were addressed with the NCII revisions, but numerous reviews and evaluations have pointed out further issues that should be addressed, including a Natural Conditions sensitivity study sponsored by the RPOs that identified some priorities for future refinements to natural haze levels[38].

The next round of RHR SIPs will come due in 2018, and each round of SIP submission offers an opportunity to refine the estimates and the approach. Because Natural Conditions are a moving target, and because our understanding of Natural Conditions continues to evolve, it is recommended that these estimates be reassessed and possibly revised with each 10-year SIP revision. Applying the best science possible on a site by site basis would be ideal, but a practical application which combines the current information available with regional sensitivity implications is likely the best approach. Based on assessments currently available, some recommendations for near term refinements of Natural Conditions estimates are listed below.

1. Individual states have the option of updating Natural Conditions, but this can be a large resource burden for a state. Because the intention of the rule is to address haze regionally, and states must take into account their impact on CIAs in other states, it is recommended that refinements continue to happen on a regionally consistent basis involving the RPO framework. With RPOs focusing on characterizing Natural Conditions and uncontrollable sources, states can focus their resources on addressing what they can control.

2. Ideally, Natural Conditions would be refined on a site specific basis, but for the next round of SIPs it may be more practical to narrow the current east/west split into smaller sub-regions with similar characteristics. Tombach's work identified sub-regions regions with similar characteristics in monitored data, sites and sub-regions that were most grievously misrepresented by current estimates, and sites and sub-regions most sensitive to refinements in Natural Conditions estimates.[39]

[37] Section III-E of CFR 40 Part 51 states "The EPA understands that estimating natural visibility conditions can involve many technically complex issues. The EPA is committed to working with the States, tribes, and FLMs on this issue to develop technical guidance on estimating natural visibility conditions."

[38] See Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions.*

[39] Page 7-6 of Tombach's 2008 *Natural Haze Levels Sensitivity, Assessment of Refinements to Estimates of Natural Conditions* includes a map of his proposed sensitivity regions, which include 13 in the contiguous US, Hawaii and Alaska.

3. Actual mass estimates could also be effectively revised for RHR planning purposes using a combination of attribution and modeling data currently available. This process could involve a science and literature review to ascertain what data are currently available, and a subsequent process of determining what estimates on a sub-region or site specific level should be used for the 2018 SIP submissions. The process of determining refined estimates should involve both stakeholders (e.g., states, RPOs, EPA, and FLMs) and technical experts to critique and revise the proposed estimates.

4. To the best possible extent, contributions of natural episodic events should be included in Natural Conditions estimates. If a characterization of episodic events during the current 5-year period is available, then the same characterization could be included in the Natural Conditions estimates. With the presumption that Natural Conditions estimates are updated every 10-years, this would allow for both the beginning and end points to have equal representation of natural episodic events, so both ends of the glide path are more comparable.

5. As it stands, the Natural Conditions definition is unattainable as long as there are transboundary and other influences from uncontrollable anthropogenic sources. Rather than addressing this problem in Natural Condition targets, it is recommended that these influences continue to be addressed in planning. Current guidance allows states to ascertain "reasonable progress" in part by substantiating and assessing the effects of any uncontrollable anthropogenic influences using the technical basis for the impacts.[40]

It is also recommended that the WRAP and various stakeholders continue to pursue changes, clarifications, and updates in EPA guidance and policy. In many cases, the initial SIPs involved the adoption of methodology that might be useful to formalize on a regionally consistent basis in guidance language. Examples of guidance and policy updates include:

- In practice, many of the initial state SIPs looked at Natural Conditions for each species component rather than the haze index alone, and assessed progress goals for each individual species in addition to the haze index alone. EPA guidance for applying this type of additional analysis would foster regional consistency.

- Because the concept of Natural Conditions is ambiguous due to human impacts on otherwise natural sources, the apportionment of natural and anthropogenic sources for emissions such as fire and dust are subjective. EPA guidance on methods to address the apportionment of these impacts, including information such as WRAP's definition of dust and fire classification projects, would help ensure that these types of sources are attributed to natural versus anthropogenic emissions in a regionally consistent way.

[40] Section III-F of CFR 40 Part 51 states "If the State determines, based on the statutory factors, that the identified uniform rate of progress needed to reach Natural Conditions is not reasonable, the State must provide in its plan submission the analysis and rationale supporting this determination."

- As a policy option, implementing emissions reduction targets might be a better practical application for haze reductions. Setting emission reductions targets towards a goal that excludes all uncontrollable sources might eliminate the need for Natural Conditions that represent a non-attainable idealized situation.

6.0 REFERENCES

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