CORRESPONDENCE/MEMORANDUM

State of Wisconsin

DATE: May 1, 2025 FILE REF: 4862

TO: File

FROM: Brianna Denk, Air Quality Planning and Standards Section Chief

SUBJECT: Implementation of the contingent response plans for the Shoreline Sheboygan County and Kenosha County, Wisconsin 2008 ozone NAAQS maintenance areas and the Door County, Door County-Revised, and Manitowoc County, Wisconsin, 2015 ozone NAAQS maintenance areas

This memo describes the actions taken by the Wisconsin Department of Natural Resources (DNR) Air Management Program in response to exceedances of the 2008 ozone National Ambient Air Quality Standard (NAAQS) in the Shoreline Sheboygan County and Kenosha County maintenance areas and of the 2015 ozone NAAQS in three maintenance areas for that NAAQS: Door County, Door County-Revised, and Manitowoc County.

Background

2008 ozone NAAQS

In May 2012, the U.S. Environmental Protection Agency (EPA) designated the entirety of Sheboygan County as nonattainment for the 2008 ozone NAAQS of 75 parts per billion (ppb), effective July 20, 2012 (77 FR 30088). In a separate action, in June 2012 EPA designated all or part of eleven counties in the Chicago-Naperville, IL-IN-WI area, including part of Kenosha County, Wisconsin, as nonattainment for the 2008 ozone NAAQS (77 FR 34221).

In July 2019, the EPA revised the Sheboygan County 2008 ozone NAAQS nonattainment area to create two distinct areas: the Inland Sheboygan County and Shoreline Sheboygan County nonattainment areas (84 FR 33699). The two nonattainment areas together constituted the geographic area of the original Sheboygan County nonattainment area for this NAAQS.

In February 2020, the DNR requested that the EPA redesignate the Shoreline Sheboygan County area to attainment of the 2008 ozone NAAQS, based on 2017-2019 monitoring data indicating the area had attained the standard. The EPA finalized its approval of the area's redesignation in July 2020. In December 2021, the DNR similarly submitted a redesignation request for the partial Kenosha County 2008 ozone NAAQS nonattainment area, based on 2019-2021 data showing the area had attained. The EPA finalized this redesignation request in April 2022.

2015 Ozone NAAQS

In April 2018, the EPA designated several areas in Wisconsin as marginal nonattainment for the 2015 ozone NAAQS of 70 ppb, effective August 3, 2018 (83 FR 25776). These areas included:

- The portion of Door County within the boundary of Newport State Park. This area was also classified as a rural transport area (RTA)
- A portion of Manitowoc County along the Lake Michigan shoreline.

In June 2021, the EPA revised Wisconsin's 2015 ozone NAAQS nonattainment areas. One result of this action was the designation of the "Door County-Revised" nonattainment area, which comprised the portion of Door County north of the Sturgeon Bay canal, excluding Newport State Park (i.e., exclusive of the original Door County nonattainment area). This marginal nonattainment area was also designated as an RTA area, and was effective July 14, 2021. In that same action, EPA also revised and expanded the boundary of the Manitowoc County nonattainment area.

Between 2020 and 2022, the DNR submitted SIP revisions to the EPA requesting that these three areas be redesignated to attainment of the 2015 ozone NAAQS, based on certified monitoring data indicating the areas had attained the standard:

- In January 2020, the DNR submitted a redesignation request for the original Door County nonattainment area, based on monitoring data from 2017-2019. The EPA finalized its approval on June 10, 2020 (85 FR 35377).
- In October 2021, the DNR submitted a redesignation request for the Manitowoc County nonattainment area, based on monitoring data from 2018-2020. The EPA finalized its approval on March 31, 2022 (87 FR 18702).
- In January 2022, the DNR submitted a redesignation request for the Door County-Revised nonattainment area, based on monitoring data from 2019-2021. The EPA finalized its approval on April 29, 2022 (87 FR 25410).[1]

Maintenance plan contingency response requirements

As part of the redesignation requests for these areas, the DNR included the elements and commitments required by Clean Air Act Section 175A to demonstrate continued attainment of the NAAQS for at least ten years after redesignation. These "maintenance plans" included projected future emissions inventories as well as contingency response actions designed to ensure prompt correction of any future violation of the applicable NAAQS.

The DNR's maintenance plans for these areas are essentially identical in their content. All five plans include two levels of contingency response if monitoring data showed a renewed exceedance or violation of the applicable NAAQS.[2] The plans contain specific measures that would be implemented if one or both of those events occurred. These are summarized below.

Warning level response

The "warning level" response would be initiated if the annual (one year) fourth highest monitored value is above the level of the NAAQS. A warning level response would initiate a study to determine whether the high ozone concentrations indicate a trend towards higher ozone levels and whether emissions are significantly higher than projected in the maintenance plans. The study is to include the following elements:

- An assessment of whether actual emissions have deviated significantly from the emissions projections contained in the maintenance plan for the area, along with an evaluation of which sectors and states are responsible for any emissions increases; and
- A study of whether unusual meteorological conditions during the high-ozone year led to the high monitored ozone concentrations.

[1] All of the redesignation requests can be found at: https://dnr.wisconsin.gov/topic/AirQuality/Ozone.html.
[2] See Section 7.3 of each maintenance plan.

Should it be determined through the warning level study that action is necessary to ensure maintenance, the DNR committed to follow the procedures for control selection and implementation outlined under the action level response.

Action level response

The "action level" response would be initiated if the three-year design value exceeded the level of the NAAQS. This response would follow a study to determine whether additional control measures are needed to assure attainment and maintenance of the NAAQS. This analysis would examine the following factors for the contributing area:

- The level, distribution, and severity of ambient ozone concentrations;
- The weather patterns contributing to ozone levels;
- Potential contributing emission sources;
- The geographic applicability of possible contingency measures;
- Upwind emission trends, including the impact of existing or forthcoming control measures that have not yet been implemented; and
- Air quality contributions from outside the maintenance area.

Should it be determined through the action level study that existing and on-the-way measures are inadequate to return the area to attainment, the DNR committed to identify and implement candidate control measures as necessary to assure attainment and maintenance of the area. Each plan included a list of potential state measures that could be considered for implementation, if deemed necessary. The plans note that Wisconsin has an extremely limited ability to affect ozone concentrations in these counties due to the influence of emissions originating in upwind states.

Exceedances of the 2008 and 2015 ozone NAAQS during the 2023 and 2024 ozone seasons

The DNR ozone monitor located at Kohler-Andrae State Park provides data for the Shoreline Sheboygan County 2008 ozone area, the Chiwaukee Prairie monitor provides data for the Kenosha County 2008 ozone NAAQS area, the monitor at Newport State Park provides data for both the Door County and Door County-Revised 2015 ozone NAAQS areas, and the Manitowoc Woodland Dunes monitor provides data for the Manitowoc County 2015 ozone NAAQS area.

Based on air quality data collected during 2023 and 2024 at these monitors, warning or action level contingent response criteria were met during the 2023 and 2024 ozone seasons for multiple monitors (see Table 1). This prompted this maintenance plan contingency response.

Table 1. Ozone values at selected Wisconsin monitors, 2021-2024. Yellow indicates value exceeds 2015 ozone NAAQS (70 ppb); orange indicates value exceeds 2008 ozone NAAQS (75 ppb).

Monitor (Site ID)	Applicable Maintenance Area(s)	4th highest 8-hour ozone value (ppb)				Design value (ppb)	
		2021	2022	2023	2024	2021-2023	2022-2024
Newport State Park (55-029-0004)	2015 Door County 2015 Door County-Revised	70	75	73	67	72	71
Manitowoc Woodland Dunes (55-071-0007)	2015 Manitowoc County	70	81	69	71	73	73
Kohler-Andrae (55-117-0006)	2008 Shoreline Sheboygan County	73	77	82	76	77	78
Chiwaukee Prairie (55-059-0019)	2008 Kenosha County	79	70	84	80	77	78

Actions taken to satisfy contingency response requirements

Both the action-level and warning-level contingency responses included in the maintenance plans require the DNR to complete a study that assesses emissions trends (and the efficacy of existing control measures) as well as the impact of meteorology on monitored ozone concentrations. The DNR completed a single study (attached) designed to satisfy the contingency response requirements for all five areas.

The study concludes that ozone concentrations measured in these maintenance areas continue to be dominated by out-of-state emissions transported to the area via prevailing lake breeze circulations and mesoscale meteorological conditions. It is likely that the elevated ozone concentrations observed in the 2021-2024 period (resulting in values exceeding the 2008 and 2015 NAAQS) are the result of above-average regional temperatures, which enhanced ozone formation in areas upwind of Door, Manitowoc, Sheboygan, and Kenosha counties. That ozone was then transported to these lakeshore counties via well-documented meteorological processes, resulting in higher ozone values at the Newport, Manitowoc, Kohler Andrae, and Chiwaukee Prairie monitors.

In addition, it is widely recognized that smoke from Canadian wildfires was in evidence across much of Wisconsin throughout the 2023 ozone season. This likely contributed to higher-than-usual ozone values at these monitors during 2023, at least in select instances.

Recent modeling efforts independently conclude that Wisconsin emissions contribute very little to ozone in these maintenance areas, with the largest contributors being the upwind states of Illinois and Indiana. In addition, the largest source of emissions is the mobile sector, a sector over which Wisconsin has limited ability to control. This indicates that additional control of ozone precursor emissions within Wisconsin – and, especially, within the maintenance areas themselves – is unlikely to have any measurable impact on ozone levels in these areas. Should additional emissions reductions be deemed necessary, those would need to be implemented in the upwind states that are driving these ozone levels. Any additional controls should be focused on the mobile sector, although emissions from stationary source emissions in these

upwind states are non-trivial and would benefit from application of widely available control technologies, where not already implemented.

Conclusion

The DNR's approved maintenance plans for the Door County, Door County-Revised, and Manitowoc County 2015 ozone NAAQS maintenance areas, as well as the Shoreline Sheboygan County and Kenosha County 2008 ozone NAAQS areas, require additional actions to be taken by the state only if the results of the required study indicate additional control measures were necessary to return the areas to attainment.

Based on the results of the study, the DNR concludes that implementing additional emissions control measures in Wisconsin would not help return the Door County, Door County-Revised, and Manitowoc County areas to attainment of the 2015 ozone standard, or the Shoreline Sheboygan County and Kenosha County areas to attainment of the 2008 ozone NAAQS. If additional emissions controls are deemed necessary, those would need to be implemented in upwind states, rather than Wisconsin, to have any effect on ozone levels in these areas. This being the case, the DNR concludes that the contingency response requirements of the maintenance plans for these five areas have been satisfied.

Contingency Response Study for the Door County, Door County-Revised, and Manitowoc County 2015 Ozone National Ambient Air Quality Standard (NAAQS) Maintenance Areas and the Shoreline Sheboygan County and Kenosha County 2008 Ozone NAAQS Maintenance Areas

April 2025

I. Introduction

Following redesignation of several Wisconsin ozone nonattainment areas to attainment, exceedances of the 2008 and 2015 ozone National Ambient Air Quality Standard (NAAQS) were measured in these areas. This analysis was conducted to satisfy "action-level" maintenance plan contingency response requirements for the Door County, Door County-Revised, and Manitowoc County 2015 Ozone NAAQS maintenance areas, which monitored 2023 and 2024 design values above the 2015 ozone NAAQS. This analysis also addresses the action-level response requirements for the Shoreline Sheboygan County and Kenosha County 2008 ozone NAAQS maintenance areas, which monitored 2023 and 2024 design values above the 2008 ozone NAAQS.

To fulfill its action-level response requirements for these five areas, the Wisconsin Department of Natural Resources (DNR) committed to completing a study to determine if existing and on-the-way measures in these areas are adequate to return them to attainment. This study would assess the following specific factors: (1) the level, distribution, and severity of ambient ozone concentrations; (2) the weather patterns contributing to ozone levels; (3) potential contributing emission sources; (4) the geographic applicability of possible contingency measures; (5) upwind emission trends, including the impact of existing or forthcoming control measures that have not yet been implemented, and (6) air quality contributions from outside the maintenance areas. This analysis satisfies the contingency response requirements of all five maintenance areas.

II. Technical references

The origins of ozone measured in Door, Manitowoc, Sheboygan, and Kenosha counties, including the complex meteorological processes that drive ozone formation, transport, and fate along the Wisconsin lakeshore, have been extensively discussed in numerous regulatory documents. Some of the more relevant references are listed below.

DNR redesignation requests and maintenance plans[1]

- Redesignation request and maintenance plan for the Door County, WI 2015 ozone NAAQS nonattainment area (January 2020)
- Redesignation request and maintenance plan for the Manitowoc County, WI 2015 ozone NAAQS nonattainment area (October 2021)
- Redesignation request and maintenance plan for the Kenosha County, WI 2008 ozone NAAQS nonattainment area (December 2021)
- Redesignation request and maintenance plan for the Door County-Revised, WI 2015 ozone NAAQS nonattainment area (January 2022)
- Redesignation request and maintenance plan for the Shoreline Sheboygan County, WI 1997 and 2008 ozone NAAQS nonattainment area (February 2022)

[1] These documents can be found at: https://dnr.wisconsin.gov/topic/AirQuality/Ozone.html.

EPA and DNR designations-related technical support documents (TSDs)

- DNR supplemental information for 2015 ozone NAAQS area designations (Apr. 20, 2017)[2]
- DNR response to the EPA's intended area designations for the 2015 ozone NAAQS (Feb. 28, 2018)[3]
- EPA 2015 ozone NAAQS final designations TSD for Wisconsin areas (April 2018)[4]
- EPA TSD for the proposed revision of Sheboygan County nonattainment designation for the 1997 and 2008 ozone standards (Nov. 2018)[5]
- EPA TSDs for 2015 ozone NAAQS designations for the Wisconsin and Chicago areas remanded to EPA (May 2021)[6]

Because these documents contain useful information applicable to many of the above-mentioned factors, they are referenced as appropriate throughout this study. They also are a source of additional background on the factors driving ozone generation and transport in these maintenance areas.

III. Contingency response analysis

The following analysis evaluates the six factors listed in the action-level contingency response commitments in all five maintenance plans.

1. <u>The level, distribution, and severity of ambient ozone concentrations</u>

The DNR ozone monitor located at Kohler-Andrae State Park provides data for the Shoreline Sheboygan County 2008 ozone area, the Chiwaukee Prairie monitor provides data for the Kenosha County 2008 ozone NAAQS area, the monitor at Newport State Park provides data for both the Door County and Door County-Revised 2015 ozone NAAQS areas, and the Manitowoc Woodland Dunes monitor provides data for the Manitowoc County 2015 ozone NAAQS area. Table 1 shows the 2021-2024 ozone values for these monitors.

2015 ozone NAAQS areas

The level of the 2015 ozone NAAQS is 70 ppb. The Door County and Door County-Revised 2005 ozone NAAQS areas were designated nonattainment based on a 2014-2016 design value at the Newport monitor of 72 ppb. The Door County area was redesignated to attainment in June 2020 based on a 2017-2019 design value at that monitor of 70 ppb. The Door County-Revised area was redesignated to attainment in April 2022 based on a 2019-2021 design value of 70 ppb.

The Manitowoc County 2015 ozone NAAQS area was designated nonattainment based on a 2014-2016 design value at the Manitowoc monitor of 72 ppb. The area was redesignated to attainment in March 2022 based on a 2018-2020 design value of 70 ppb.

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[2] https://dnr.wisconsin.gov/sites/default/files/topic/AirQuality/OzoneTSD20170420.pdf.
[3] https://dnr.wisconsin.gov/sites/default/files/topic/AirQuality/DNRResponse120DayLetter20180228.pdf.
[4] https://www.epa.gov/sites/default/files/2018-05/documents/wi_tsd_final.pdf.
[5] https://www.regulations.gov/document/EPA-R05-OAR-2018-0035-0004.
[6] https://www.epa.gov/sites/default/files/2021-05/documents/wi_tsd_remand_final.pdf and https://www.epa.gov/sites/default/files/2021-05/documents/il_in_wi_chicago_tsd_remand_final.pdf.

Table 1. Ozone values at selected Wisconsin monitors, 2021-2024. Yellow indicates value exceeds 2015 ozone NAAQS (70 ppb); orange indicates value exceeds 2008 ozone NAAQS (75 ppb).

Monitor (Site ID)	Applicable Maintenance Area(s)	4th highest 8-hour ozone value (ppb)				Design value (ppb)	
		2021	2022	2023	2024	2021-2023	2022-2024
Newport State Park (55-029-0004)	2015 Door County 2015 Door County-Revised	70	75	73	67	72	71
Manitowoc Woodland Dunes (55-071-0007)	2015 Manitowoc County	70	81	69	71	73	73
Kohler-Andrae (55-117-0006)	2008 Shoreline Sheboygan County	73	77	82	76	77	78
Chiwaukee Prairie (55-059-0019)	2008 Kenosha County	79	70	84	80	77	78

The design values at the Newport monitor were 72 ppb in 2023 and 71 in 2024. For the Manitowoc monitor, the values were 73 ppb in both 2023 and 2024. These values exceed the 2015 ozone NAAQS, which prompts the action-level contingency response described in the maintenance plans for the affected maintenance areas.

2008 ozone NAAQS areas

The level of the 2008 ozone NAAQS is 75 ppb. The entirety of Sheboygan County was originally designated nonattainment of the 2008 ozone NAAQS in 2012. The EPA revised that designation in 2019 to create two distinct areas: the Inland Sheboygan County and the Shoreline Sheboygan County nonattainment areas, each with their own regulatory ozone monitor (84 FR 33699). Both the Inland Sheboygan County area and the Shoreline Sheboygan County area were redesignated to attainment in July 2020.

Part of Kenosha County was designated as nonattainment of the 2008 ozone NAAQS in 2012 as part of the multistate Chicago, IL-IN-WI nonattainment area. The area was redesignated to attainment in April 2022 based on 2019-2021 design values across the nonattainment area that met the standard.

The design values at both the Sheboygan Kohler Andrae and the Kenosha Chiwaukee Prairie monitors were 77 ppb in 2023 and 78 ppb in 2024. These values exceed the level of the 2008 ozone NAAQS, which prompts the action-level contingency response described in the maintenance plans for the affected maintenance areas.[7]

[7] The Shoreline Sheboygan County area has continued to attain the 2008 ozone NAAQS, with design values remaining at or below 75 ppb through 2022-2024 design value period. Sheboygan County also has a nonattainment area for the 2015 ozone NAAQS; that area remains in nonattainment and is not the subject of this contingency study.

Long-term ozone trends

Figure 1 shows the trend in ozone concentrations (both design values and fourth-highest values) at these monitors since 2001. This data indicates that ozone values steadily have decreased over time, while flattening somewhat beginning in the 2014-2016 time frame. As will be discussed in Section #2, the higher ozone values measured in 2020-2022 were likely influenced by above-average regional temperatures in those years. However, as is also described in that section, the long-term trend in ozone values in these counties continue to decline, even when year-over-year temperature variations are accounted for and despite intermittent peaks in annual ozone values.

Door, Manitowoc, Sheboygan, and Kenosha counties are located along the Lake Michigan shoreline and, as such, are heavily impacted by upwind ozone formation and transport via lake breeze circulations and southerly winds over Lake Michigan. Given the relative lack of ozone-causing emissions originating from these counties, Figure 2 shows ozone trends in the contributing upwind areas of Milwaukee and the three-state Chicago area. Monitors in these two large metro areas also have measured long-term reductions in ambient ozone concentrations.

Figure 1. Ozone trends at the Newport, Manitowoc, Sheboygan Kohler-Andrae, and Kenosha Chiwaukee Prairie monitors, 2001-2024. Solid red line indicates the 2015 ozone NAAQS (70 ppb); dashed red line indicates the 2008 ozone NAAQS (75 ppb). Green line is 4th highest value; blue line is design value (DV). Graphics courtesy of LADCO.

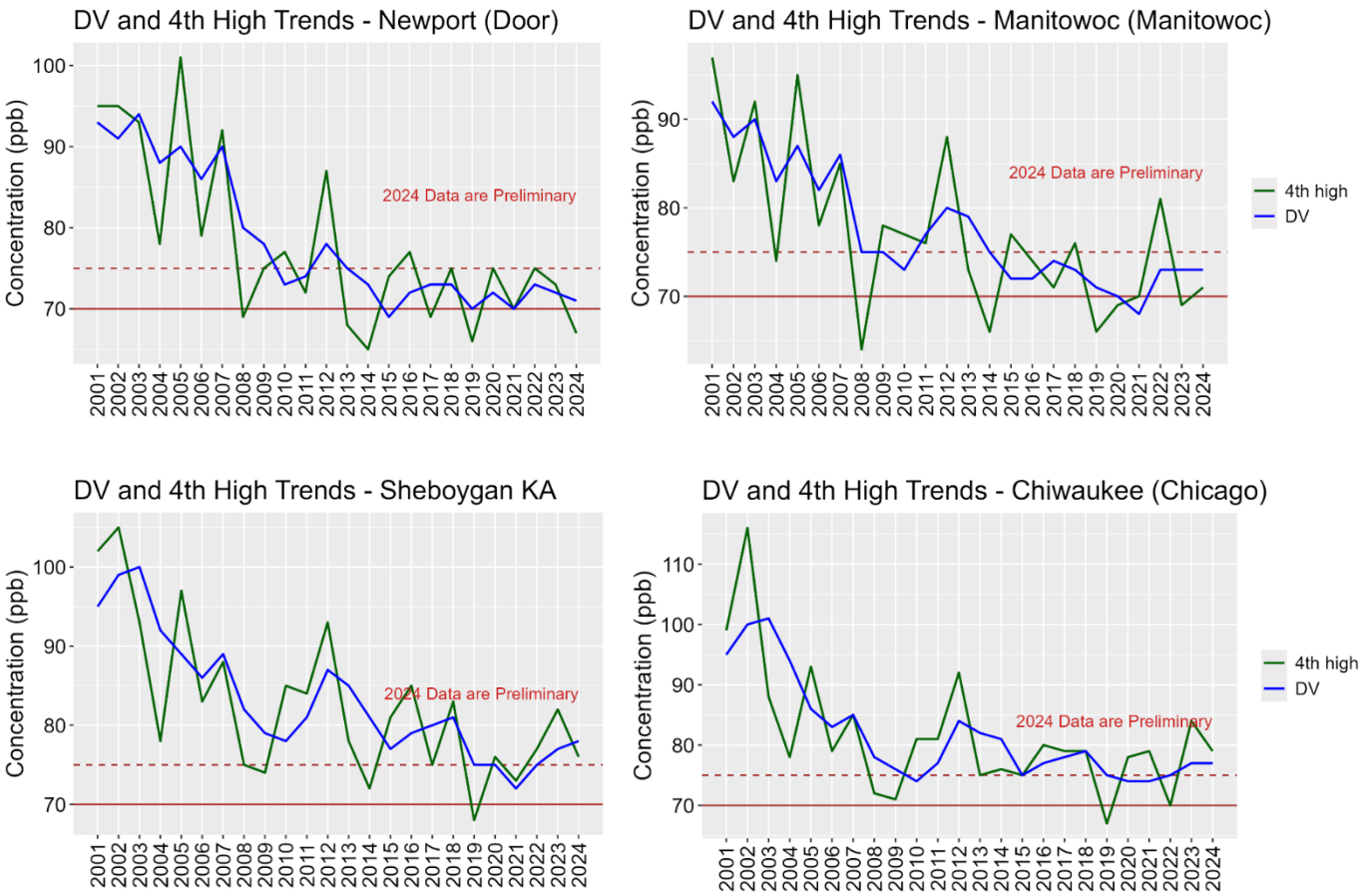
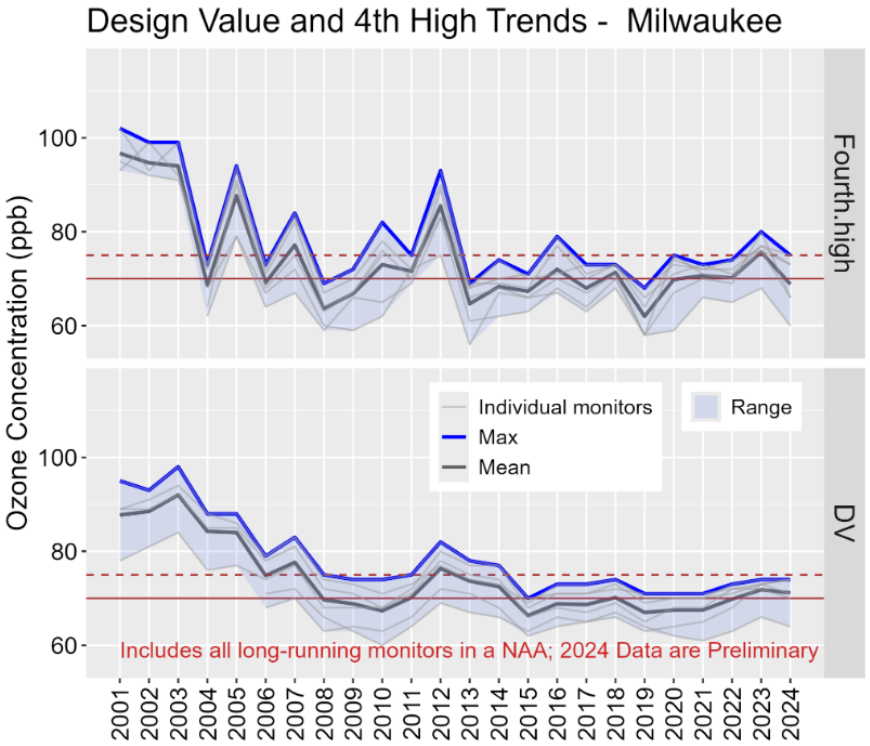
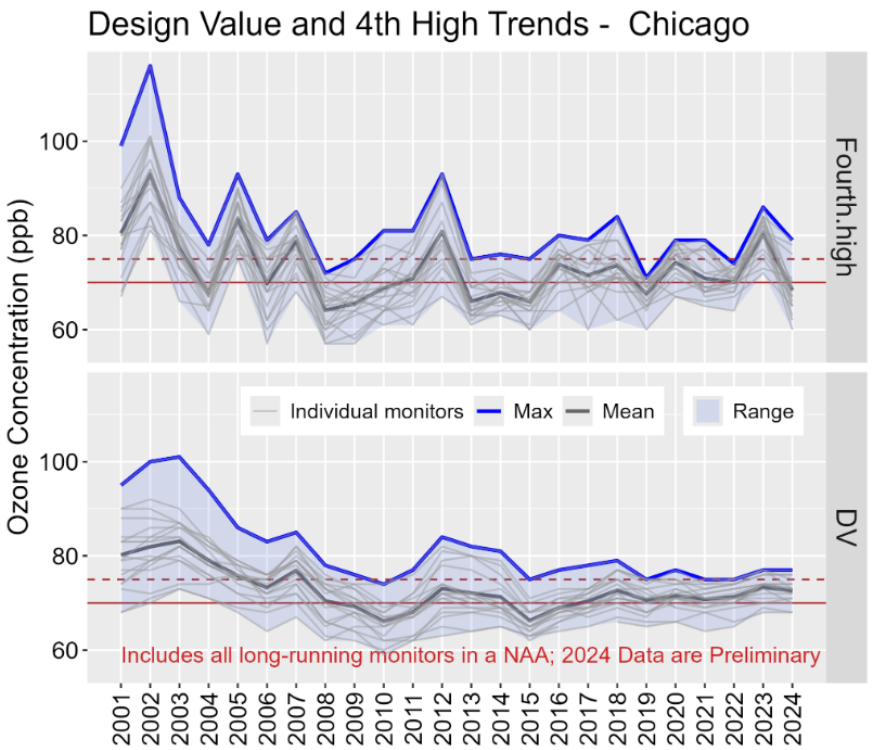


Figure 2. Ozone trends at Milwaukee and Chicago area monitors, 2001-2024. Solid red line indicates the 2015 ozone NAAQS (70 ppb); dashed red line indicates the 2008 ozone NAAQS (75 ppb). Graphics courtesy of LADCO.





Weather patterns contributing to ozone levels

Regional annual temperature trends

Ozone formation in the Lake Michigan area is heavily influenced by meteorological conditions, especially temperature. Figure 3 shows regional temperature variability relative to the climatological average during the June-August peak ozone months for the years 2021 through 2024. This figure shows that parts of the upper Midwest, including Wisconsin, experienced above-average temperatures in 2021 and 2023. While 2022 and 2024 temperatures in Wisconsin were close to average, temperatures were above normal in many upwind areas to the south (such as Indiana, Kentucky and Ohio) known to contribute to Wisconsin's ozone levels.

Given the well-understood relationship between temperature and ozone formation, the above-average regional temperatures in 2021 and 2023 likely enhanced ozone formation chemistry in areas located upwind of Door, Manitowoc, Sheboygan, and Kenosha counties. These elevated ozone concentrations, when transported to the Newport, Manitowoc, Kohler-Andrae, and Chiwaukee Prairie monitors, would have contributed to the higher ozone values measured at those monitors during this period.

It is noteworthy that the fourth highest ozone values at the Manitowoc, Newport, and Kohler Andrae monitors remained at attainment levels for the applicable NAAQS in 2021 (and Manitowoc again in 2023), despite warmer-than-average ozone seasons those years. This indicates that regional decreases in ozone-causing emissions may still be driving ozone values lower in spite of warmer conditions. This is consistent with long term trends.

Although not specifically evaluated in this study, smoke from Canadian wildfires, known to be present across large areas of Wisconsin (including these lakeshore areas) throughout the summer of 2023, likely contributed to the high ozone values measured in these nonattainment areas during that year.

Long-term ozone levels compared to temperature

Long-term trends indicate that ozone values at the Newport, Manitowoc, Kohler-Andrae, and Chiwaukee Prairie monitors are decreasing independent of temperature. Figures 4 through 7 show that ozone concentrations at these monitors (blue lines) have decreased substantially since the 1998-2001 period, even as temperatures (red and yellow lines) have remained relatively constant, or even increased. This result is strong evidence that reductions in emissions, rather than meteorology, are driving the long-term reductions in ozone concentrations at these monitors.

Figure 3. Regional average maximum temperature departure from mean (June-August), 2021-2024.
Source: Midwest Regional Climate Center.

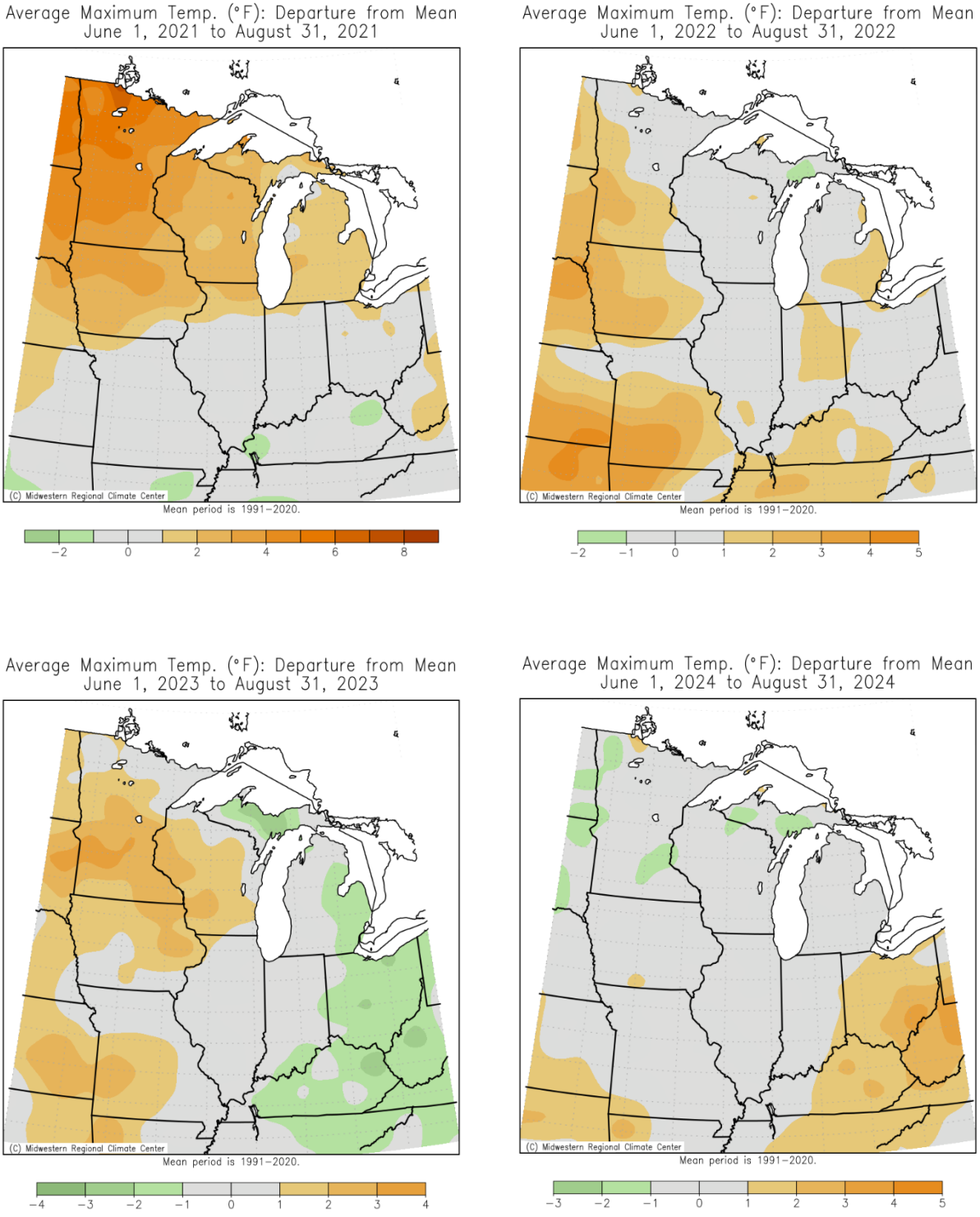
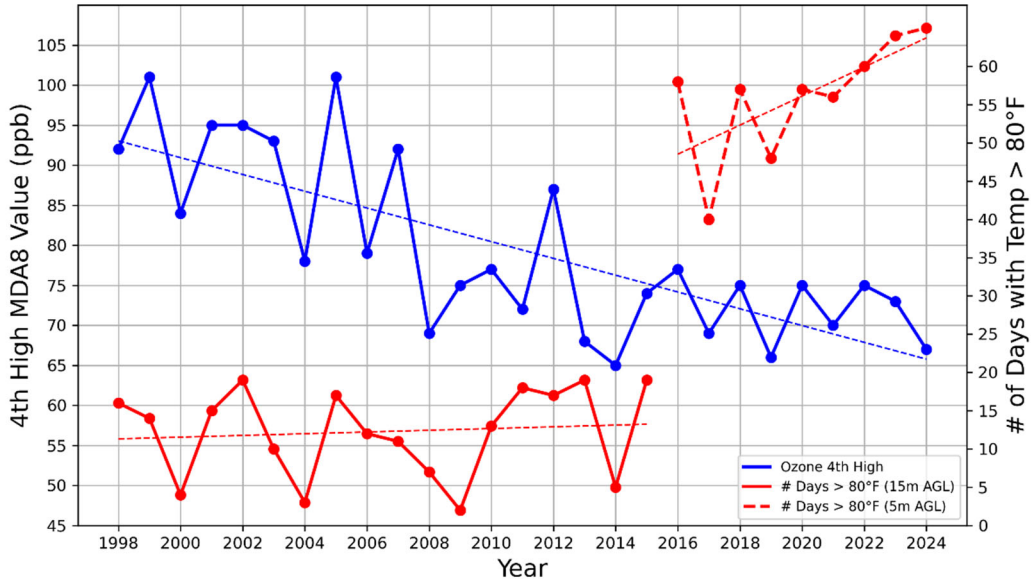
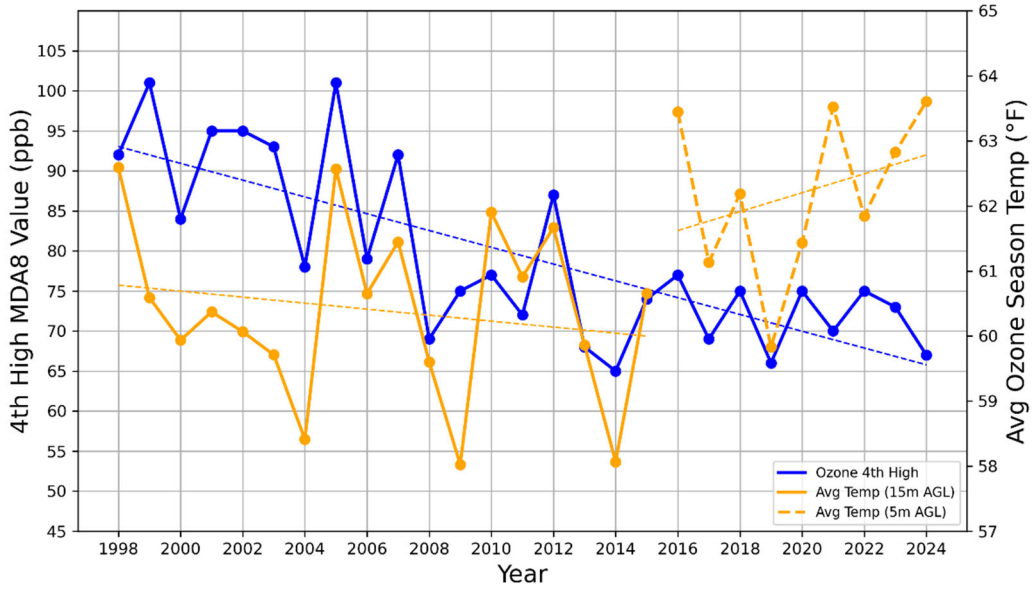


Figure 4. Comparison of Door County ozone values to temperature (1998-2024). Annual fourth highest maximum daily 8-hour average ozone concentrations plotted with (top) the number of days with temperatures over 80 °F and (bottom) the average ozone season temperatures for the Newport monitor.[8] Dotted lines are best-fit linear regressions.





[8] The temperature probe at the Newport monitoring site was relocated in 2016 from 15 meters to 5 meters above ground level (AGL) to align with EPA guidance. This change led to noticeable increases in recorded temperatures, such that the 1998 to 2015 record should not be directly compared with the 2016 to 2022 temperature record.

Figure 5. Comparison of Manitowoc County ozone values to temperature (2001-2024). Annual fourth highest maximum daily 8-hour average ozone concentrations plotted with (top) the number of days with temperatures over 80 °F and (bottom) the average ozone season temperatures for the Manitowoc monitor. Dotted lines are best-fit linear regressions.

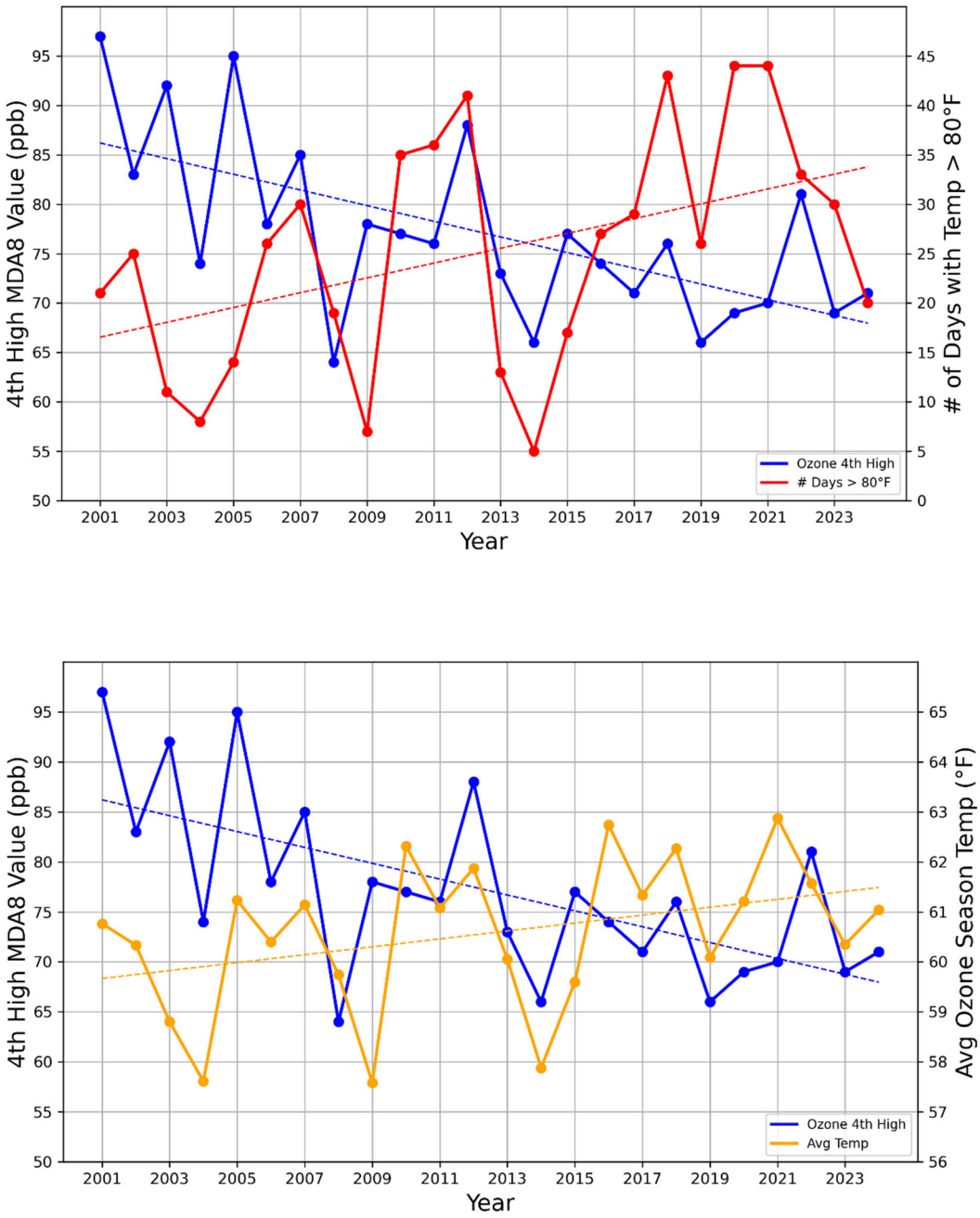


Figure 6. Comparison of Sheboygan Kohler-Andrae ozone values to temperature (2001-2024). Annual fourth highest maximum daily 8-hour average ozone concentrations plotted with (top) the number of days with temperatures over 80 °F and (bottom) the average ozone season temperatures for the Kohler-Andrae monitor. Dotted lines are best-fit linear regressions. Note temperature data for 2004 is unavailable.

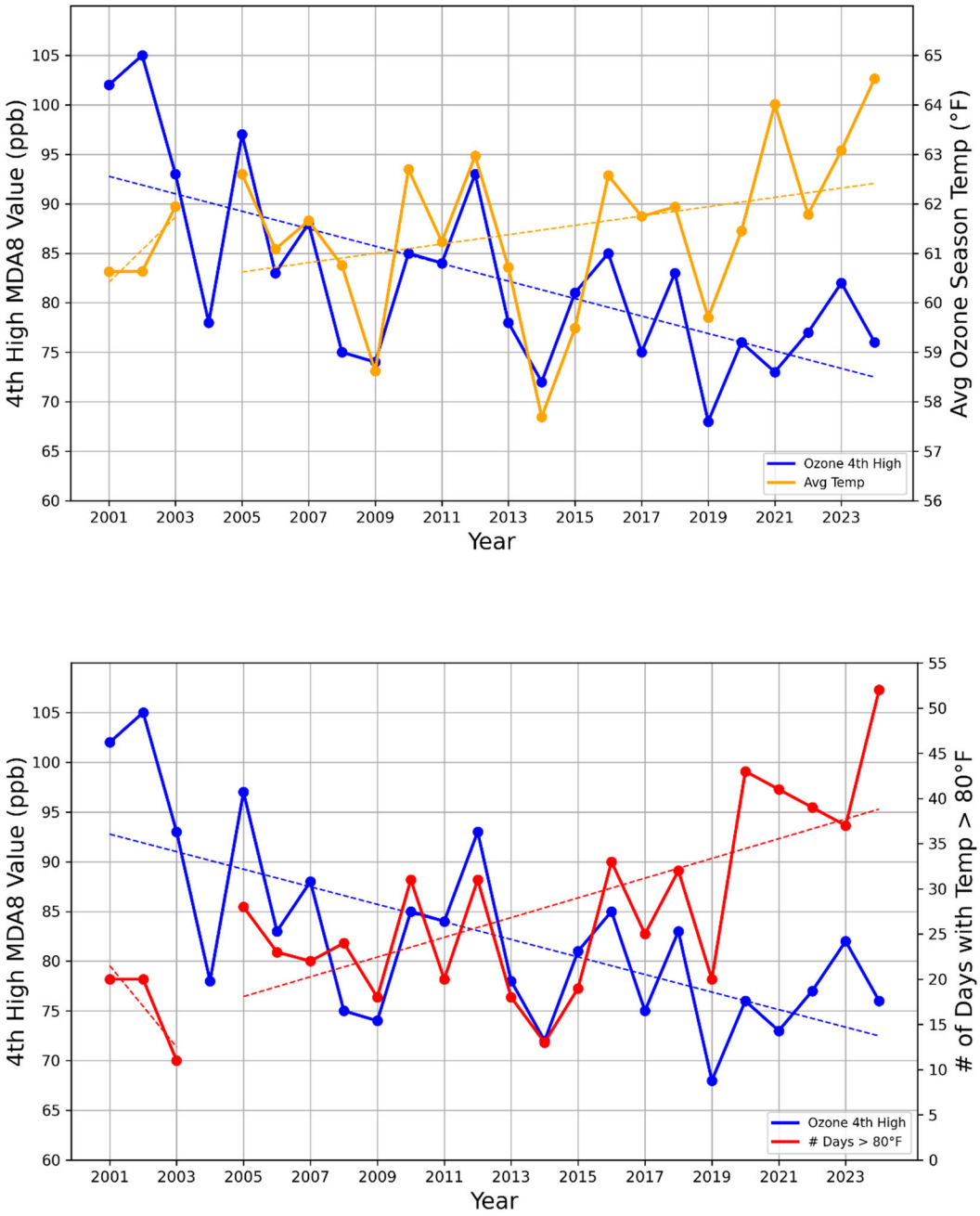
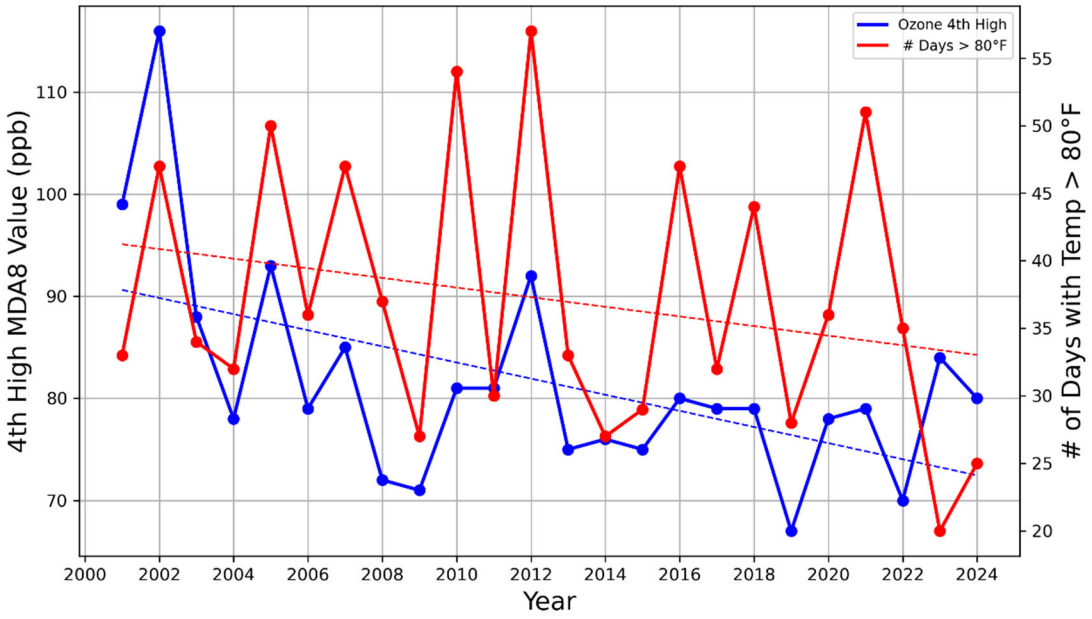
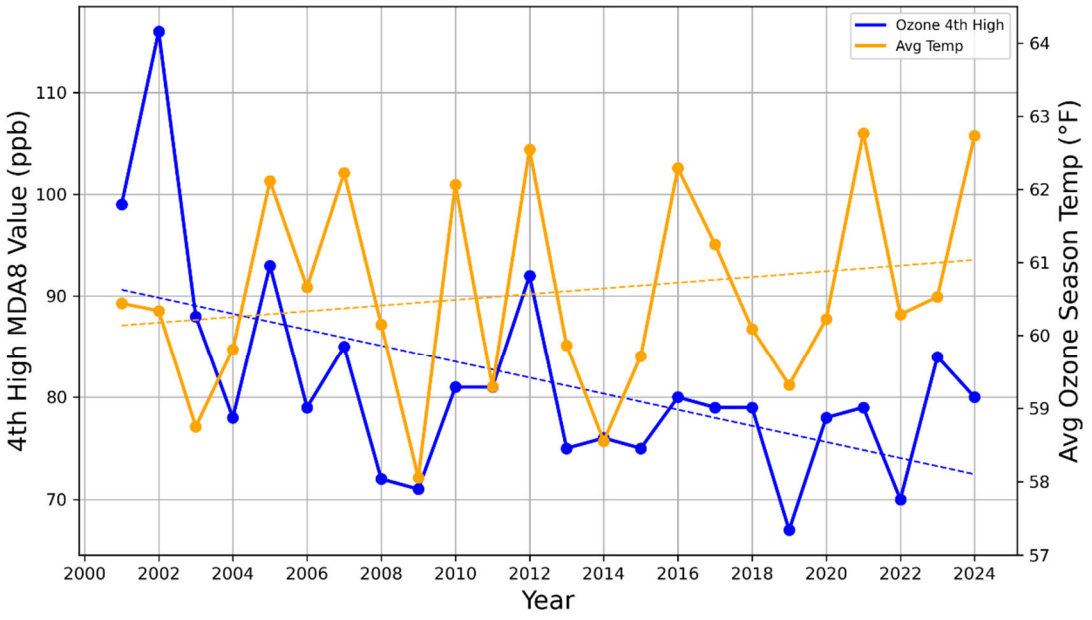


Figure 7. Comparison of Kenosha Chiwaukee Prairie ozone values to temperature (2001-2024). Annual fourth highest maximum daily 8-hour average ozone concentrations plotted with (top) the number of days with temperatures over 80 °F and (bottom) the average ozone season temperatures for the Chiwaukee Prairie monitor. Dotted lines are best-fit linear regressions.





Classification and regression tree (CART) analysis of ozone levels and meteorology

A classification and regression tree (CART) analysis completed by the Lake Michigan Air Directors Consortium (LADCO) in 2023 also explored the impact of temperature on ozone values at the Newport, Manitowoc, Kohler-Andrae, and Chiwaukee Prairie monitors.[9] LADCO conducted this analysis to determine the meteorological conditions most associated with high ozone days at ozone nonattainment and maintenance areas throughout the upper Midwest, including in Door, Manitowoc, Sheboygan, and Kenosha counties.[10]

Figure 8 shows the results of LADCO's CART analysis at the Newport, Manitowoc, Kohler Andrae, and Chjwaukee Prairie monitors during periods of high ozone (i.e., conditions associated with ozone levels exceeding 50 ppb).[11] This figure supports several conclusions. First, that ozone levels have consistently decreased since 2005 when considering the specific meteorological conditions (nodes) associated with high ozone levels. Second, that the high-ozone nodes from the CART analysis for these monitors are associated with southerly winds/transport and hot temperatures. This further reinforces that elevated ozone levels in these maintenance areas are dominated by transported ozone originating from outside the maintenance areas (and as noted in #3-6, from outside of the state). Together, these indicate that upwind emissions are driving ozone levels within Door, Manitowoc, Sheboygan, and Kenosha counties, and that, should ozone need to be further decreased, it would be necessary to reduce emissions in these upwind areas.

2. Potential contributing emission sources

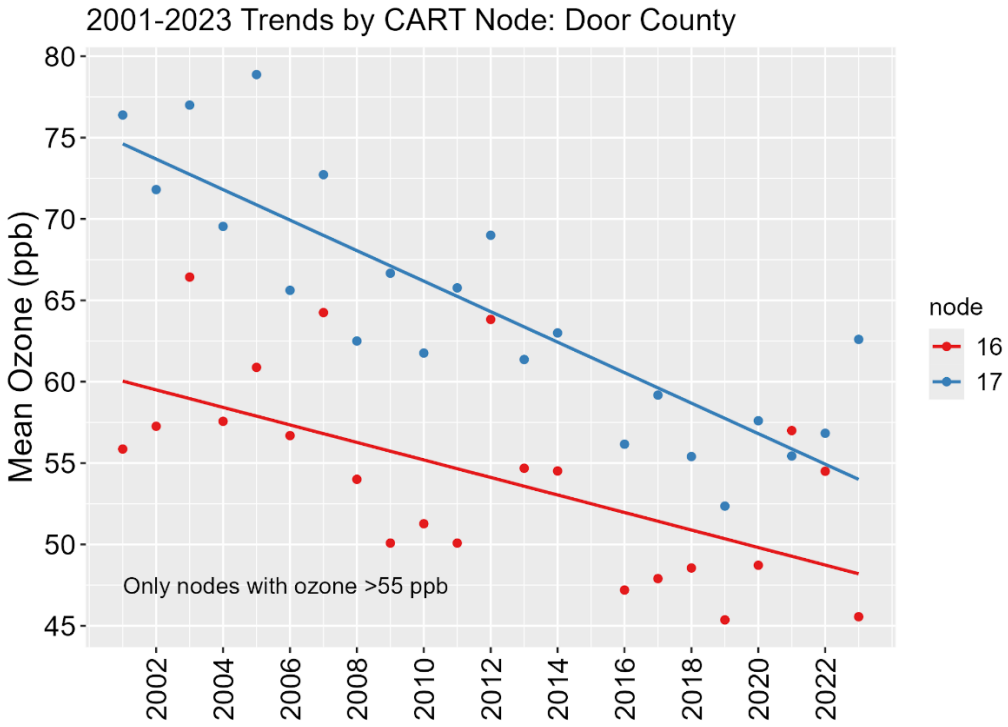
As described extensively in the references, there are few sources of ozone precursor emissions in these counties (especially Door County), and even fewer emissions from within the maintenance areas themselves. Any emissions sources contributing to ozone concentrations in these lakeshore counties would be located outside and upwind of the counties. This includes point, area, onroad and nonroad sources located in upwind areas and, especially, in the upwind states of Illinois and Indiana. Information about these contributing emissions source areas is discussed in #5.

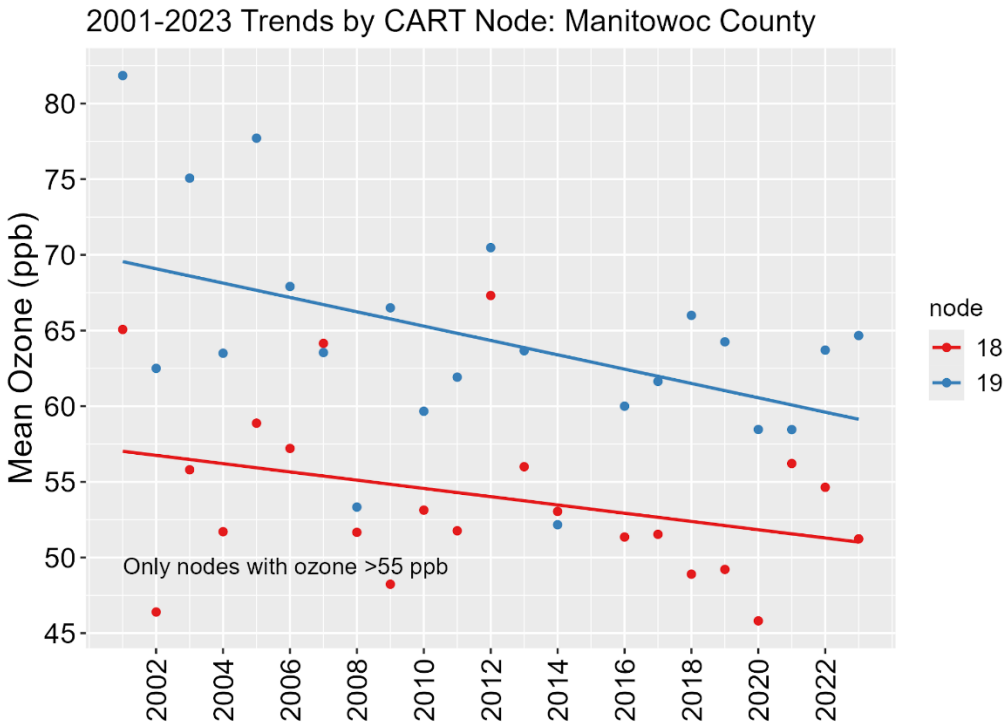
[9] A CART analysis normalizes the influence of year-to-year meteorological variability on ozone concentrations, and any remaining trend is assumed to be the result of non-meteorological factors, such as reductions in emissions of ozone precursors. This is done by comparing ozone values over time associated with specific combinations of meteorological conditions ("nodes"), such as temperature, wind direction, and humidity.

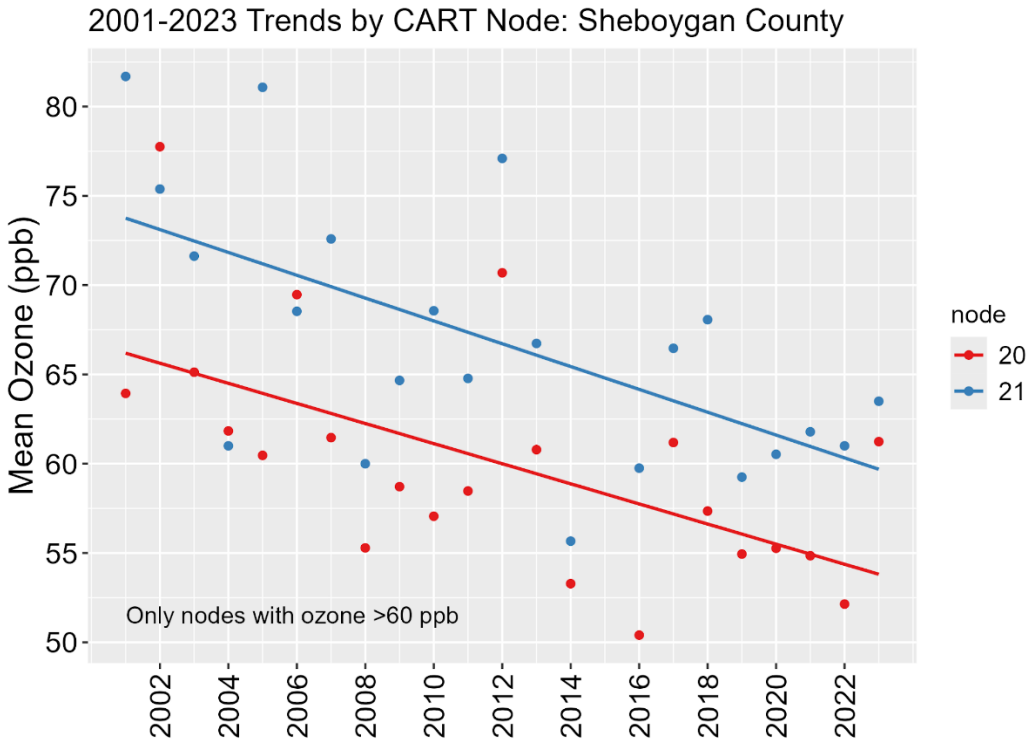
[10] Since completing a CART analysis is a resource-intensive exercise, an updated analysis (e.g., with data after 2023) was not completed solely for the purpose of this study. The conclusions from the 2023 assessment presented here remain germane, given the long-term scope of the analysis. Note the Sheboygan analysis is based on Kohler-Andrae monitor data so is specific to the shoreline area.

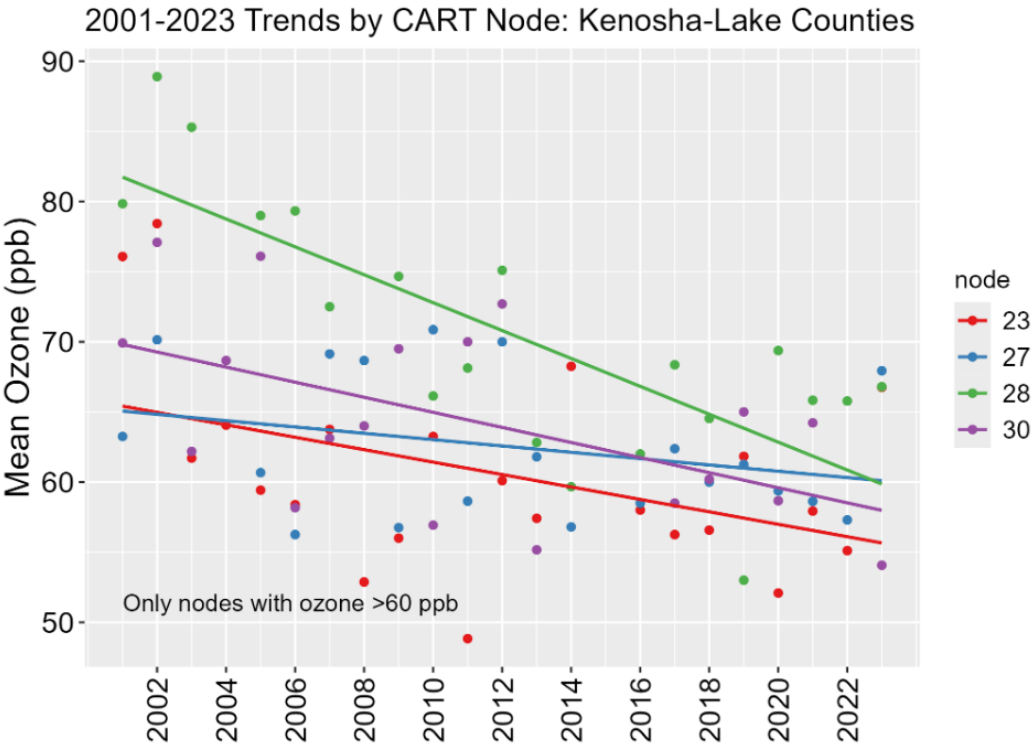
[11] For a complete description of LADCO's methodology, see the complete CART analysis document on LADCO's website (www.ladco.org).

Figure 8. CART analysis results for Door County, Manitowoc County, Sheboygan County, and Kenosha County (2001-2023). Figure continues next page. The nodes represent specific groupings of meteorological factors associated with ozone levels above 50 ppb at monitors in these areas.









Note: Kenosha County, Wisconsin and Lake County, Illinois, both part of the Chicago nonattainment area, were evaluated together due to their close geographic proximity and similar characteristics in terms of ozone values, meteorological conditions, and transport influences.

3. The geographic applicability of possible contingency measures

As described in the maintenance plans, Wisconsin has an extremely limited ability to affect ozone concentrations in Door, Manitowoc, Sheboygan, and Kenosha counties due to the influence of emissions originating in upwind areas. Because of this, any contingency measures deemed necessary to bring the areas back into attainment would need to be applied outside of the areas. This would include the upwind metropolitan areas of Green Bay, Milwaukee, and Chicago.

Since Chicago-area emissions are significantly larger than the emissions from any upwind Wisconsin areas (see #5), the implementation of additional emissions reductions measures at both the state and federal level within the Chicago area, particularly in Illinois, would be most effective at reducing ozone levels further in Door, Manitowoc, Sheboygan, and Kenosha counties. This is further supported by source apportionment modeling results, which indicate the outsized contributions of Illinois sources to ozone concentrations measured at the monitors in these maintenance areas (see #6).

4. Upwind emission trends, including the impact of existing or forthcoming control measures that have not yet been implemented

In its designation-related technical support documents for the Door County 2015 ozone standard areas, the EPA determined that emissions in Door County do not significantly contribute to ozone concentrations in the area itself. Instead, Door County ozone levels are driven by emissions originating outside and upwind of the county. Specifically, the EPA analyzed ozone precursor emissions from three metro areas upwind of Door County: Green Bay, Milwaukee, and Chicago. The EPA noted that the five-county Milwaukee metro area (Ozaukee, Washington, Waukesha, Milwaukee, and Racine counties) has emissions approximately 14 times greater than Door County, and the multistate Chicago ozone nonattainment area collectively has emissions over 80 times greater.

Similarly, the EPA's revised designation evaluation for Manitowoc County noted the relative lack of ozone-causing emissions within the county, especially when compared to the considerably larger upwind metropolitan areas of Milwaukee and Chicago. The EPA's analysis concluded that the "dominating factor" contributing to ozone formation in Manitowoc County is upwind impacts from higher precursor-emitting areas.[12]

In terms of Sheboygan County, the EPA has repeatedly noted the relatively low emissions in Sheboygan County as compared to larger, upwind metropolitan areas.[13] The EPA has similarly described how Kenosha County is by far the smallest contributor to emissions in the tristate Chicago area, contributing only about 2% each to the area's total emissions of NOx and VOCs.[14]

Consistent with the EPA's technical assessments, the DNR evaluated NOx and VOC emission trends in Green Bay, Milwaukee and Chicago for 2019, as well as projections for the years 2030 and 2035 (see Tables 3 and 4).[15] These figures show that precursor emissions from these areas are expected to

[12] EPA TSD for the remanded Manitowoc County 2015 ozone NAAQS area, p. 64.
[13] For example: EPA TSD for the remanded Sheboygan County 2015 ozone NAAQS area and the TSD supporting the split of the Sheboygan County 1997 and 2008 ozone NAAQS areas.
[14] EPA TSD for the remanded Chicago, IL-IN-WI 2015 ozone NAAQS area, p. 12.
[15] Data from the DNR's "Redesignation Request and Maintenance Plan for the Door County-Revised 2015 ozone NAAQS Area" (2022). Green Bay is included because of the potential impact on Door County.

continue to decrease substantially in future years, based on existing control measures. Given that emissions from these areas, especially Chicago, are the dominate drivers of ozone formation in Door, Manitowoc, and Sheboygan counties, these reductions will help the maintenance areas subject to this maintain the NAAQS.

Table 3. NOx emissions in Chicago, Green Bay and Milwaukee.

	Total NOx emissions (tons per ozone season day)			
	2019	**2030**	**2035**	**Net Change (2019-2035)**
Chicago Metropolitan Area				
Point	117.05	101.84	102.13	-14.92 (-13%)
Area	95.23	89.52	86.83	-8.40 (-9%)
Onroad	171.02	69.03	40.91	-130.11(-76%)
Nonroad	131.72	113.96	110.87	-20.85 (-16%)
TOTAL	**515.02**	**374.35**	**340.75**	**-174.27 (-34%)**
Green Bay Metropolitan Area				
Point	6.30	5.61	5.64	-0.66 (-10%)
Area	2.60	2.56	2.54	-0.06 (-2%)
Onroad	6.49	1.86	0.46	-6.03 (-93%)
Nonroad	2.58	148	1.00	-1.58 (-61%)
TOTAL	**17.98**	**11.51**	**9.65**	**-8.33 (-46%)**
Milwaukee Metropolitan Area				
Point	17.39	17.90	17.78	0.39 (2%)
Area	17.66	17.11	16.89	-0.77 (-4%)
Onroad	29.15	10.17	4.94	-24.21 (-83%)
Nonroad	16.49	13.31	12.58	-3.91 (-24%)
TOTAL	**80.68**	**58.48**	**52.19**	**-28.49 (-35%)**

Table 4. VOC emissions in Chicago, Green Bay and Milwaukee.

	Total VOC emissions (tons per ozone season day)			
	2019 attainment year	**2030 interim year**	**2035 maintenance year**	**Net Change (2019-2035)**
Chicago Metropolitan Area				
Point	47.73	46.45	46.23	-1.50 (-3%)
Area	242.83	249.38	252.30	9.47 (4%)
Onroad	99.75	49.96	33.82	-65.93 (-66%)
Nonroad	68.78	66.68	67.68	-1.1 (-2%)
TOTAL	**459.10**	**412.46**	**400.02**	**-59.08 (-13%)**
Green Bay Metropolitan Area				
Point	4.54	4.55	4.56	0.02 (0%)
Area	9.01	9.38	9.54	0.53 (6%)
Onroad	3.78	1.97	1.43	-2.35 (-62%)
Nonroad	1.64	1.41	1.35	-0.29 (-18%)
TOTAL	**18.97**	**17.30**	**16.87**	**-2.10 (-11%)**
Milwaukee Metropolitan Area				
Point	9.41	9.75	9.73	0.32 (3%)
Area	50.81	51.43	51.70	0.89 (2%)
Onroad	16.42	8.68	6.20	-10.2 (-62%)
Nonroad	11.51	10.82	10.79	-0.72 (-6%)
TOTAL	**88.15**	**80.69**	**78.42**	**-9.73 (-11%)**

5. Air quality contributions from outside the maintenance areas

Contributions to ozone levels from outside these maintenance areas can be assessed in several ways. First, since ozone formation is driven by precursor emissions, evaluating the location and magnitude of those emissions can help determine the relative degree upwind areas may be contributing to an area. The EPA provides an extensive evaluation of this in its designation-related technical support documents for the 2015 ozone NAAQS for these areas (as described in #5). In all cases, emissions from outside of the nonattainment areas were found to have an outsized impact on the ozone values measured in these areas, especially on high ozone days. This is due not only to the relatively small contributions of in-area emissions to local ozone levels, but also the transport of ozone and ozone precursors into the maintenance areas from areas primarily to the south.

Source apportionment modeling can also determine what emissions are contributing to ozone levels in these areas, and the origin of those emissions. Figure 8 shows the relative contributions of different emissions sectors and geographical regions to ozone levels at the Newport, Manitowoc, Kohler-Andrae,

and Chiwaukee Prairie monitors, based on the results of such modeling conducted by LADCO in September 2022.[16]

Figure 9 shows that Illinois is the dominant contributor to concentrations in these areas (23-37 percent) followed by Indiana (8-12 percent). In contrast, Wisconsin is estimated to contribute just 2-8 percent, with most of these emissions from the greater Milwaukee ("SoutheastWI") area. Other upwind states, such as Missouri, Michigan, Ohio, and Texas, also contribute at non-trivial levels, in some cases exceeding Milwaukee's contribution.

These results are broadly consistent with the ozone photochemical modeling independently completed by the EPA in March 2023 in support of the final "Good Neighbor Plan" for the 2015 ozone NAAQS.[17] Those results showed that, for Door and Manitowoc counties, Wisconsin contributes 5-6 percent, while other, upwind states contribute around 54-56 percent. At Sheboygan, the EPA shows Wisconsin contributing about 9 percent, compared with 47 percent from other states. For Kenosha County, Wisconsin was determined to contribute just 7 percent, compared with 51 percent from other states. As with LADCO's modeling, in all cases Illinois and Indiana are the largest contributing states to these Wisconsin areas, considerably exceeding Wisconsin's own contribution.

The emissions sector results from the LADCO modeling also show the significant role mobile source emissions have on Wisconsin ozone levels. Onroad emissions alone are responsible for about 22 percent of the ozone in these three areas, with all mobile emissions collectively approaching 40 percent. In contrast, "point" sources, like power plants and industrial facilities, contribute about 15 percent.

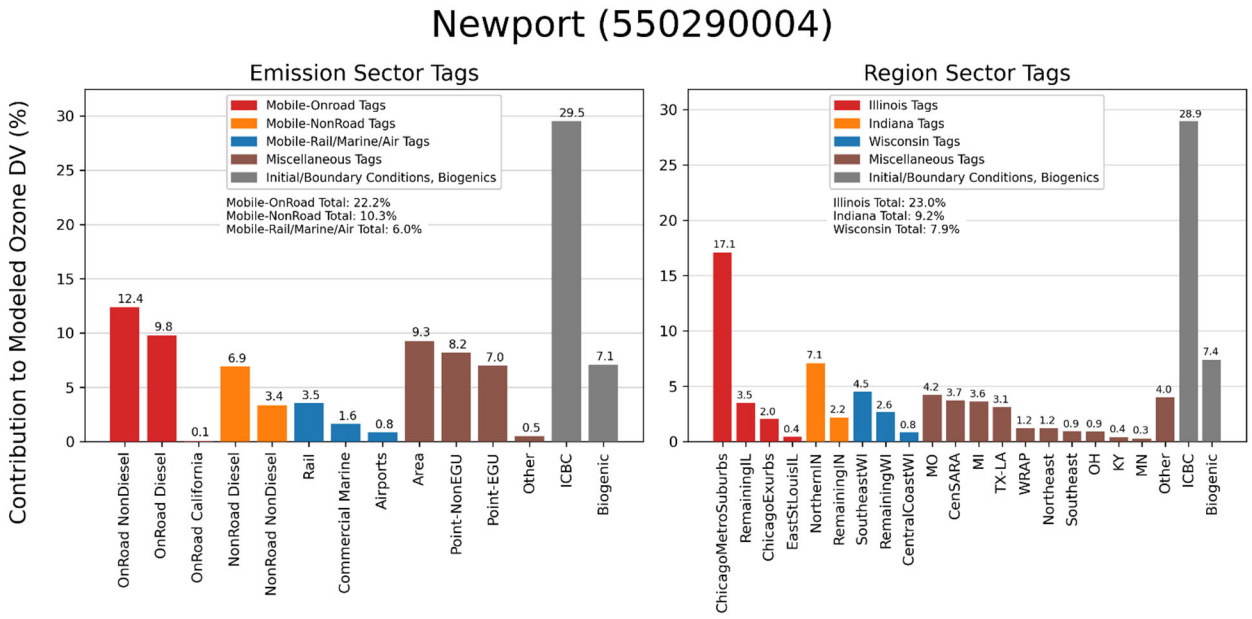
These modeling results consistently show that reductions in the neighboring upwind states of Illinois and Indiana would have a greater impact on ozone concentrations measured at the Newport, Manitowoc, Kohler-Andrae, and Chiwaukee Prairie monitors than reductions from Wisconsin sources. In addition, since the largest source of emissions is the mobile sector, additional controls on mobile sources in upwind states, especially Illinois, would have the most impact. Given limited state authority over those emissions, this underscores the critical need for additional federal action in this area.

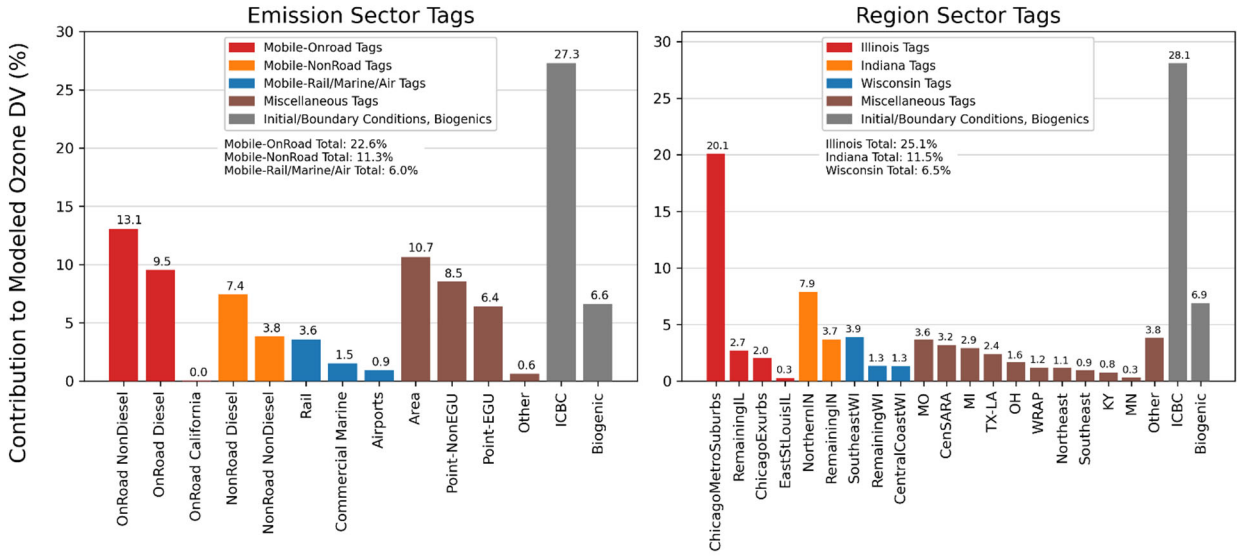
Given the small contribution of Wisconsin sources to concentrations at these monitors, there is no evidence that additional emissions controls within the state would have any measurable impact on ozone levels in these maintenance areas.

[16] Data from LADCO's "Attainment Demonstration Modeling for the 2015 Ozone National Ambient Air Quality Standard" (Sept. 2022). The complete technical support document (TSD) and supporting information can be found at: https://www.ladco.org/technical/ladco-internal/ladco-projects/ladco-2015-o3-naaqs-moderate-area-sip-technical-support-document/. Data was projected for 2023.

[17] Available at: https://www.epa.gov/csapr/good-neighbor-plan-2015-ozone-naaqs. Data cited is from the EPA's CAMx modeling results for 2026.

Figure 9. Ozone source apportionment results for the Newport (Door County), Manitowoc, Sheboygan Kohler-Andrae, and Kenosha Chiwaukee Prairie monitors. Figure continues next page. Results by emissions sector (left) and geographic region (right).





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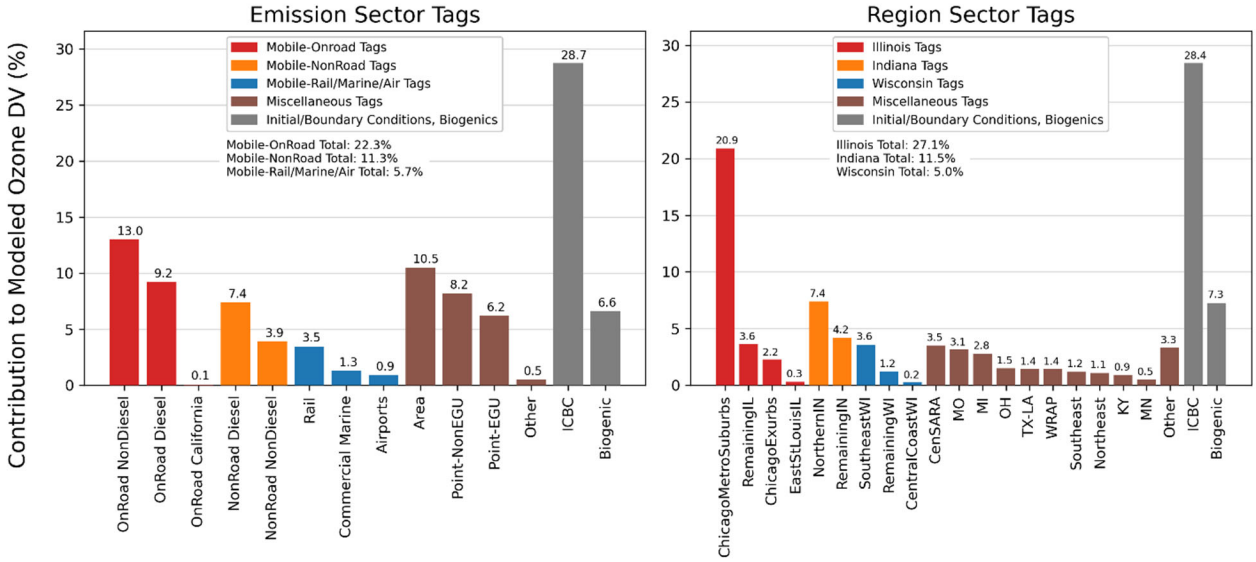

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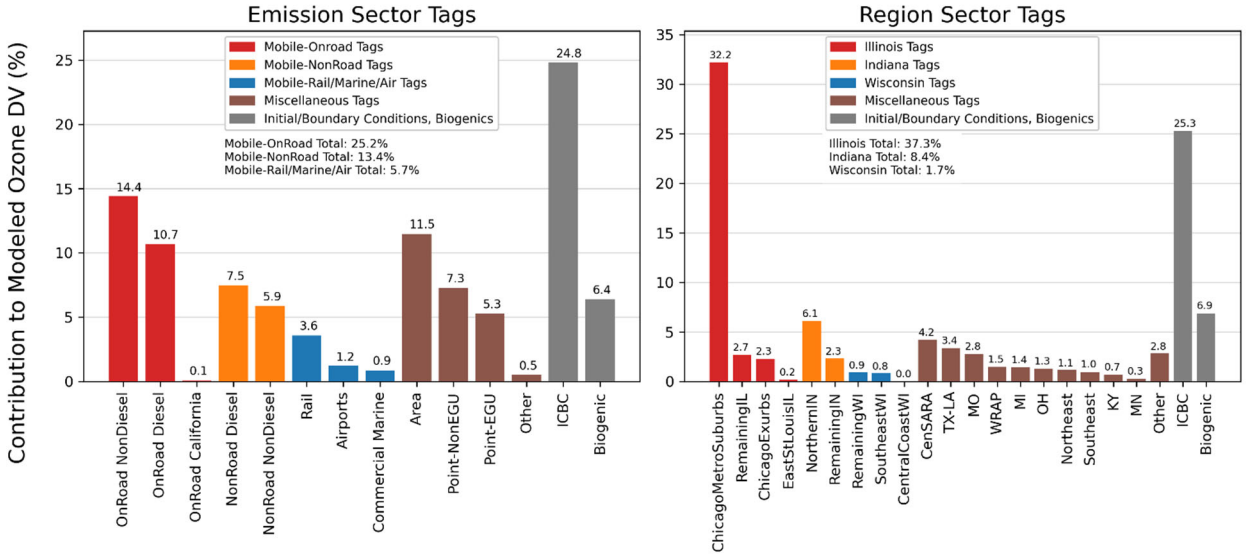

IV. Conclusion

This study demonstrates that ozone concentrations measured in the Door County, Door County-Revised, and Manitowoc County 2015 ozone NAAQS maintenance areas, as well as the Shoreline Sheboygan County and Kenosha County 2008 ozone NAAQS maintenance areas, continue to be dominated by out-of-state emissions transported to the area via prevailing lake breeze circulations and mesoscale meteorological conditions. It is likely that the elevated ozone concentrations observed in the 2021-2024 period (resulting in exceedances of the 2008 and 2015 NAAQS) are the result of above-average regional temperatures and other meteorological conditions, which enhanced ozone formation in areas upwind of Door, Manitowoc, and Sheboygan counties. That ozone was then transported to these lakeshore counties via well-documented meteorological processes, resulting in higher ozone values at the Newport, Manitowoc, Kohler-Andrae, and Chiwaukee Prairie monitors.

Recent modeling efforts independently conclude that Wisconsin emissions contribute very little to ozone in these maintenance areas, with the largest contributors being the upwind states of Illinois and Indiana. In addition, the largest source of emissions is the mobile sector, an area over which Wisconsin has limited ability to control. This indicates that additional control of ozone precursor emissions within Wisconsin – and, especially, within the maintenance areas themselves – is unlikely to have any measurable impact on ozone levels in these areas. Should additional emissions reductions be deemed necessary, those would need to be implemented in the upwind states that are driving these ozone levels. Any additional controls should be focused on the mobile sector, although emissions from stationary source emissions in these upwind states are non-trivial and would benefit from application of widely available control technologies, where not already implemented.

Given these factors, this study concludes that it is unnecessary for the DNR to implement additional emissions control measures within Wisconsin, including the Door County, Door County-Revised, and Manitowoc County 2015 Ozone NAAQS maintenance areas, and the Shoreline Sheboygan County and Kenosha County 2008 ozone NAAQS maintenance areas, for the purpose of maintaining the applicable ozone standards.