APPENDIX F

PHOTOCHEMICAL MODELING

REGIONAL HAZE STATE IMPLEMENTATION PLAN REVISION

PROJECT NUMBER 2019-112-SIP-NR

This page intentionally left blank

TABLE OF CONTENTS

List of Tables ii
List of Figures ii
Chapter 1: Regional Photochemical Modeling 1
  1.1 2016 Base Case Model Performance 1
    1.1.1 Model Performance Statistics 4
    1.1.2 Model Performance on 20% Most Impaired and 20% Clearest Days by Quarter 4
  1.2 2028 Future Case Results 19
    1.2.1 PSAT Setup 19
    1.2.2 Uniform Rate of Progress (Glidepath), Results 20
    1.2.3 PSAT Light Extinction Results 34
    1.2.4 PSAT Particulate Matter Species Results 41
  1.3 Sensitivity Run Analysis 79
    1.3.1 Emission Changes 79
    1.3.2 Visibility Impairment Changes 80
References 83

LIST OF TABLES

Table 1-1: List of Inorganic PM Species for the CAMx CF Aerosol Option 1
Table 1-2: CAMx to IMPROVE Particulate Matter Species Cross Reference and Conversion 2
Table 1-3: IMPROVE Monitors Representing Class I Areas In and Near Texas 3
Table 1-4: PSAT Emission Source Categories 19
Table 1-5: Conversion of IMPROVE Monitor PM Species to PSAT PM Species 43

LIST OF FIGURES

Figure 1-1: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Big Bend 5
Figure 1-2: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Guadalupe Mountains 6
Figure 1-3: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Bosque del Apache 7
Figure 1-4: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Salt Creek 8
Figure 1-5: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at White Mountain 9
Figure 1-6: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Wheeler Peak 10
Figure 1-7: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Great Sand Dunes 11
Figure 1-8: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Rocky Mountain 12
Figure 1-9: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Wichita Mountains 13
Figure 1-10: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Hercules-Glades 14
Figure 1-11: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Mingo 15
Figure 1-12: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Caney Creek 16
Figure 1-13: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Upper Buffalo 17
Figure 1-14: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Breton Island 18
Figure 1-15: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Big Bend 21

Figure 1-16: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Guadalupe Mountains....................................22
Figure 1-17: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Bosque del Apache..23
Figure 1-18: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Salt Creek...24
Figure 1-19: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at White Mountain 25
Figure 1-20: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Wheeler Peak 26
Figure 1-21: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Great Sand Dunes...27
Figure 1-22: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Rocky Mountain 28
Figure 1-23: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Wichita Mountains 29
Figure 1-24: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Hercules-Glades 30
Figure 1-25: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Mingo 31
Figure 1-26: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Caney Creek...32
Figure 1-27: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Upper Buffalo 33
Figure 1-28: Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Breton Island 34
Figure 1-29: Light Extinction Source Influence from PSAT Categories at Nearby Class I Areas 35
Figure 1-30: PSAT Light Extinction Source Influence at Bosque del Apache..................36
Figure 1-31: PSAT Light Extinction Source Influence at Salt Creek 36
Figure 1-32: PSAT Light Extinction Source Influence at White Mountain 37
Figure 1-33: PSAT Light Extinction Source Influence at Wheeler Peak 37
Figure 1-34: PSAT Light Extinction Source Influence at Great Sand Dunes....................38
Figure 1-35: PSAT Light Extinction Source Influence at Rocky Mountain.......................38
Figure 1-36: PSAT Light Extinction Source Influence at Hercules-Glades 39
Figure 1-37: PSAT Light Extinction Source Influence at Mingo 39
Figure 1-38: PSAT Light Extinction Source Influence at Caney Creek.............................40
Figure 1-39: PSAT Light Extinction Source Influence at Upper Buffalo..........................40
Figure 1-40: PSAT Light Extinction Source Influence at Breton Island 41

Figure 1-41: Extinction by Ranked PM Species on the 20% Most Impaired Days at Guadalupe Mountains and Carlsbad Caverns 42
Figure 1-42: PSAT Particulate Sulfate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 44
Figure 1-43: PSAT Particulate Nitrate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 45
Figure 1-44: PSAT Particulate Ammonium Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 46
Figure 1-45: PSAT Primary Elemental Carbon Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 47
Figure 1-46: PSAT Primary Organic Aerosol Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 48
Figure 1-47: PSAT Fine Crustal Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 49
Figure 1-48: PSAT Other Fine Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 50
Figure 1-49: PSAT Coarse Crustal Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 51
Figure 1-50: PSAT Other Coarse Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days 52
Figure 1-51: Extinction by Ranked PM Species on the 20% Most Impaired Days at Big Bend......53
Figure 1-52: PSAT Particulate Sulfate Source Influence at Big Bend on the 20% Most Impaired Days 54
Figure 1-53: PSAT Particulate Nitrate Source Influence at Big Bend on the 20% Most Impaired Days 55
Figure 1-54: PSAT Primary Organic Aerosol Source Influence at Big Bend on the 20% Most Impaired Days 56
Figure 1-55: PSAT Primary Elemental Carbon Source Influence at Big Bend on the 20% Most Impaired Days 57
Figure 1-56: Extinction by Ranked PM Species on the 20% Most Impaired Days at Bosque del Apache 58
Figure 1-57: Ratio of Texas to New Mexico Source Influence on Particulate Species at Bosque del Apache 59
Figure 1-58: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Bosque del Apache......60
Figure 1-59: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Bosque del Apache......61
Figure 1-60: Extinction by Ranked PM Species on the 20% Most Impaired Days at Salt Creek 62
Figure 1-61: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Salt Creek......63

Figure 1-62: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Salt Creek....64
Figure 1-63: Extinction by Ranked PM Species on the 20% Most Impaired Days at White Mountain....65
Figure 1-64: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at White Mountain....66
Figure 1-65: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at White Mountain....67
Figure 1-66: Extinction by Ranked PM Species on the 20% Most Impaired Days at Great Sand Dunes....68
Figure 1-67: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Great Sand Dunes....69
Figure 1-68 Extinction by Ranked PM Species on the 20% Most Impaired Days at Wichita Mountains....70
Figure 1-69: Ratio of Texas to Oklahoma Source Influence on Particulate Species at Wichita Mountains....71
Figure 1-70: Extinction by Ranked PM Species on the 20% Most Impaired Days at Hercules-Glades....72
Figure 1-71: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Hercules-Glades....73
Figure 1-72: Extinction by Ranked PM Species on the 20% Most Impaired Days at Caney Creek....74
Figure 1-73: Ratio of Texas to Arkansas Source Influence on Particulate Species at Caney Creek....74
Figure 1-74: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Caney Creek....75
Figure 1-75: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Caney Creek....76
Figure 1-76: Extinction by Ranked PM Species on the 20% Most Impaired Days at Upper Buffalo....77
Figure 1-77: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Upper Buffalo....78
Figure 1-78: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Upper Buffalo....79
Figure 1-79: Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU and 2028NoControls Cases....80
Figure 1-80: Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU&SO2 and ZeroOKU Scenarios....81
Figure 1-81: Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU&SO2&NOx and ZeroOKU&SO2 Scenarios....82

CHAPTER 1: REGIONAL PHOTOCHEMICAL MODELING

The Federal Clean Air Act (FCAA) and the United States Environmental Protection Agency (EPA) regulations require states to submit a state implementation plan (SIP) to make "reasonable progress" in reducing visibility impairment at Class I areas resulting from anthropogenic pollution. FCAA, §169A(a)(1), "declares as a national goal the prevention of any future, and the remedying of any existing impairment of visibility in mandatory Class I areas which impairment results from man-made air pollution." The Texas Commission on Environmental Quality (TCEQ) conducted photochemical modeling using Comprehensive Air Quality Model with Extensions[1] (CAMx) to assess visibility at Class I areas in and near Texas for the second implementation period covering 2019 through 2028. This appendix provides additional details of the TCEQ's photochemical modeling for the 2021 Regional Haze SIP Revision, hereafter referred to as the Regional Haze SIP Revision.

1.1 2016 BASE CASE MODEL PERFORMANCE

The CAMx particulate matter calculation option the TCEQ used, coarse/fine (CF), tracks chemically inert particles in two sizes: coarse and fine. The cutoff size between the categories is a diameter of 2.5 micrometers (µm). The complete list of inorganic particulate matter (PM) species modeled in the CAMx CF aerosol option is shown in Table 1-1: *List of Inorganic PM Species for the CAMx CF Aerosol Option*.

Table 1-1: List of Inorganic PM Species for the CAMx CF Aerosol Option

CAMx Label	Name
PSO_4	Particulate Sulfate
PNO_3	Particulate Nitrate
PNH_4	Particulate Ammonium
PEC	Primary Elemental Carbon
FPRM	Fine Other Primary Particulate (part of $PM_{2.5}$)
FCRS	Fine Crustal Particulate (part of $PM_{2.5}$)
CPRM	Coarse Other Primary Particulate
CCRS	Coarse Crustal Particulate
PH_20	Aerosol Water Content
NA	Sodium
PCL	Particulate Chloride

Note, $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 µm.

CAMx calculates secondary organic aerosols (SOA) produced from chemical reactions of primary emissions. The CAMx SOA chemistry option the TCEQ used, SOAP2.2, computes and partitions SOA into six species: SOA1, SOA2, SOA3, SOA4, SOPA, and SOPB. CAMx also tracks directly emitted and non-chemically evolving organic aerosols as primary organic aerosols (POA). The anthropogenic SOA species SOA1 and SOA2 are partitioned based on chemical volatility, as are the biogenic SOA species SOA3 and SOA4. The non-volatile anthropogenic aerosols are tracked as SOPA, and non-volatile aerosols condensed from biogenic sources are tracked as SOPB.

[1] http://www.camx.com

When calculating light extinction, the CAMx species used need to be mapped onto the PM species measured at Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors. Table 1-2: *CAMx to IMPROVE Particulate Matter Species Cross Reference and Conversion*, shows the mapping.

Table 1-2: CAMx to IMPROVE Particulate Matter Species Cross Reference and Conversion

IMPROVE PM Species	Short Name	CAMx Species and Conversion Formula
Ammonium Sulfate	AmmSO4	1.375 x PSO_4
Ammonium Nitrate	AmmNO3	1.290 x PNO_3
Organic Aerosol	OA or OMC	POA + SOA1 + SOA2 + SOPA + SOA3 + SOA4 + SOPB
Elemental Carbon	EC	PEC
Crustal Material	Soil	FPRM + FCRS
Sea salt	Sea salt	NA + PCL
Coarse Mass	CM	CPRM + CCRS

Visibility impairment at IMPROVE monitors is calculated using Equation 8-1: *IMPROVE Equation* of the Regional Haze SIP Revision documentation, which uses PM species concentrations and relative humidity data to calculate visibility impairment, or light extinction, in units of inverse megameters (Mm^{-1}).

Rayleigh scattering is the light extinction due to scattering from the non-particulate molecules of the air. It is site-specific because it depends on average atmospheric pressure at the site. Rayleigh scattering is not modeled because it is not due to particulate matter, nor is it related to the speciated particulate matter gathered and measured by the IMPROVE monitors.

The IMPROVE monitors listed in Table 1-3: *IMPROVE Monitors Representing Class I Areas In and Near Texas* were used by the TCEQ’s contractor to evaluate model performance. The table also indicates whether the monitor is included in the uniform rate of progress (URP) calculation of visibility in 2028 or merely the model performance evaluation (MPE).

Table 1-3: IMPROVE Monitors Representing Class I Areas In and Near Texas

Class I Area Identifier	Class I Area Name	Class I Area State	IMPROVE Monitor Identifier	IMPROVE Monitor State	Analysis MPE and/or URP
BIBE	Big Bend National Park	TX	BIBE1	TX	MPE & URP
GUMO	Guadalupe Mountains National Park	TX	GUMO1	TX	MPE & URP
BAND	Bandelier National Monument	NM	BAND1	NM	MPE
BOAP	Bosque del Apache Wilderness Area	NM	BOAP1	NM	MPE & URP
CAVE	Carlsbad Caverns National Park	NM	GUMO1	TX	MPE & URP
GICL	Gila Wilderness	NM	GICL1	NM	MPE
SACR	Salt Creek Wilderness Area	NM	SACR1	NM	MPE & URP
SAPE	San Pedro Parks Wilderness	NM	SAPE1	NM	MPE
WHIT	White Mountain Wilderness Area	NM	WHIT1	NM	MPE & URP
WHPE	Wheeler Peak Wilderness Area	NM	WHPE1	NM	MPE & URP
GRSA	Great Sand Dunes Wilderness Area	CO	GRSA1	CO	MPE & URP
MEVE	Mesa Verde National Park	CO	MEVE1	CO	MPE
MOZI	Mount Zirkel Wilderness	CO	MOZI1	CO	MPE
ROMO	Rocky Mountain National Park	CO	ROMO1	CO	MPE & URP
SHIM	Shamrock Mine	CO	SHMI1	CO	MPE
WEMI	Weminuche Wilderness	CO	WEMI1	CO	MPE
WHRI	White River National Forest	CO	WHRI1	CO	MPE
WIMO	Wichita Mountains Wilderness	OK	WIMO1	OK	MPE & URP
CEBL	Cedar Bluff	KS	CEBL1	KS	MPE
TALL	Tallgrass	KS	TALL1	KS	MPE
VILA	Viking Lake	IA	VILA1	IA	MPE
BOND	Bondville	IL	BOND1	IL	MPE
HEGL	Hercules-Glades Wilderness Area	MO	HEGL1	MO	MPE & URP
MING	Mingo Wilderness Area	MO	MING1	MO	MPE & URP
CACR	Caney Creek Wilderness Area	AR	CACR1	AR	MPE & URP
UPBU	Upper Buffalo Wilderness Area	AR	UPBU1	AR	MPE & URP
MACA	Mammoth Cave National Park	KY	MACA1	KY	MPE
BIRM	North Birmingham	AL	BIRM1	AL	MPE
SIPS	Sipsey Wilderness	AL	SIPS1	AL	MPE
BRIS	Breton Island Wilderness Area	LA	BRIS1	LA	MPE & URP

Note: Guadalupe Mountains and Carlsbad Caverns are represented by the same GUMO1 monitor in Texas.

1.1.1 Model Performance Statistics

In addition to the statistics show in this appendix, the following model performance statistics and plots can be found in *Regional Haze Modeling to Evaluate Progress in Improving Visibility In and Near Texas*, the modeling project report from the TCEQ contractor (Ramboll, 2020):

- Spatial plots of $PM_{2.5}$ and CAMx PM species normalized mean bias by calendar quarter at the monitors listed in Table 1-3; and
- Annual model performance of PM species concentration and light extinction on the 20% most impaired and clearest days at the Table 1-3 monitoring sites with a URP analysis.

1.1.2 Model Performance on 20% Most Impaired and 20% Clearest Days by Quarter

In this section, the base case simulation is evaluated for light extinction at the IMPROVE monitoring sites in and near Texas listed in Table 1-3.

The predicted and observed PM species concentrations at the IMPROVE monitors are converted to light extinction in units of Mm^{-1} using Equation 8-1: *IMPROVE Equation* of the Regional Haze SIP Revision documentation.

The following 14 sections describe light extinction error and bias for each calendar quarter; January/February/March (Q1), April/May/June (Q2), July/August/September (Q3), and October/November/December (Q4), for each Table 1-3 monitor with a URP analysis.

1.1.2.1 Big Bend National Park, Texas

Model performance at Big Bend National Park in Texas shows underprediction across the aggregate most impaired days especially for CM and AmmSO4.

When evaluated by quarter, CAMx underpredicts AmmSO4 and AmmNO3 in Q2 and Q3, but overpredicts both in Q4, as seen in Figure 1-1: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Big Bend*. In this and subsequent figures of this format, the model error, modeled minus observed light extinction calculated from PM species in each quarter, is displayed in the top bar chart with units of Mm^{-1} on the left vertical axis, and the bias, error divided by the observation, appears on the bottom bar chart with units of percent on the right vertical axis. Coarse mass has large negative error in all quarters, most in Q1 and Q2. However, the bias is almost equal in each quarter.

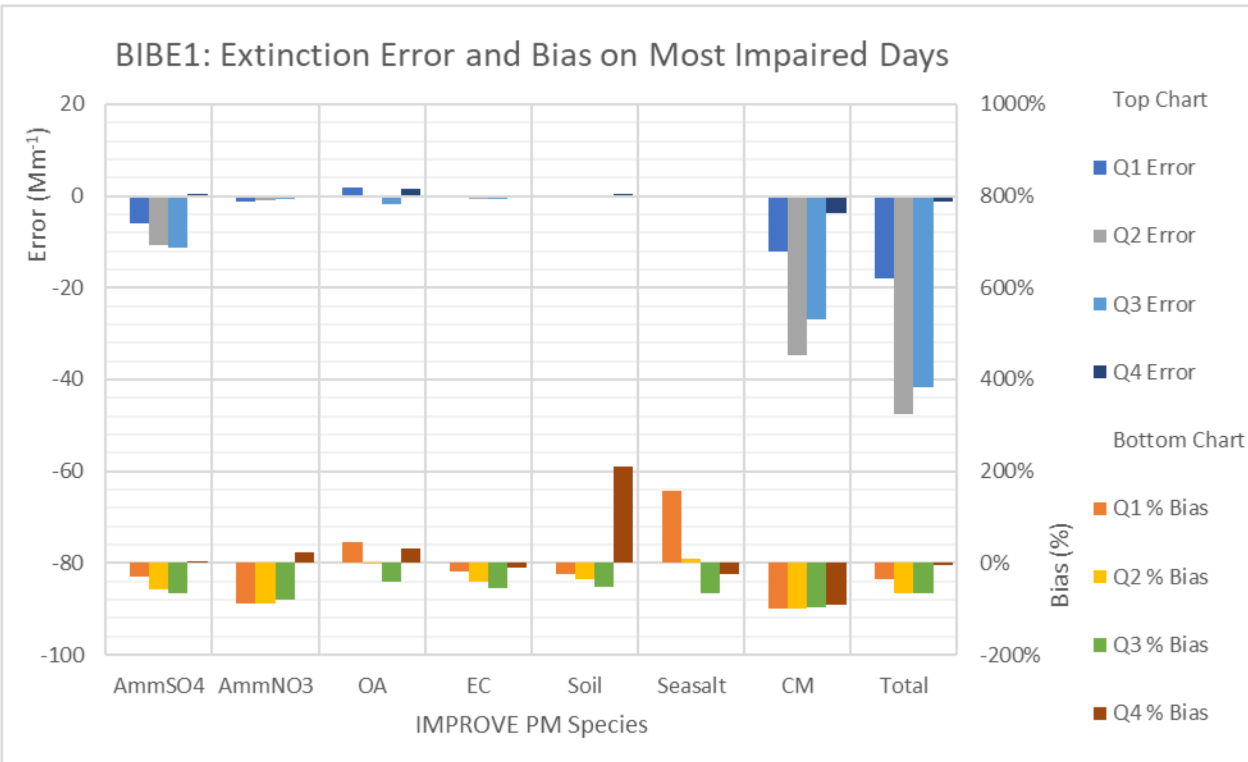

Figure 1-1: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Big Bend

1.1.2.2 Guadalupe Mountains National Park, Texas, and Carlsbad Caverns National Park, New Mexico

Aggregate annual performance at the GUMO1 monitor serving Guadalupe Mountains and Carlsbad Caverns National Parks shows underprediction during the most impaired days.

Quarterly model performance on the most impaired days, as seen in Figure 1-2: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Guadalupe Mountains*, shows underprediction in all quarters for coarse mass, with bias nearly uniform across Q2, Q3, and Q4. Ammonium nitrate is underpredicted in all quarters, most in Q2 and Q3. Ammonium sulfate is underpredicted in warmer Q2 and Q3, while overpredicted in colder Q1 and Q4. Bias in soil in Q4 is the largest of any PM species or quarter at this site. Large positive bias in soil prediction is consistently seen in the modeling However, soil contributes a small amount of extinction at GUMO1, like it does in most quarters at most IMPROVE monitors.

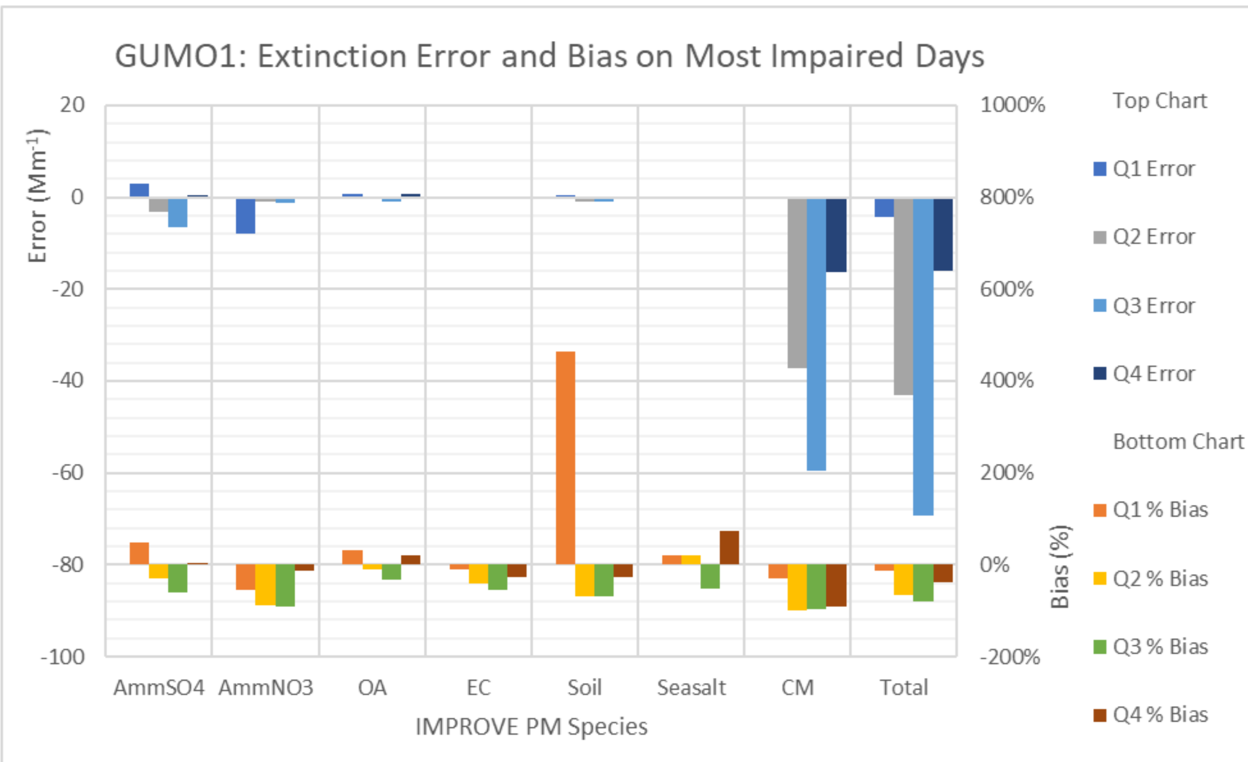

Figure 1-2: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Guadalupe Mountains

1.1.2.3 Bosque del Apache Wilderness Area, New Mexico

Model performance by quarter on the most impaired days at the BOAP1 monitor serving the Bosque del Apache Wilderness Area in New Mexico is seen in Figure 1-3: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Bosque del Apache*. Ammonium sulfate is overpredicted in Q1 and Q4, with the most in Q1, and underpredicted in Q2 and Q3, with the most in Q3. Ammonium nitrate follows a similar pattern, with less overprediction in Q1 and more underprediction in Q2 and Q3. The coarse mass underprediction at BOAP1 is less uniform than at some monitors evaluated and is the largest contributor to error.

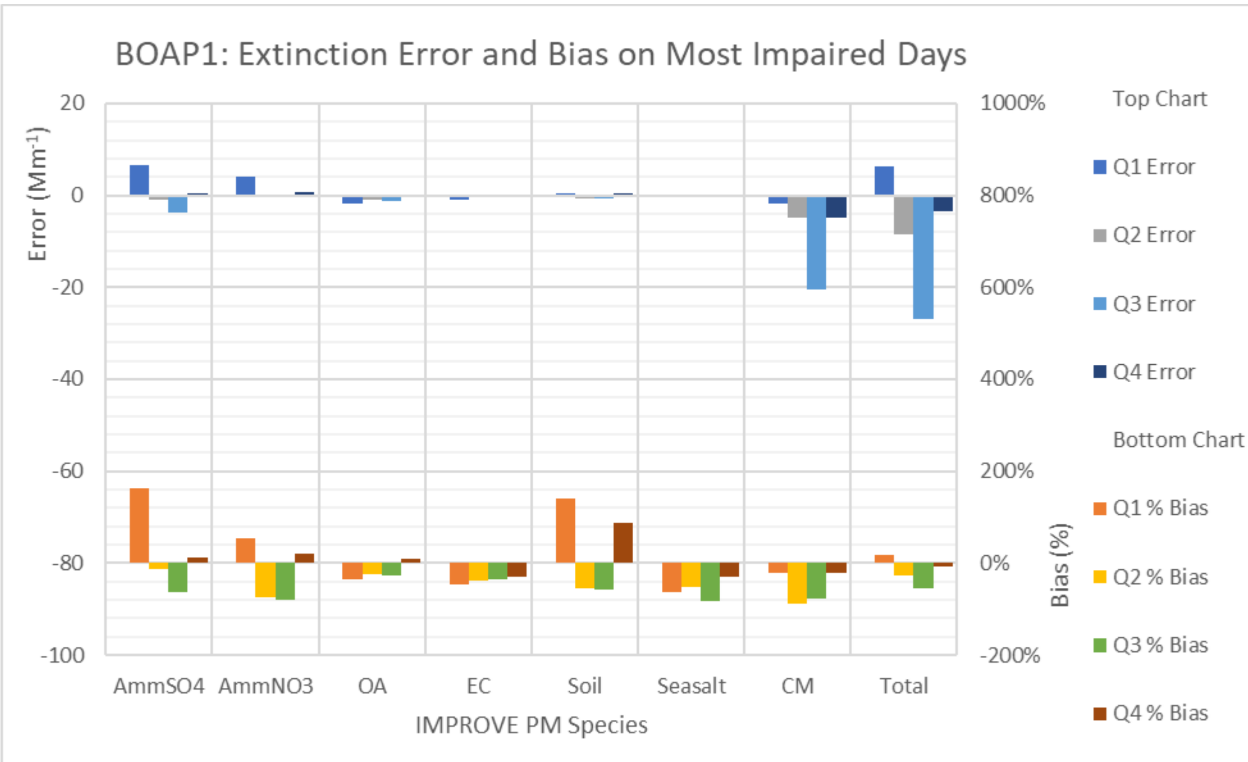

Figure 1-3: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Bosque del Apache

1.1.2.4 Salt Creek Wilderness Area, New Mexico

CAMx overpredicts concentrations and light extinction on the clearest days at the SACR1 monitor serving the Salt Creek Wilderness Area.

Quarterly model performance on the most impaired days at Salt Creek is seen in Figure 1-4: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Salt Creek*. The model overpredicts total extinction in Q1 and with contributions to extinction error due to ammonium nitrate, organic aerosols, soil, and coarse mass. Underprediction of ammonium sulfate and nitrate is seen in Q2 and Q3, while the negative bias of coarse mass varies by quarter. Coarse mass extinction error is the major component of total error in all quarters.

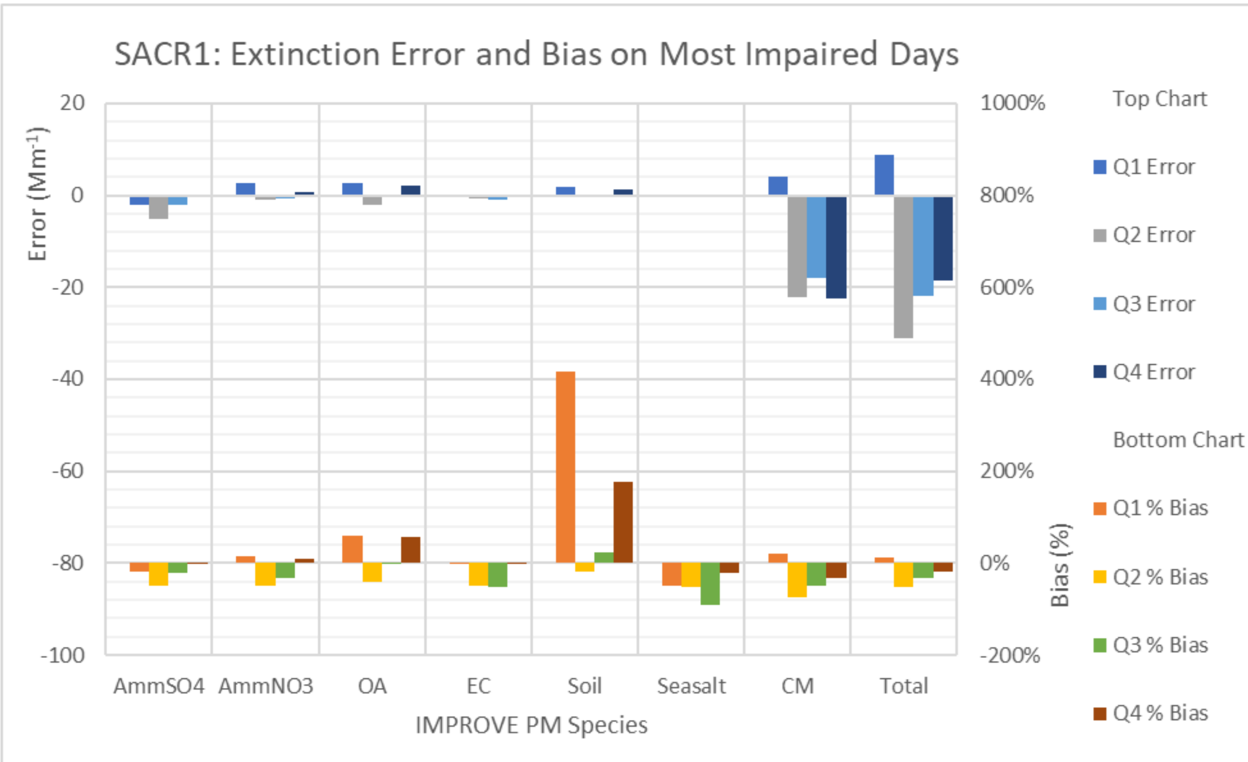

Figure 1-4: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Salt Creek

1.1.2.5 White Mountain Wilderness Area, New Mexico

For the White Mountain Wilderness Area, CAMx underpredicts extinction on the most impaired days and overpredicts on the clearest days in the annual average.

The quarterly light extinction model bias at the WHIT1 monitor is seen in Figure 1-5: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at White Mountain*. Quarterly performance for Q2 and Q3 ammonium sulfate and nitrate shows underprediction, like other monitors. However, ammonium sulfate is anomalously underpredicted in Q1, as is ammonium nitrate in Q4. Soil prediction is better than at other monitors analyzed, with lower positive bias. Coarse mass bias is uniformly negative over the first three quarters and the largest component of total error.

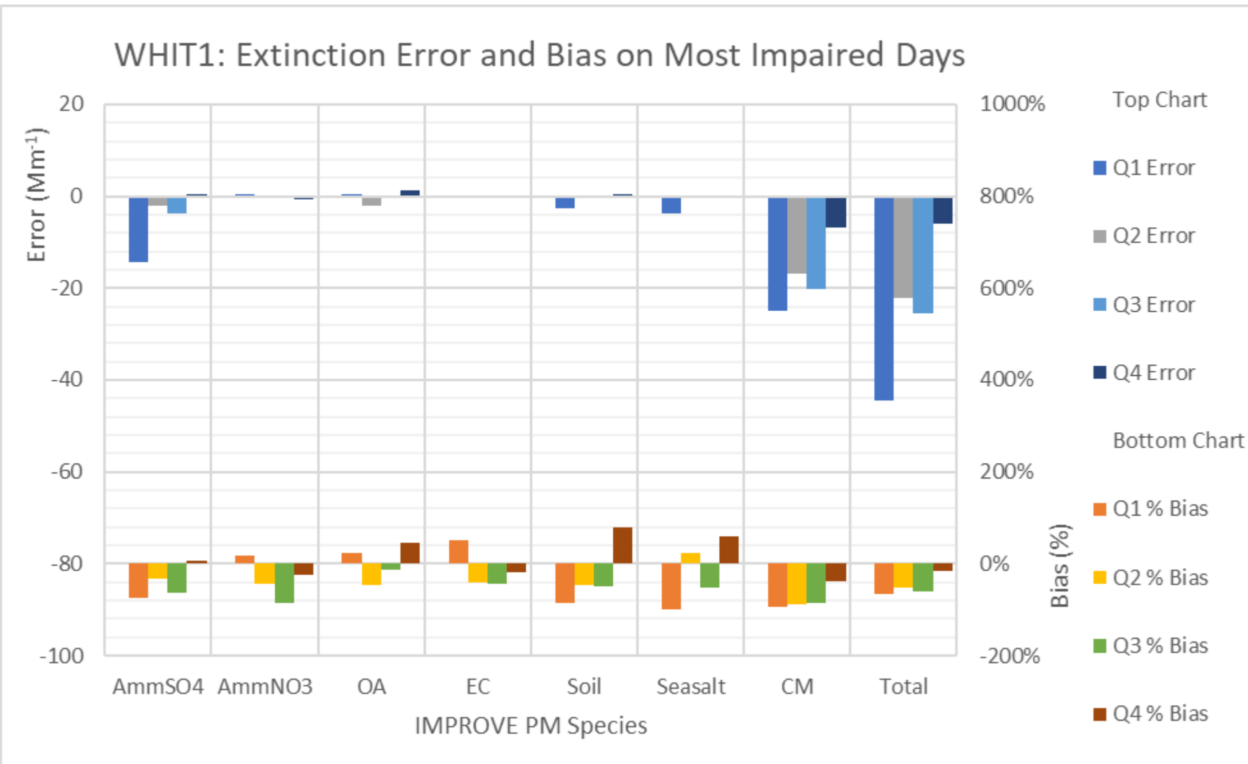

Figure 1-5: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at White Mountain

1.1.2.6 Wheeler Peak Wilderness Area, New Mexico

The annual average of the most impaired days at the Wheeler Peak Wilderness Area in New Mexico shows underprediction, while the clearest days show slight overprediction.

When viewed by quarter in Figure 1-6: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Wheeler Peak*, model performance at the WHPE1 monitor indicates ammonium sulfate underprediction in all quarters, the most in Q3. Ammonium nitrate is underpredicted in all quarters except Q4, when it is overpredicted. Coarse mass is underpredicted by a similar percentage in Q3 and Q4, with greater and varying underprediction in Q1 and Q2. Overall, model performance at Wheeler Peak is the best of these 14 monitors.

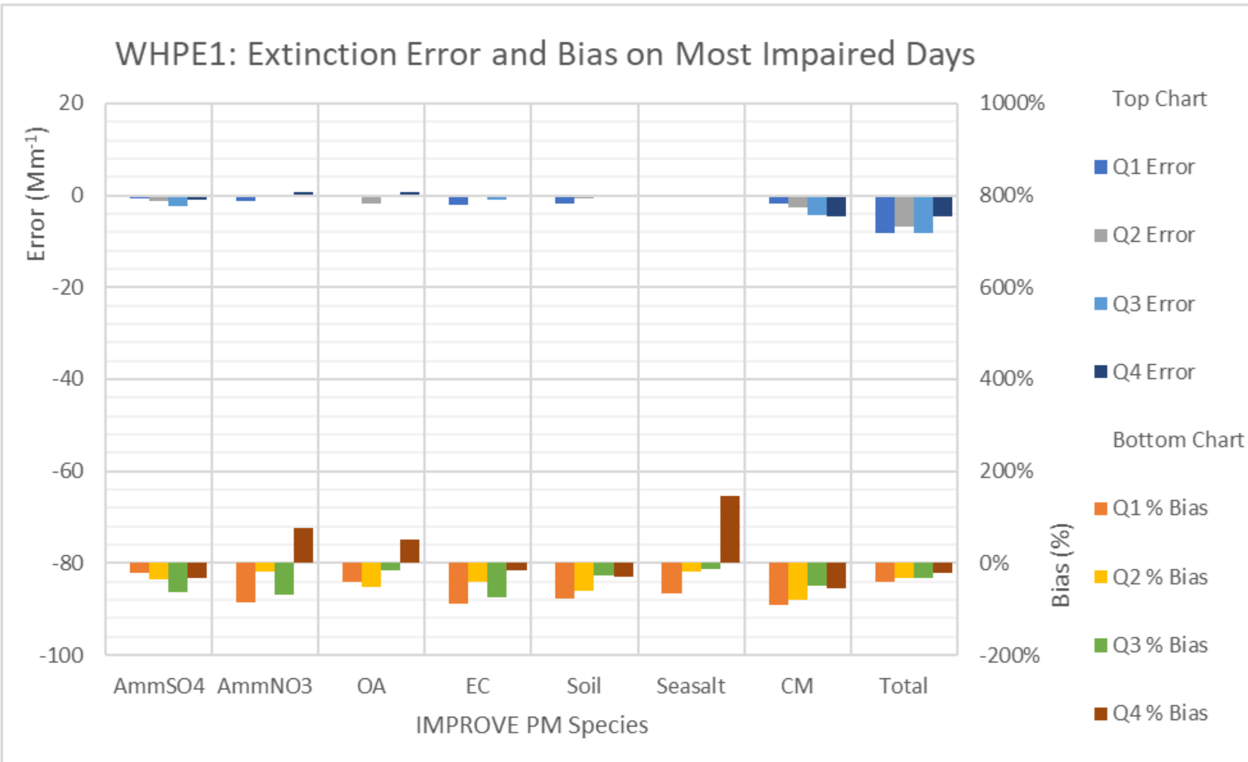

Figure 1-6: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Wheeler Peak

1.1.2.7 Great Sand Dunes Wilderness, Colorado

Annual model performance at the Great Sand Dunes Wilderness Area shows underprediction on the most impaired days. These results are qualitatively like nearby Wheeler Peak.

Quarterly performance at the GRSA1 monitor on the most impaired days, as seen in Figure 1-7: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Great Sand Dunes*, is also like Wheeler Peak. One difference is that ammonium sulfate is overpredicted in Q1. Another is that soil is overpredicted by more than ten times, although this is still a small contributor to light extinction at GRSA1. Coarse mass exhibits similar negative bias in Q2, Q3, and Q4.

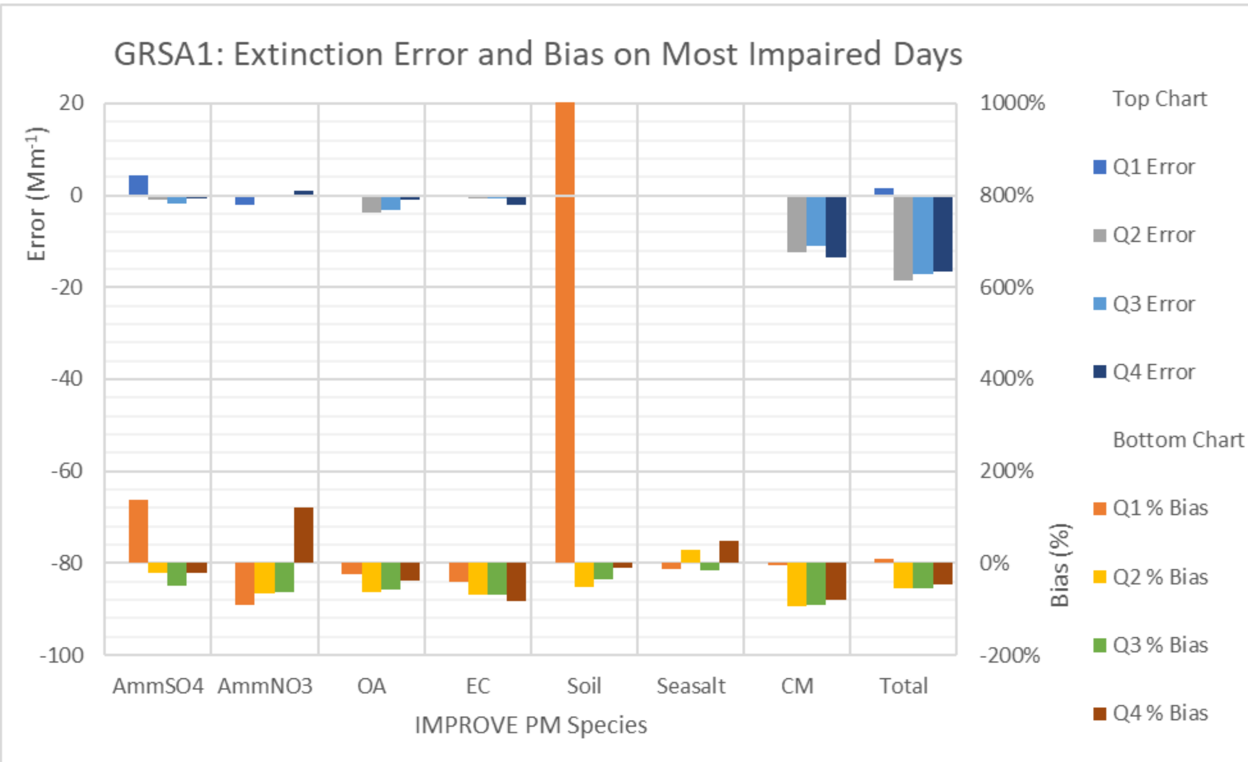

Figure 1-7: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Great Sand Dunes

1.1.2.8 Rocky Mountain National Park, Colorado

At Rocky Mountain National Park, CAMx underpredicts light extinction on the most impaired days and overpredicts on the clearest days.

When examined by quarter as shown in Figure 1-8: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Rocky Mountain*, the CAMx performance at the ROMO1 monitor is more nuanced. Ammonium sulfate is underpredicted in each quarter, the largest amount in Q4. Ammonium nitrate is underpredicted in Q1 and Q2, and overpredicted in Q3 and Q4. Sea salt is overpredicted by over 10 times in Q1, but it only amounts to a small concentration and light extinction impact at this site far from any ocean. Coarse mass shows a uniform negative bias in Q2, Q3, and Q4.

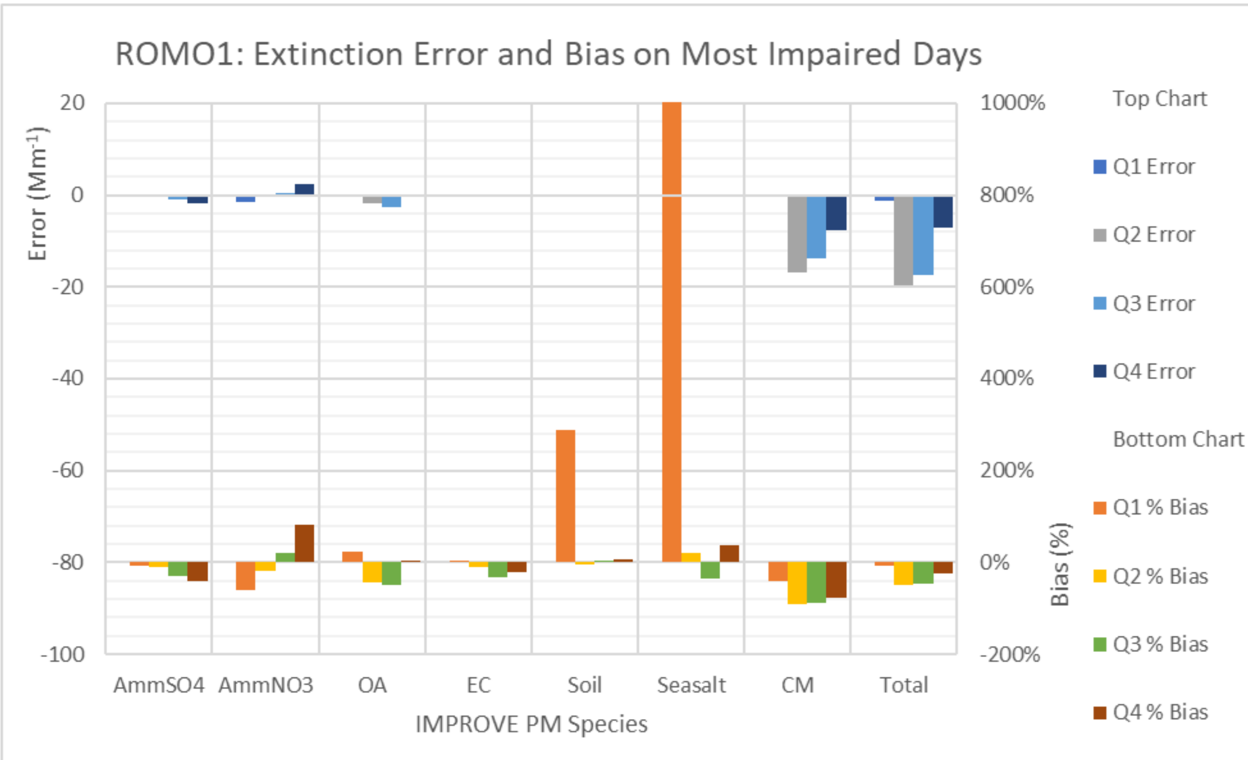

Figure 1-8: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Rocky Mountain

1.1.2.9 Wichita Mountains Wilderness Area, Oklahoma

The one IMPROVE monitor analyzed in Oklahoma, WIMO1 serving the Wichita Mountains Wilderness Area, showed small extinction underprediction on the most impaired days and slight overprediction on the clearest days.

Quarterly performance is seen in Figure 1-9: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Wichita Mountains*. Ammonium sulfate is underpredicted in Q2 and Q3, but only overpredicted in Q4. Meanwhile, ammonium nitrate shows underprediction in the first three quarters and overprediction in Q4. Coarse mass is somewhat underpredicted with similar negative bias in each quarter. Soil bias in Q1 and Q4 is high, but its light extinction is small.

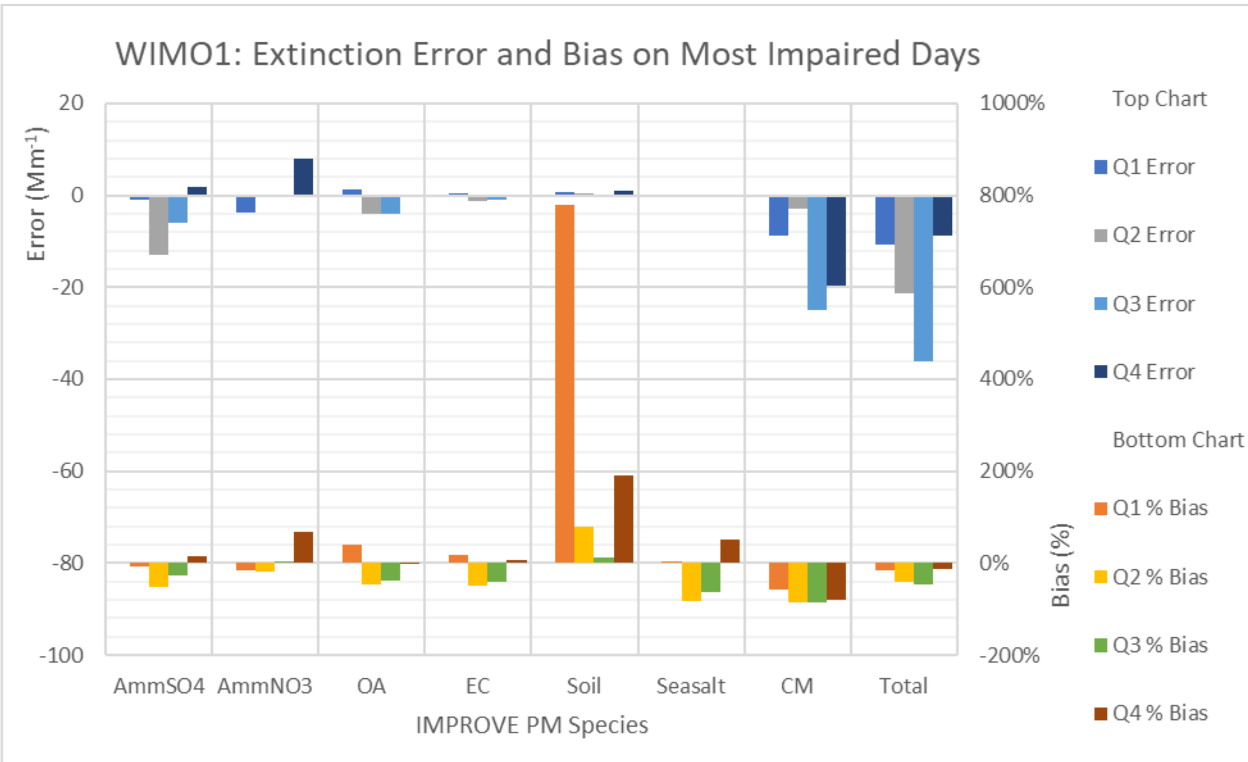

Figure 1-9: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Wichita Mountains

1.1.2.10 Hercules-Glades Wilderness Area, Missouri

The annual light extinction performance at the HEGL1 monitor serving the Hercules-Glades Wilderness Area shows slight average underprediction on the most impaired days and overprediction on the clearest days.

Quarterly performance of modeled light extinction at the HEGL1 monitor is seen in Figure 1-10: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Hercules-Glades*. Both ammonium sulfate and ammonium nitrate are underpredicted in Q1, Q2, and Q3, but overpredicted in Q4. Soil prediction is six to ten times high in Q1 and Q4, however error is small. Coarse mass exhibits similar negative bias in Q1, Q2, and Q3.

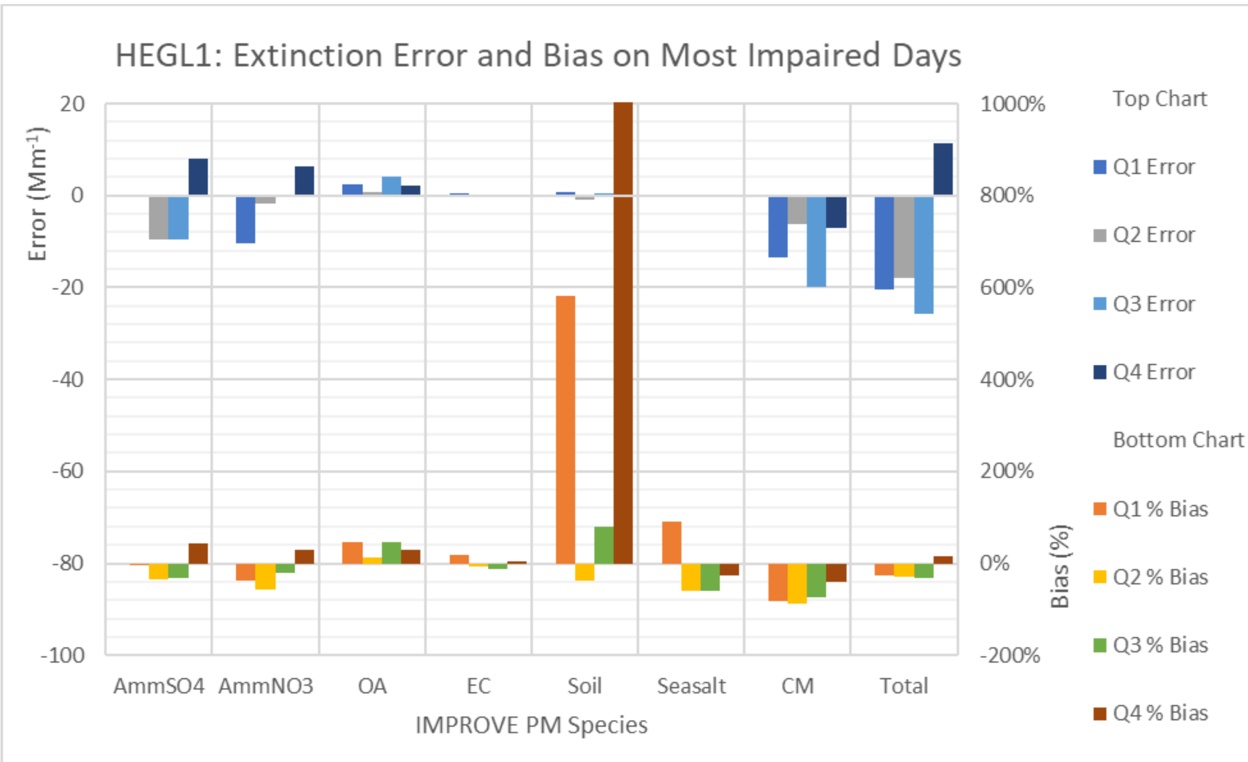

Figure 1-10: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Hercules-Glades

1.1.2.11 Mingo Wilderness Area, Missouri

Annual CAMx concentration and light extinction performance at the MING1 monitor representing the Mingo Wilderness Area is different than the other monitors studied. Light extinction is overpredicted on both the most impaired days and the clearest days.

When analyzed by quarter, light extinction performance at MING1 seen in Figure 1-11: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Mingo*, exhibits different performance than other sites analyzed. Ammonium nitrate is overpredicted by more than 200% during Q3. Extinction bias due to soil is 300% to 1000% in each quarter. Soil prediction error at MING1 is unique among the monitors studied because its magnitude is comparable to several other PM species. Coarse mass is overpredicted in Q2, Q3, and Q4. Only one other site, Salt Creek, had a single quarter, Q1, with positive coarse mass bias.

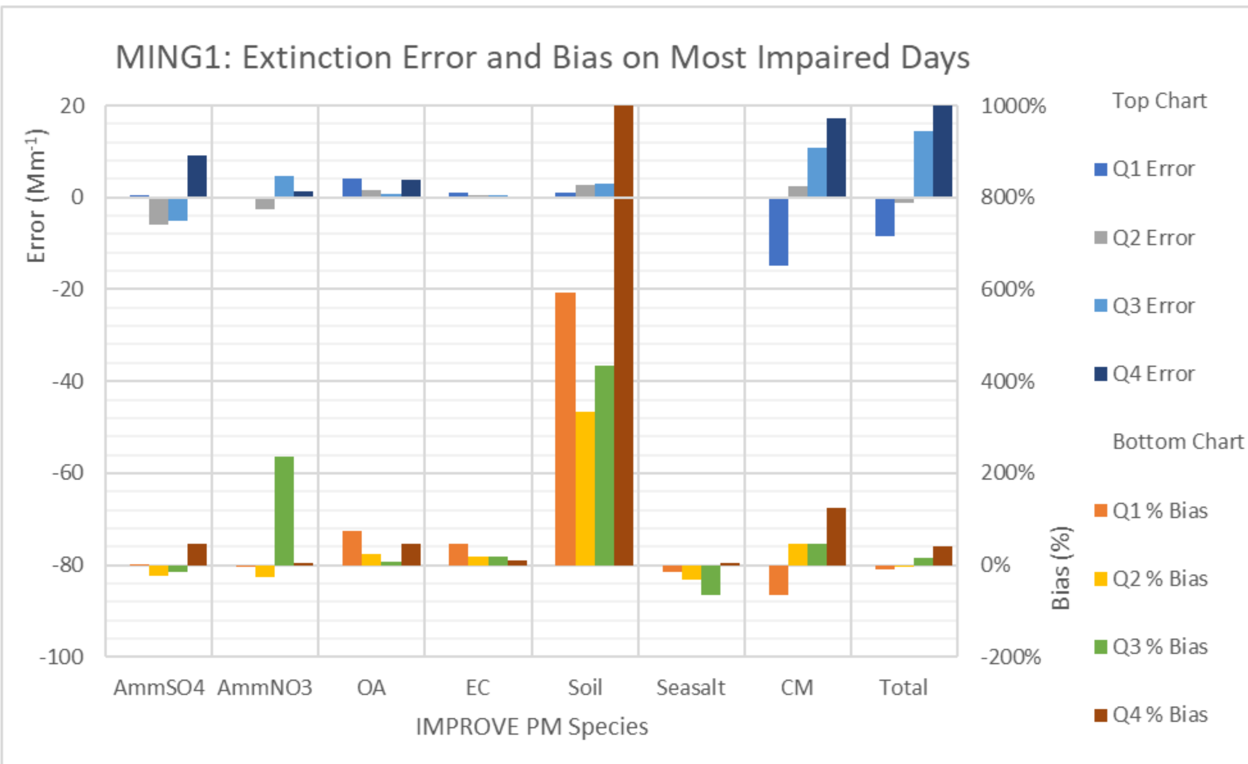

Figure 1-11: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Mingo

1.1.2.12 Caney Creek Wilderness Area, Arkansas

Annual performance at the CACR1 monitor serving the Caney Creek Wilderness Area in Arkansas shows slight extinction underprediction on the most impaired days and overprediction on the clearest days. Overprediction of organic aerosols is evident in both day groups.

When viewed quarterly, as in Figure 1-12: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Caney Creek*, additional nuance is evident. Ammonium sulfate and ammonium nitrate are underpredicted in Q2 and Q3, while overpredicted in Q4. The organic aerosol overprediction is noteworthy among the monitors studied as large positive error and bias in each quarter, and larger than nearby Upper Buffalo. Soil bias is positive 400% to 600% in Q1 and Q4, while coarse mass is underpredicted in each quarter with similar negative bias.

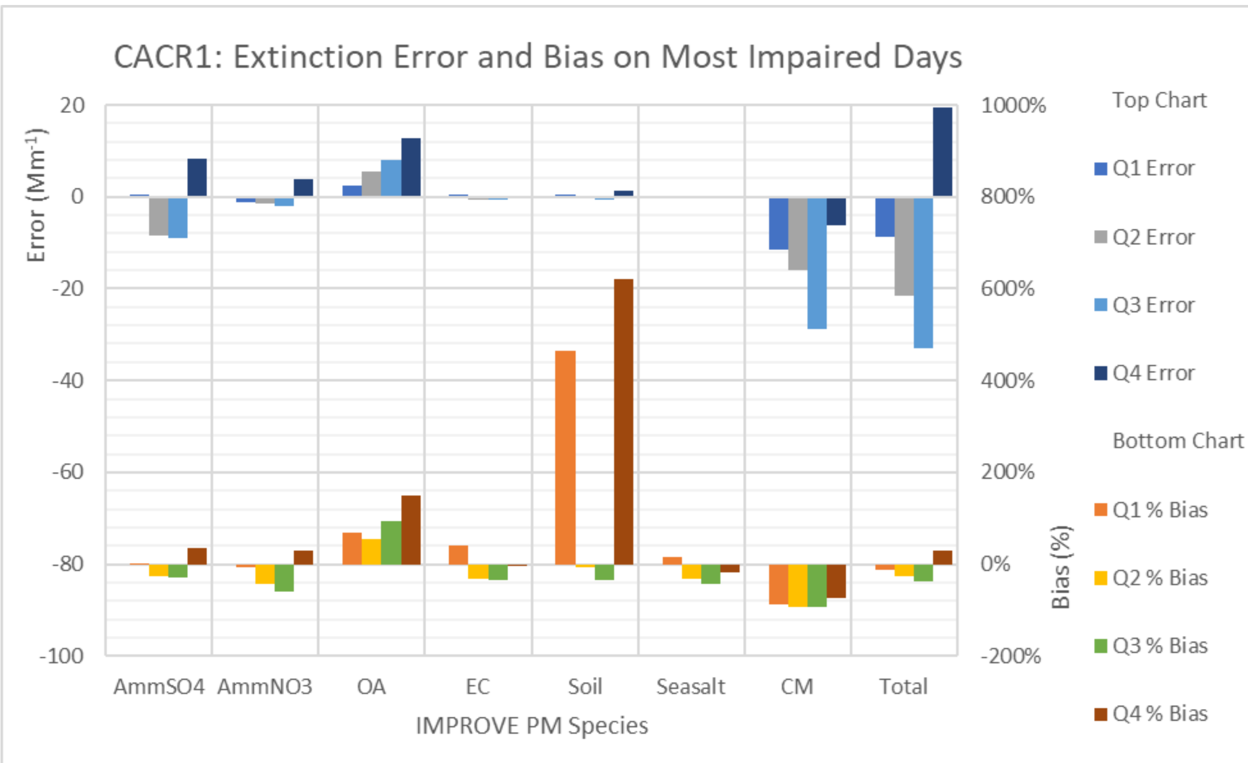

Figure 1-12: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Caney Creek

1.1.2.13 Upper Buffalo Wilderness Area, Arkansas

The annual average concentration and light extinction model performance at the other Arkansas monitor, UPBU1, serving the Upper Buffalo Wilderness Area, is like Caney Creek.

Evaluation of CAMx performance at UPBU1 by quarter shows differences from CACR1. As seen in Figure 1-13: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Upper Buffalo*, ammonium sulfate and ammonium nitrate are predicted with the familiar underprediction in Q2 and Q3, and overprediction in Q1 and Q4. Organic aerosol is underpredicted in Q2, offsetting overprediction in the other quarters. Soil bias in Q2 and Q4 is positive 400% to over 800%, but with small error. Coarse mass is underpredicted with nearly uniform bias in each quarter.

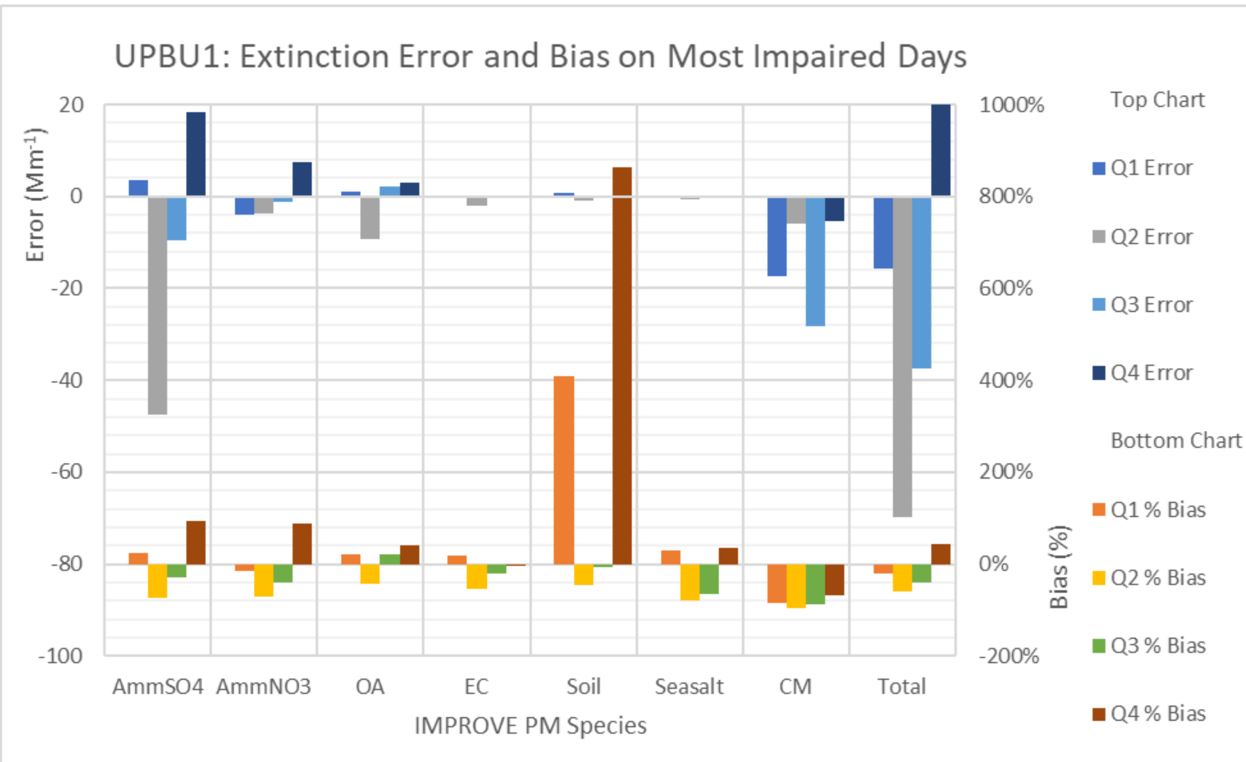

Figure 1-13: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Upper Buffalo

1.1.2.14 Breton Island Wilderness Area, Louisiana

Annual model performance at Breton Island shows underprediction on both the most impaired and clearest days.

Ammonium sulfate and ammonium nitrate are underpredicted in all quarters, a result unique among these 14 monitors. Coarse mass shows similar negative bias in all quarters, as seen in Figure 1-14: *Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Breton Island.*

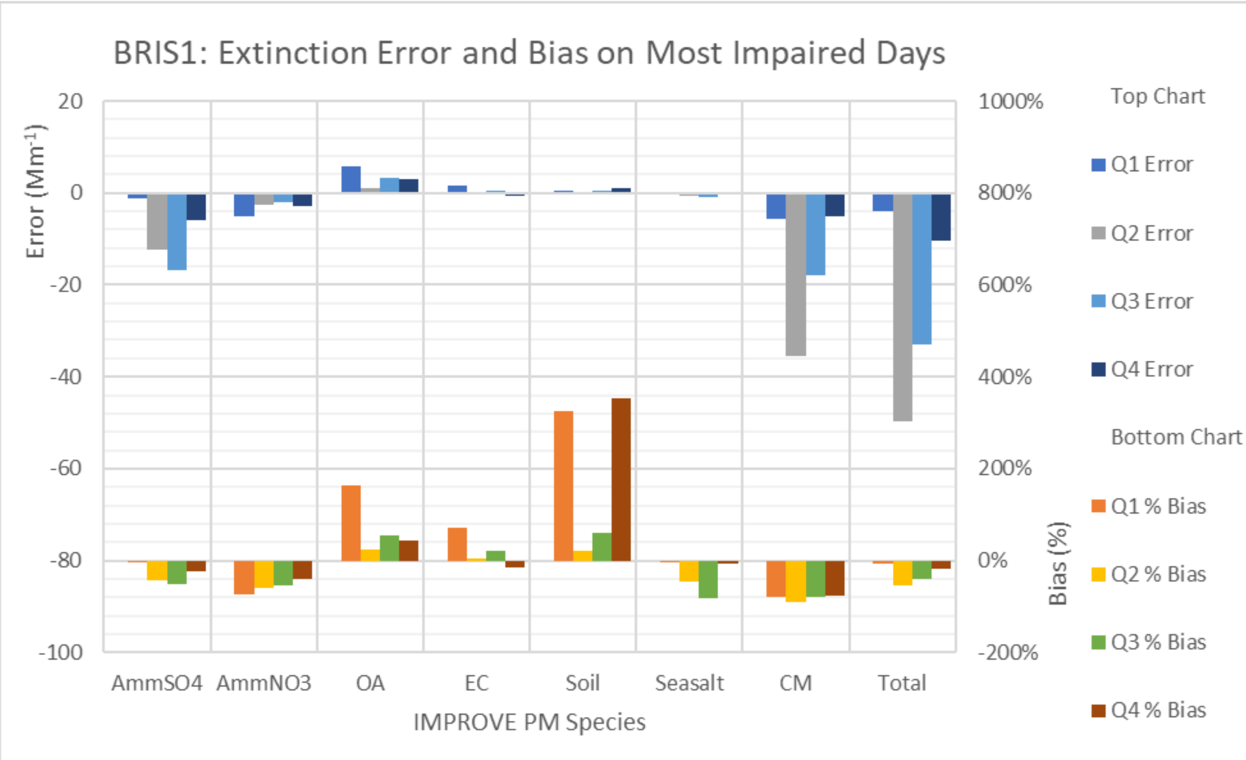

Figure 1-14: Extinction Error (top) and Bias (bottom) on the 20% Most Impaired Days by Quarter at Breton Island

The presence of uniform negative bias in coarse mass prediction across multiple quarters at multiple monitors suggests a systemic negative bias in coarse mass prediction and the potential for an alteration in the way the CAMx model simulates coarse mass concentrations. Soil concentrations and light extinction exhibit a substantial positive model bias and are another good candidate for model improvement. However, the benefit for improvements in soil modeling in reduced light extinction error would be smaller due to low soil concentrations.

1.2 2028 FUTURE CASE RESULTS

1.2.1 PSAT Setup

The CAMx model provides a Particulate Matter Source Apportionment (PSAT) analysis tool that tracks emissions from user-defined source groups and model-generated emissions to determine their influence on modeled particulate matter concentrations. The TCEQ used PSAT to analyze source contributions to modeled PM concentrations at IMPROVE monitors. Version 6.5 of CAMx PSAT apportions PM into the following classes:

- Particulate Sulfate,
- Particulate Nitrate,
- Particulate Ammonium, and
- Primary PM (comprised of PEC, POA, FCRS, FPRM, CCRS, and CPRM).

Secondary organic aerosol formed from anthropogenic (e.g., aromatics) and biogenic VOC precursors (e.g., isoprene, monoterpene) are obtained from CAMx. The anthropogenic SOA is the sum of CAMx species SOA1, SOA2, and SOPA. The biogenic SOA is the sum of CAMx species SOA3, SOA4, and SOPB.

To determine the influence of emissions of interest originating in Texas, neighboring states, and other regions the TCEQ chose the PSAT source categories listed in Table 1-4: *PSAT Emission Source Categories*.

Table 1-4: PSAT Emission Source Categories

Source Category	Category Label	Natural or Anthropogenic
Texas Electric Generating Units (EGU)	TX EGU	Anthropogenic
Texas non-EGU point sources	TX non-EGU	Anthropogenic
Texas Oil and Gas, area source	TX Oil and Gas	Anthropogenic
Texas on-road mobile	TX on-road	Anthropogenic
Texas other anthropogenic	TX other anthro	Anthropogenic
Non-Texas U.S. anthropogenic; Arkansas, Colorado, Louisiana, Missouri, New Mexico, and Oklahoma are tracked separately	Other U.S. anthro AR, CO, LA, MO, NM, and OK	Anthropogenic
Canada and Mexico anthropogenic	Can/Mex anthro	Anthropogenic
Other international anthropogenic including shipping and other Central American countries and islands	Other non-U.S. anthro	Anthropogenic
All fires including agricultural and prescribed burns	Fire	Natural
Other natural sources including biogenic, wind-blown dust, lightning NO_x, ocean sulfates, sea salt	Natural	Natural
Boundary and initial conditions	BC/IC	Anthropogenic and Natural
Biogenic SOA	Bio SOA	Natural
Anthropogenic SOA	Anthro SOA	Anthropogenic

1.2.2 Uniform Rate of Progress (Glidepath), Results

As described in Section 8.4: *Reasonable Progress Goal Status* of the 2021 Regional Haze SIP Revision documentation, a line called a "glidepath" is calculated from the 2000 through 2004 baseline period visibility condition for the same set of days to the calculated 2064 natural visibility conditions. The URP is the slope of the glidepath. The Regional Haze Rule allows an adjustment to the glidepath to account for international anthropogenic contribution to visibility impairment.

The graphs on the following figures, Figure 1-15: *Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Big Bend* through Figure 1-28: *Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Breton Island* depict the glidepath for each monitor, the modeling results, and the source sector contributions for the 20% most impaired days. The solid lines represent the unadjusted (dark blue) and adjusted (green) glidepath. Diamond shapes depict visibility impairment in both 2028 and 2064 (right axis of the plot). The blue 2064 diamond depicts the modeled natural conditions in 2064 while the green 2064 diamond reflects the 2064 natural conditions plus the international anthropogenic contribution to visibility impairment. The 2014 through 2017 observed annual average light extinction values on the 20% most impaired days are shown as black dots; the horizontal light blue line represents the 4-year average. The left-most stacked bar (labeled "Observed 2016") shows the average observed light extinction composition for 2016 on the 20% most impaired days. The PM species plotted are those observed by the IMPROVE monitors and listed in Table 1-2 plus Rayleigh. The second stacked bar (labeled "Modeled 2016") shows the 2016 modeled light extinction composition on the 20% most impaired days plus Rayleigh scattering. The PM species plotted in the second bar are the CAMx PM species converted to match the observed species according to the conversion factors listed in Table 1-2 and the IMPROVE equation. The third stacked bar (labeled "SMAT 2028") represents the projected 2028 visibility impairment calculated using the EPA's Software for the Modeled Attainment Test (SMAT) program, with an "x" marking the total with a numerical label. The number can be compared with the 2028 blue and green diamonds to determine the amount of light extinction above or below the default or adjusted glidepath in 2028. The PSAT source categories shown in Table 1-4, along with Rayleigh, comprise the SMAT 2028 stacked bar. The vertical axis is light extinction in Mm^{-1}. For corresponding visibility impairment measures of 2028 URP see Table 8-43: *Visibility for Class I Areas on 20% Most Impaired Days and 20% Clearest Days* of the Regional Haze SIP Revision documentation. When comparing the light extinction numbers in this section with Section 8.4 of the Regional Haze SIP Revision documentation, it is important to note that the numbers in this section are in Mm^{-1} and the numbers in Section 8.4 are in deciviews.

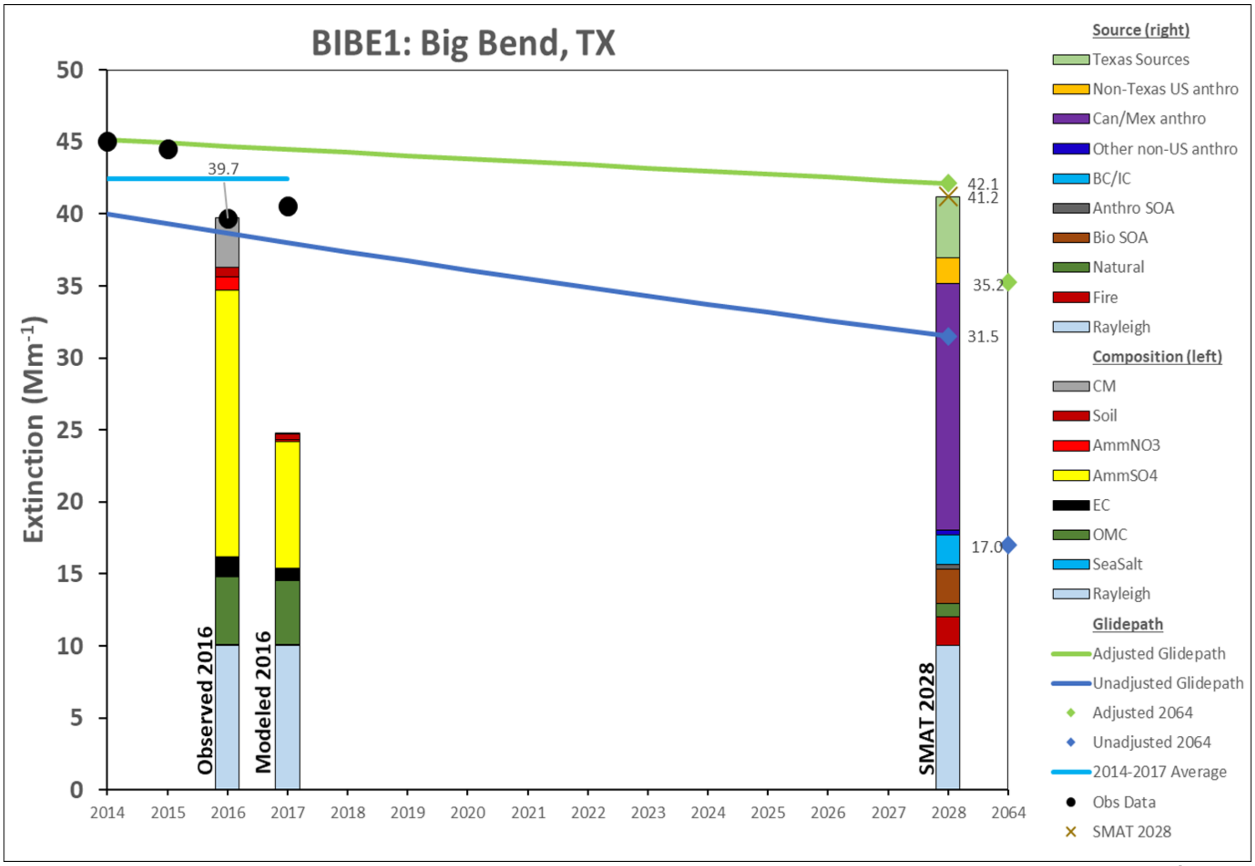

Figure 1-15:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Big Bend

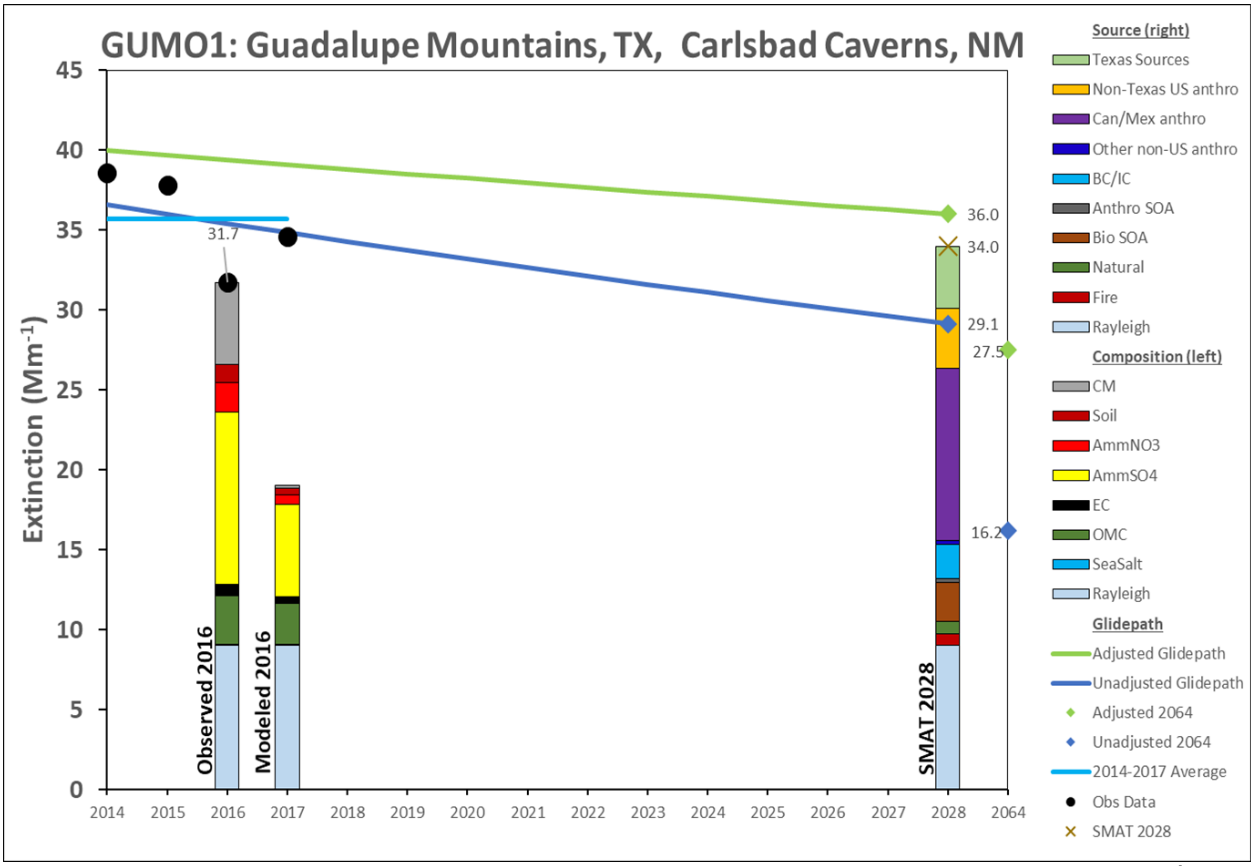

Figure 1-16:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Guadalupe Mountains

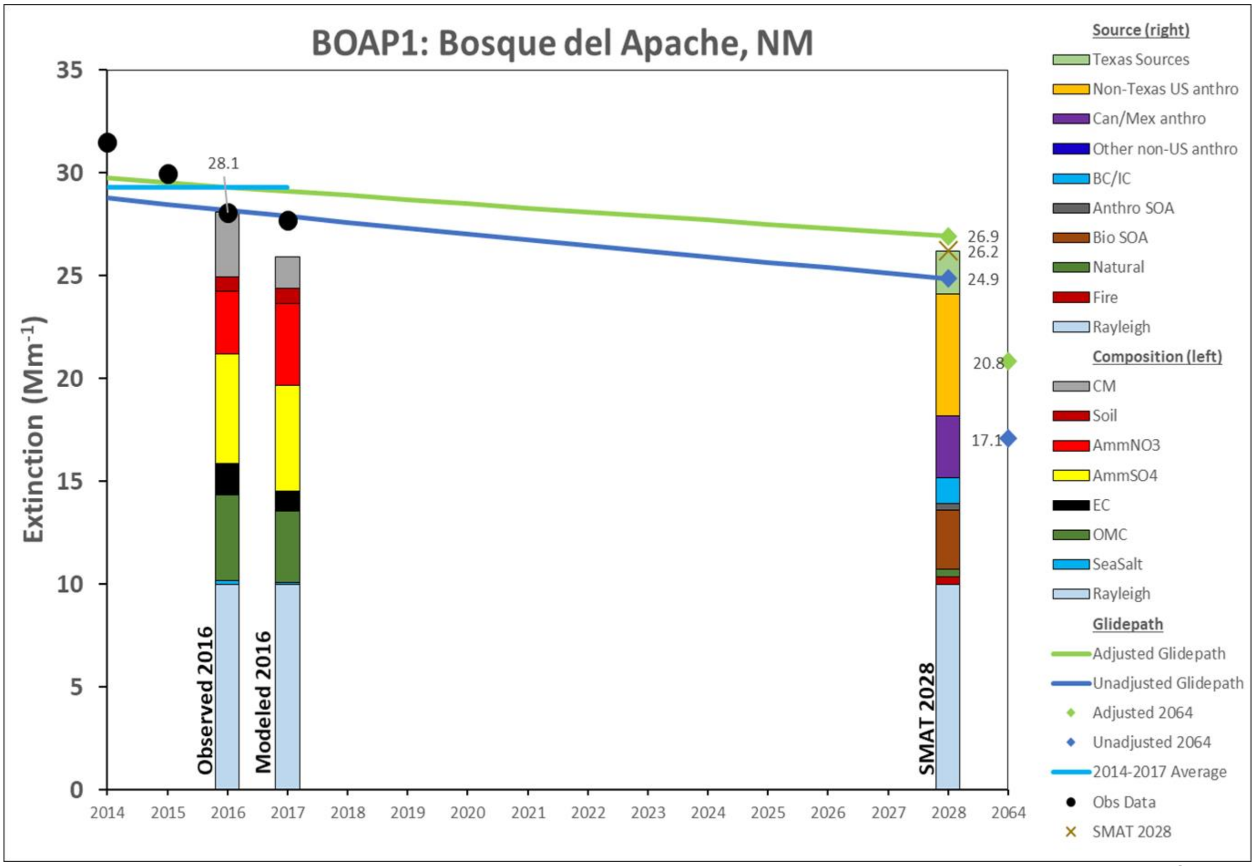

Figure 1-17:**Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Bosque del Apache**

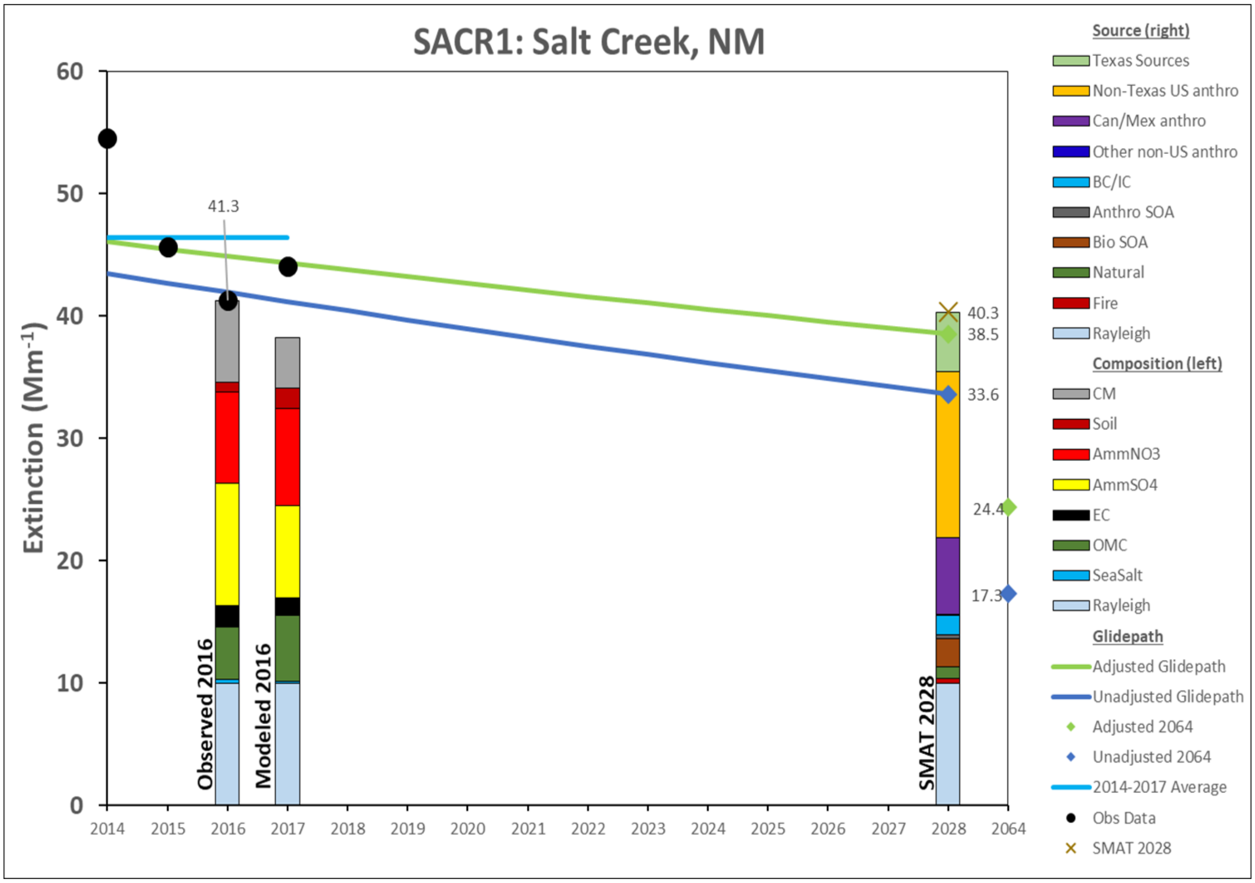

Figure 1-18:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Salt Creek

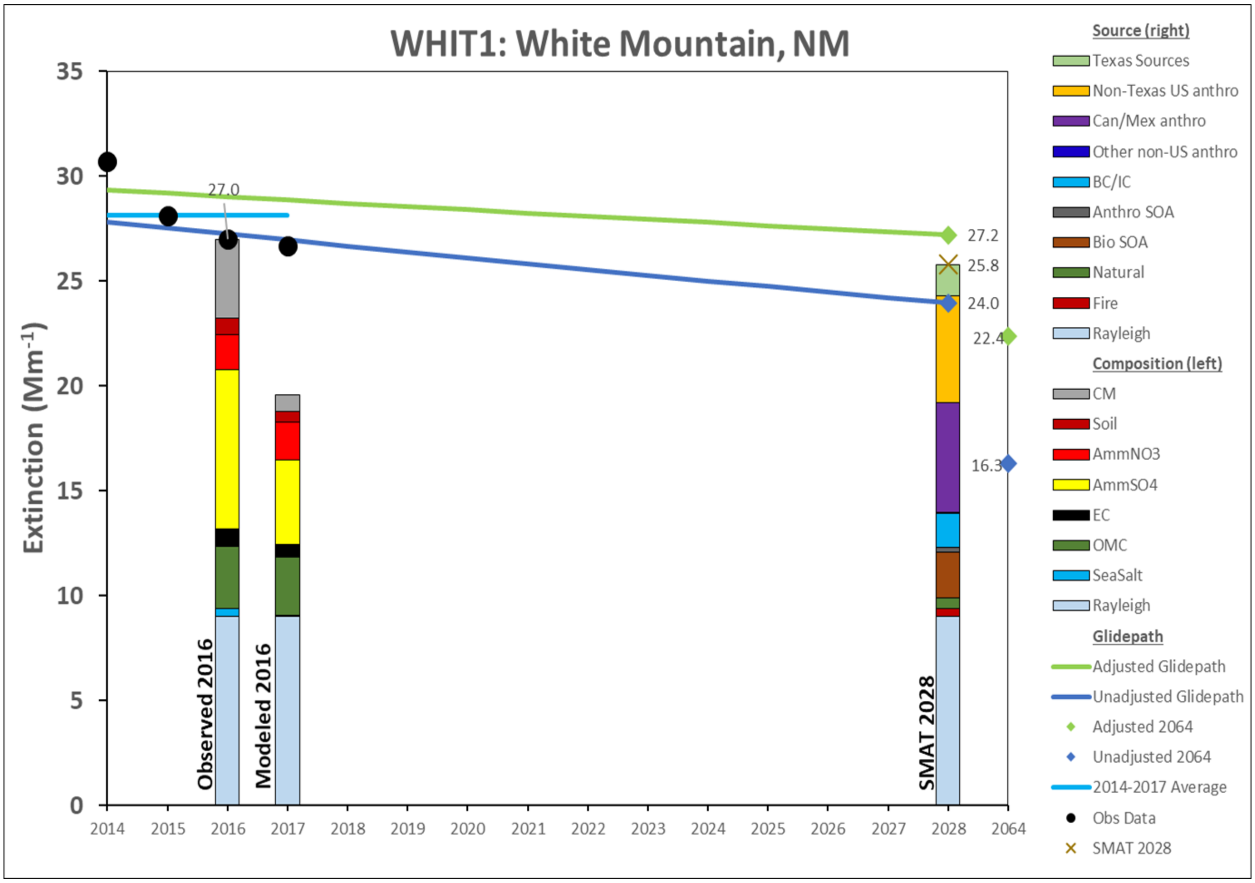

Figure 1-19:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at White Mountain

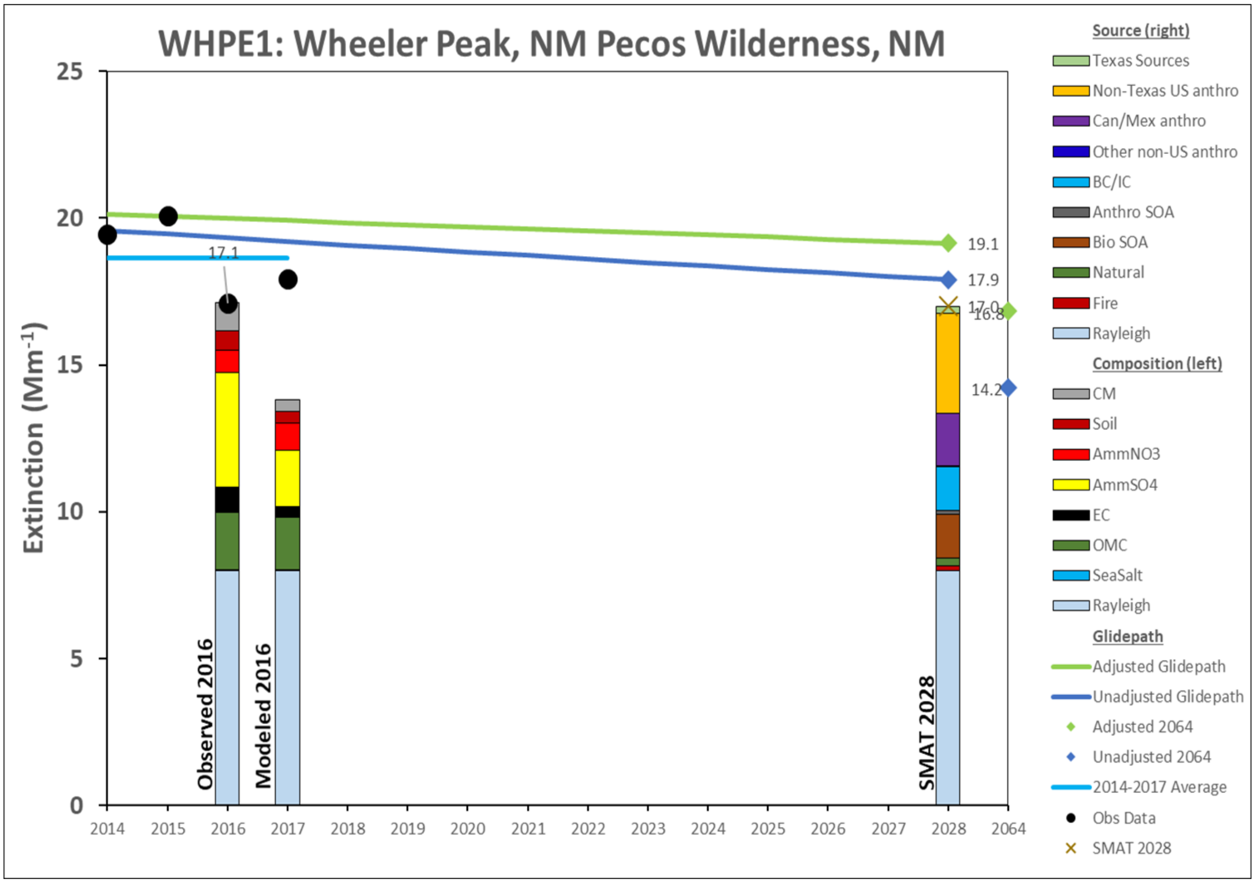

Figure 1-20:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Wheeler Peak

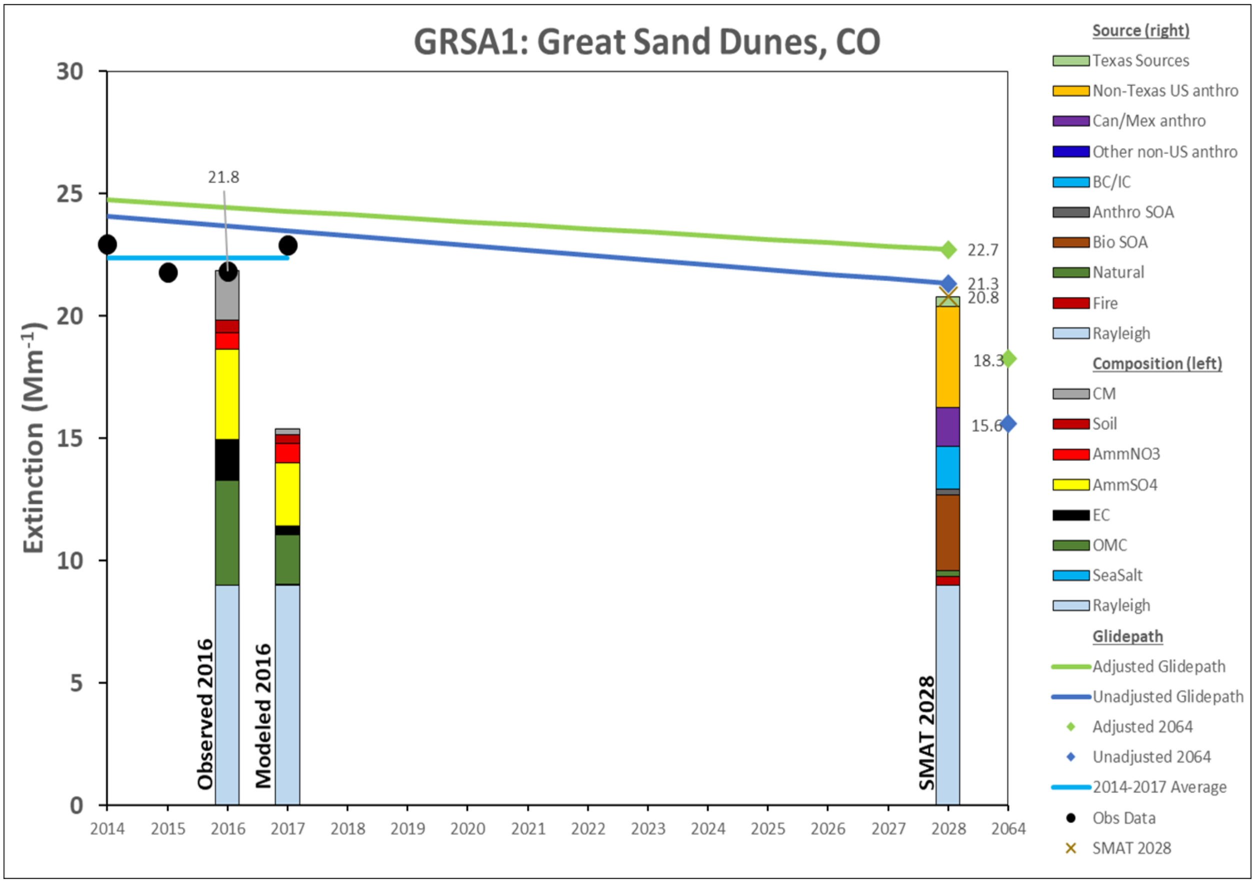

Figure 1-21:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Great Sand Dunes

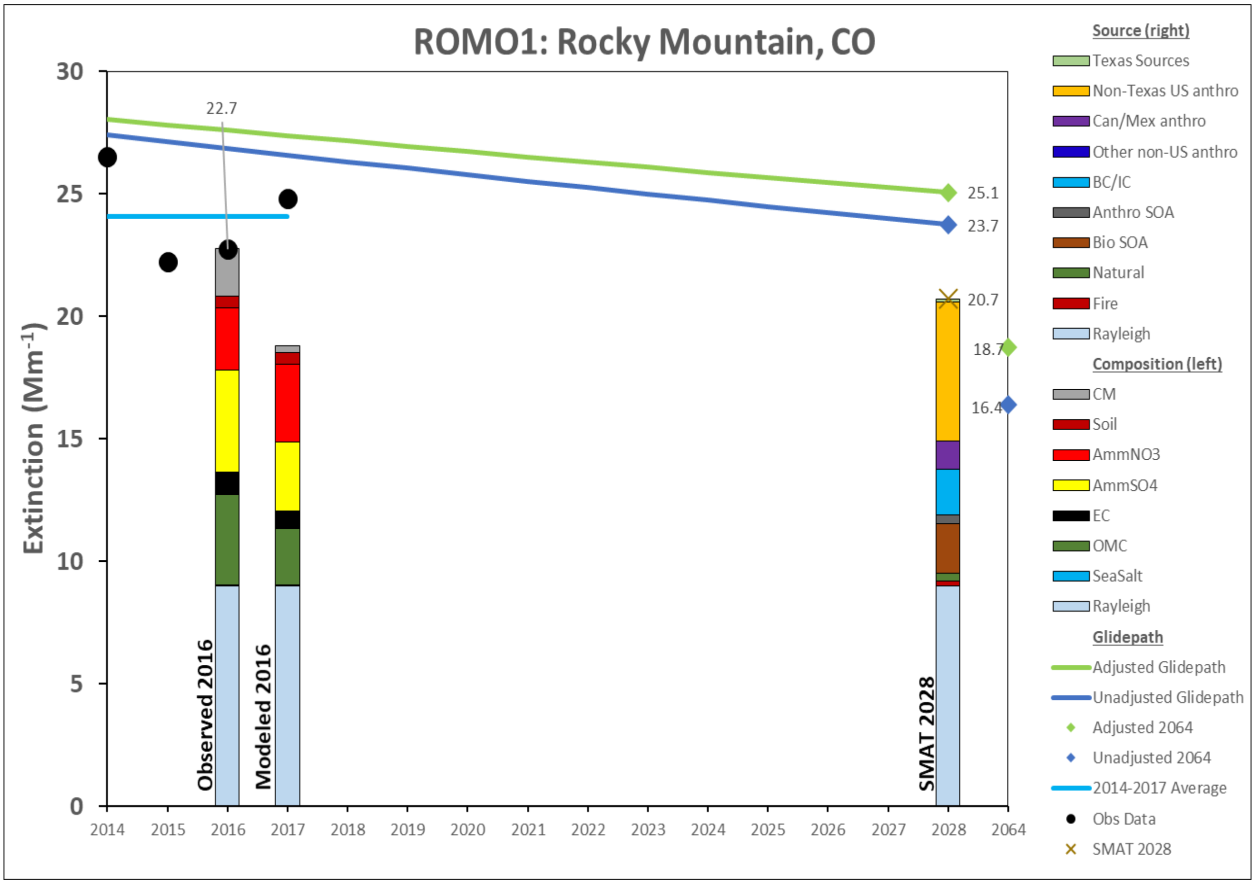

Figure 1-22**:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Rocky Mountain**

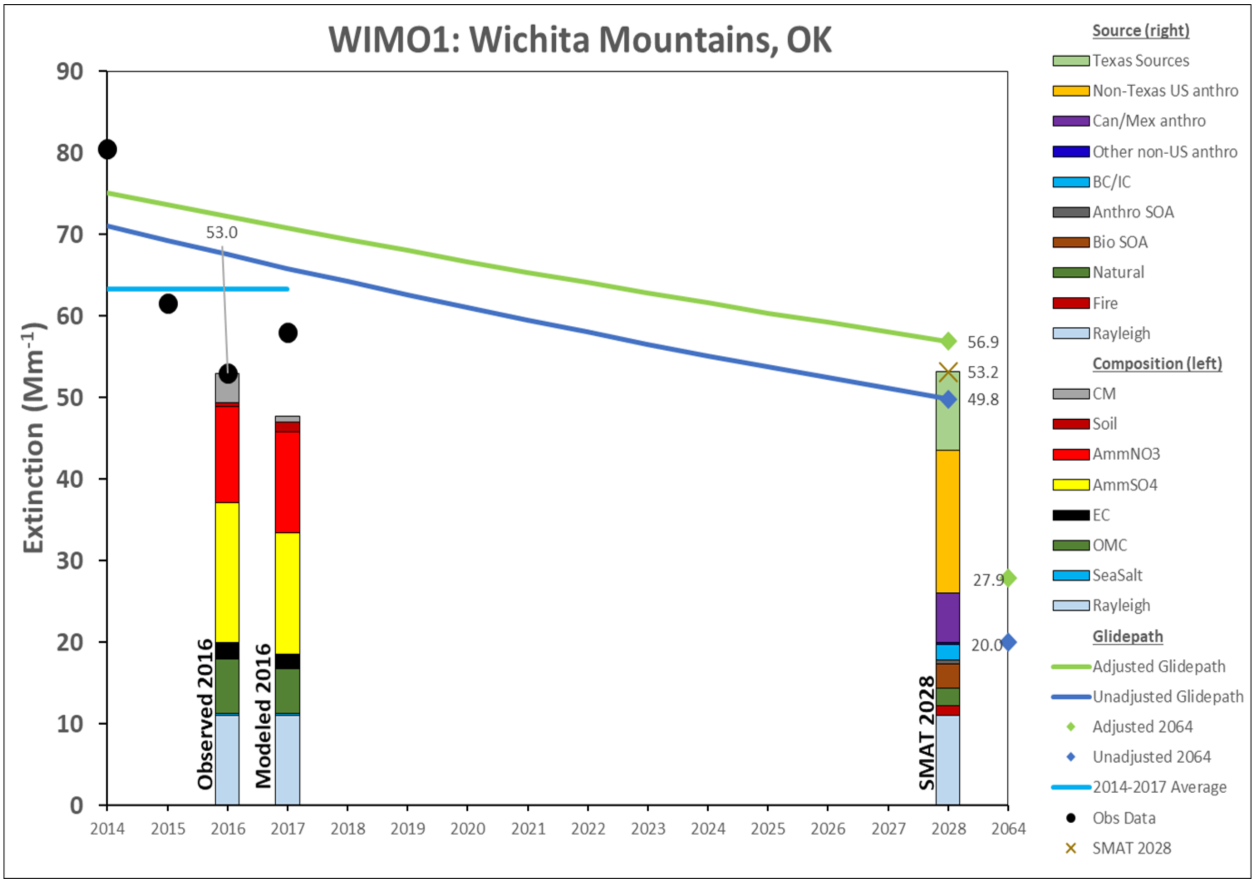

Figure 1-23:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Wichita Mountains

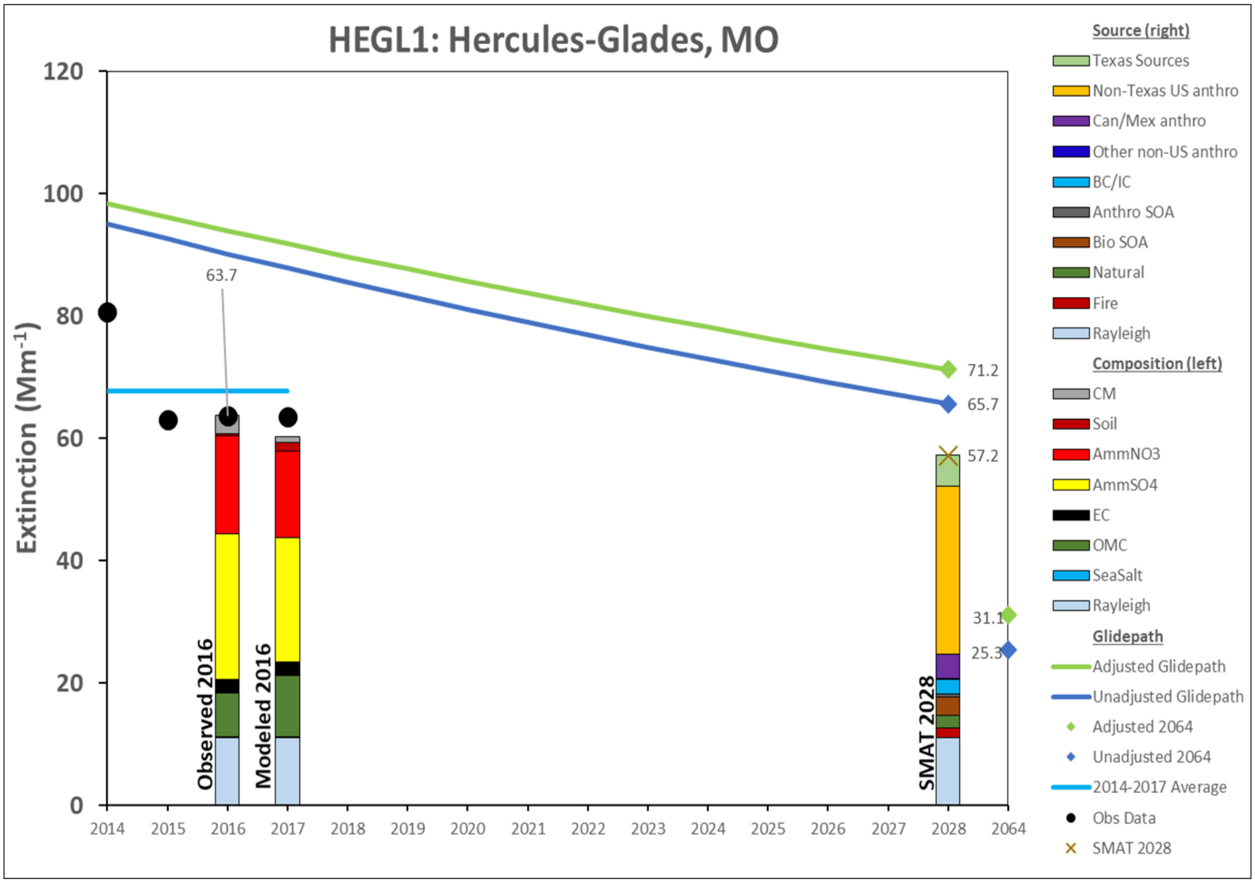

Figure 1-24:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Hercules-Glades

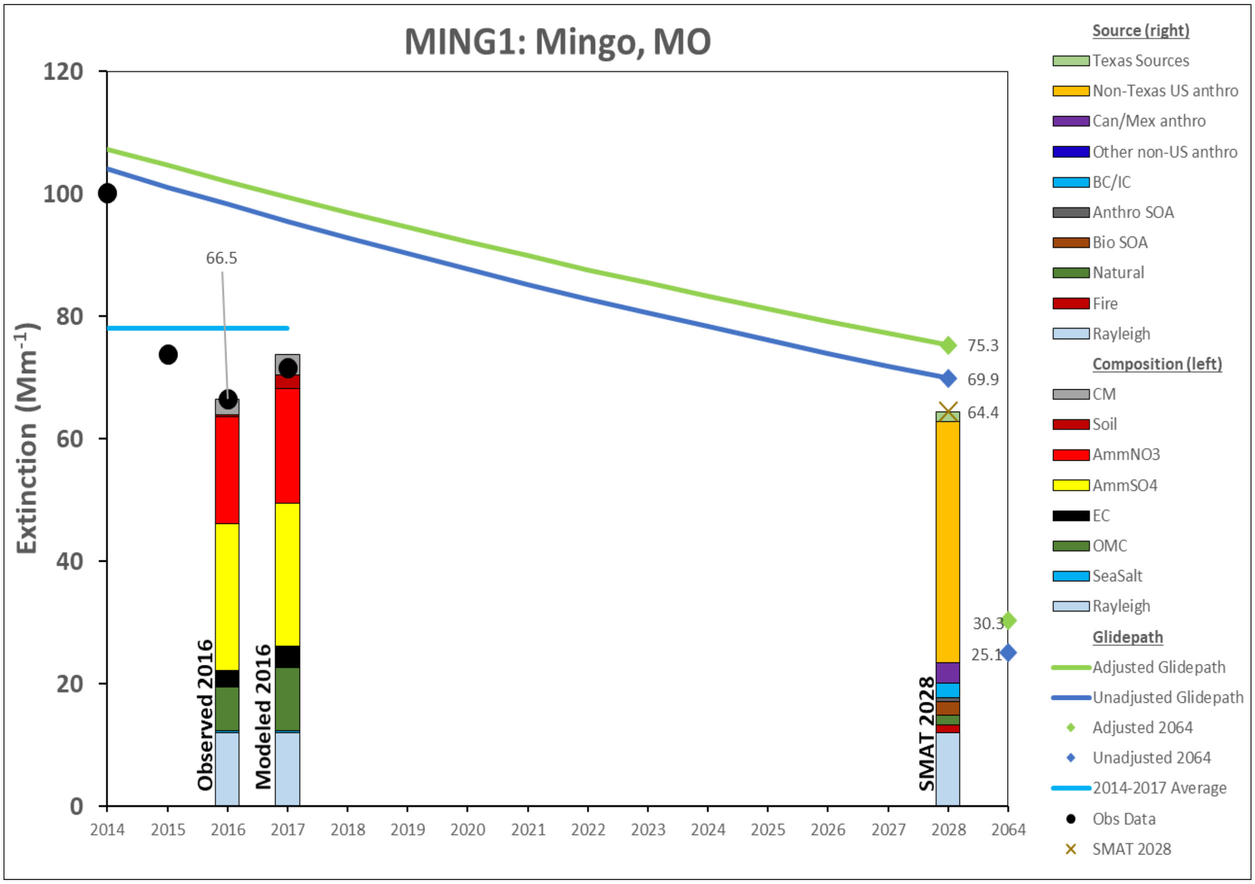

Figure 1-25:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Mingo

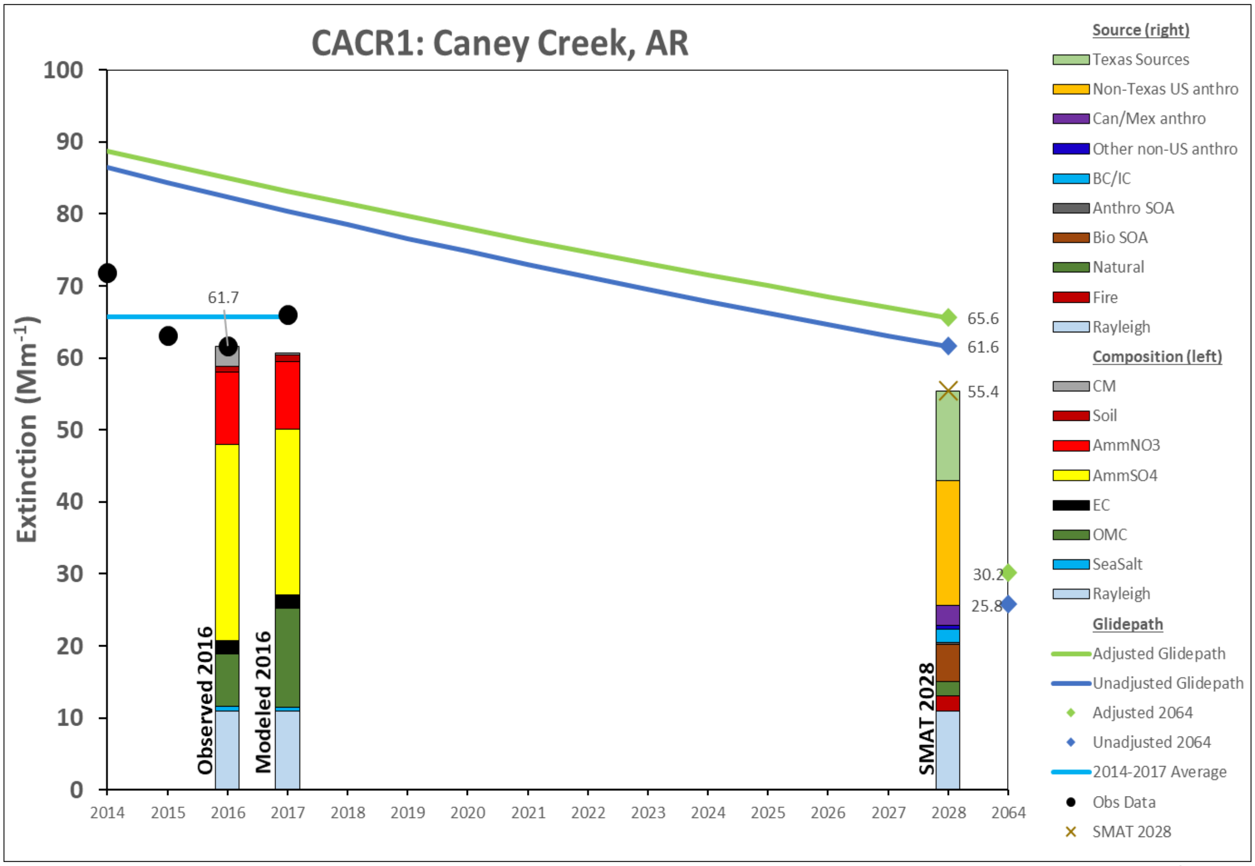

Figure 1-26:Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Caney Creek

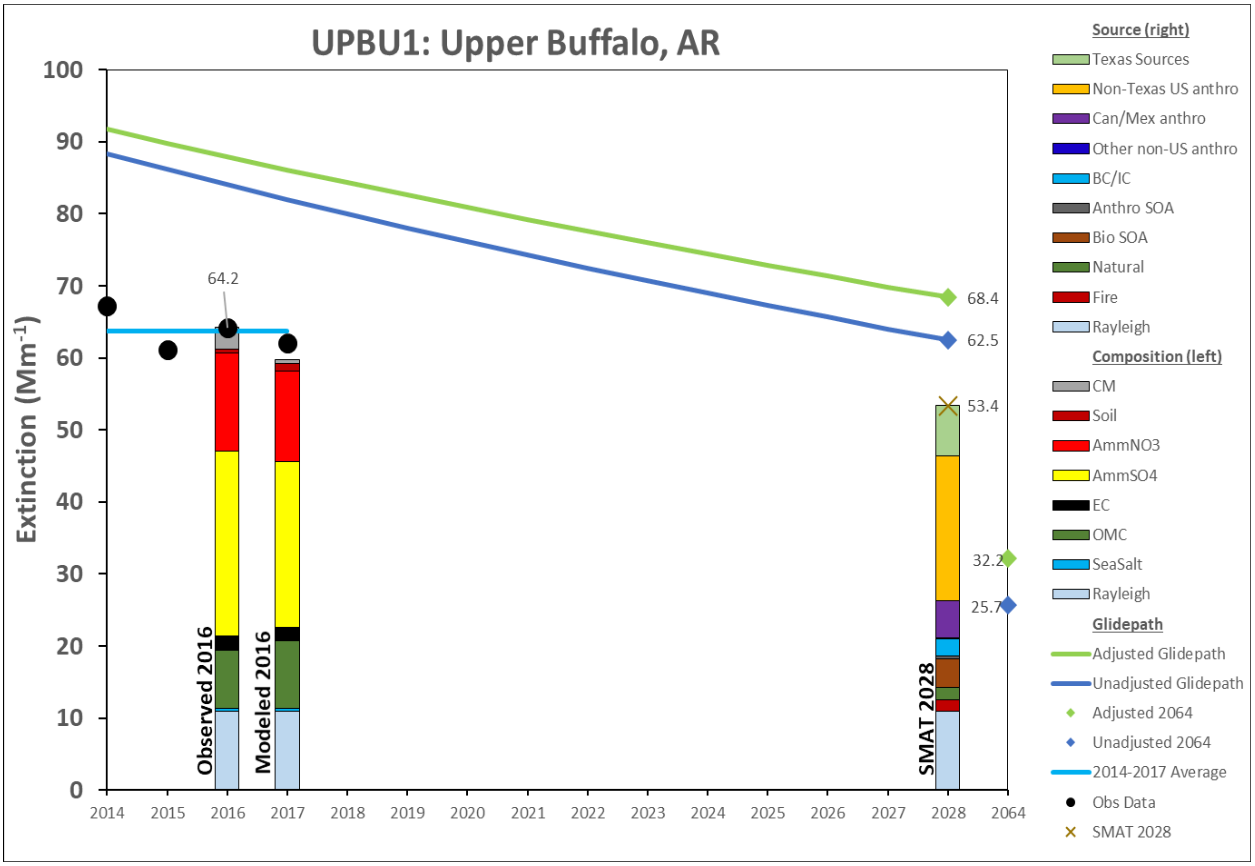

Figure 1-27:**Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Upper Buffalo**

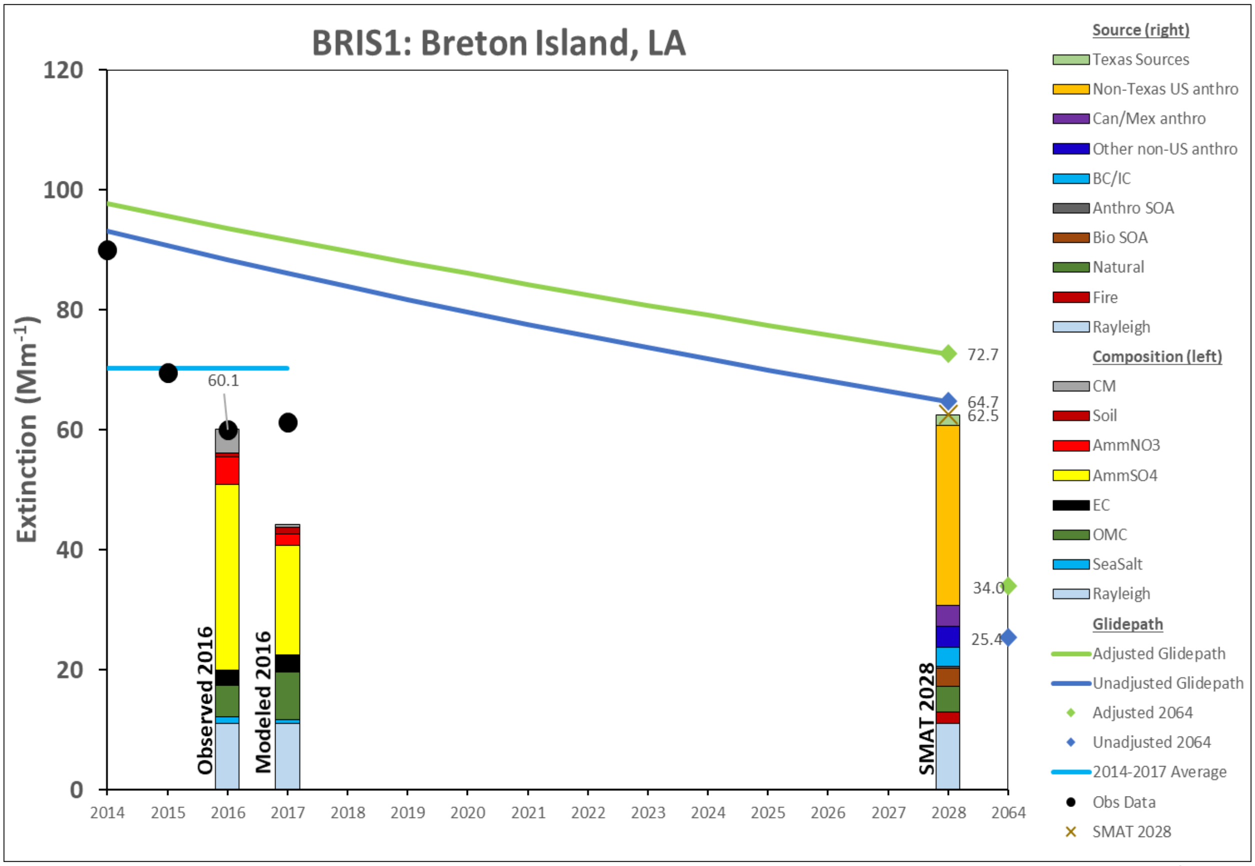

Figure 1-28:**Light Extinction Glidepaths with PSAT Source Sector Contributions for the 20% Most Impaired Days at Breton Island**

1.2.3 PSAT Light Extinction Results

Light extinction results for all Class I areas listed in Table 1-3 with a calculated URP are shown in Figure 1-29: *Light Extinction Source Influence from PSAT Categories at Nearby Class I Areas*. In this figure, the legend entries are in the same vertical order as the plotted PSAT source categories in Figure 1-15 through Figure 1-28, with seven states split out from non-Texas U.S sources and Texas sources split into five categories. The IMPROVE monitors are also arranged in the same order as Table 1-3, with the GUMO1 monitor serving both Guadalupe Mountains National Park in Texas and Carlsbad Caverns National Park in New Mexico. The influence of emissions from various regions are evident. The purple section of Canada/Mexico anthropogenic emissions, which are mostly from Mexico, is consistently seen with larger impairment at sites closer to Mexico. Influence from the monitor home state is usually greater than neighboring states and influence from neighbors decreases with distance. Except for fire emissions at Big Bend, fire and natural emission sources have greater influence on light extinction at sites east of Texas. The Other U.S. source category increases influence for the farther northeast sites in this comparison and is the largest non-Rayleigh category for both sites in Missouri and UPBU1 in northern Arkansas.

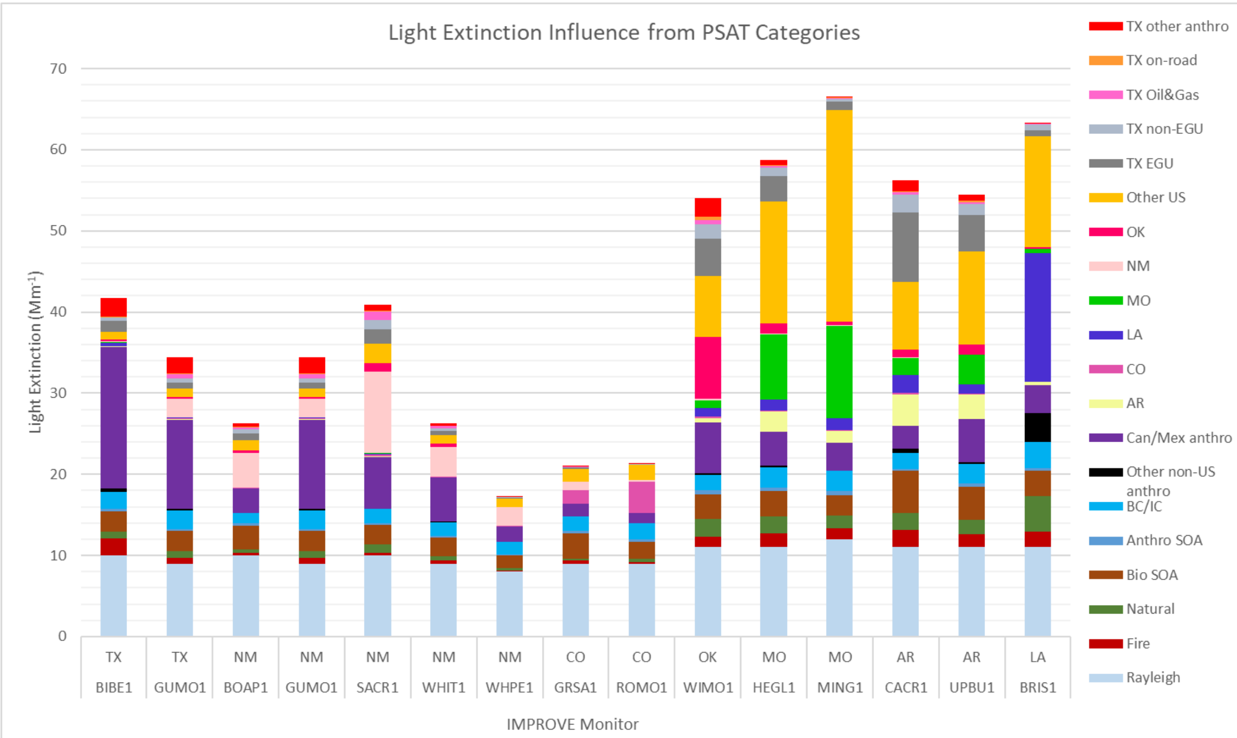

Figure 1-29: Light Extinction Source Influence from PSAT Categories at Nearby Class I Areas

Chapter 8 of the Regional Haze SIP Revision documentation includes Figure 8-22: *PSAT Light Extinction Influence at Big Bend National Park in Texas*, Figure 8-23: *PSAT Light Extinction Influence at Guadalupe Mountain and Carlsbad Caverns*, and Figure 8-24: *PSAT Light Extinction Influence at Wichita Mountains*, describing the PSAT results for three of the Table 1-3 Class I areas with a calculated URP. Results for the other 11 Class I areas will be presented here in Figure 1-30: *PSAT Light Extinction Source Influence at Bosque del Apache* through Figure 1-40: *PSAT Light Extinction Source Influence at Breton Island*.

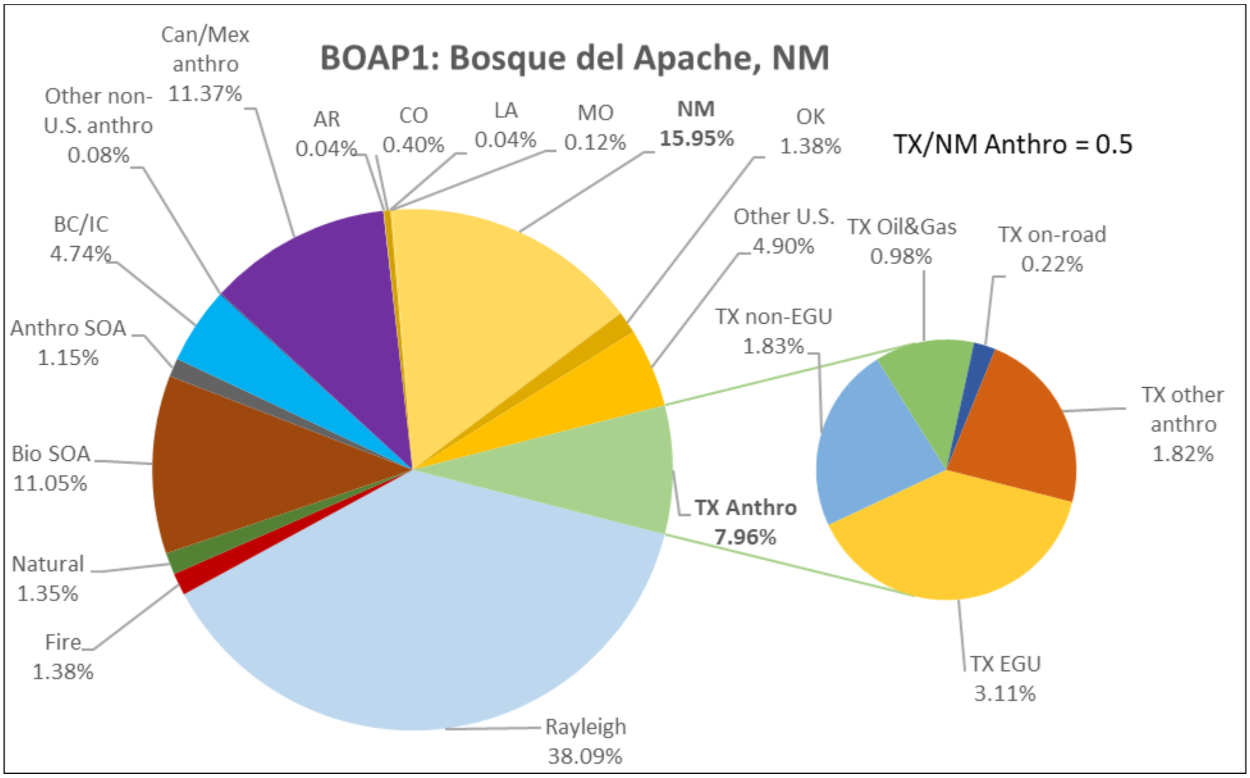

Figure 1-30: PSAT Light Extinction Source Influence at Bosque del Apache

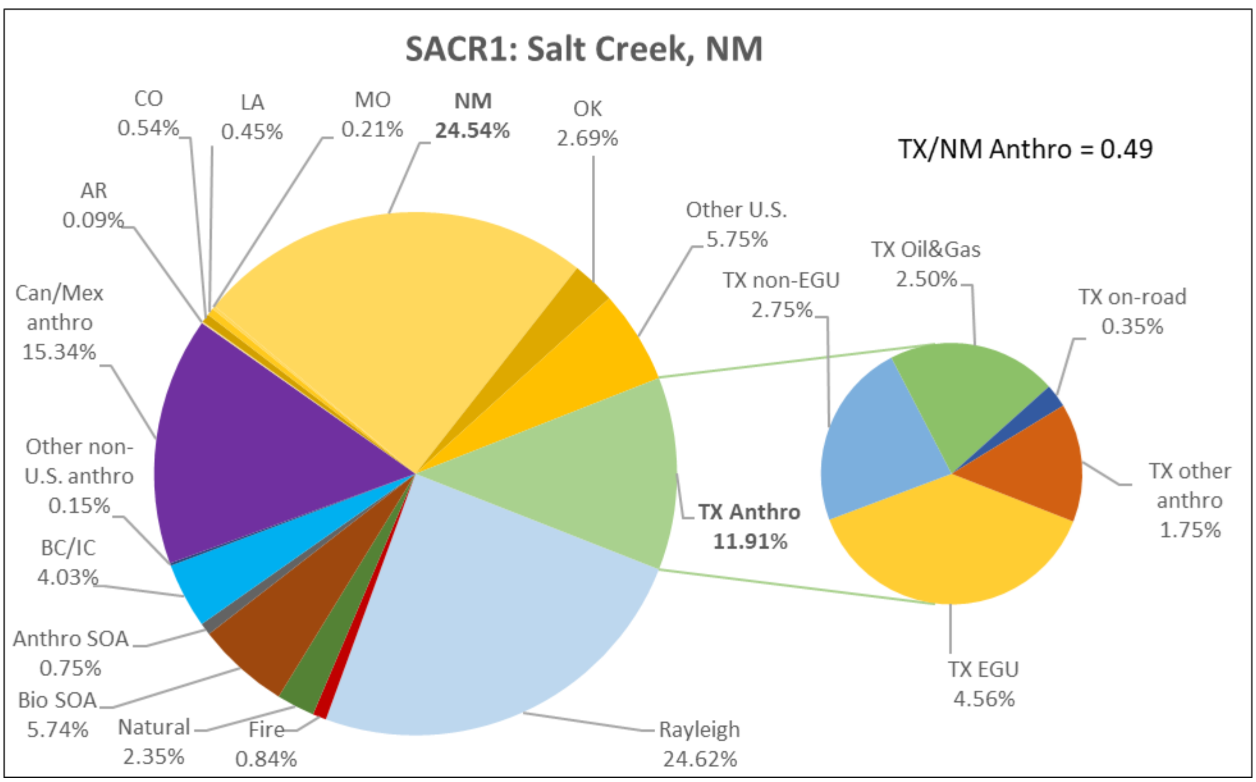

Figure 1-31: PSAT Light Extinction Source Influence at Salt Creek

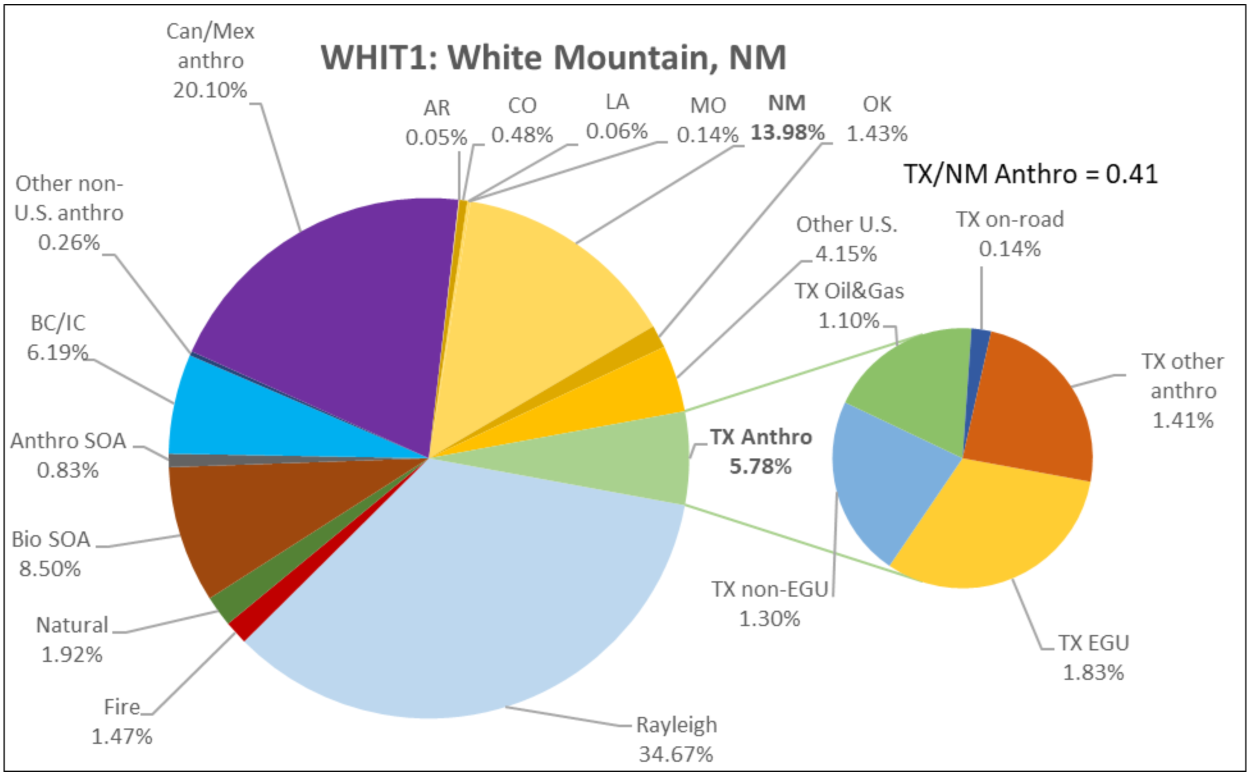

Figure 1-32: PSAT Light Extinction Source Influence at White Mountain

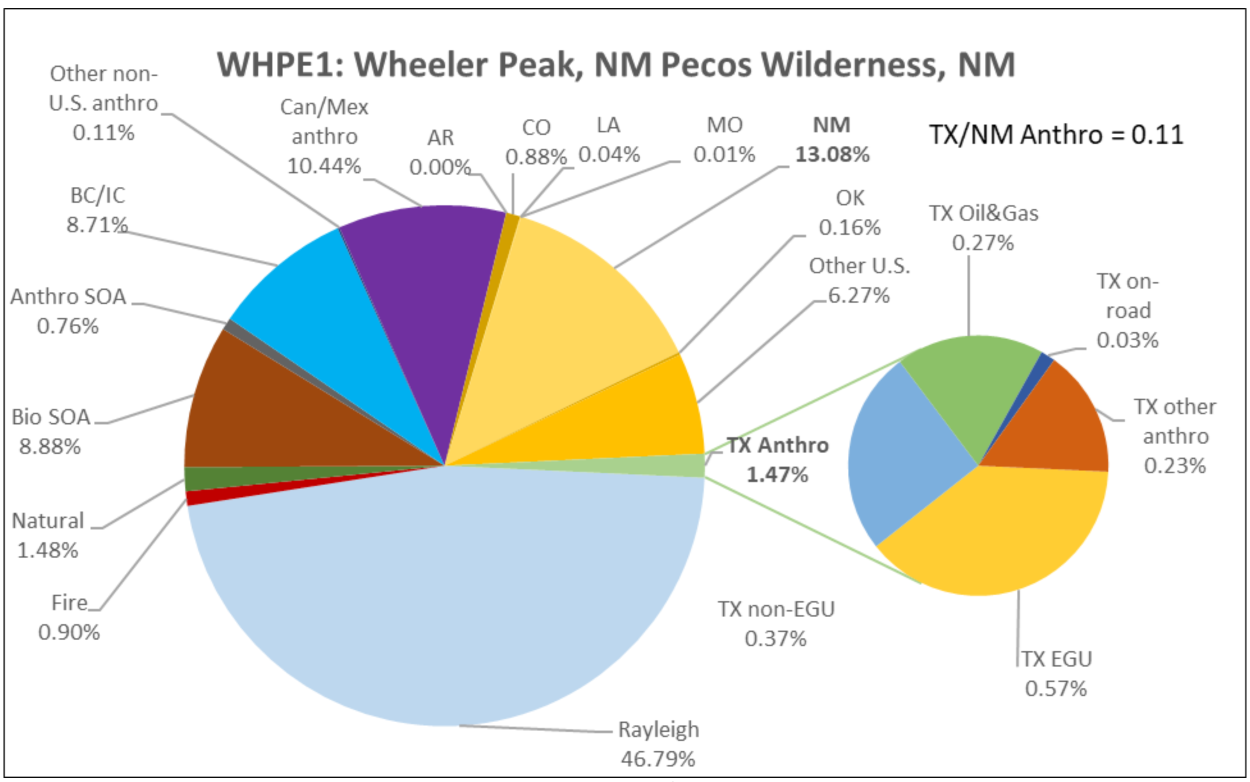

Figure 1-33: PSAT Light Extinction Source Influence at Wheeler Peak

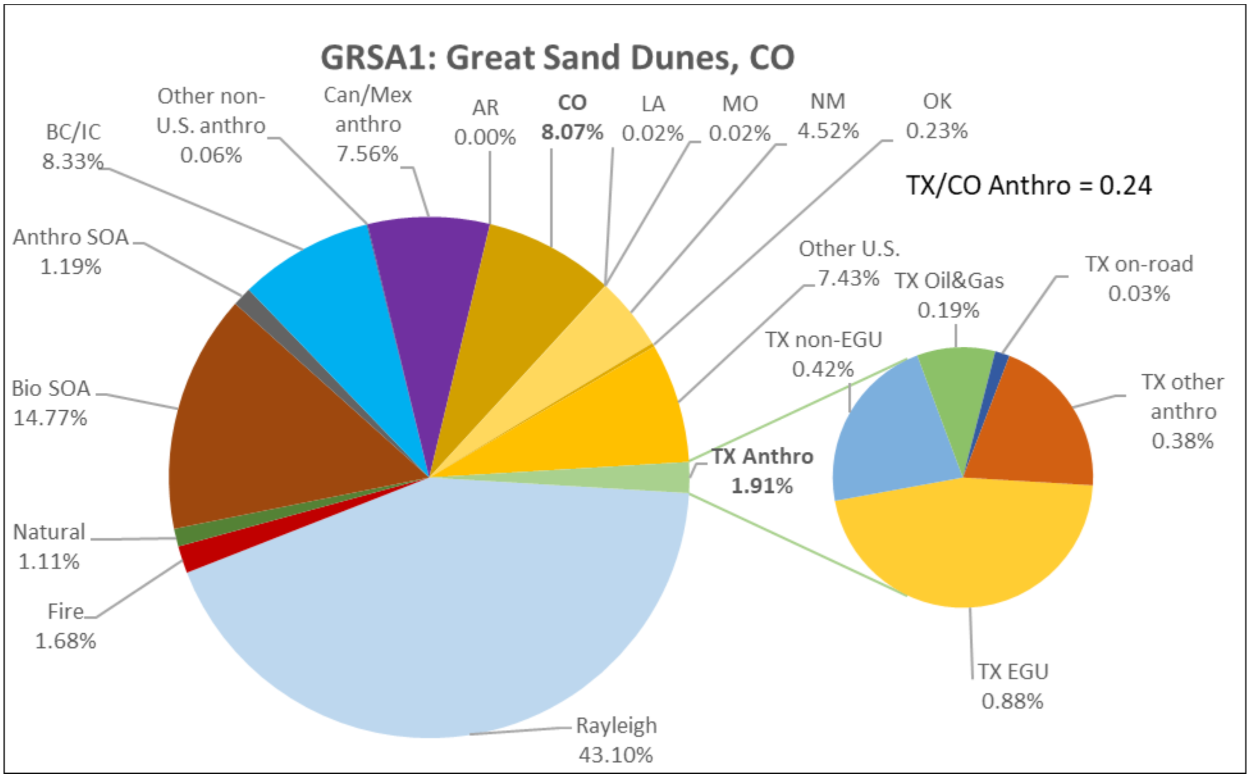

Figure 1-34: PSAT Light Extinction Source Influence at Great Sand Dunes

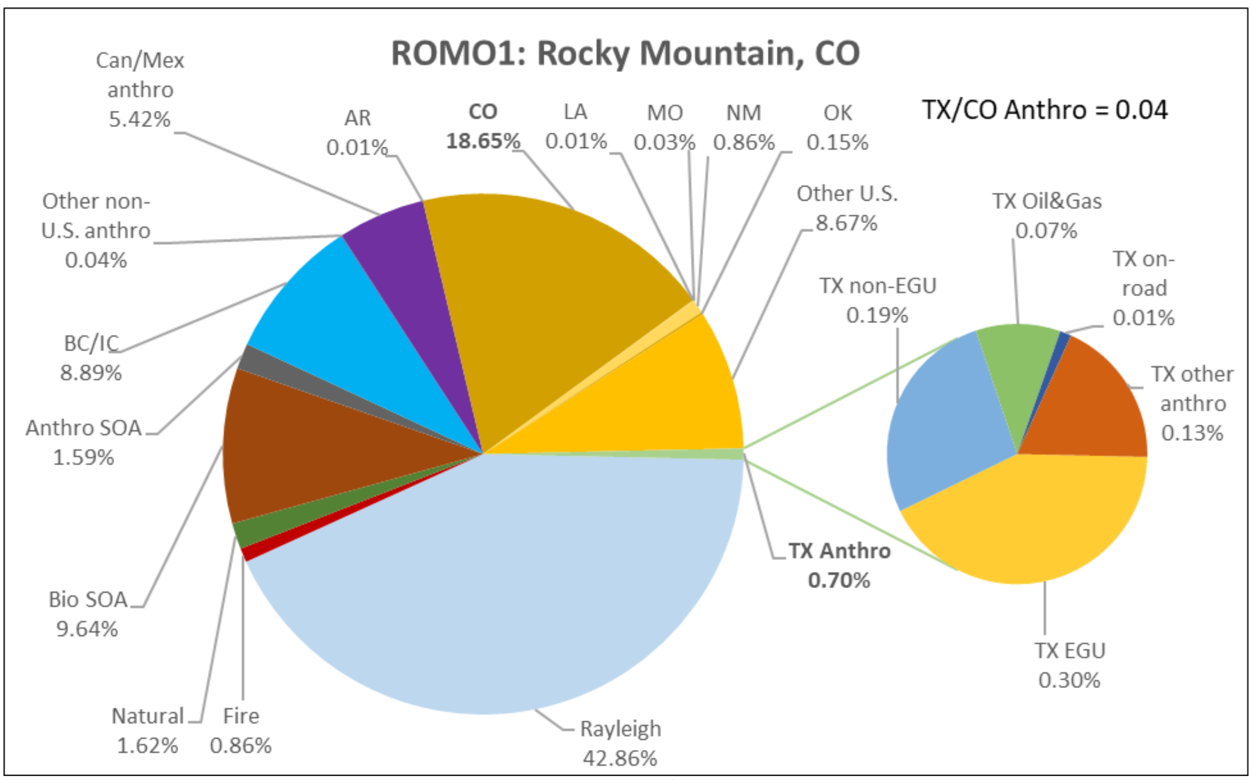

Figure 1-35: PSAT Light Extinction Source Influence at Rocky Mountain

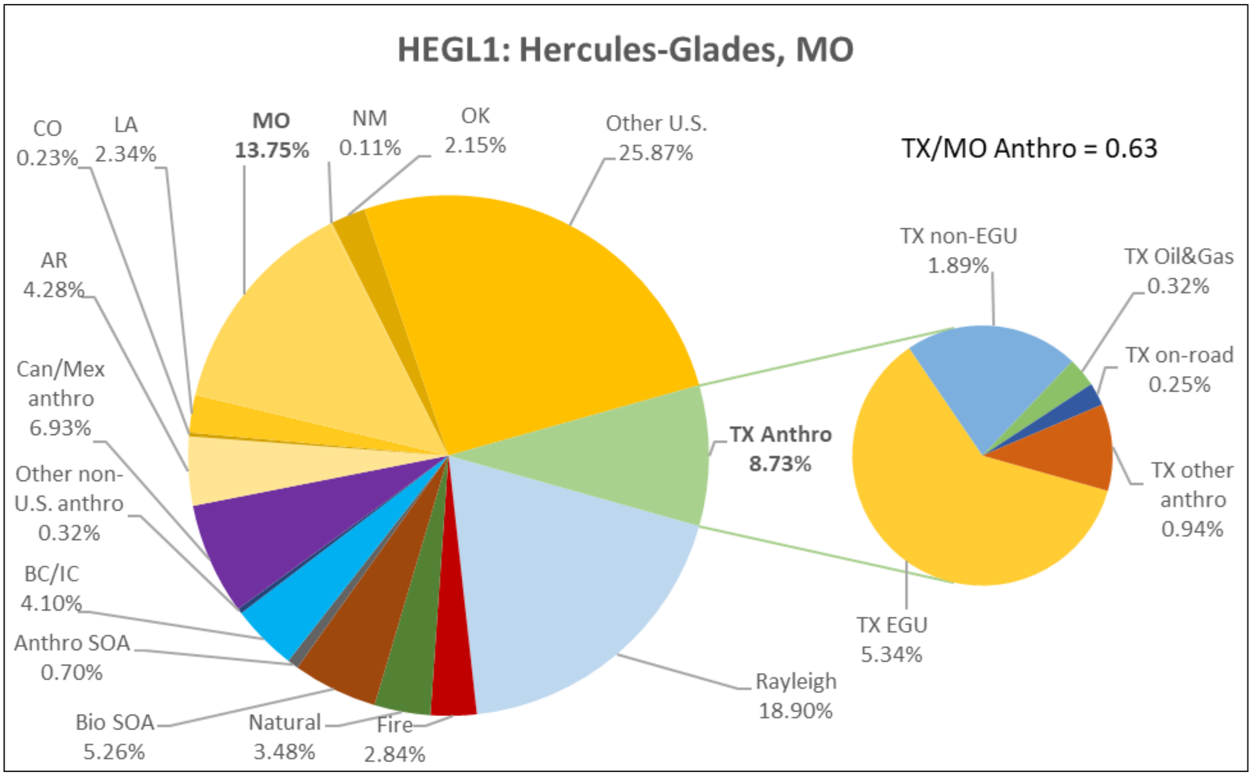

Figure 1-36: PSAT Light Extinction Source Influence at Hercules-Glades

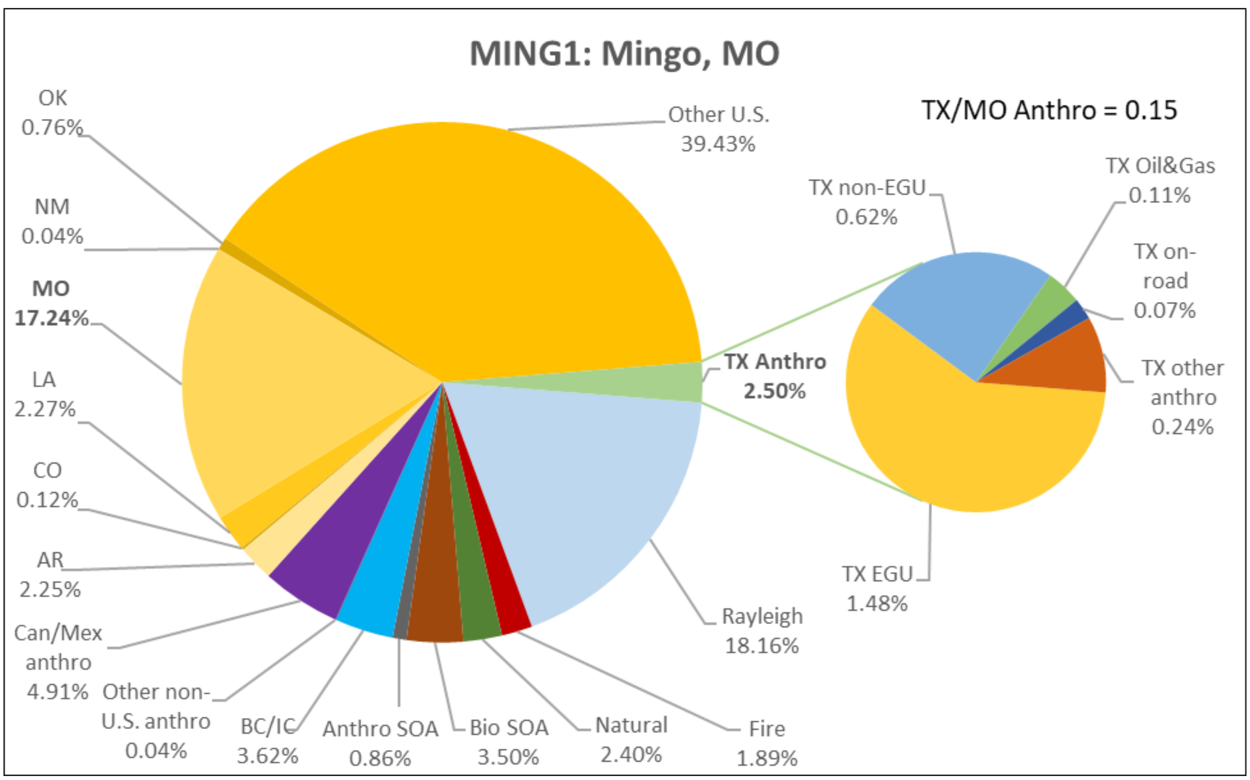

Figure 1-37:PSAT Light Extinction Source Influence at Mingo

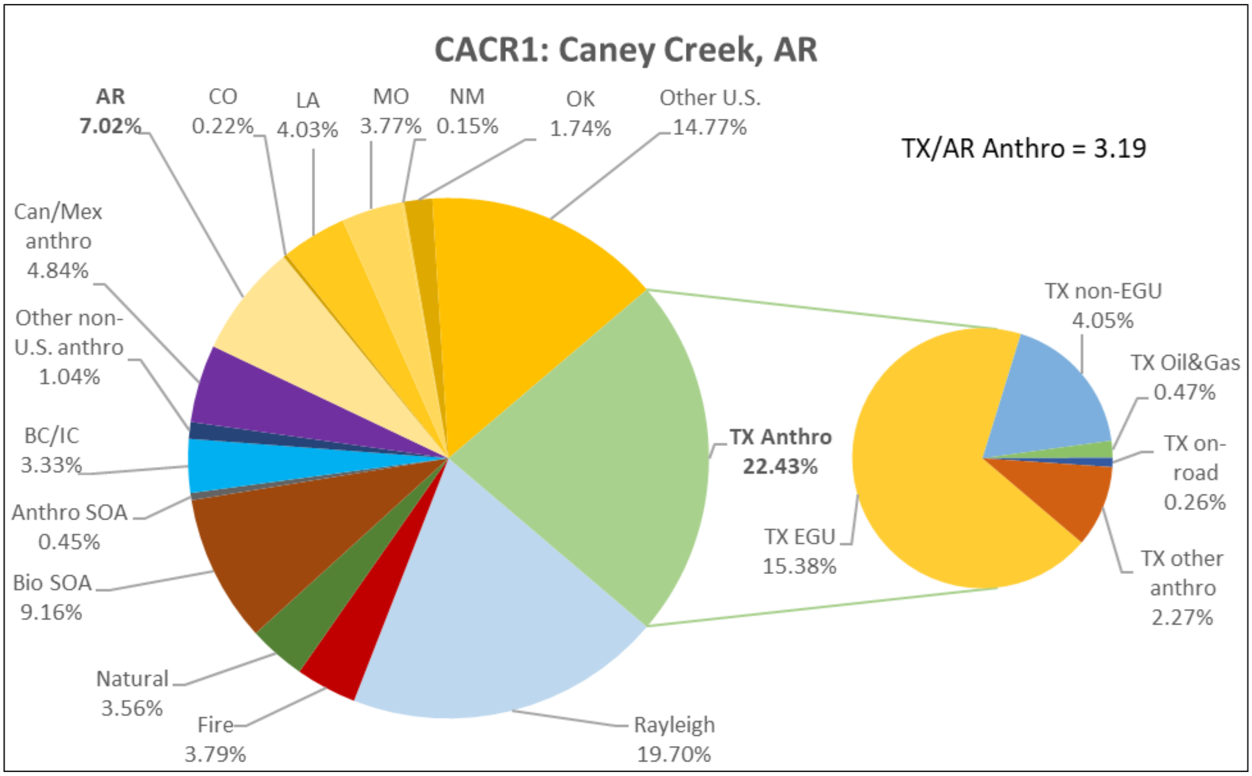

Figure 1-38: PSAT Light Extinction Source Influence at Caney Creek

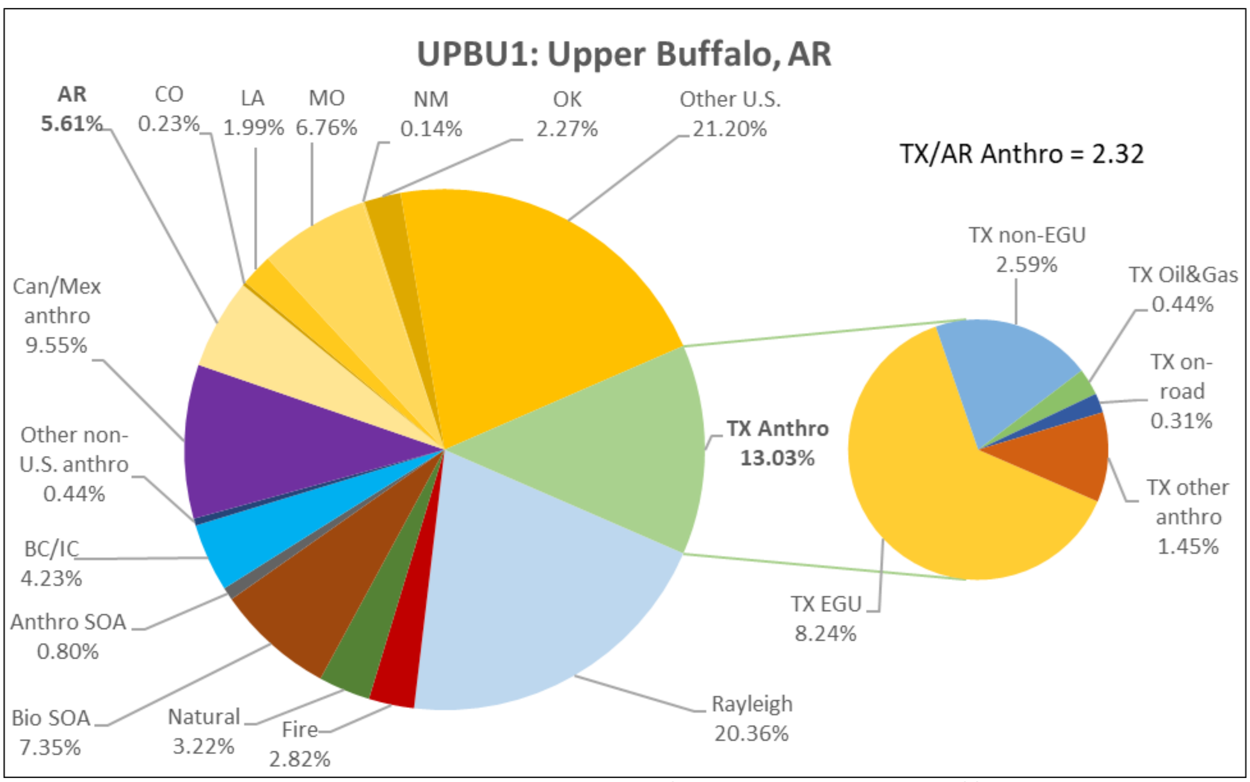

Figure 1-39: PSAT Light Extinction Source Influence at Upper Buffalo

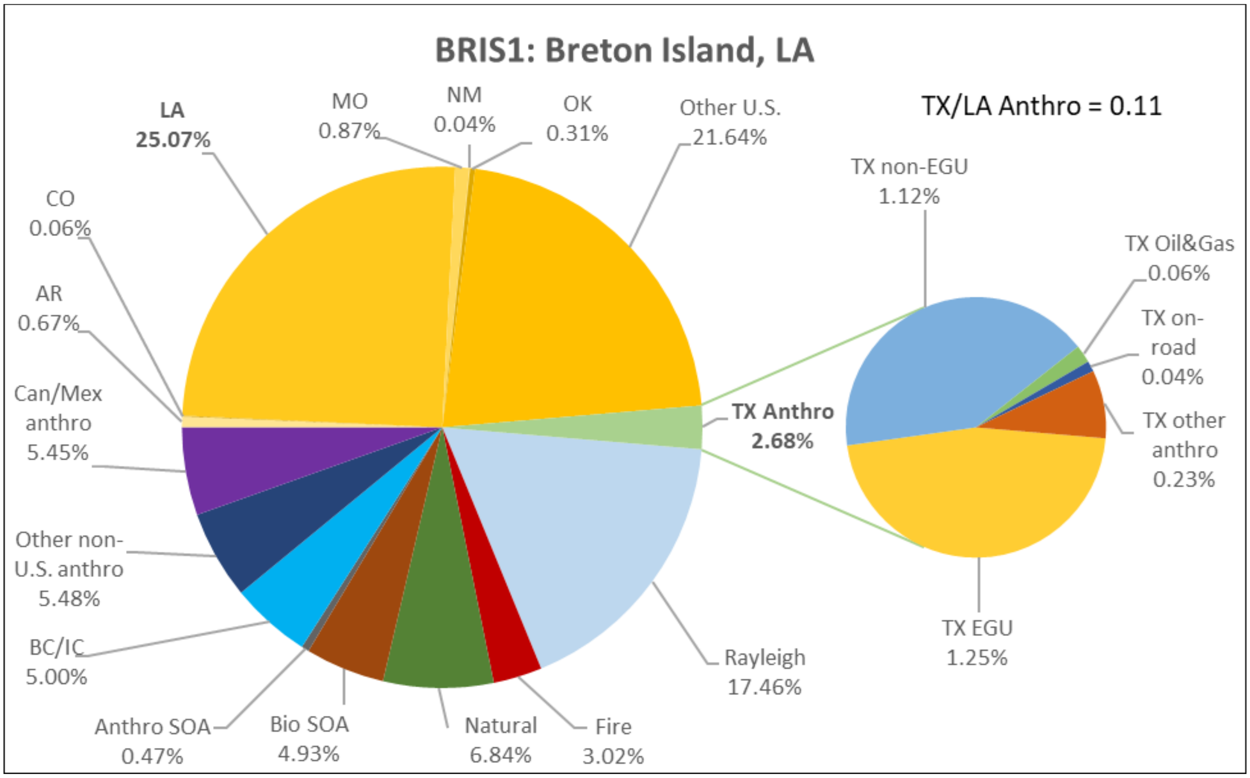

Figure 1-40:PSAT Light Extinction Source Influence at Breton Island

1.2.4 PSAT Particulate Matter Species Results

In this section, PSAT results for source category influence on PM species concentrations will be presented for select Class I areas. The Class I areas were chosen because Texas has more influence on the Class I area than the home state for particulate sulfate and/or particulate nitrate. The following Class I areas are included in this list:

- Bosque del Apache Wilderness Area;
- Carlsbad Caverns National Park;
- Salt Creek Wilderness Area;
- White Mountain Wilderness Area;
- Great Sand Dunes Wilderness Area;
- Wichita Mountains Wilderness;
- Hercules-Glades Wilderness Area;
- Caney Creek Wilderness Area; and
- Upper Buffalo Wilderness Area.

In addition, results will be shown for Big Bend National Park to better describe the influence of Texas sources, and for Guadalupe Mountain National Park because it shares an IMPROVE monitor with Carlsbad Caverns.

1.2.4.1 Guadalupe Mountains National Park, Texas and Carlsbad Caverns National Park, New Mexico

Figure 1-41: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Guadalupe Mountains* shows the ranking of light extinction caused by the IMPROVE PM species observed at the GUMO1 IMPROVE monitor serving Guadalupe Mountains and Carlsbad Caverns National Parks. The PM species are the IMPROVE species listed in Table 1-2. The largest amount of non-Rayleigh light extinction is due to ammonium sulfate, 47%, followed by coarse mass at 23%, organic aerosol at 13%, ammonium nitrate at 8%, with smaller contributions from soil, elemental carbon, and sea salt.

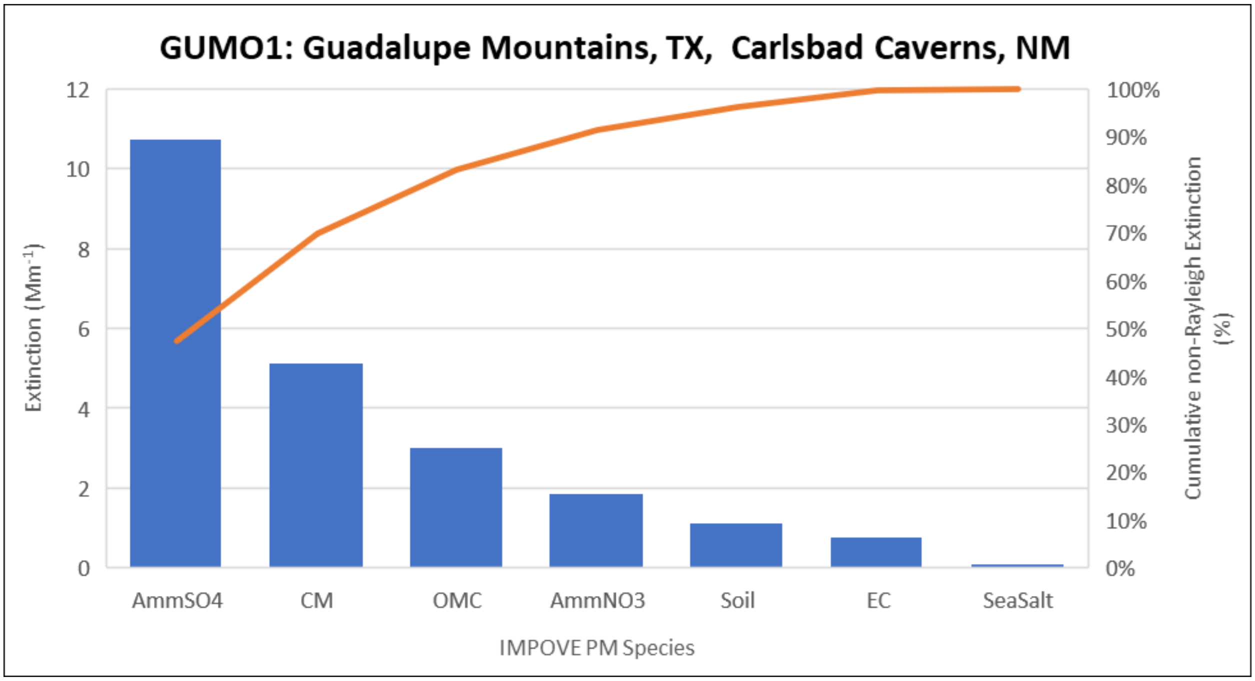

Figure 1-41: Extinction by Ranked PM Species on the 20% Most Impaired Days at Guadalupe Mountains and Carlsbad Caverns

The IMPROVE PM species map onto the larger set of PSAT PM species as described in Table 1-5: *Conversion of IMPROVE Monitor PM Species to PSAT PM Species*. The IMPROVE AmmSO4 specie is a combination of particulate sulfate and particulate ammonium with an assumed stoichiometric mass increase of 1.375 times the particulate sulfate amount. Likewise, AmmNO3 is a combination of particulate nitrate and particulate ammonium with a mass increase of 1.290 times the particulate nitrate amount. The stoichiometry assumption is not consistent with the TCEQ model results, as seen in Table 8-38: *Conversion of Particulate Sulfate and Nitrate to Ammonium Sulfate and Nitrate* of the Regional Haze SIP Revision documentation.

Table 1-5: Conversion of IMPROVE Monitor PM Species to PSAT PM Species

IMPROVE PM Species	PSAT PM Species
AmmSO4	1.375 x PS04 Stoichiometric combination of particulate sulfate and particulate ammonium
AmmNO3	1.375 x PS04 Stoichiometric combination of particulate sulfate and particulate ammonium
OMC	Primary Organic Aerosol
CM	Coarse Crustal Particulate and Other Coarse Particulate
Soil	Fine Crustal Particulate and Other Fine Particulate
EC	Primary Elemental Carbon
Seasalt	Not partitioned by PSAT

Sources contributing to particulate sulfate concentration at the GUMO1 monitor are seen in Figure 1-42: *PSAT Particulate Sulfate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days.* The largest source group is Canada and Mexico emissions, at 70% and Texas anthropogenic emissions at 12%, which are 4.4 times as much as New Mexico anthropogenic emissions. Within Texas, EGU emissions are the largest category, followed by non-EGU point sources – which include oil and gas point sources, and oil and gas nonpoint sources. For this and subsequent monitors in this section, refer to Section 7.2: *Source Selection and Control Measure Evaluation for Determining Reasonable Progress* of the Regional Haze SIP Revision documentation for sources evaluated for NO_X and SO_2 reductions.

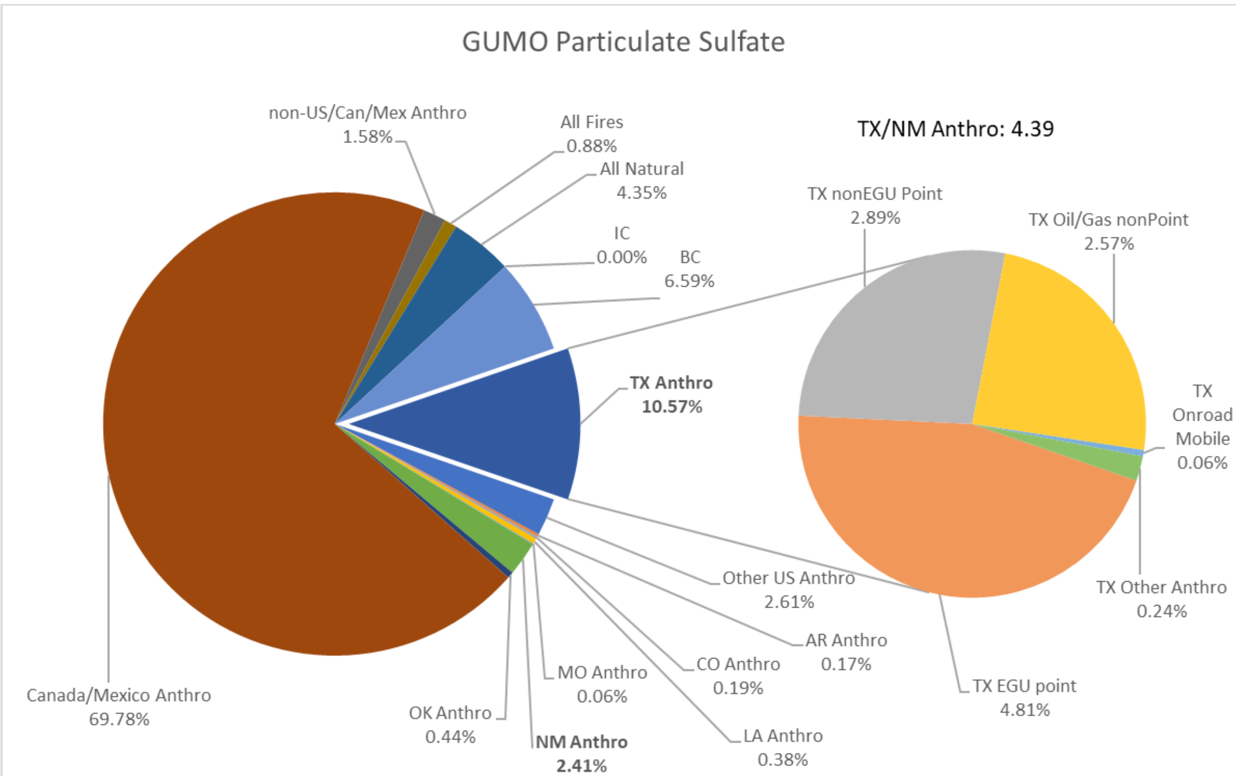

Figure 1-42:**PSAT Particulate Sulfate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days**

Particulate nitrate observed at the GUMO1 monitor is attributed to sources as shown in Figure 1-43: *PSAT Particulate Nitrate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days*. Sources in Canada and Mexico contribute the most, at 29%, followed by Texas anthropogenic sources at 31%, which is 3.5 times the New Mexico anthropogenic amount of 9%. Within Texas, oil and gas nonpoint sources are the largest group at 19%, followed by non-EGU point sources.

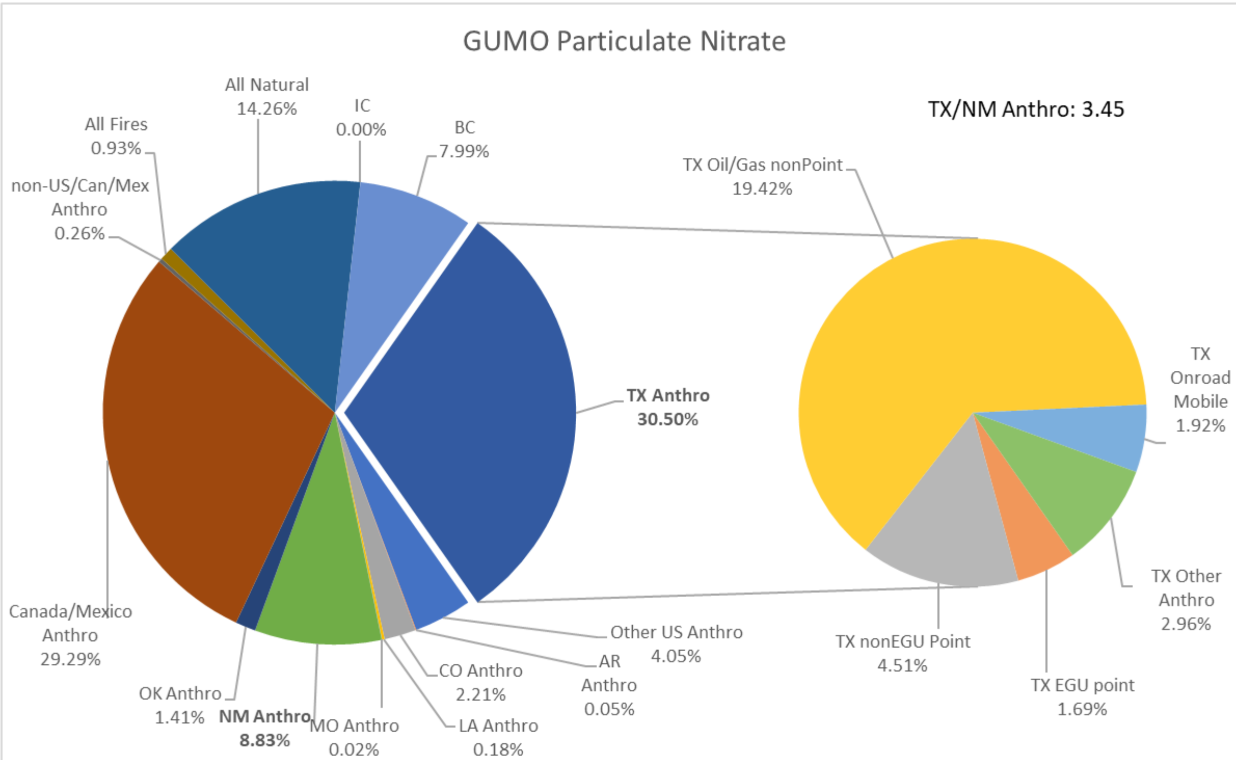

Figure 1-43:**PSAT Particulate Nitrate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days**

Sources contributing to particulate ammonium modeled at the GUMO1 monitor are shown in Figure 1-44: *PSAT Particulate Ammonium Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days*. Local and regional anthropogenic sources are the largest categories, with Texas anthropogenic sources leading with 39%, which are 10.7 times as much as the New Mexico anthropogenic sources, followed by Canada/Mexico sources. Within Texas, the Other Anthropogenic category contributes 33% - the largest of any source category.

PSAT results for particulate ammonium at all monitors show a similar source mix with local and regional anthropogenic sources contributing the largest shares. In all locations, the largest emissions of ammonia, the precursor of ammonium, are from agricultural sources.

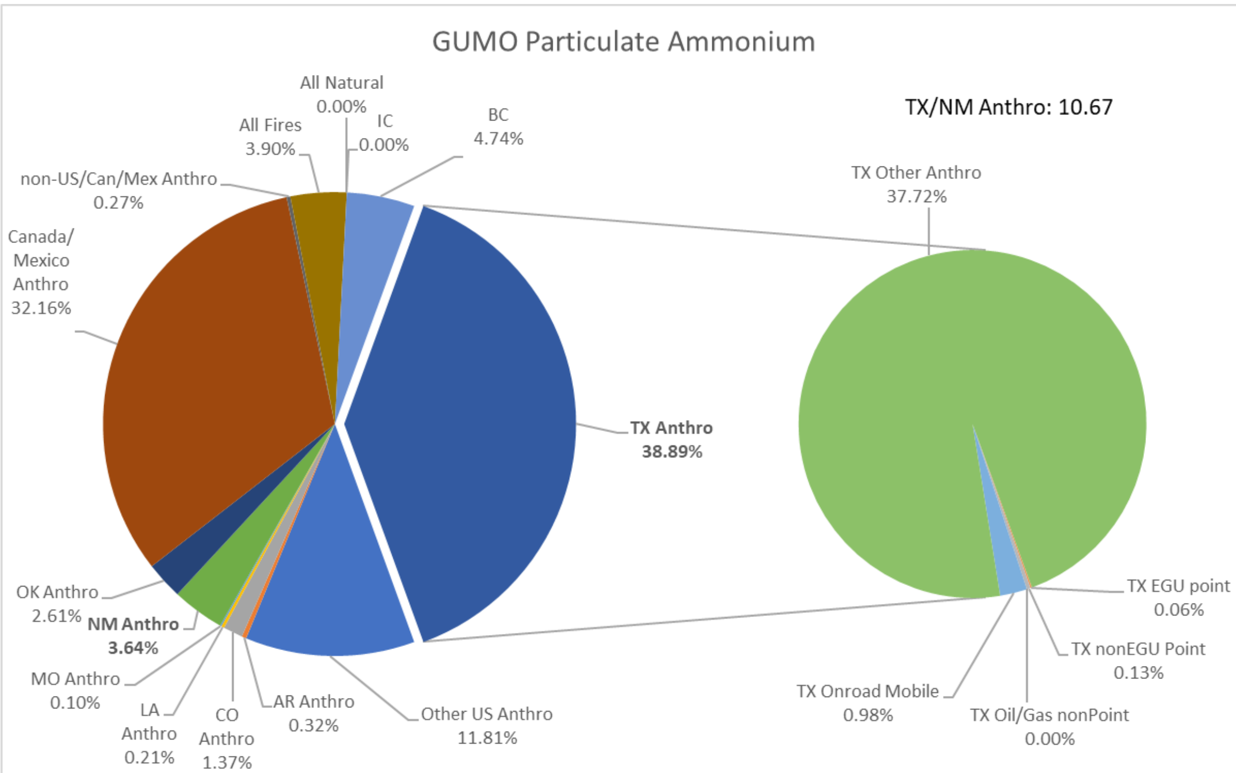

Figure 1-44:PSAT Particulate Ammonium Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days

Primary elemental carbon PSAT results are shown in Figure 1-45: *PSAT Primary Elemental Carbon Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days*. The leading source group is Canada/Mexico anthropogenic sources at 46%, followed by fire at 17%. Texas anthropogenic emissions at 15% are 3.1 times as influential as New Mexico anthropogenic emissions, but less than fire emissions. Within Texas, the Other Anthro category leads, followed by non-EGU and EGU point sources.

For all monitors, the fire sources contribute a substantial portion of the primary elemental carbon observed.

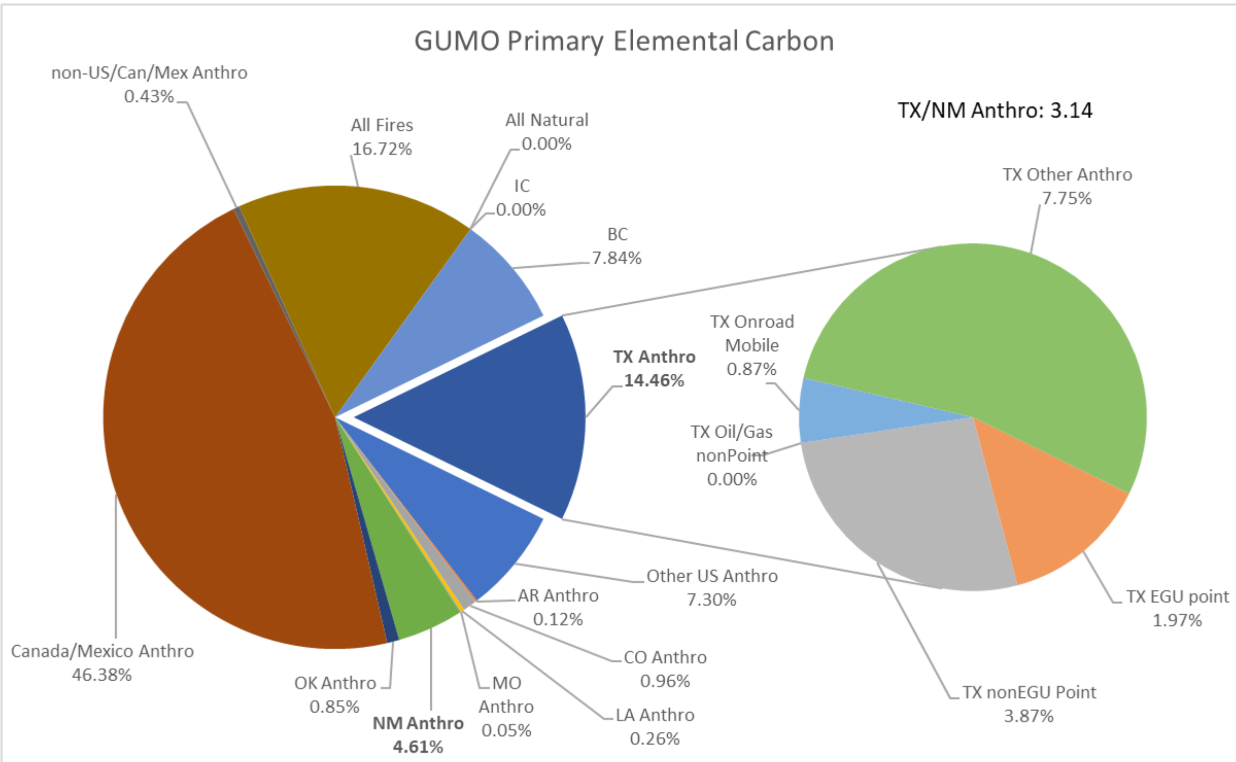

Figure 1-45:PSAT Primary Elemental Carbon Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days

Primary organic aerosol sources, as depicted in Figure 1-46: *PSAT Primary Organic Aerosol Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days*, show fire emissions at 50%, followed by Canada/Mexico, Boundary Conditions, and Texas in fourth place at 9%, 2.2 times as much as New Mexico. Agricultural burning beyond the model boundary, such as southern Mexico and Central America could be contributing to the boundary condition values.

The substantial contribution to primary organic aerosol from fire emissions is a common influence at all monitors evaluated in this modeling.

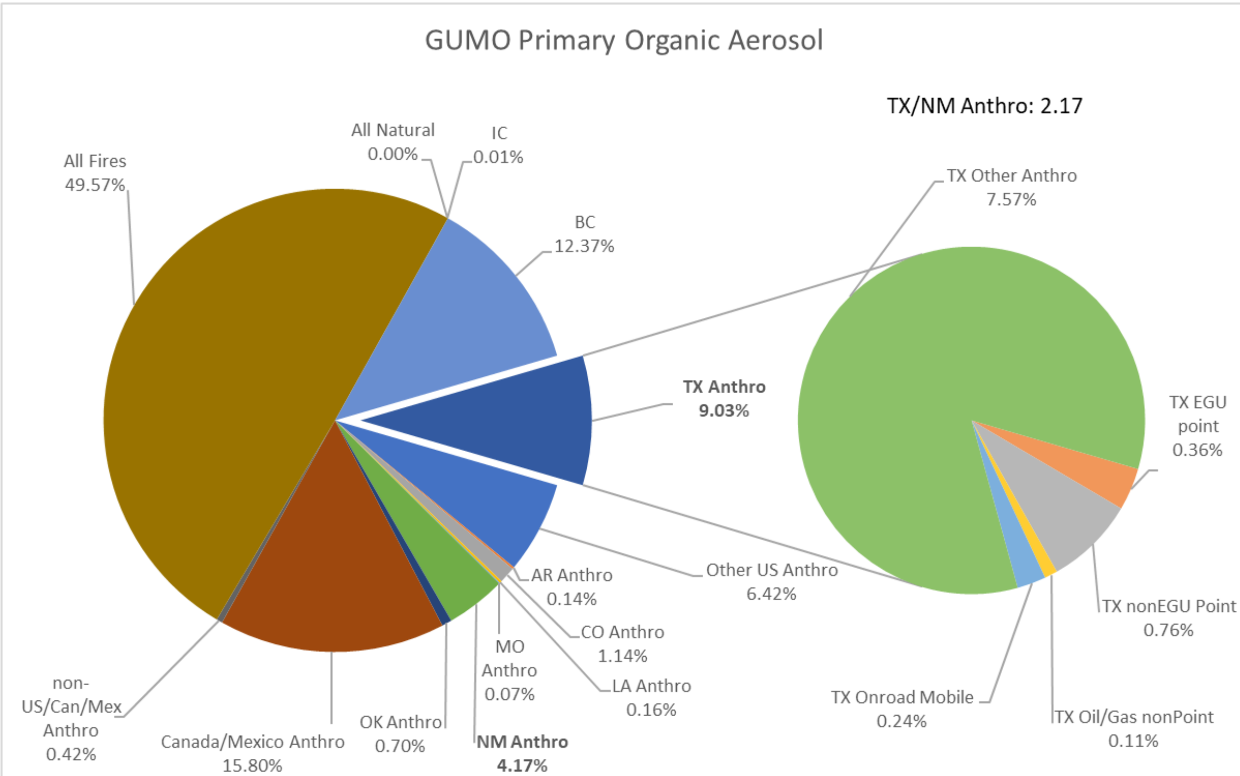

Figure 1-46:PSAT Primary Organic Aerosol Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days

Figure 1-47: *PSAT Fine Crustal Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days* shows the sources of fine crustal particulate concentrations at the GUMO1 monitor. The largest source, by far, is boundary conditions, at 78%, followed by Texas and Canada/Mexico anthropogenic sources. The Texas sources, which are 1.7 times the New Mexico sources, are almost all from the Other Anthropogenic category. Agricultural dust is included in the Other Anthropogenic category. The preponderance of boundary sources indicates that long-range transport of these fine particles could be an important factor. Texas consistently observes dust coming from the Sahara Desert in the summer months.

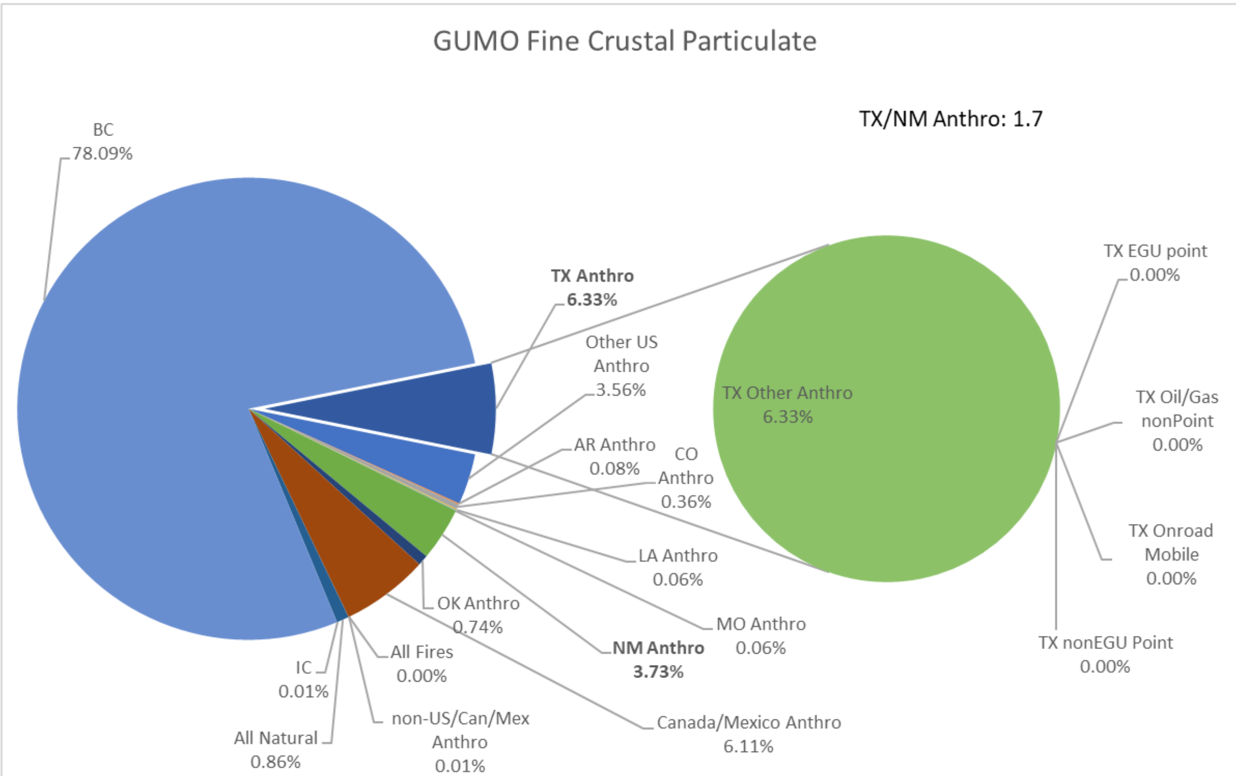

Figure 1-47:PSAT Fine Crustal Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days

The source influence for the other fine particulate category is shown in Figure 1-48: *PSAT Other Fine Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days*. Canada/Mexico anthropogenic sources lead with 31% of the influence, followed by Texas anthropogenic sources with 29%, which is 1.7 times larger than the New Mexico sources. Within Texas, the Other Anthropogenic category is the largest. This category includes agricultural dust.

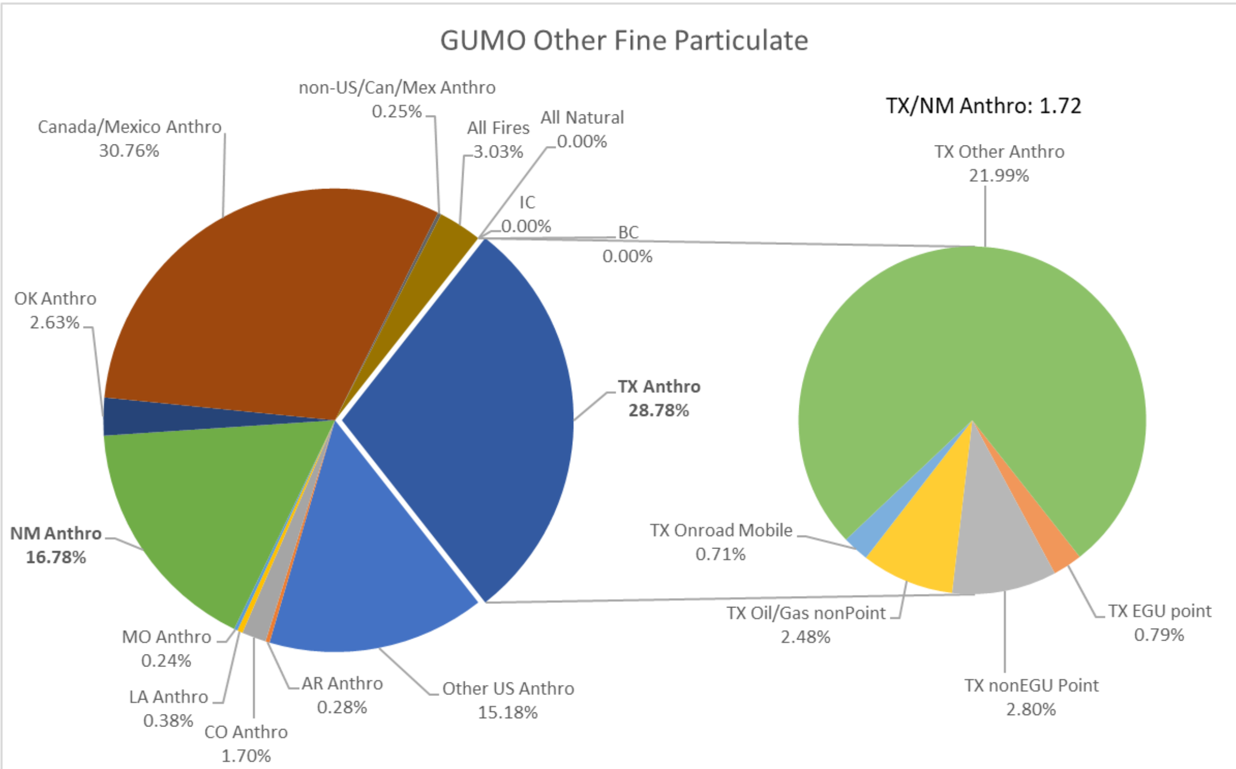

Figure 1-48:PSAT Other Fine Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days

Coarse crustal particulate, one percent of the total modeled PM at the GUMO1 monitor, is comprised of 81.79% from boundary conditions and 18.21% natural sources, as seen in Figure 1-49: *PSAT Coarse Crustal Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days*. The coarse crustal particulate PSAT influence seen at the GUMO1 monitor is typical for the other monitors evaluated, with Boundary Conditions and Natural sources comprising over 98% of the total influence. This indicates that the model is not attributing coarse crustal particulate concentrations to local or regional anthropogenic sources, suggesting some imbalance in the boundary values and regional values. TCEQ has initiated a research project to evaluate and improve the CAMx modeling of windblown dust, including coarse crustal particulates.

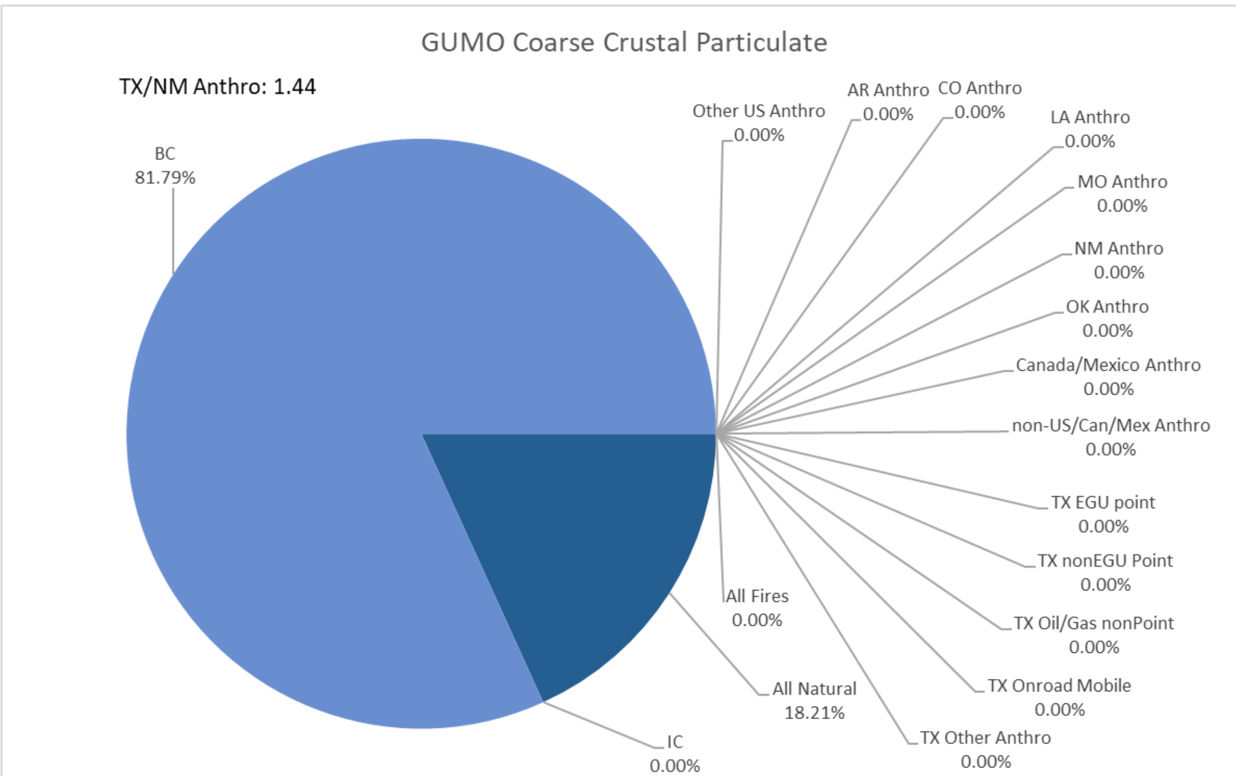

Figure 1-49:**PSAT Coarse Crustal Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days**

Other coarse particulate influence at the GUMO1 monitor is shown in Figure 1-50: *PSAT Other Coarse Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days*. Texas sources, almost all in the Other Anthropogenic category, lead with 45%, followed by New Mexico anthropogenic sources at 37%. Natural sources and boundary values comprise less than 0.1% of the influence.

The Canada/Mexico sources, mostly to the south of this monitor, exhibit a disproportionately low influence compared with the Texas and New Mexico sources to the east and west, respectively, potentially indicating an inventory discrepancy.

This source influence pattern is typical of other monitors studied, with a preponderance of influence from nearby U.S. anthropogenic sources.

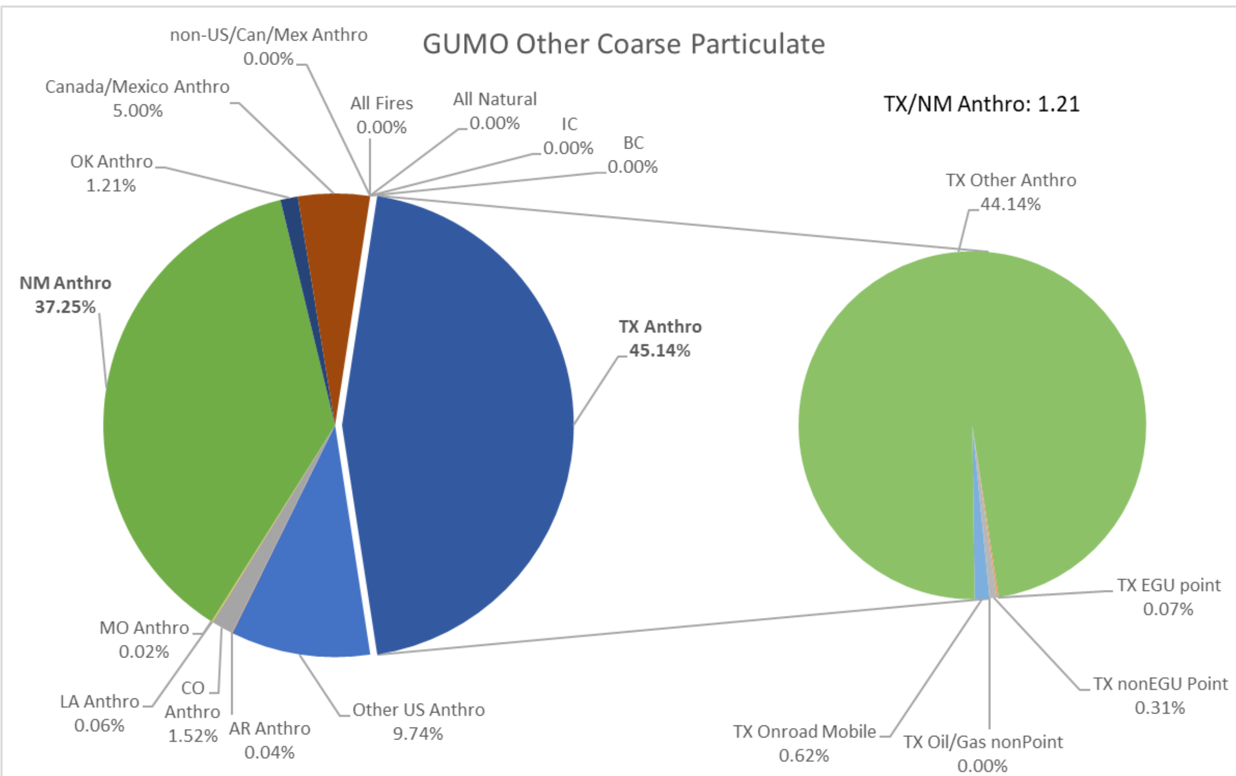

Figure 1-50: PSAT Other Coarse Particulate Source Influence at Guadalupe Mountains and Carlsbad Caverns on the 20% Most Impaired Days

1.2.4.2 Big Bend National Park, Texas

Figure 1-51: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Big Bend* shows the distribution light extinction by PM species at Big Bend. The largest categories are ammonium sulfate, at 62% of the non-Rayleigh extinction, organic aerosol at 16%, coarse mass at 12%, and ammonium nitrate is 3%. For Big Bend and subsequent IMPROVE monitors in Section 1.2.4: PSAT *Particulate Matter Species Results*, the influence of particulate sulfate at 62%, particulate nitrate at 3%, and other PM species of interest will be displayed.

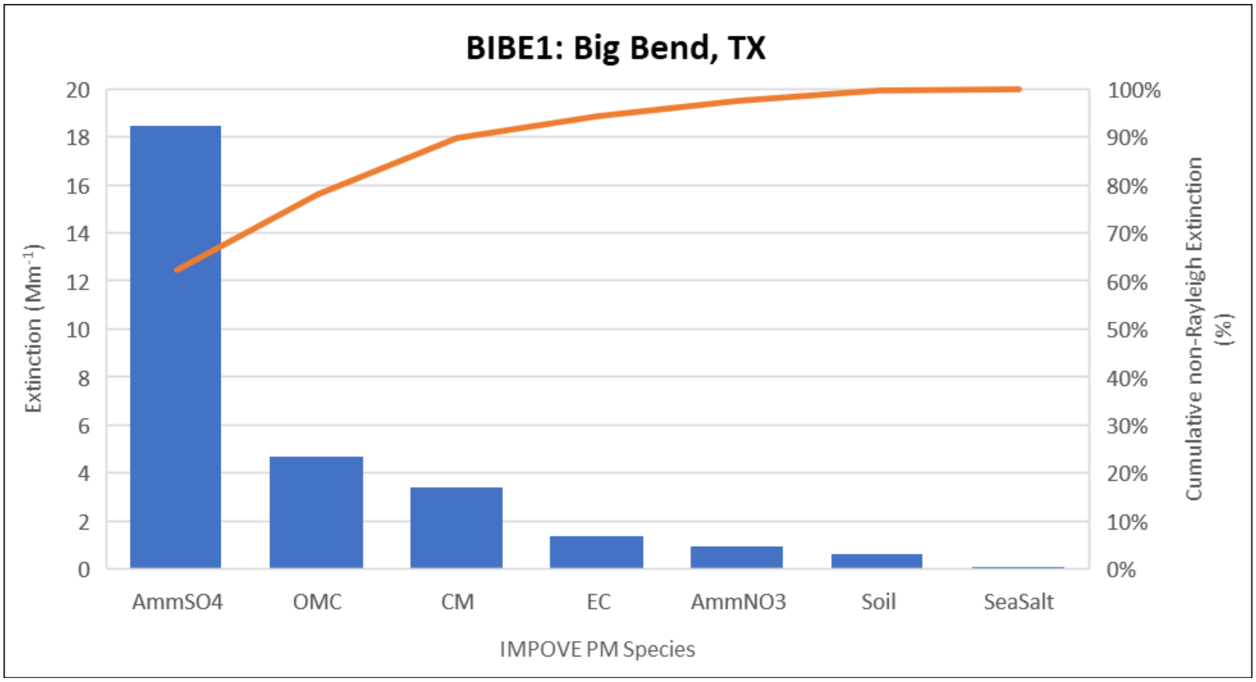

Figure 1-51:Extinction by Ranked PM Species on the 20% Most Impaired Days at Big Bend

The PSAT-derived source influence on particulate sulfate concentrations, and thus ammonium sulfate extinction, at Big Bend are displayed in Figure 1-52: *PSAT Particulate Sulfate Source Influence at Big Bend on the 20% Most Impaired Days*. The largest source group is Canada/Mexico anthropogenic at 73%, Texas is the next largest at 9%, which is one-eighth as much. Within Texas, the EGUs comprise the most at 7%. Emissions from the Carbon I and II coal-fired EGUs in the Mexican portion of the Big Bend SO_2 AOI are likely to be the largest single contributing SO_2 source.

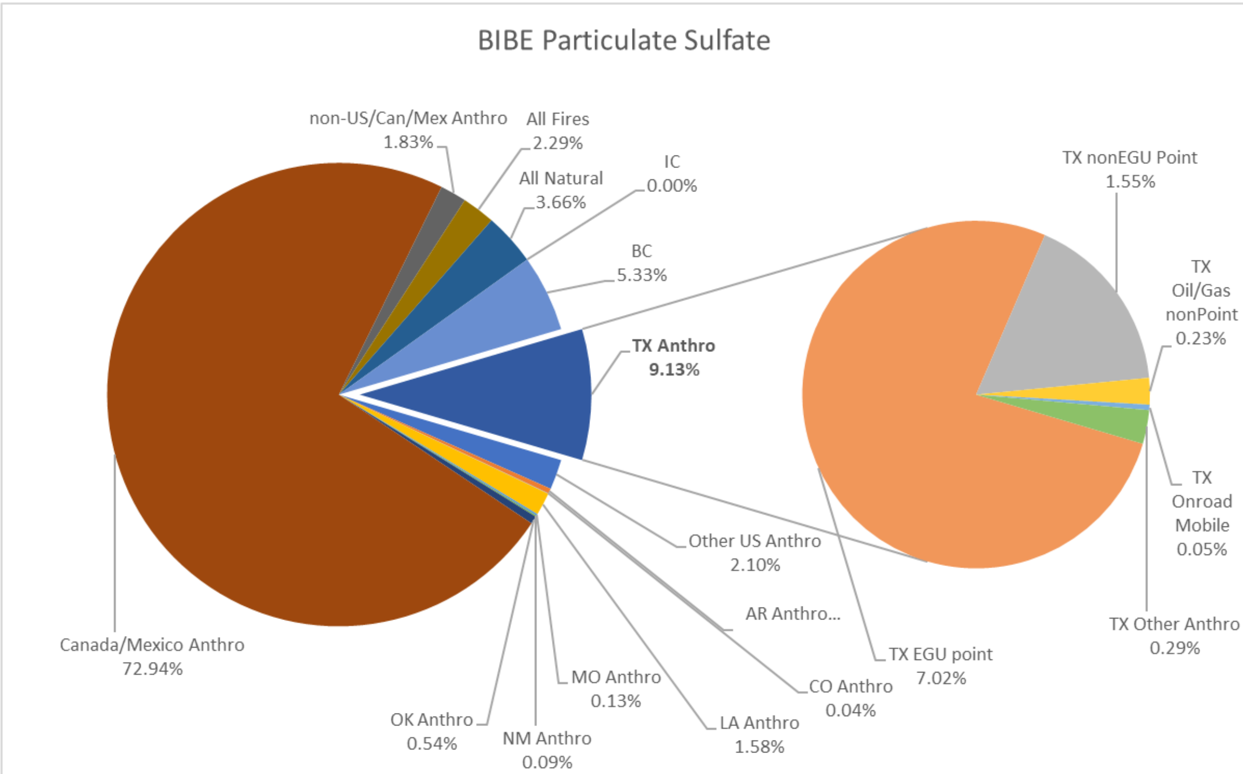

Figure 1-52:**PSAT Particulate Sulfate Source Influence at Big Bend on the 20% Most Impaired Days**

Figure 1-53: *PSAT Particulate Nitrate Source Influence at Big Bend on the 20% Most Impaired Days* shows the relative influence of sources on the particulate nitrate concentrations at Big Bend. Like particulate sulfates, Canada/Mexico anthropogenic emissions are the largest group at 53%, followed by natural sources at 15%. Texas sources comprise 11% and are almost evenly split between EGU, non-EGU point, on-road mobile, oil and gas nonpoint, and other.

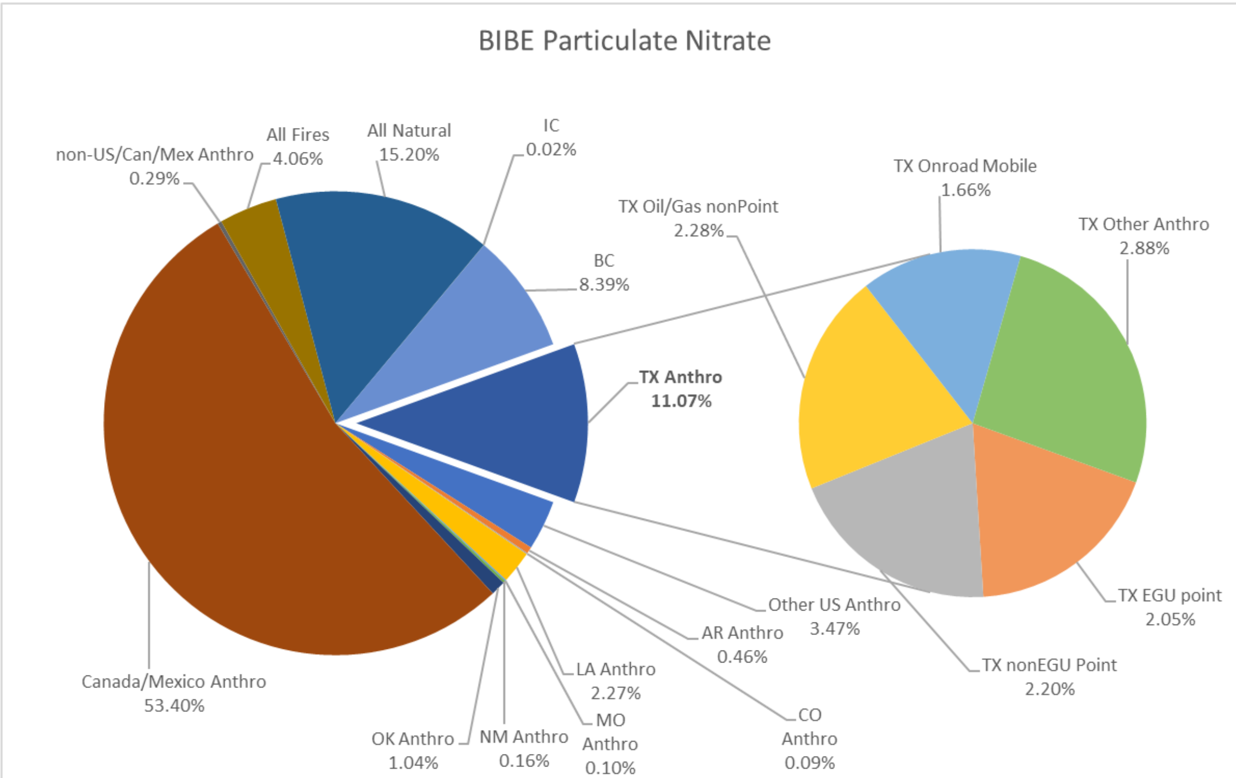

Figure 1-53:PSAT Particulate Nitrate Source Influence at Big Bend on the 20% Most Impaired Days

Figure 1-54: *PSAT Primary Organic Aerosol Source Influence at Big Bend on the 20% Most Impaired Days* shows the impact of fires on primary organic aerosol concentration at Big Bend, with 60% of the total.

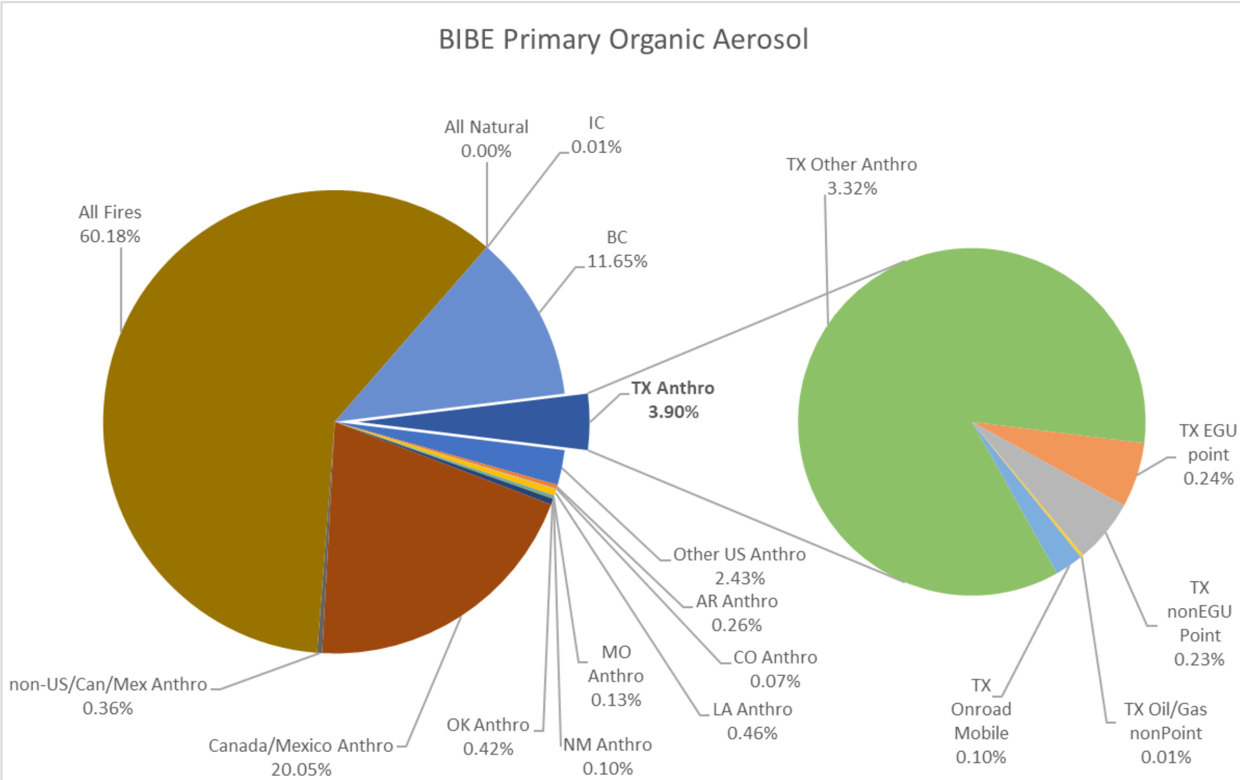

Figure 1-54:PSAT Primary Organic Aerosol Source Influence at Big Bend on the 20% Most Impaired Days

Fires produce 26% of the primary elemental carbon concentration at Big Bend as seen in Figure 1-55: *PSAT Primary Elemental Carbon Source Influence at Big Bend on the 20% Most Impaired Days* while Canada/Mexico anthropogenic contributes 54%, and Texas sources contribute 7%.

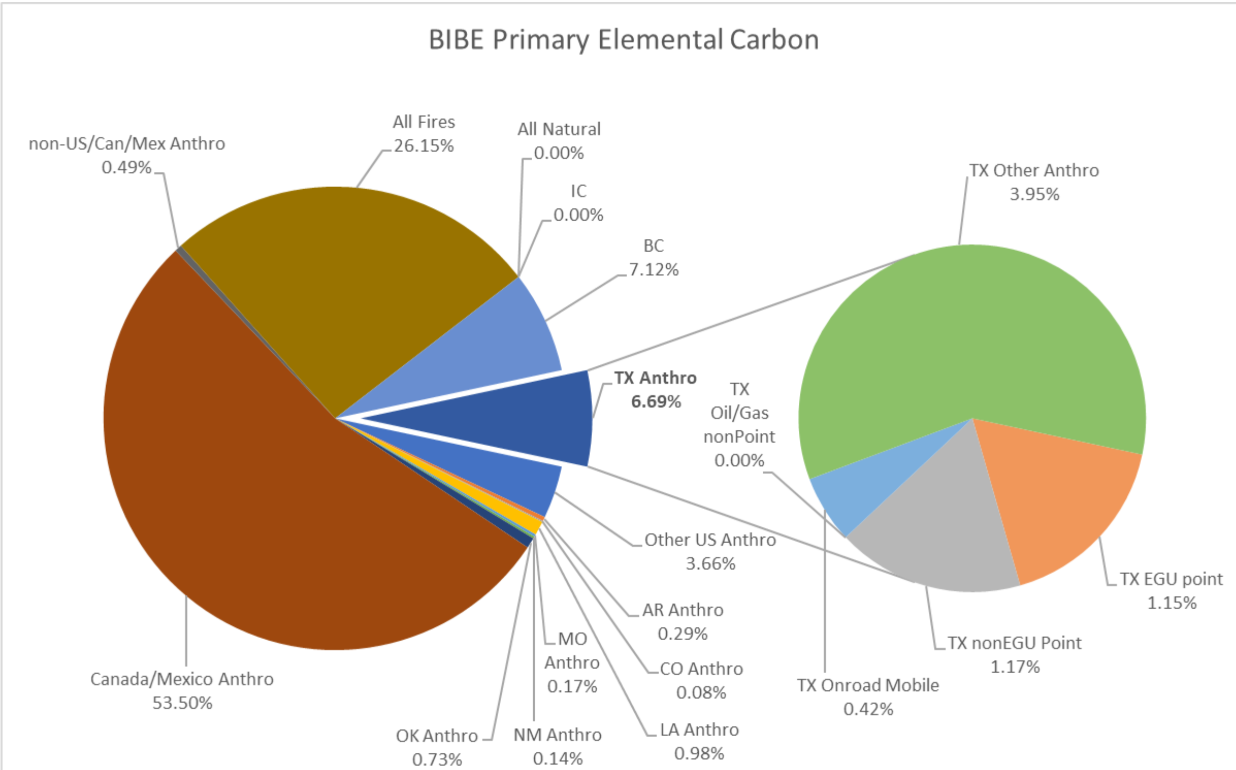

Figure 1-55: PSAT Primary Elemental Carbon Source Influence at Big Bend on the 20% Most Impaired Days

1.2.4.3 Bosque del Apache Wilderness Area

The distribution of light extinction by IMPROVE PM species at Bosque del Apache is seen in Figure 1-56: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Bosque del Apache*. The largest category is ammonium sulfate at 29%, followed by organic aerosols at 23%, with coarse mass and ammonium nitrate at 17%.

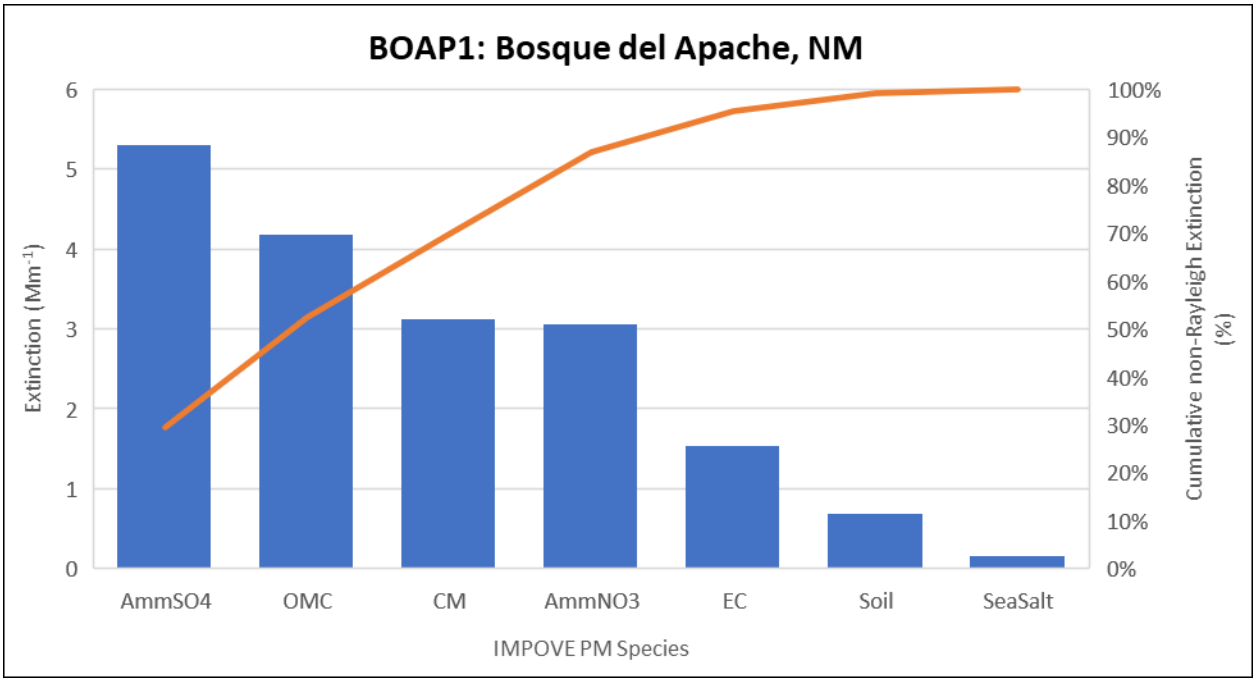

Figure 1-56:**Extinction by Ranked PM Species on the 20% Most Impaired Days at Bosque del Apache**

As seen in Figure 1-57: *Ratio of Texas to New Mexico Source Influence on Particulate Species at Bosque del Apache*, Texas sources have a larger influence than New Mexico sources at Bosque del Apache for particulate sulfate, nitrate, and ammonium. The orange line at 1.0 in this figure and similar ones for Wichita Mountains and Caney Creek indicates equal contributions between Texas and the IMPROVE monitor home state.

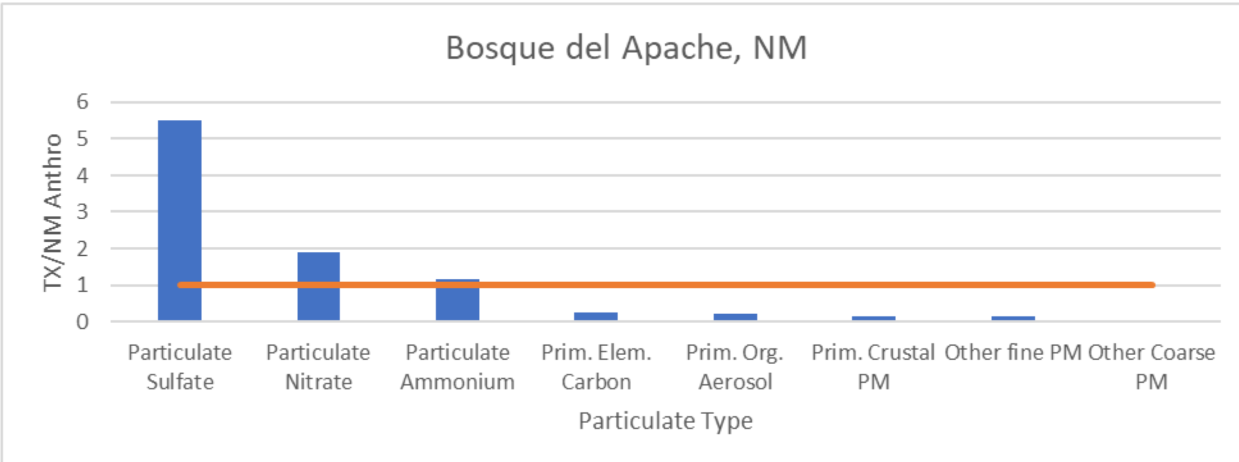

Figure 1-57:**Ratio of Texas to New Mexico Source Influence on Particulate Species at Bosque del Apache**

The PSAT-derived source influence on particulate sulfate at Bosque del Apache is show in Figure 1-58: *PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Bosque del Apache*. The largest source category is Canada/Mexico anthropogenic at 44%, followed by Texas anthropogenic sources at 24%, which is 5.5 times the New Mexico amount. EGUs are the largest Texas source at 14%.

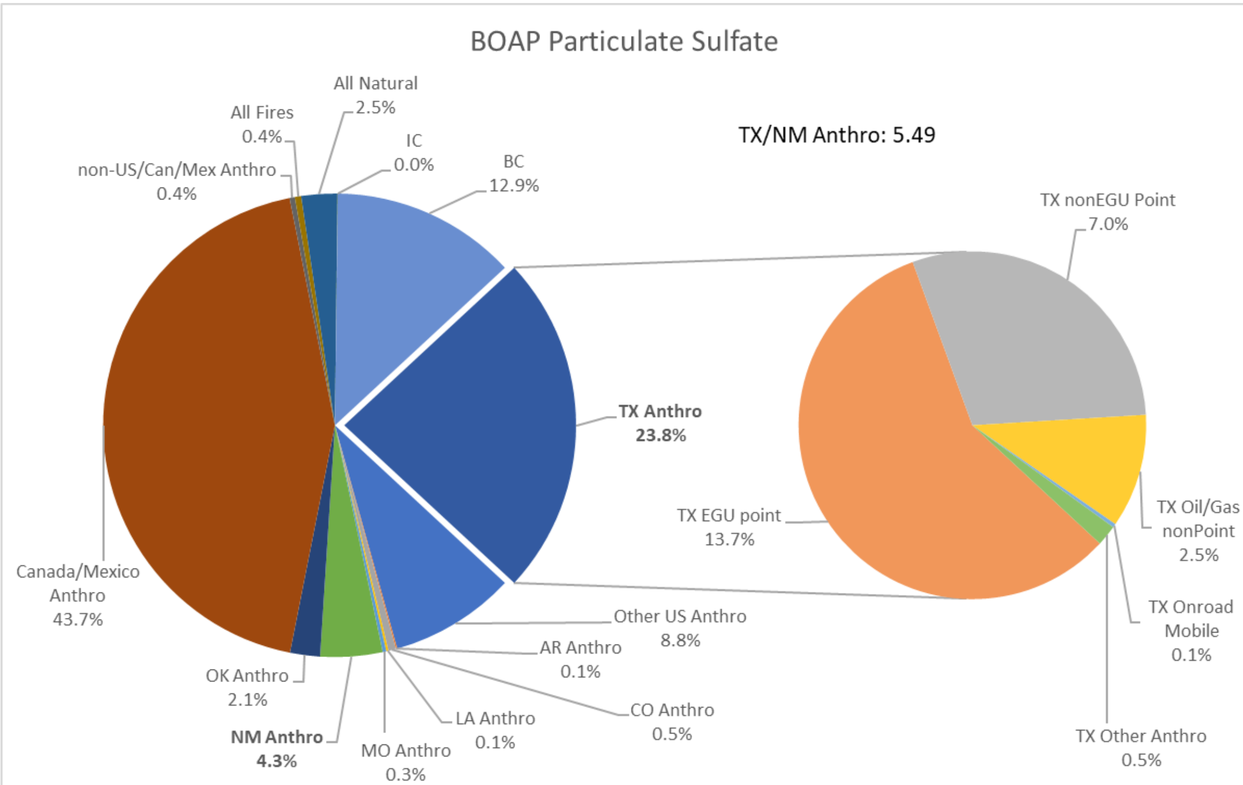

Figure 1-58:PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Bosque del Apache

The sources contributing to particulate nitrate concentrations at Bosque del Apache can be seen in Figure 1-59: *PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Bosque del Apache*. Texas anthropogenic sources are the largest group at 27% and are 1.9 times larger than the New Mexico anthropogenic sources. Within Texas the largest category is oil and gas nonpoint sources at 9%.

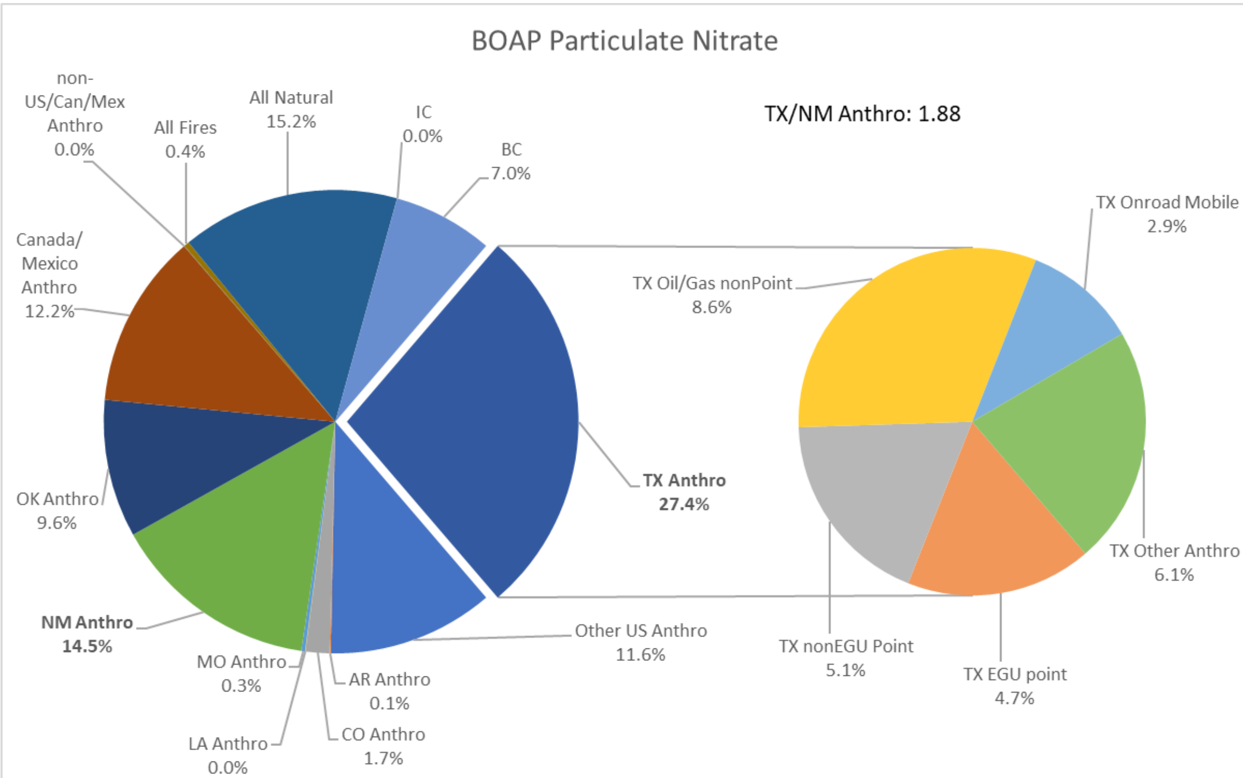

Figure 1-59: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Bosque del Apache

1.2.4.4 Salt Creek Wilderness Area

The observed light extinction at Salt Creek, as depicted in Figure 1-60: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Salt Creek*, is mostly due to ammonium sulfate at 32%, ammonium nitrate at 24%, coarse mass at 21%, and organic aerosols at 14%.

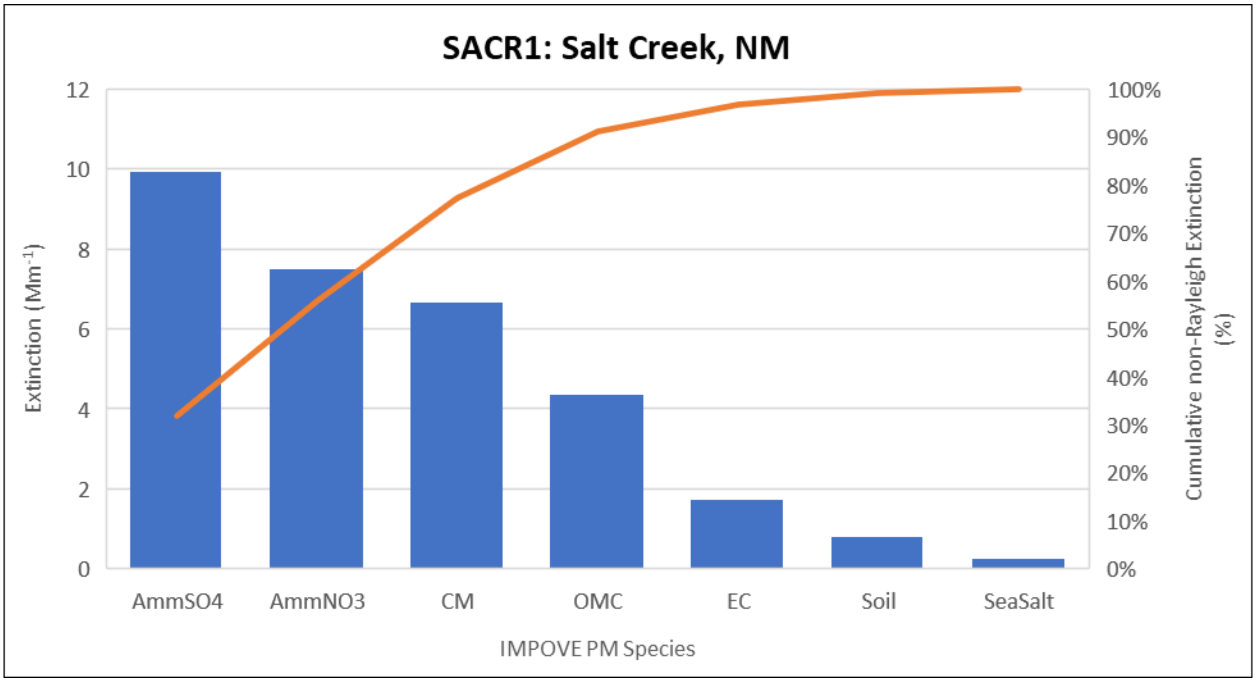

Figure 1-60:**Extinction by Ranked PM Species on the 20% Most Impaired Days at Salt Creek**

When PSAT splits the influence of sources on particulate sulfate at Salt Creek, the results are as shown in Figure 1-61: *PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Salt Creek*. The largest source category is Canada/Mexico anthropogenic sources at 43%, followed by Texas anthropogenic at 24%, which is 2.8 times larger than the New Mexico sources. The most influential Texas sources are EGUs at 13%, followed by non-EGU point sources at 7% and oil and gas nonpoint sources at 4%.

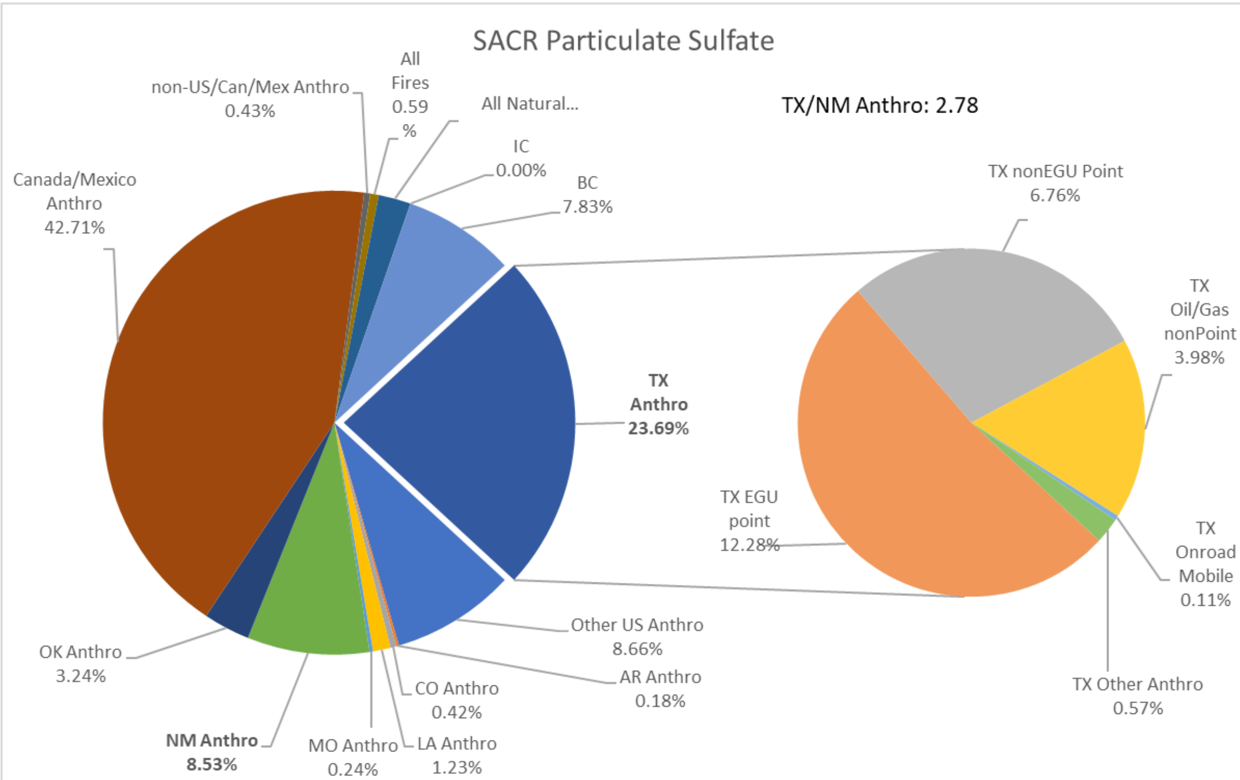

Figure 1-61:PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Salt Creek

PSAT-derived source influence on particulate nitrate at Salt Creek is seen in Figure 1-62: *PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Salt Creek*. The largest source, Texas anthropogenic at 27%, is 1.5 times larger than the next largest source, New Mexico anthropogenic sources. Within these Texas sources, oil and gas nonpoint form the largest group at 12%, followed by Other Anthropogenic, EGU, and non-EGU point sources.

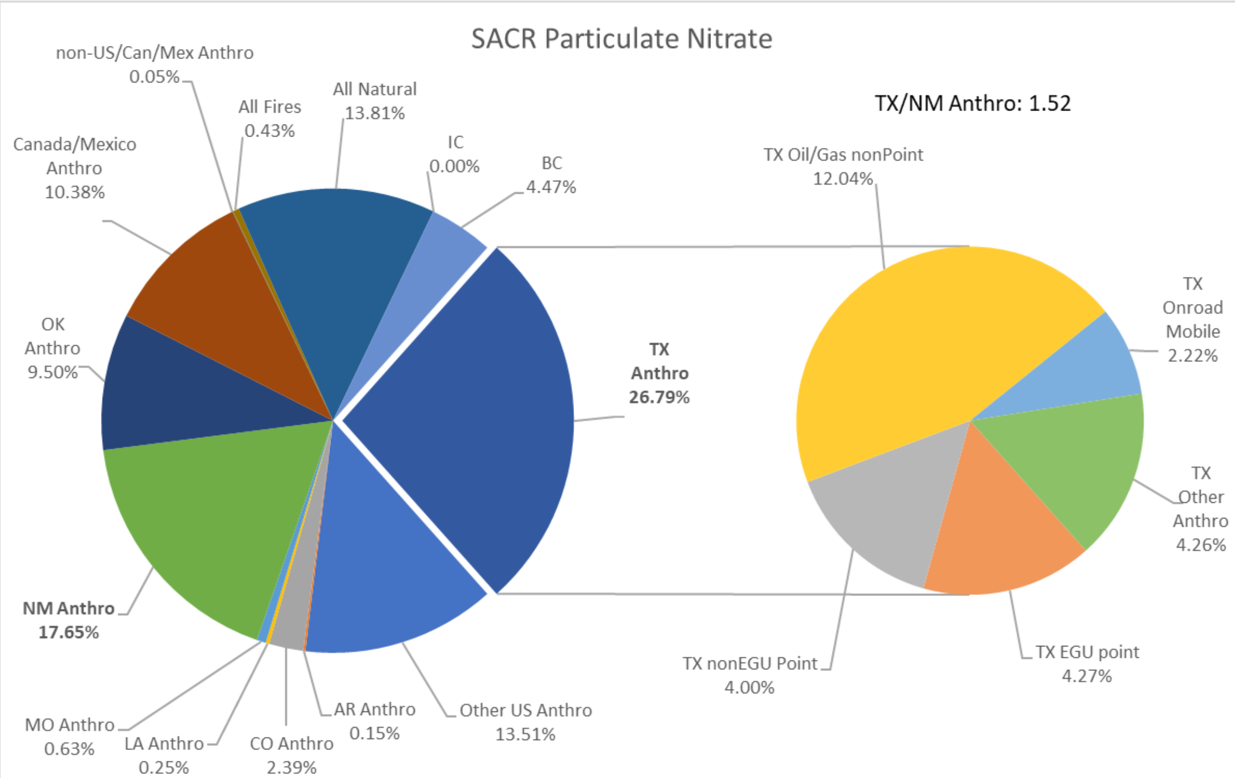

Figure 1-62: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Salt Creek

1.2.4.5 White Mountain Wilderness Area

Observed non-Rayleigh light extinction at White Mountain is due mostly to ammonium sulfate at 42%, coarse mass at 21%, organic aerosols at 17%, and ammonium nitrate at 9%, as seen in Figure 1-63: *Extinction by Ranked PM Species on the 20% Most Impaired Days at White Mountain*.

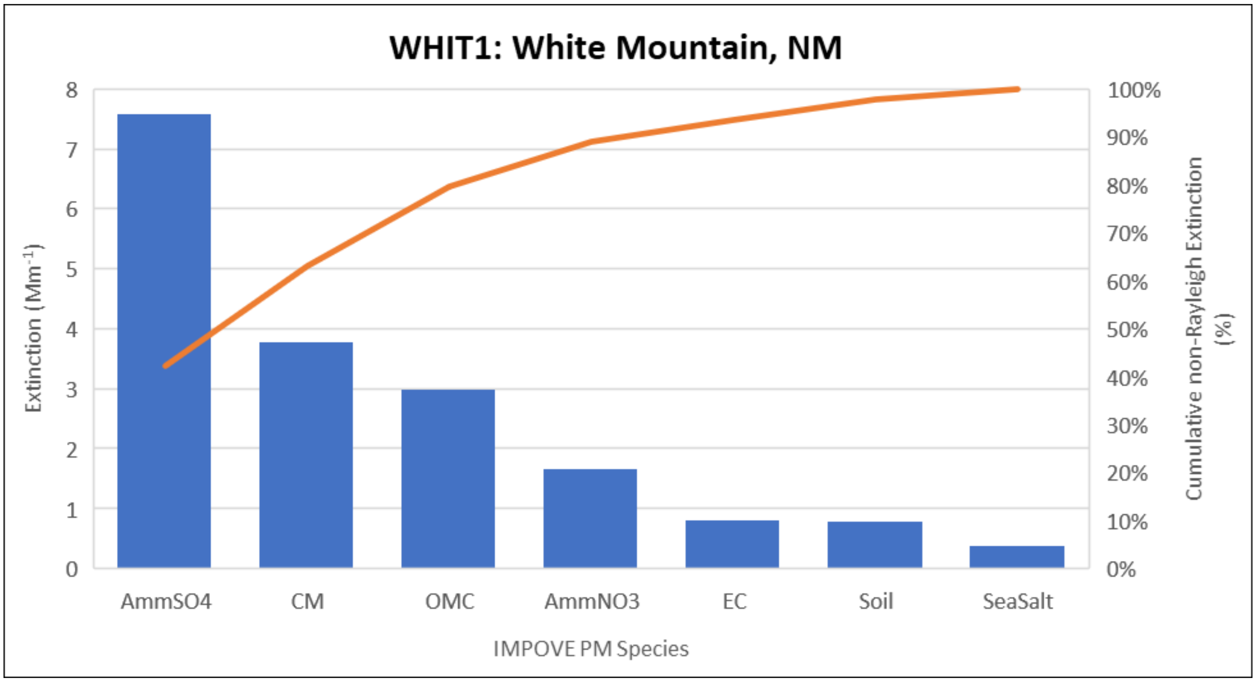

Figure 1-63: Extinction by Ranked PM Species on the 20% Most Impaired Days at White Mountain

The PSAT-derived source influence on particulate sulfate observed at White Mountain can be seen in Figure 1-64: *PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at White Mountain*. The largest source category is Canada/Mexico anthropogenic sources at 61%, followed by boundary conditions, with Texas anthropogenic sources at 12%, which is 4.2 times more than New Mexico sources. The largest Texas source categories are EGUs at 6%, followed by non-EGU point sources at 4% and oil and gas nonpoint sources at 2%.

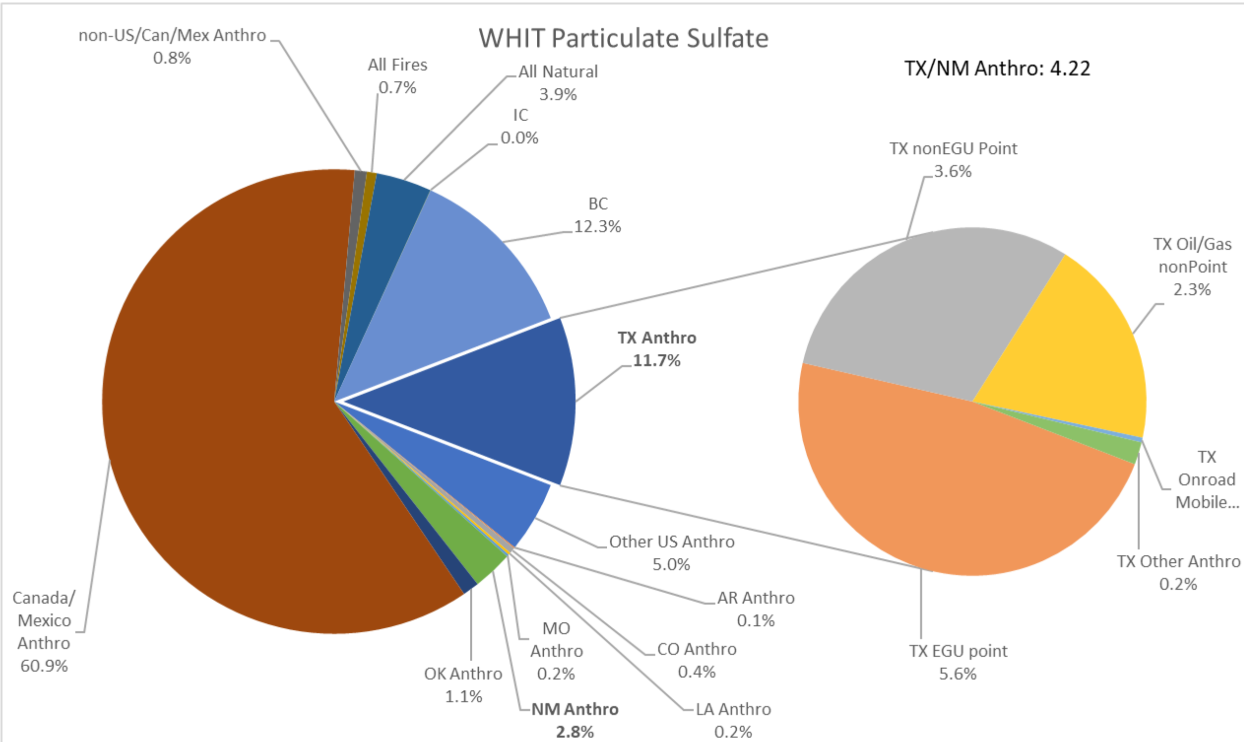

Figure 1-64:**PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at White Mountain**

The relative influence of emission sources on particulate nitrate content at White Mountain is seen in Figure 1-65: *PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at White Mountain*. Texas anthropogenic sources are the largest category at 23%, which is 3.0 times as large as New Mexico sources, and Canada/Mexico sources, natural, and Oklahoma anthropogenic sources are the next largest. Among Texas sources, oil and gas nonpoint sources comprise the largest percentage, followed by non-EGU point sources.

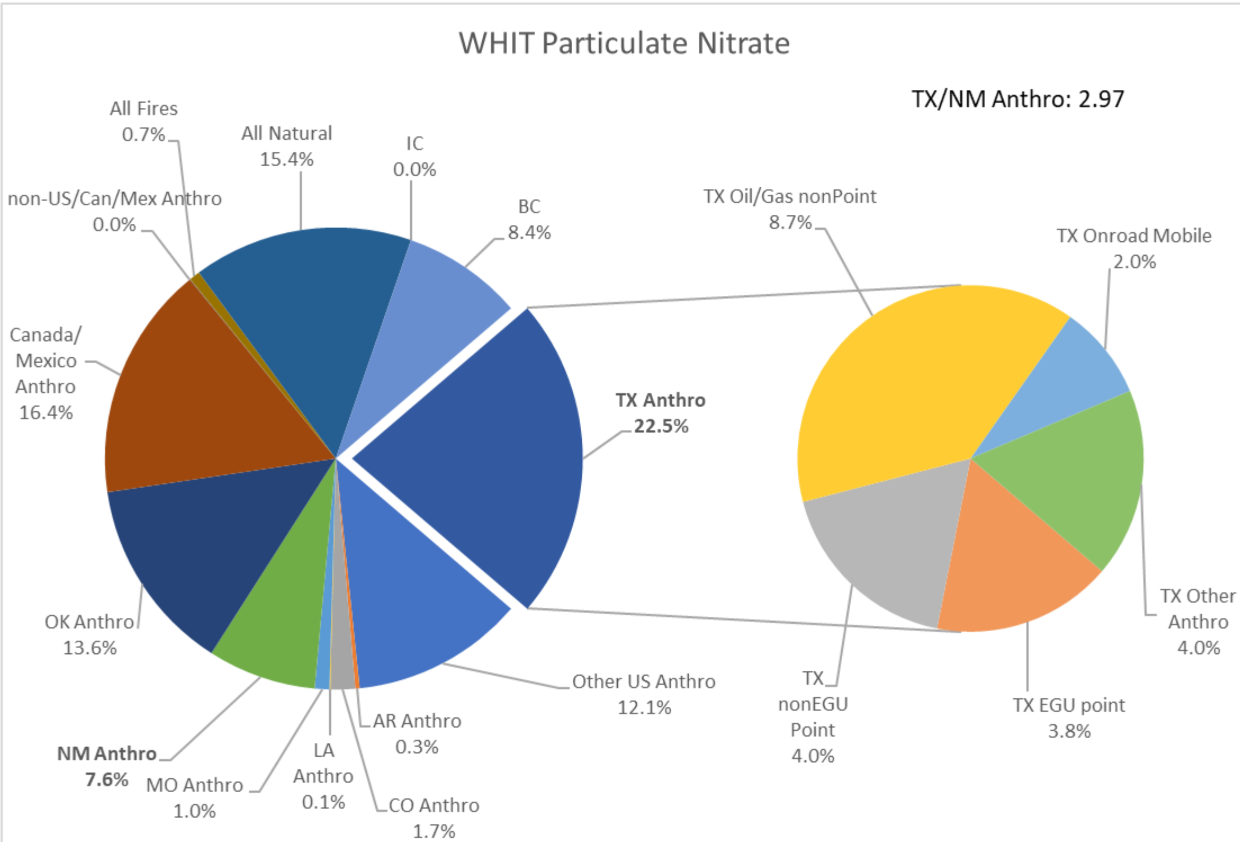

Figure 1-65: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at White Mountain

1.2.4.6 Great Sand Dunes Wilderness Area

The Great Sand Dunes Wilderness Area in Colorado is unique among the 14 Class I areas in and near Texas. As seen in Figure 1-66: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Great Sand Dunes* organic aerosols produce the most non-Rayleigh light extinction at 33%, followed by ammonium sulfate at 29%, coarse mass at 16%, elemental carbon at 13%, with ammonium nitrate at 7% as the fifth largest contributor.

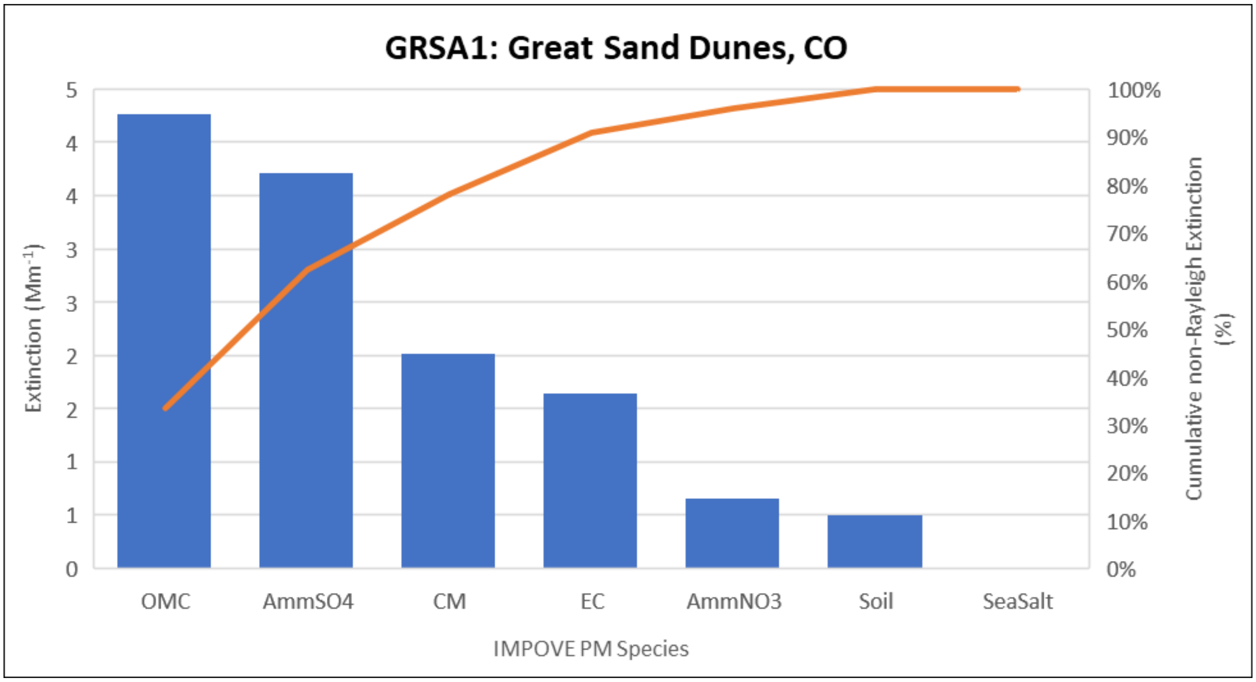

Figure 1-66: Extinction by Ranked PM Species on the 20% Most Impaired Days at Great Sand Dunes

PSAT shows that Canada/Mexico anthropogenic sources are the largest category influencing particulate nitrate at Great Sand Dunes, followed by boundary conditions, other U.S. anthropogenic sources, and Texas anthropogenic sources, which are twice as large as Colorado anthropogenic sources, as seen in Figure 1-67: *PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Great Sand Dunes.* Texas EGU sources are the most influential Texas sources, followed by non-EGU point sources and oil and gas nonpoint sources. The Texas anthropogenic source influence on particulate nitrate is 0.5 times the Colorado anthropogenic influence and will not be shown here.

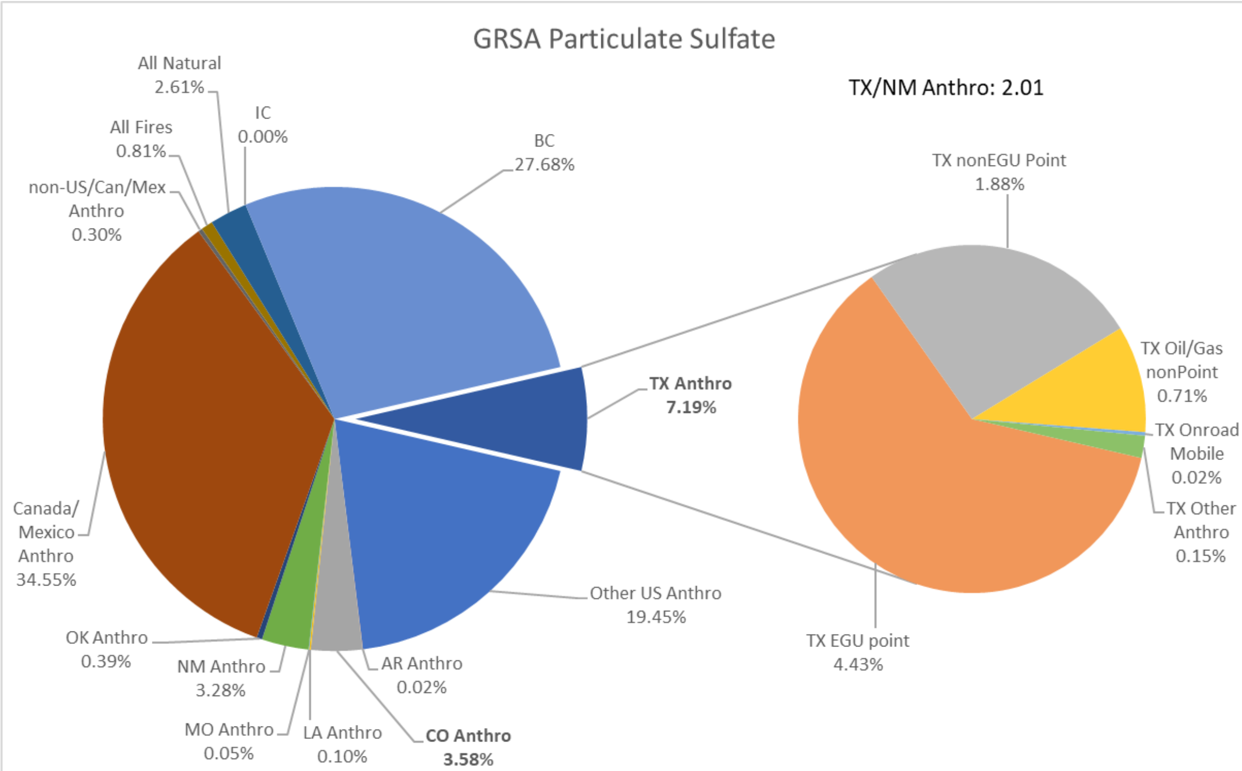

Figure 1-67: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Great Sand Dunes

1.2.4.7 Wichita Mountains Wilderness Area

At Wichita Mountains in Oklahoma, the PM category with the largest influence on extinction is ammonium sulfate at 28%, followed by ammonium nitrate at 28%, and organic aerosols at 16%, as seen in Figure 1-68: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Wichita Mountains.*

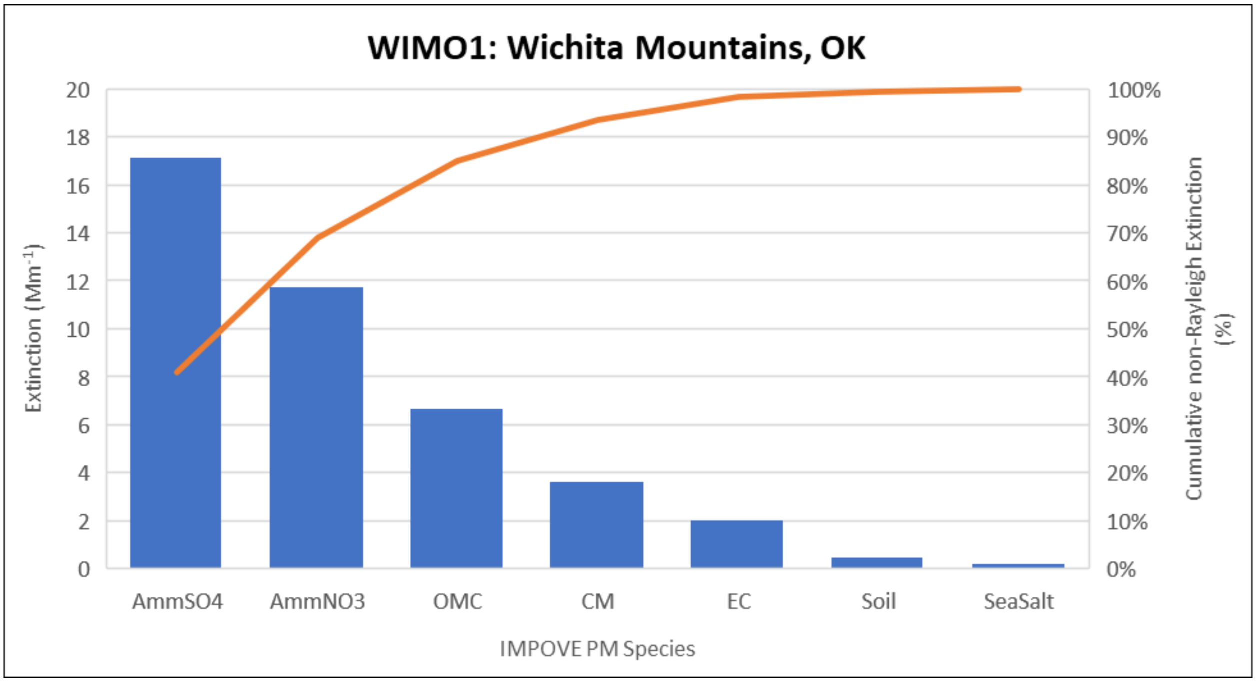

Figure 1-68 **Extinction by Ranked PM Species on the 20% Most Impaired Days at Wichita Mountains**

As seen in Figure 1-69: *Ratio of Texas to Oklahoma Source Influence on Particulate Species at Wichita Mountains*, in addition to particulate sulfate, Texas has a larger influence than Oklahoma on particulate ammonium, primary elemental carbon, primary organic aerosol, and other fine particulate matter at the Wichita Mountains monitor.

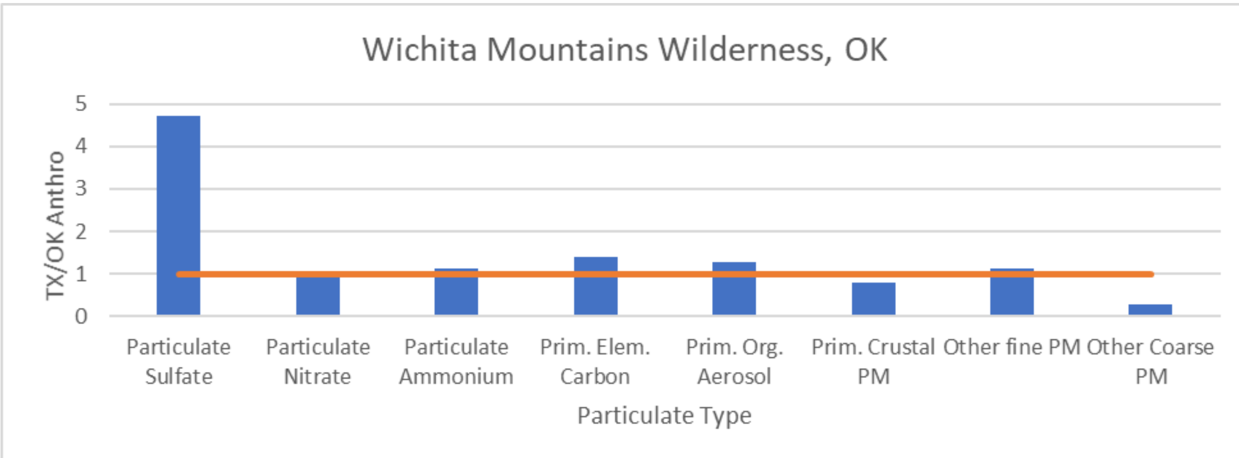

Figure 1-69**:Ratio of Texas to Oklahoma Source Influence on Particulate Species at Wichita Mountains**

The PSAT-derived source category influence on particulate sulfate is shown in Figure 8-25: *PSAT Particulate Sulfate Influence at Wichita Mountains* of the Regional Haze SIP Revision documentation. Within Texas anthropogenic sources, which contributed 31% of the total influence, the most influential source category is EGUs, followed by non-EGU point sources.

As seen in Figure 8-26: *PSAT Particulate Nitrate Influence at Wichita Mountains* of the Regional Haze SIP Revision documentation, the Texas sources with the largest influence on particulate nitrate were non-EGU point sources.

1.2.4.8 Hercules-Glades Wilderness Area

The PM species with the largest observed influence on light extinction were ammonium sulfate at 45%, followed by ammonium nitrate at 30% and organic aerosol at 14%, as seen in Figure 1-70: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Hercules-Glades.*

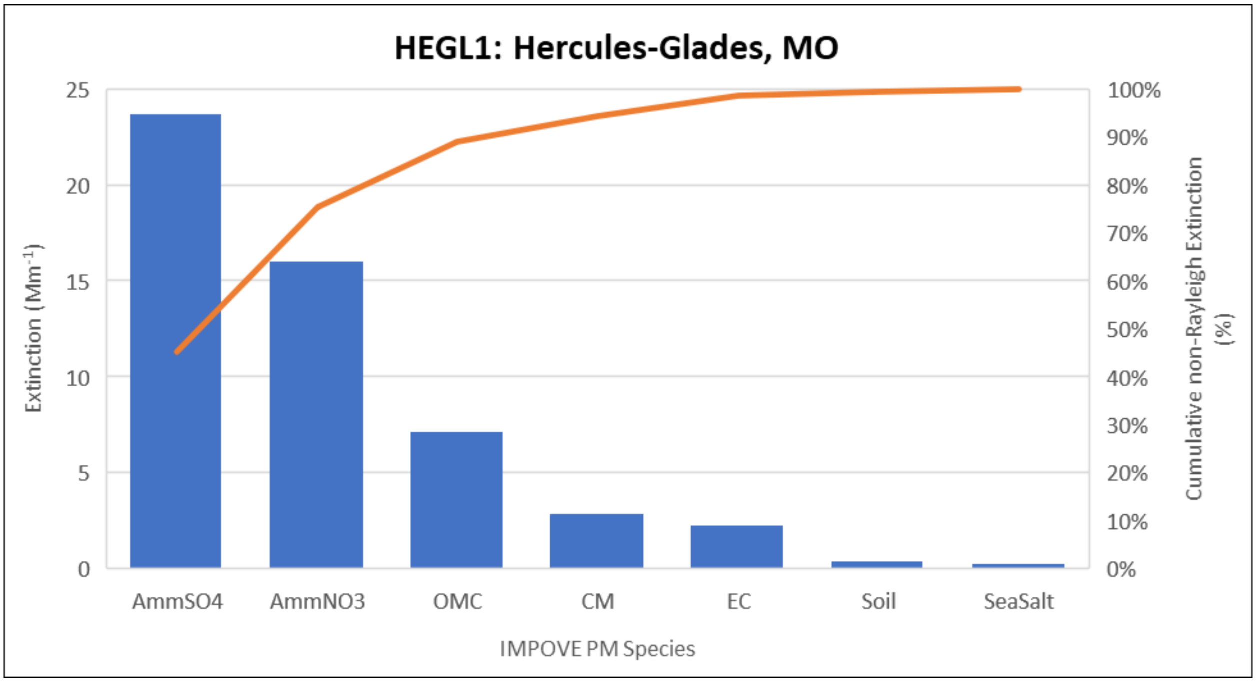

Figure 1-70:Extinction by Ranked PM Species on the 20% Most Impaired Days at Hercules-Glades

A PSAT analysis of particulate sulfate extinction at Hercules-Glades shows that the largest source category is Other U.S. anthropogenic sources, followed by Canada/Mexico anthropogenic, and Texas anthropogenic sources at 17%, which are 1.8 times more influential than Missouri anthropogenic sources, as seen in Figure 1-71: *PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Hercules-Glades*. Within Texas the most influential source category is EGUs, followed by non-EGU point sources. The chart of PSAT-derived source influence on particulate nitrate concentrations at this monitor were not shown because the Texas source influence was 0.5 times the Missouri source influence.

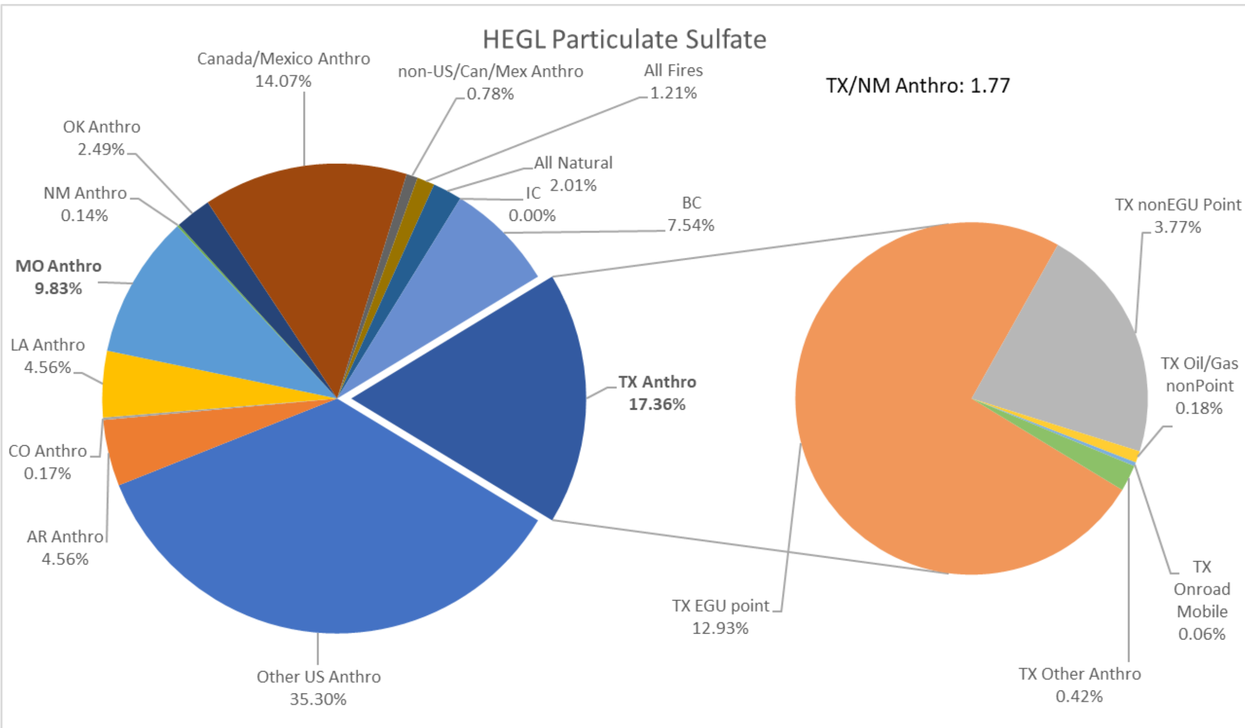

Figure 1-71: PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Hercules-Glades

1.2.4.9 Caney Creek Wilderness Area

The PM species with the most influence on the Caney Creek Wilderness Area are ammonium sulfate at 54%, followed by ammonium nitrate at 20%, and organic aerosol at 14%, as seen in Figure 1-72: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Caney Creek*.

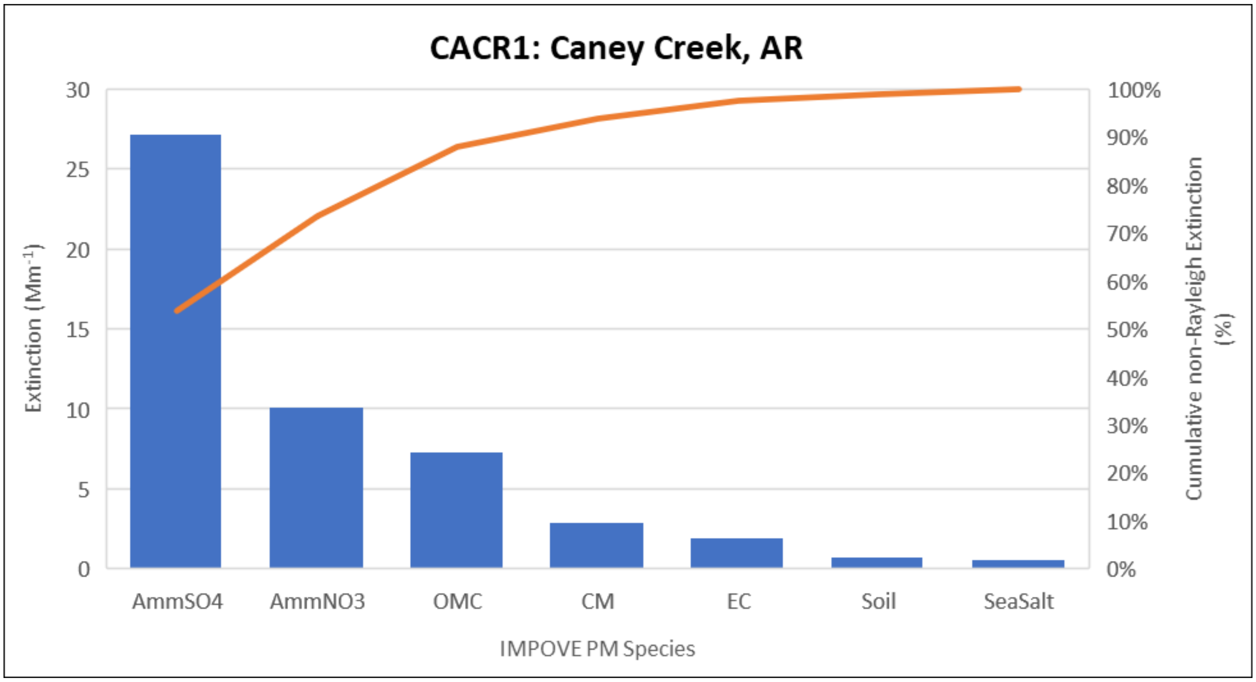

Figure 1-72: Extinction by Ranked PM Species on the 20% Most Impaired Days at Caney Creek

As seen in Figure 1-73: *Ratio of Texas to Arkansas Source Influence on Particulate Species at Caney Creek*, in addition to particulate sulfate and nitrate, Texas has a greater influence than Arkansas on primary elemental carbon and other fine particulate matter observed at Caney Creek.

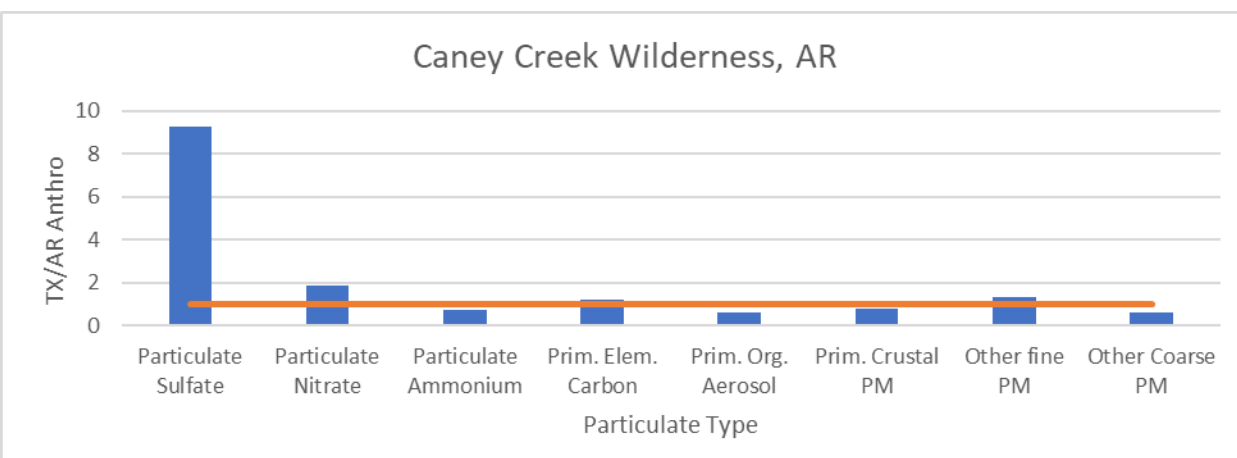

Figure 1-73: Ratio of Texas to Arkansas Source Influence on Particulate Species at Caney Creek

The emission sources with the most influence on particulate sulfate at Caney Creek are seen in Figure 1-74: *PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Caney Creek*. Texas anthropogenic sources comprise 41% of the influence, which is 9.3 times as much as Arkansas anthropogenic sources, and more than twice as large as the next-largest category; Other U.S. anthropogenic sources. The Texas sources are predominantly EGUs with 32% followed by non-EGU point sources.

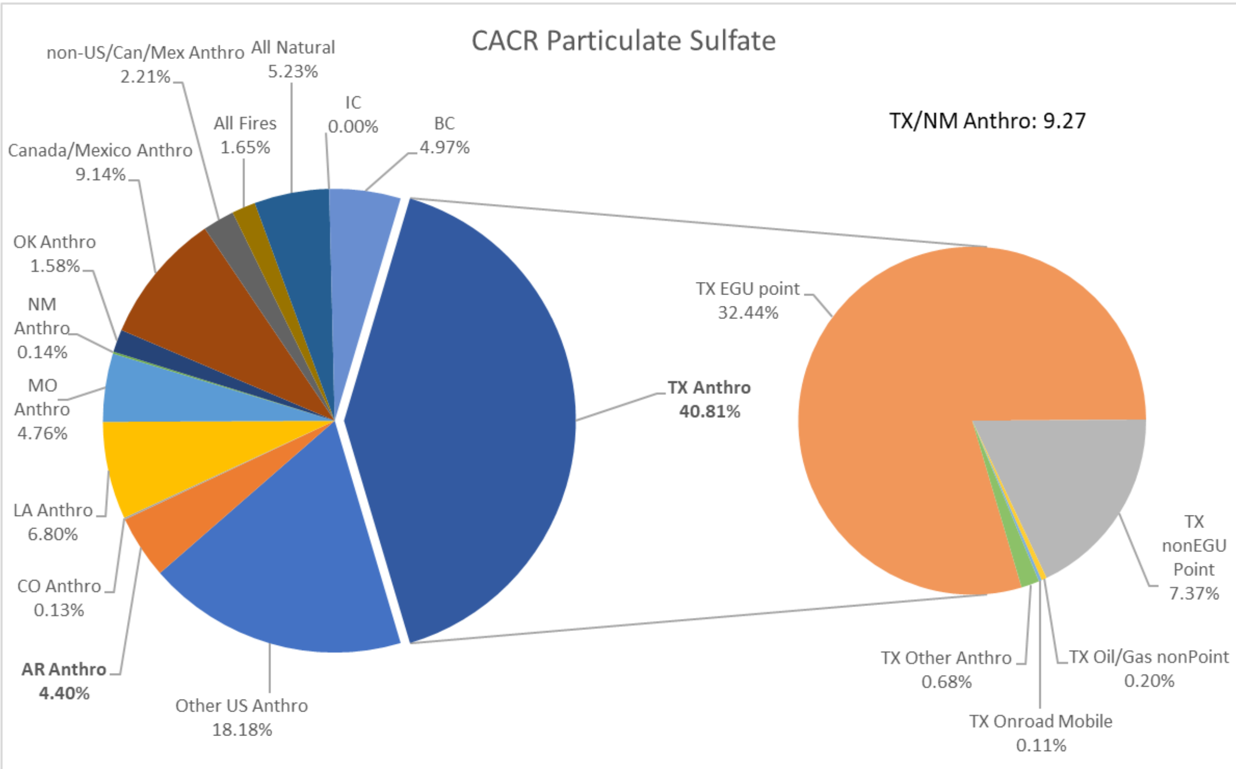

Figure 1-74:PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Caney Creek

The sources influencing particulate nitrate at Caney Creek can be seen in Figure 1-75: *PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Caney Creek*. Other U.S. anthropogenic sources are the most influential at 39%, followed by Texas anthropogenic sources at 14%, which is 1.9 times larger than the Arkansas anthropogenic sources. Among the Texas sources, non-EGU point sources are the most influential, followed by oil and gas nonpoint and EGUs.

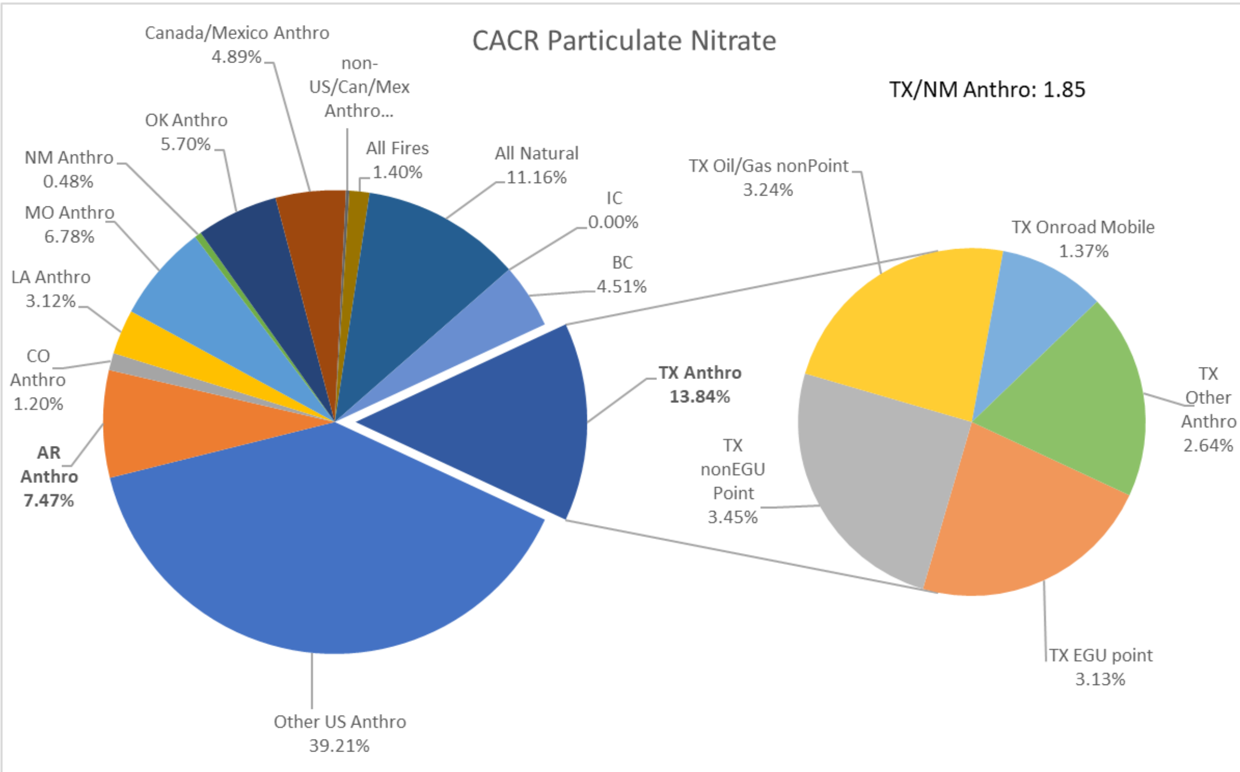

Figure 1-75: PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Caney Creek

1.2.4.10 Upper Buffalo Wilderness Area

The other Class I area in Arkansas, Upper Buffalo Wilderness Area, shows a similar PM light extinction influence with ammonium sulfate at 48%, ammonium nitrate at 25% and organic aerosol at 15% as the most influential, as seen in Figure 1-76: *Extinction by Ranked PM Species on the 20% Most Impaired Days at Upper Buffalo*.

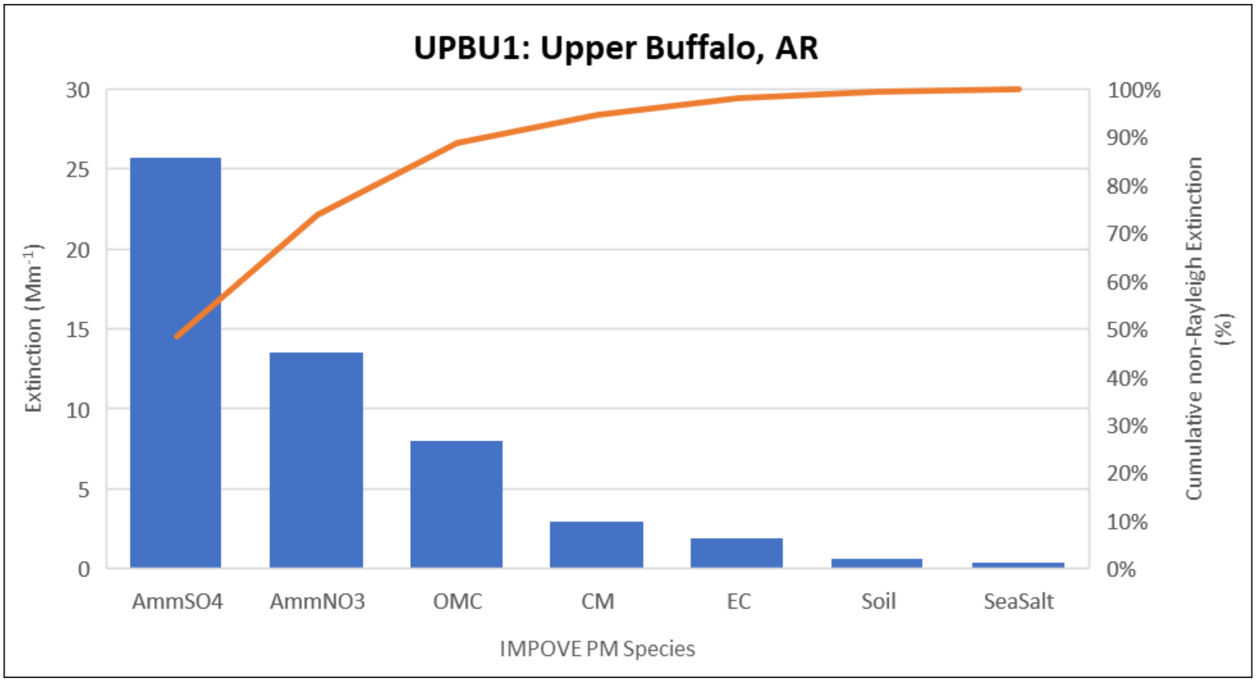

Figure 1-76:Extinction by Ranked PM Species on the 20% Most Impaired Days at Upper Buffalo

An evaluation of source influence on particulate sulfate at Upper Buffalo, as seen in Figure 1-77: *PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Upper Buffalo*, shows that Other U.S. anthropogenic sources are the most influential at 28%, followed by Texas anthropogenic sources at 25%, which is 5.7 times as influential as Arkansas anthropogenic sources. Among the Texas sources, EGUs dominate at 19%, followed by non-EGU sources at 5%.

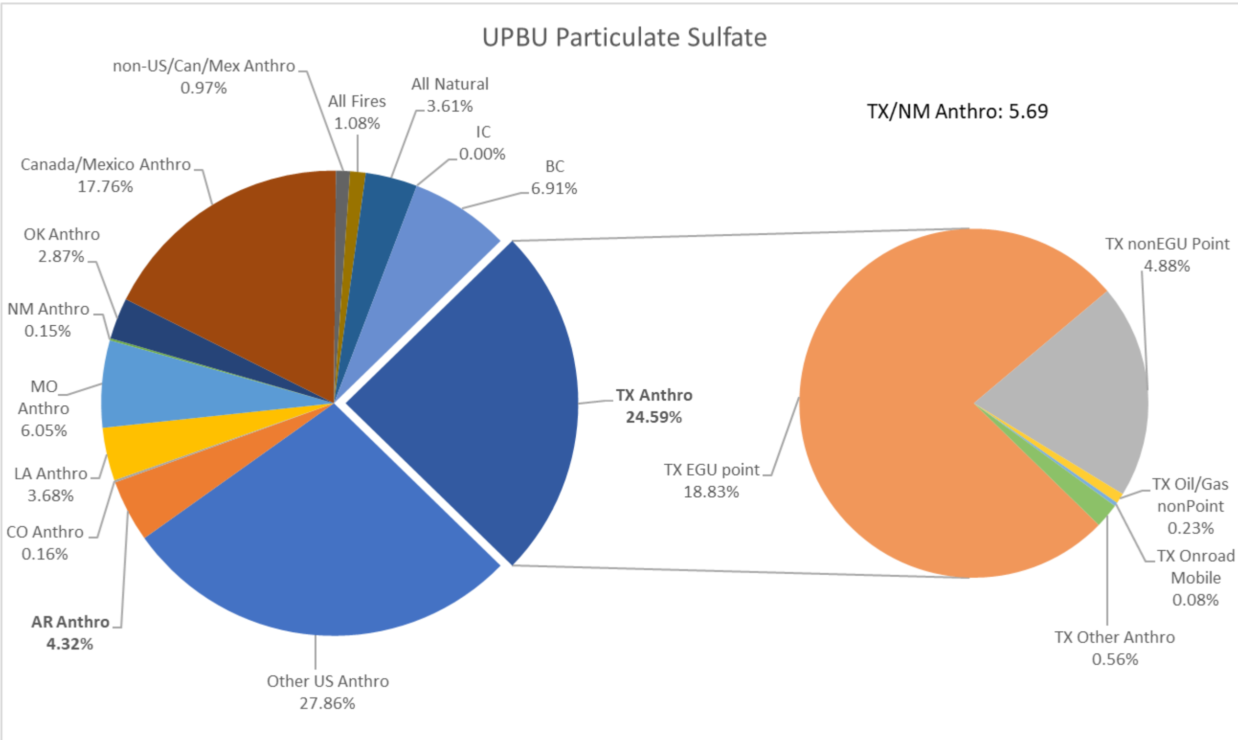

Figure 1-77:PSAT Particulate Sulfate Source Influence on the 20% Most Impaired Days at Upper Buffalo

The PSAT-derived source influence on particulate nitrate at the Upper Buffalo monitor is seen in Figure 1-78: *PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Upper Buffalo.* Like particulate sulfate, Other U.S. anthropogenic sources are the largest category, followed by Texas anthropogenic sources at 12%, which is 3.0 times larger than the Arkansas anthropogenic sources. Other anthropogenic sources are the largest Texas category, followed by non-EGU point sources.

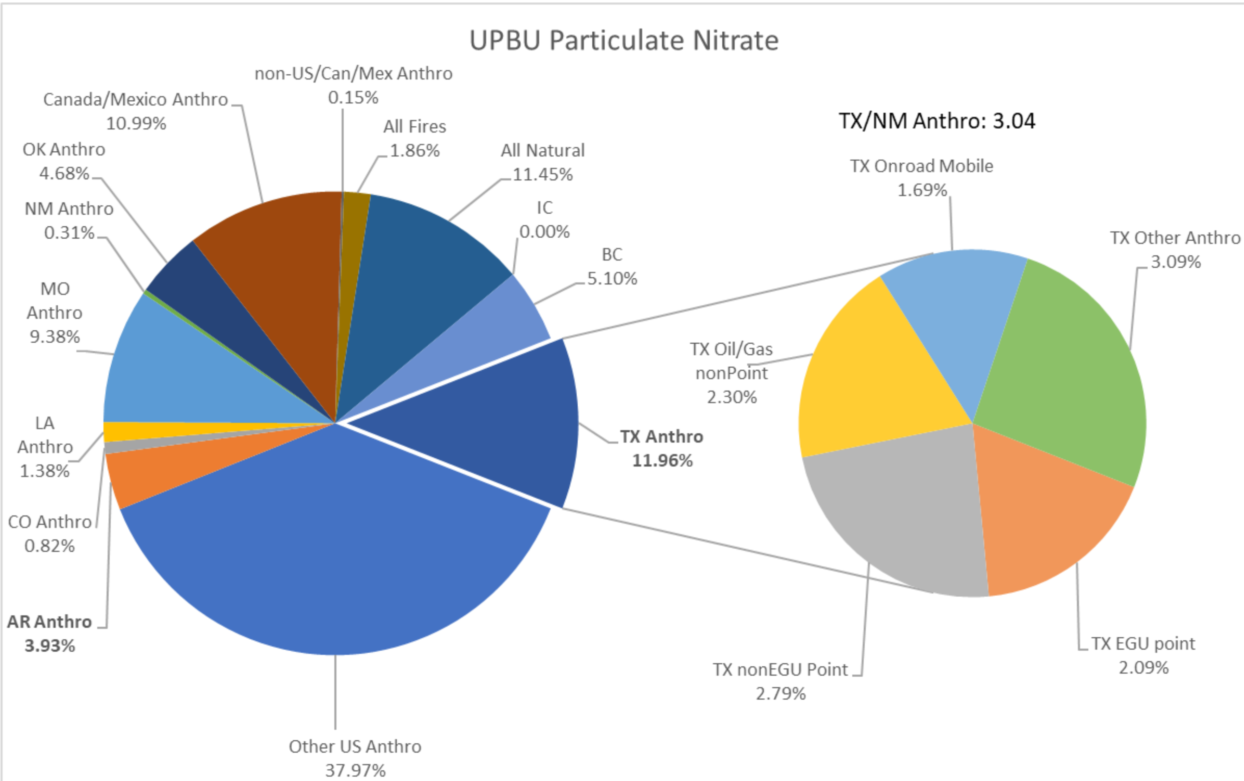

Figure 1-78:PSAT Particulate Nitrate Source Influence on the 20% Most Impaired Days at Upper Buffalo

1.3 SENSITIVITY RUN ANALYSIS

1.3.1 Emission Changes

As part of the Regional Haze SIP Revision, three sensitivity analysis scenarios were conducted to estimate the impact of potential NO_X and SO_2 reductions in Texas on visibility at Class I areas in 2028. The sensitivities were conducted by reducing NO_X and/or SO_2 emissions at specific EGU and non-EGU point sources. The non-EGU sources include cement manufacturing, flat glass manufacturing, natural gas compression station, paper mill, and packaging materials sites. More information about the source selection can be found in Section 7.2.2.2: *Four Factor Analysis Process* of the Regional Haze SIP Revision documentation. The three scenarios were organized as follows:

- Scenario 1: Removal of the Oklaunion Power Station as its owners have announced its retirement in 2020 (ERCOT, 2020). This scenario will be labeled ZeroOKU.
- Scenario 2: In addition to Scenario 1, SO_2 reductions at specific sources in several of the sites described above. This scenario will be labeled ZeroOKU&SO2.
- Scenario 3: In addition to Scenario 2, NO_x reductions at specific sources several of the sites described above. This scenario will be labeled ZeroOKU&SO2&NOX.

In this section, the sensitivity runs will be compared against each other and the 2028 future case run without additional controls (2028NoControls).

1.3.2 Visibility Impairment Changes

Visibility impairment changes due to the three scenarios were shown in Table 8-46: *Sensitivity Run 2028 Visibility Impairment on 20% Most Impaired Days and Adjusted Glidepath* of the Regional Haze SIP Revision documentation.

As seen in Figure 1-79: *Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU and 2028NoControls Cases*, there are substantial differences in the change in extinction due to ammonium sulfate and ammonium nitrate at the GUMO1, BOAP1, SACR1, and WHIT1 monitors serving Class I areas in southern New Mexico. All monitors except WHIT1 show greater extinction reduction from ammonium sulfate extinction than ammonium nitrate. The GUMO1 and BOAP1 monitors show an increase in extinction due to ammonium nitrate in response to NO_x and SO_2 decreases at the Oklaunion Power Station. The emission reductions are outside the NO_x and SO_2 AOIs for these monitors. See Section 7.2.1: *Area of Influence and Q/d Analysis for Source Selection* of the Regional Haze SIP Revision documentation for AOI details. This indicates that NO_x and SO_2 reductions do not have uniform effects with greater distance, potentially due to interactions with ammonium.

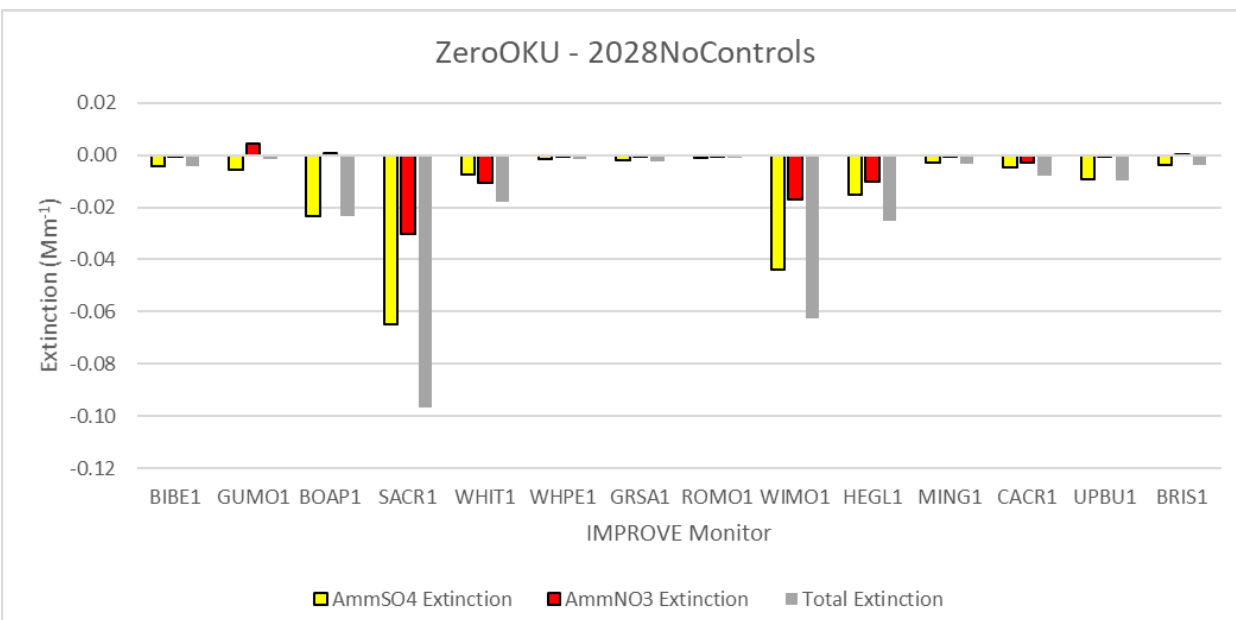

Figure 1-79: Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU and 2028NoControls Cases

The effects of additional SO_2 controls in the ZeroOKU&SO2 scenario beyond the ZeroOKU scenario are seen in Figure 1-80: *Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU&SO2 and ZeroOKU Scenarios*. Ammonium sulfate extinction reductions are seen at downwind monitors where they are expected by the AOI analysis (See Section 7.2.1 of the Regional Haze SIP documentation). Increases in extinction due to ammonium nitrate are also seen at all the monitors evaluated. This is an additional indication of a tradeoff between ammonium sulfate and ammonium nitrate extinction potentially due to the need for both NO_X and SO_2 to bind with limited ammonium. Since there is a greater chemical affinity between SO_2 and ammonium, when available SO_2 is reduced beyond the molar availability of ammonium, the unbound ammonium can bind with more unbound NO_x to produce ammonium nitrate and create more light extinction due to ammonium nitrate.

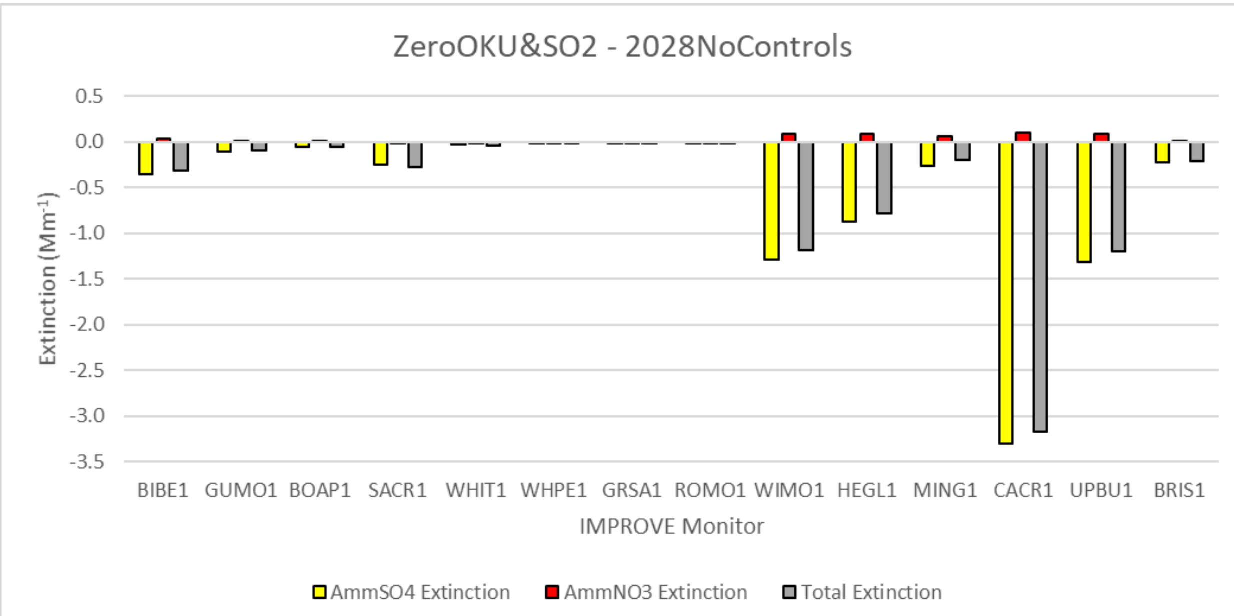

Figure 1-80:Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU&SO2 and ZeroOKU Scenarios

The effects of additional NO_x controls in the ZeroOKU&SO2&NOx scenario beyond the ZeroOKU&SO2 scenario are seen in Figure 1-81: *Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU&SO2&NOx and ZeroOKU&SO2 Scenarios*. Reductions in light extinction due to ammonium nitrate are seen at all monitors except GUMO1, as anticipated by additional NO_x controls. Increases in light extinction due to ammonium sulfate are seen at 10 of the 14 monitors, potentially due to the chemical competition for available ammonium. The small increase in total light extinction and light extinction due to ammonium nitrate at the GUMO1 monitor requires additional investigation because four of the sources with additional NO_x emission reductions are in the GUMO NO_x AOI. The GUMO1 monitor exhibited the lowest conversion percentage, 67%, of particulate sulfate and nitrate to ammonium sulfate and ammonium nitrate, as seen in Table 8-38: *Conversion of Particulate Sulfate and Nitrate to Ammonium Sulfate and Nitrate* in the Regional Haze SIP Revision documentation, indicating a shortage of ammonium.

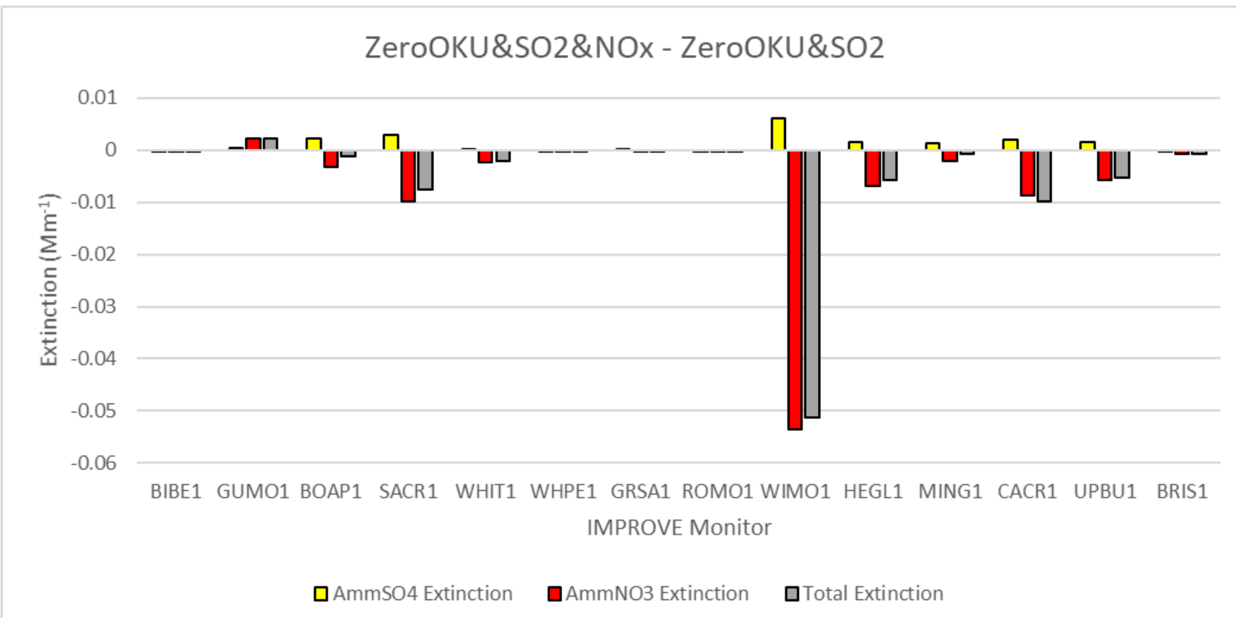

Figure 1-81:Light Extinction changes in Ammonium Sulfate, Ammonium Nitrate, and Total Extinction between the ZeroOKU&SO2&NOx and ZeroOKU&SO2 Scenarios

REFERENCES

ERCOT, 2020. "W-A012120-02 Reliability analysis determination for Public Service Company of Oklahoma - Oklaunion (OKLA_OKLA_G1)," http://www.ercot.com/services/comm/mkt_notices/archives/4428, February, 2020.

Ramboll, 2020. "Regional Haze Modeling to Evaluate Progress in Improving Visibility in and near Texas," https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/pm/5822010567009-20200625-ramboll-RegionalHazeModelingEvaluateProgressVisibility.pdf, Ramboll US Corporation, June, 2020.