2.15 EXTREME/EXCESSIVE HEAT

Extreme heat, or Excessive Heat, in the general sense refers to a prolonged period of time where temperatures are much hotter and/or humid than average. As “average” is subject to factors revolving around time and location, there is not a universal temperature range used to define extreme heat and different sources may have different criteria in the recording and issuing of extreme heat events. In Ohio the five local National Weather Service (NWS) Offices maintain uniformed criteria for issuing Heat Advisories, Excessive Heat Watches, and Excessive Heat Warnings:

- **Excessive Heat Warning**: Issued when the heat index is *expected* to reach around 105°F or higher for a period of at least 2 hours. A warning would also be appropriate if heat advisory criteria are expected to be reached for 4 consecutive days.
- **Excessive Heat Watch**: Issued when there is *potential* for heat index values of 105°F or hotter within the next 24 to 48 hours.
- **Heat Advisories**: Issued for heat index of equal to 100°F and less than 105°F for a period of at least 2 hours.

The NWS utilizes the ‘Heat Index’ to measure the impact of heat experienced by individuals and to gauge potentially dangerous conditions. This table uses relative humidity and air temperature to produce the "apparent temperature" or the temperature the body "feels". While these values were devised for shady and light wind conditions, exposure to direct sunshine can increase heat index values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous as the wind adds heat to the body.

Table 2.15.a – NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure and/or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

	Heat Index/Apparent Temp	Effect on the body
Caution	**80°F - 89°F**	**Fatigue possible with prolonged exposure and/or physical activity**
Extreme Caution	**90°F -104°F**	**Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity**
Danger	**105°F-129°F**	**Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity**
Extreme Danger	**130°F or higher**	**Heat stroke highly likely**

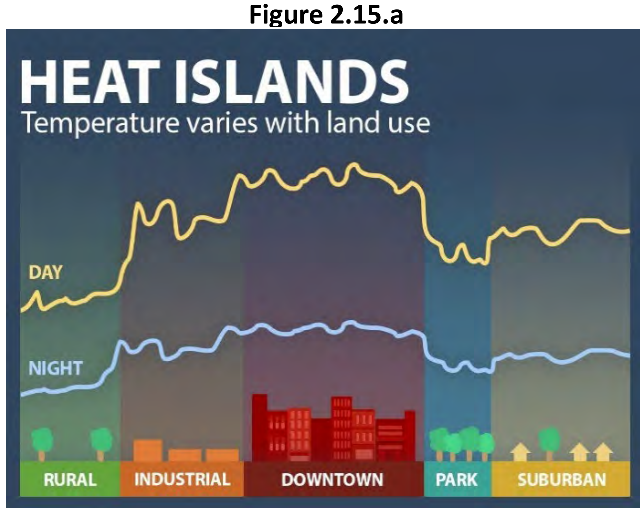
Extreme heat is responsible for the highest number of annual deaths among all weather-related hazards. Some statistical approaches estimate that more than 2,200 deaths per year in the United States are due to extreme heat- and this is expected to increase as extreme heat events (i.e., heat waves) have become more frequent in the United States in recent decades. Studies project that the frequency and intensity of extreme heat events will continue to increase as a consequence of climate change.

When people are exposed to extreme heat, they can suffer from potentially deadly heat-related illnesses such as heat exhaustion and heat stroke. Population groups that face greater risks to the effects of extreme heat include: elderly adults, infants and young children, pregnant women, impoverished households, homeless and transient populations, those with disabilities, and those with pre-existing health conditions. Tracking the rate of reported overall heat-related deaths and heat-related CVD deaths over time provides a measure of how climate change may affect human well-being.

Extreme/Excessive Heat is a statewide hazard and all areas are susceptible to Extreme Heat. Those in highly-developed urban areas face increased exposure susceptibility due to higher densities of people as well from u*rban heat island* effects. Per the National Integrated Heat Health Information System (NIHHIS), the term urban heat island (UHI) refers to the fact that cities tend to get much warmer than their surrounding rural landscapes, particularly during the summer.

This temperature difference occurs when cities' unshaded roads and buildings gain heat during the day and radiate that heat into the surrounding air. Other contributors to UHIs include lack of trees and vegetation, urban canyon effects that block wind flow, and waste heat (heat-emitting devices and vehicles). As a result, highly developed urban areas can experience mid-afternoon temperatures that are 15°F to 20°F warmer than surrounding, vegetated areas. This becomes problematic for developed areas as over 80% of Americans live in urban areas according to the U.S. Census Bureau, and the Urban Heat Island effect means that those urban areas are likely hotter than rural areas.

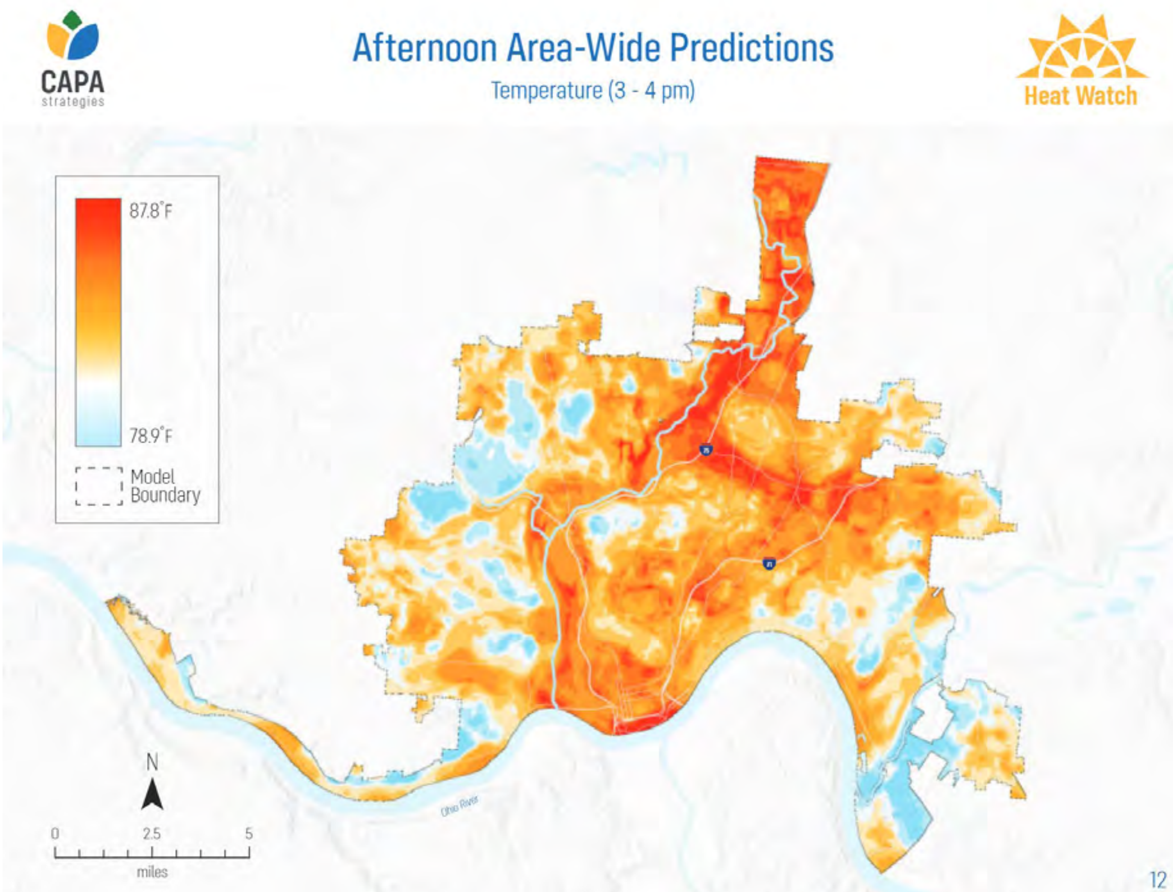
Figure 2.15.a



Source: U.S. EPA 2012, Graphic by [Climate Central]

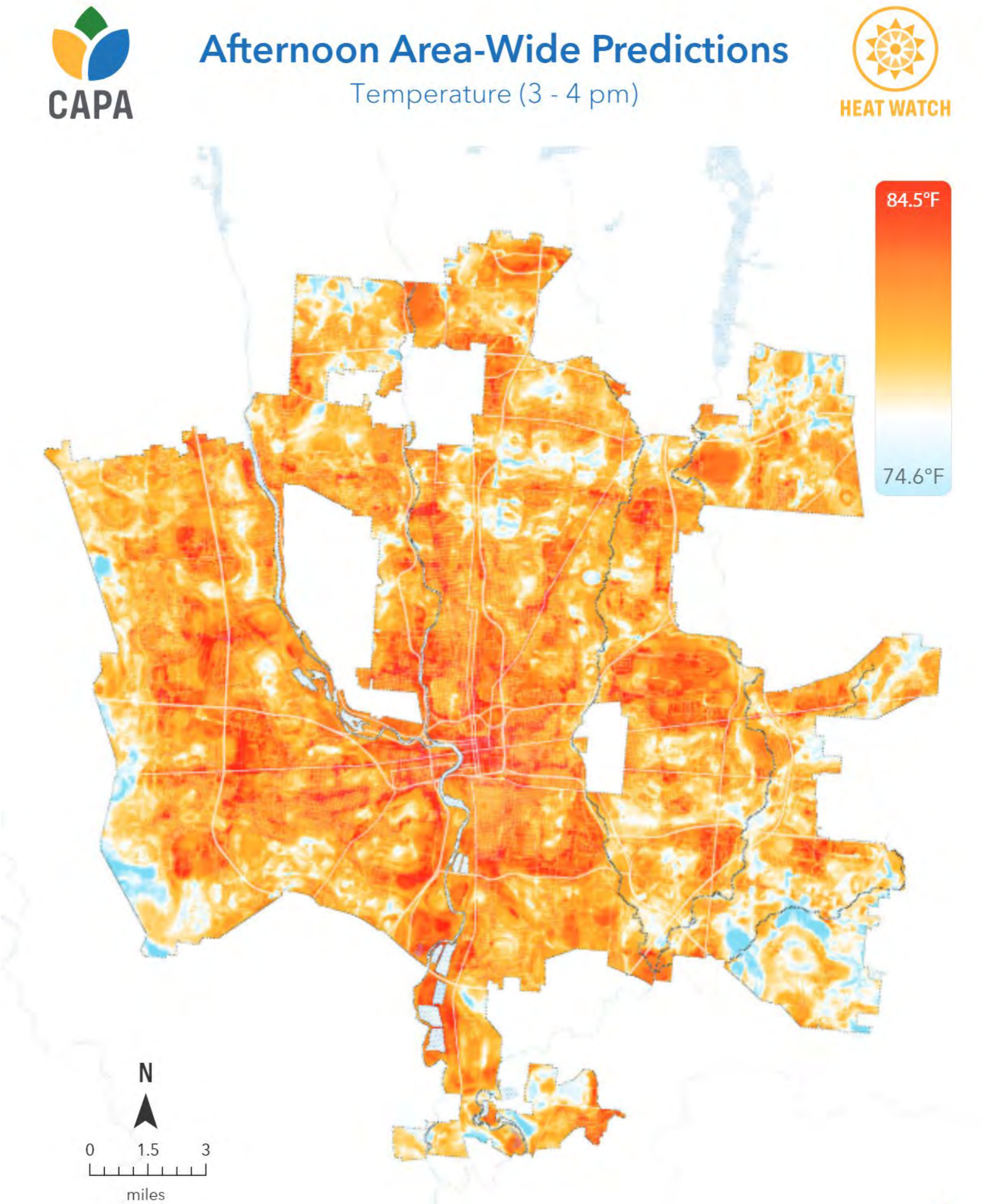
Over the past six years, NOAA (Office of Education, Climate Program Office, National Integrated Heat Health Information System (NIHHIS)) has funded CAPA Heat Watch to support 60+ communities across the United States in mapping their urban heat islands (UHI). This includes a study conducted for Cincinnati (Hamilton County) in August 2020, and Columbus (Franklin County) in August 2022. The City of Toledo (Lucas County) was selected for their 2023 UHI Mapping Campaign, however the study has yet to be published. These heat mapping studies collect thousands of temperature and humidity data points in the morning, afternoon, and evening to generate heat index predictions for different points of the day.

Figure 2.15.b – Projected Areas of Urban Heat Island Effects for Cincinnati, Ohio



Source: NOAA, NIHHIS, CAPA Heat Watch August 2020

Figure 2.15.c– Projected Areas of Urban Heat Island Effects for Columbus, Ohio



Source: NOAA, NIHHIS, CAPA Heat Watch August 2022

Urban heat islands have also been discussed in Local hazard Mitigation Plans (LHMPs) around the state. Butler and Delaware Counties, two of the five fastest growing counties in the state, shows growth in urban areas where excessive heat can also be concentrated and create UHIs. As with most developed areas, the urbanized centers of these counties both hold the highest concentrations of people, and UHI-contributing factors in their respective counties.

Figure 2.15.d – Urban Heat Severity map from the Butler County 2023 HMP

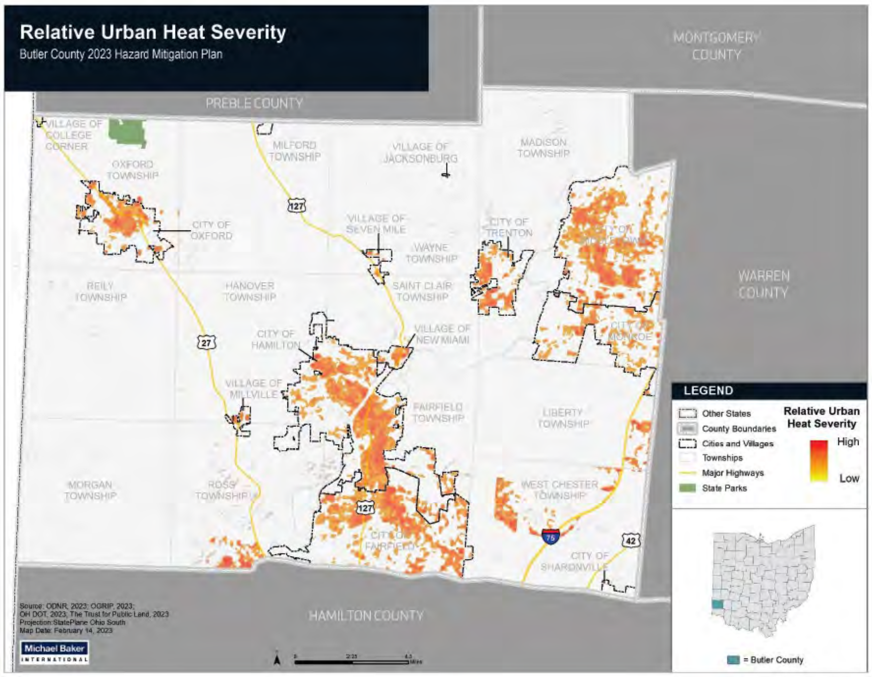
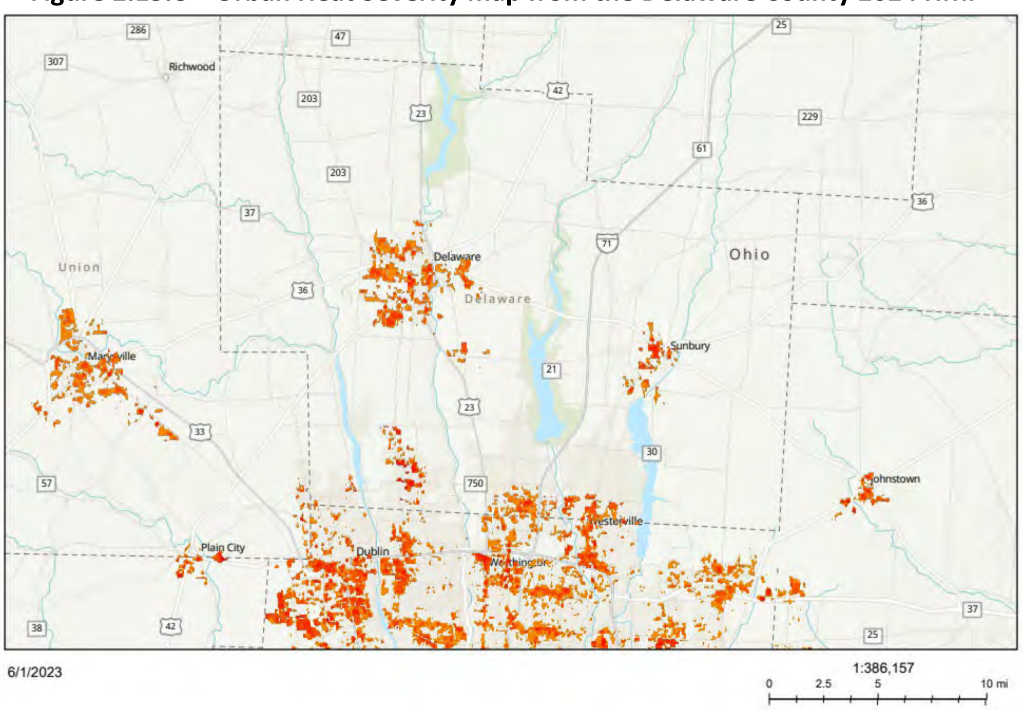


Figure 2.15.e – Urban Heat Severity map from the Delaware County 2024 HMP



PAST OCCURRENCES AND PROBABILITY OF FUTURE EVENTS

Over the 20-year period of January 2003 to January 2023, Heat and Excessive Heat events were reported on the NOAA Storm Events Database on 13 distinct days from different counties around Ohio. These events happen over large regions and are recorded as zone-based events. Based on this, it is estimated that there is approximately a 65% chance of an extreme heat event happening in a given year. This equates to 1-2 events every two years. This 65% is roughly equivalent to the estimated annual frequency rate of Heatwave of the median Ohio county, 65.02%, as estimated by the FEMA National Risk Index (table 2.15.b)

Table 2.15.b

FEMA NRI Heatwave Estimated Annual Frequency by County					
OEMA Region 1		OEMA Region 2		OEMA Region 3	
County	Annual Frequency	County	Annual Frequency	County	Annual Frequency
Allen	111.46%	Ashland	37.15%	Adams	123.84%
Auglaize	86.69%	Butler	142.41%	Ashtabula	16.82%
Champaign	80.50%	Clinton	111.46%	Athens	43.34%
Clark	80.50%	Cuyahoga	37.94%	Belmont	37.15%
Crawford	55.73%	Delaware	68.11%	Brown	130.03%
Darke	86.69%	Fairfield	86.69%	Carroll	30.96%
Defiance	105.26%	Fayette	92.88%	Clermont	148.61%
Erie	50.26%	Franklin	80.50%	Columbiana	30.96%
Fulton	99.07%	Geauga	37.15%	Coshocton	37.15%
Hancock	74.30%	Greene	86.69%	Gallia	37.15%
Hardin	80.50%	Hamilton	352.94%	Guernsey	37.15%
Henry	105.26%	Knox	37.15%	Harrison	37.15%
Huron	49.54%	Lake	30.97%	Highland	105.26%
Logan	86.69%	Licking	74.30%	Hocking	86.69%
Lucas	89.93%	Lorain	43.87%	Holmes	37.15%
Marion	55.73%	Madison	74.30%	Jackson	43.34%
Mercer	86.69%	Medina	30.96%	Jefferson	30.96%
Miami	86.69%	Montgomery	260.06%	Lawrence	37.15%
Ottawa	122.51%	Morrow	43.34%	Mahoning	24.77%
Paulding	111.46%	Pickaway	86.69%	Meigs	37.15%
Preble	99.07%	Portage	24.77%	Monroe	37.15%
Putnam	111.46%	Richland	37.15%	Morgan	43.34%
Sandusky	55.73%	Stark	37.15%	Muskingum	37.15%
Seneca	61.92%	Summit	30.96%	Noble	37.15%
Shelby	86.69%	Union	74.30%	Perry	43.34%
Van Wert	111.46%	Warren	130.03%	Pike	117.65%
Williams	99.07%	Wayne	37.15%	Ross	92.88%
Wood	74.30%			Scioto	123.84%
Wyandot	61.92%			Trumbull	24.77%
				Tuscarawas	37.15%
				Vinton	43.34%
				Washington	37.15%

CDC PROVISIONAL MORTALITY STATISTICS: HEAT-RELATED FATALITIES

The Centers for Disease Control and Prevention (CDC) WONDER is a database that provides access to statistical research data published by the CDC, as well as reference materials, reports and guidelines on health-related topics. It also allows users to query numeric data sets on CDC's computers, via "fill-in-the blank" web pages. Public-use data sets about many other topics are available for query, and the requested data are readily summarized and analyzed, with dynamically calculated statistics, charts and maps. This database was utilized to query CDC statistics on Heat-Related Fatalities:

Table 2.15.c

CDC Provisional Mortality Statistics Heat-Related Deaths [1]		
Year	**Ohio**	**United States**
2018	22	1,012
2019	14	911
2020	19	1,156
2021	16	1,602
2022	13	1,722
2023	18	2,231
TOTAL	**102**	**8,634**

Source: CDC Provisional Mortality Statistics

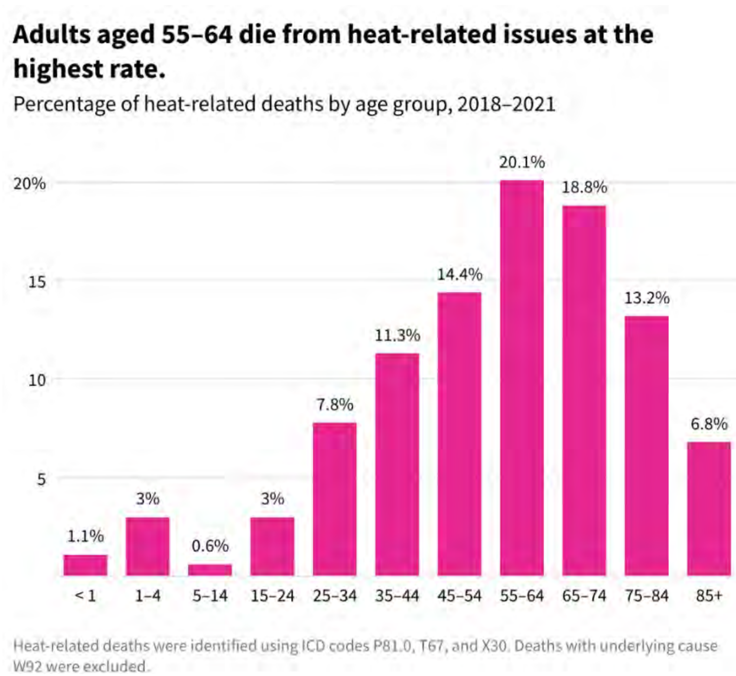
1- Statistics were queried using MCD – ICD- 10 Codes:
P81.0 (Environmental hyperthermia of newborn);
T67.0 (Heatstroke and sunstroke);
T67.1 (Heat syncope);
T67.2 (Heat cramp);
T67.3 (Heat exhaustion, anhydrotic);
T67.4 (Heat exhaustion due to salt depletion);
T67.5 (Heat exhaustion, unspecified);
T67.6 (Heat fatigue, transient);
T67.7 (Heat oedema);
T67.8 (Other effects of heat and light);
T67.9 (Effect of heat and light, unspecified);
X30 (Exposure to excessive natural heat (hyperthermia))

Over the past 6 years, CDC mortality statistics estimate that there was a total of 102 heat-related fatalities in Ohio, and 8,634 fatalities in the entire United States. This is substantially more than what was recorded in the NOAA Storm Events Database.

USAFacts is a not-for-profit, nonpartisan civic-initiative that collects, compiles, and assesses government data and statistics. Using the same Statistic Mortality Codes queried from CDC WONDER, they found that from the years 2018 to 2021, the largest age groups suffering heat-related deaths are between the ages of 55 and 64. This followed by the next age group of 65 to 74.

The CDC notes that older adults, the very young, and people with mental illness and chronic diseases are at the greatest risk for heat-related illnesses and deaths, however even young and healthy people can be affected: more than one in five heat-related deaths occur in Americans aged 15 to 44.

Figure 2.15.f



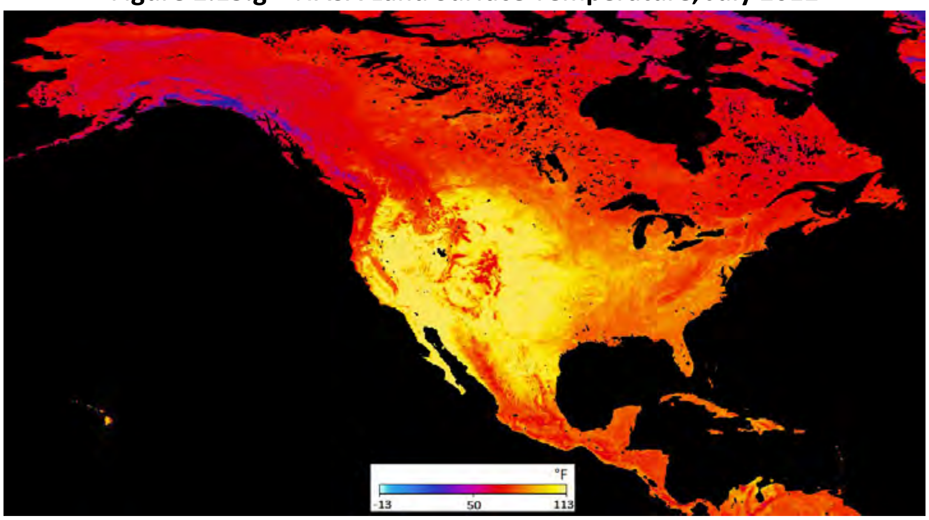
Source: CDC Provisional Mortality Statistics compiled by USAFacts

2012 NORTH AMERICAN HEAT WAVE

Not to be mistaken with the 2012 North American Drought, which happened around the same time in the Summer of 2012. That event is discussed in Section 2.11, Drought. The 2012 North American Heatwave event caused cascading impacts throughout 2012, causing increased evaporation of groundwater, lakes, reservoirs, rivers and streams.

The 2012 North American Heat Wave was one of the most severe heat waves recorded in North American history. Dubbed the "Hottest Year Ever in U.S." by the New York Times *in 2013*, the heat wave was formed when high pressure moved over Baja California, Mexico, strengthened then spread to other parts of North America throughout the Summer of 2012. Under high pressure, the air subsides toward the surface and acts like a dome that traps heat instead of allowing it to lift.

Figure 2.15.g – NASA Land Surface Temperature, July 2012



Source: NASA Earth Observations

Over the Midwest, this high pressure resulted in the warmest year for many states. The state of Ohio as a whole ended up with the warmest year on record. The contiguous United States average annual temperature of 55.3°F was 3.2°F above the 20th century average, and was the warmest year in the 1895-2012 period of record for the nation. One hundred fifty-five (155) people died as a result of extreme heat in 2012. This number is well above the 10-year average for heat related fatalities, 119. The most dangerous place to be was in a permanent home, likely with little or no air conditioning, where a reported 84 (54%) of deaths occurred. Missouri numbered the most heat victims, 34, followed closely by Illinois with 32 heat related deaths. Extreme heat most strongly affected adults aged 50+, with 117 deaths (75%). Many more males, 99 (64%), than females, 56 (36%), were killed by heat. In Ohio, three direct fatalities were reported in Licking County.

While 2012 was dubbed "Hottest Year Ever in US", that statement stood true for only another few years. The New York Times 2013 article cited the sentiment of scientists, doubting that the record would have been set without the backdrop of global warming caused by the human release of greenhouse gasses. They then warned that 2012 was "a foretaste of things to come, as continuing warming makes heat extremes more likely". This ominous prediction is proving to be true as in the following years, NASA and the NOAA declared 2016 to be the warmest year on record globally, tied that record in 2020, and most recently declared 2023 to be North America's (and the world's) warmest year on record by far.

CLIMATE PROJECTIONS

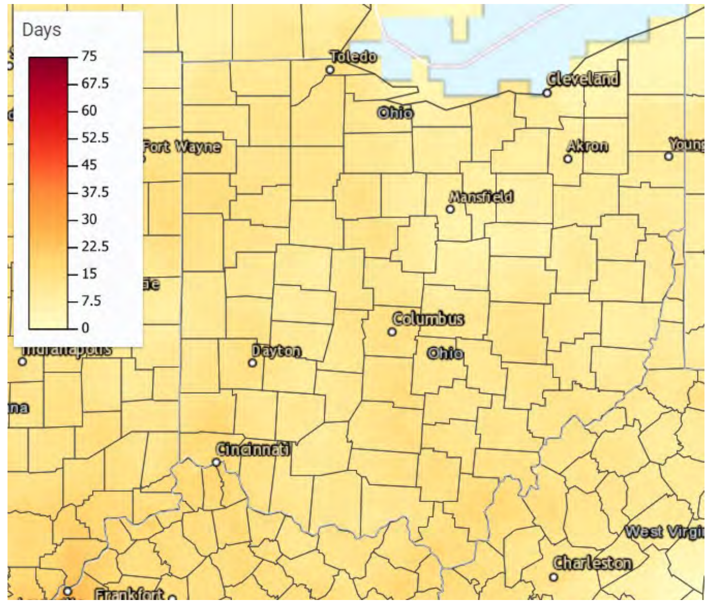
Built to accompany the U.S. Climate Resilience Toolkit, the Climate Explorer graphs projections for two possible futures: one in which humans drastically reduce and stabilize global emissions of heat-trapping gasses (labeled Lower emissions, also known as RCP4.5), and one in which we continue increasing emissions through the end of the 21st century (labeled Higher emissions, also known as RCP8.5).

The Climate Explorer allows users to view temperature and precipitation projections by county. In Ohio, these projections were disseminated for five counties based on different features and attributes: Cuyahoga, Franklin, Hamilton, Washington, and Williams. See "Features and Attributes" for tables 2.15.d/e.

Figure 2.15.h

Projected Days with Maximum Temperature > 105°F

RCP 8.5 (Higher Emissions)



Source: The Climate Explorer

By the year 2090, the Climate Explorer predicts that if humans continue to increase emissions (RCP8.5), Cuyahoga County may face upward of 9 days a year with temperatures over 105°F. For Franklin and Hamilton Counties, the projections are even worse with estimates of 15 to 18 days over 105°F annually. If humans are able to reduce global emissions (RCP 4.5), this projection would be cut down to only one to two days per year. For these larger counties, the increase in hotter days will directly impact the health of larger concentrations of people, as well as contribute to effects such as urban heat islands and increased stress onto the electric grid. Smaller counties will also face a higher number of days over 105°F which will detrimentally impact people and agricultural production.

Tables 2.15.d/e

Projected Days with Maximum Temperature > 105°F RCP 4.5 (Lower Emissions)				
County	Projected Average Number of Days by Year [1]			
	Historic [2]	2030	2060	2090
Cuyahoga [a]	0	0	0	1
Williams [b]	0	0	1	1
Franklin [c]	0	0	1	2
Washington [d]	0	0	1	1
Hamilton [e]	0	0	2	2

Projected Days with Maximum Temperature > 105°F RCP 8.5 (Higher Emissions)				
County	Projected Average Number of Days by Year [1]			
	Historic [2]	2030	2060	2090
Cuyahoga [a]	0	0	2	9
Williams [b]	0	0	3	12
Franklin [c]	0	0	4	15
Washington [d]	0	0	4	13
Hamilton [e]	0	0	5	18

1- *Weighted mean of projected days. Values rounded to nearest integer.*

2- *Based on average of weighted means from years 2005 to 2023. Values rounded to nearest integer.*

Features and Attributes

a- *Northeast Ohio - Population 1,264,817. Higher density, next to Lake Erie.*

b- *Northwest Ohio - Population 37,102. Low density, rural and agricultural.*

c- *Central Ohio- Population 1,323,807. Higher density, relatively flat with mild elevation.*

d- *Southeast Ohio - Population 59,711. Low density, rural and forested, next to Ohio River.*

e- *Southwest Ohio - Population 830,639. Higher density, mild hills, next to Ohio River.*

VULNERABILITY ANALYSIS & LOSS ESTIMATION

IMPACTS ON PROPERTY AND INFRASTRUCTURE

Extreme/Excessive Heat does not pose a direct threat to the structural integrity of buildings. However, the larger threat from extreme heat to buildings would be to their occupants, especially if they fall within a population group with increased risks. The hazard may also indirectly cause physical and economic damage to buildings in regards to maintenance of their mechanical systems such as air conditioning, plumbing, and other utilities. These impacts may be exacerbated by infrastructure failure in an event where increased stress on the electrical grid causes power outages in the form of rolling blackouts and results in losses of function.

Extreme Heat events can also cause damage to roads. Higher temperatures can cause asphalt to soften and form tire-track depressions and eventually crack. Concrete roads can "buckle" when segments expand without the spacing to support it, causing them to push up against each other and potentially raising or breaking. Not only is this damaging to the road itself but to the people and their safety, access to lifelines, and other economic activities. Statistics on road buckling due to heat isn't readily available, however it can be expected that vulnerabilities increase as infrastructure ages and extreme heat events have become more frequent. Maps of local, state, and interstate roads and average annual daily traffic counts can be obtained on the ODOT's Transportation Information Mapping System (TIMS).

Figure 2.15.i – Road Buckling due to Heat on I-77, Noble County

Source: Ohio Department of Transportation, District 10

Additionally, extreme heat can play a cascading role in occurrences and impacts from drought (section 2.11) and wildfires (section 2.7). It also contributes to urban heat island effects within higher-density communities, and the emission greenhouse gases.

IMPACTS ON PEOPLE

As mentioned earlier in this section, the most direct impacts of extreme heat are the impacts to people. Extreme heat is responsible for the highest number of annual deaths among all weather-related hazards. Some statistical approaches estimate that more than 2,200 deaths per year in the United States are due to extreme heat. That number is expected to increase as extreme heat events have become more frequent in recent decades. When people are exposed to extreme heat, they can suffer from potentially deadly heat-related illnesses such as heat exhaustion and heat stroke (see table 2.15.a). Population groups that particularly face greater risks to the effects of extreme heat include: elderly adults, infants and young children, pregnant women, impoverished households, homeless and transient populations, those with disabilities, and those with pre-existing health conditions. As shown in figure 2.15.e, approximately 39% of heat-related deaths in the United States are within the 55 to 74 age group.

Based on the past six years (table 2.15.c, there is an average of 17 heat-related deaths in Ohio annually. Similar to the methodology in the FEMA National Risk Index, population loss is monetized with a *Value of Statistical Life* approach in which each fatality is counted as $11.6 million of economic loss, which equates to an estimated annual population equivalence loss of $197,200,000. This is considered a high estimate as it utilizes CDC WONDER provisional mortality deaths, which is a different dataset from the FEMA National Risk Index which utilizes various data sources including SHELDUS loss records for their estimates seen in tables 2.15.h, i, and j.

Table 2.15.f below summarizes the estimates of people, particularly vulnerable and at-risk populations in the state of Ohio. From the year 2000 to 2020, the state population grew 4% while also gaining over 1-million people in the 55 to 74 age group, roughly 60%. Every county in the state has experienced growth in this particular age group- from Jefferson County having lost 12% of its population over this time while growing 23% specifically in the 55-74 age group. Delaware County seen a 94% growth in total population and a growing 221% in the 55-74 age group.

According to the National Alliance to End Homelessness, between 2007 and 2022, Ohio's total homeless population actually decreased by 5%. The sheltered homeless population decreased by 7%, while the unsheltered population increased by 3%. This small but considerable increase raises concern as this population group lacks access to needs such as shelter, water, and cooling.

It can be expected that impacts on people (especially to vulnerable populations) will increase as the general population grows older, more are people relocating to higher-density areas susceptible to urban heat islands effects, and extreme heat events becoming more frequent.

Table 2.15.f

Extreme Heat Populations at Risk

OEMA Region 1

County	Population Total [1]	Population Under 5	Population 55 to 74	20-year %Δ Pop 55 to 74 [2]	Est. # of Homeless [3]
Allen	102,206	5,982	25,651	48%	66
Auglaize	46,422	2,849	11,869	66%	30
Champaign	38,714	2,160	10,136	54%	25
Clark	136,001	7,719	35,251	39%	88
Crawford	42,025	2,246	11,271	32%	27
Darke	51,881	3,080	13,465	46%	34
Defiance	38,286	2,133	9,883	54%	25
Erie	75,622	3,810	22,152	51%	49
Fulton	42,713	2,438	11,104	75%	28
Hancock	74,920	4,335	18,522	69%	49
Hardin	30,696	1,854	7,039	43%	20
Henry	27,662	1,616	7,227	55%	18
Huron	58,565	3,611	14,914	63%	38
Logan	46,150	2,653	12,395	58%	30
Lucas	431,279	25,063	104,785	55%	494
Marion	65,359	3,535	16,594	53%	42
Mercer	42,528	3,204	10,680	65%	28
Miami	108,774	6,379	27,414	61%	71
Ottawa	40,364	1,710	13,271	60%	26
Paulding	18,806	1,136	4,864	45%	12
Preble	40,999	2,184	11,340	56%	27
Putnam	34,451	2,193	8,703	70%	22
Sandusky	58,896	3,158	16,127	57%	38
Seneca	55,069	2,982	14,124	50%	36
Shelby	48,230	2,994	11,962	69%	31
Van Wert	28,931	1,763	7,364	45%	19
Williams	37,102	2,046	9,781	53%	24
Wood	132,248	6,842	30,335	86%	86
Wyandot	21,900	1,265	5,833	49%	14
Total	**1,976,799**	**112,940**	**504,056**	**56%**	**1,285**

OEMA Region 2

County	Population Total [1]	Population Under 5	Population 55 to 74	20-year %Δ Pop 55 to 74 [2]	Est. # of Homeless [3]
Ashland	52,447	2,930	13,436	54%	34
Butler	390,357	22,751	87,808	86%	254
Clinton	42,018	2,445	10,834	78%	27
Cuyahoga	1,264,817	66,746	320,205	40%	1,574
Delaware	214,124	12,776	45,362	221%	139
Fairfield	158,921	9,489	37,081	97%	103
Fayette	28,951	1,643	7,380	49%	19
Franklin	1,323,807	85,902	251,996	87%	1,912
Geauga	95,397	4,952	26,881	73%	62
Greene	167,966	9,210	40,363	72%	109
Hamilton	830,639	49,503	188,316	47%	1,081
Knox	62,721	3,767	15,692	72%	41
Lake	232,603	10,995	65,166	65%	151
Licking	178,519	10,349	44,027	85%	116
Lorain	312,964	16,799	81,809	84%	203
Madison	43,824	2,271	10,613	77%	28
Medina	182,470	9,259	48,223	114%	119
Montgomery	537,309	31,034	131,086	42%	656
Morrow	34,950	1,945	9,307	79%	23
Pickaway	58,539	3,213	13,631	65%	38
Portage	161,791	7,113	40,988	81%	105
Richland	124,936	6,738	31,989	41%	81
Stark	374,853	20,211	98,537	51%	247
Summit	540,428	28,734	140,081	61%	441
Union	62,784	3,993	12,805	137%	41
Warren	242,337	13,821	55,359	161%	158
Wayne	116,894	7,376	28,569	64%	76
Total	**7,837,366**	**445,965**	**1,857,544**	**65%**	**5,094**

OEMA Region 3

County	Population Total [1]	Population Under 5	Population 55 to 74	20-year %Δ Pop 55 to 74 [2]	Est. # of Homeless [3]
Adams	27,477	1,676	7,152	49%	18
Ashtabula	97,574	5,331	26,859	52%	63
Athens	62,431	2,617	12,093	62%	41
Belmont	66,497	3,080	19,026	43%	43
Brown	43,676	2,452	11,834	77%	28
Carroll	26,721	1,363	8,043	50%	17
Clermont	208,601	11,715	52,776	115%	136
Columbiana	101,877	4,986	29,046	47%	66
Coshocton	36,612	2,370	9,566	45%	24
Gallia	29,220	1,754	7,583	35%	19
Guernsey	38,438	2,185	10,412	41%	25
Harrison	14,483	736	4,314	36%	9
Highland	43,317	2,668	10,897	55%	28
Hocking	28,050	1,507	7,701	50%	18
Holmes	44,223	3,864	8,386	68%	29
Jackson	32,653	1,965	8,159	51%	21
Jefferson	65,249	3,251	18,443	23%	42
Lawrence	58,240	2,989	15,319	31%	38
Mahoning	228,614	11,542	63,971	37%	174
Meigs	22,210	1,123	6,172	45%	14
Monroe	13,385	667	3,931	24%	9
Morgan	13,802	718	3,957	36%	9
Muskingum	86,410	4,993	21,734	53%	56
Noble	14,115	684	3,474	55%	9
Perry	35,408	2,162	9,081	73%	23
Pike	27,088	1,655	6,849	52%	18
Ross	77,093	4,215	19,354	63%	50
Scioto	74,008	3,977	18,520	32%	48
Trumbull	201,977	10,160	56,894	38%	131
Tuscarawas	93,263	5,499	24,165	54%	61
Vinton	12,800	646	3,503	62%	8
Washington	59,771	2,979	16,659	42%	39
Total	**1,797,801**	**97,905**	**479,769**	**49%**	**1,169**

1- Population estimates based on US Decennial 2020 Census
2- 20-year Percent Change in population groups based on comparison of population age groups from the 2000 and 2020 Decennial Census
3- 2022 Estimate using: U.S Department of Housing and Urban Development (HUD) PIT Data, and further curated by the National Alliance to End Homelessness.

IMPACTS ON AGRICULTURE

According to the Fourth National Climate Assessment (NCA2018), projections of mid-century yields of commodity crops show declines of 5% to over 25% below extrapolated trends broadly across the region for corn and more than 25% for soybeans in the southern half of the Midwest, with possible increases in yield in the northern half of the region. Increases in growing-season temperature in the Midwest are projected to be the largest contributing factor to declines in the productivity of U.S. agriculture. In particular, heat stress in corn during the reproductive period is projected to reduce yields in the second half of the 21st century. The NCA2018 cited *Climate Impacts on Agriculture: Implications for Crop Production* by J. L. Hatfield, K. J. Boote, B. A. Kimball, L. H. Ziska, R. C. Izaurralde, D. Ort, A. M. Thomson, D. Wolfe in which it was found that the rate of reproduction for corn begins to decrease at 35°C, or 95°F, and the photosynthetic rates declined by 50-60% at 105°F. For soybeans, the rate of reproduction begins to decrease at 102°F while the rate of grow decreases at 101°F.

In the USDA 2022 State of Ohio Agricultural Overview, Corn and Soybeans accounted for the majority of the crops planted, harvested, and the value of crop production in the State. Soybeans accounted for 5,100,000 acres (56%) planted for crops and $4,059,936,000 (40%) of the crop production value. Corn accounted for 3,400,000 (37%) of acres planted and $3,835,557,000 (38%) of crop production value. For estimates of crop cash receipts for each county, see Section 2.11, tables 2.11.f/g/h. For additional information on specific crop types and production by county, refer to the USDA Annual Statistical Bulletins. As the number of days over 105°F in Ohio are expected increase by the end of the century, it will pose a direct threat to the agricultural economy in many parts of the state.

Table 2.15.g

Crops - Planted, Harvested, Yield, Production, Price (MYA), Value of Production †
Sorted by Value of Production in Dollars

Commodity	Planted All Purpose Acres	Harvested Acres	Yield	Production	Price per Unit	Value of Production in Dollars
SOYBEANS						
SOYBEANS	5,100,000	5,080,000	55.5 BU / ACRE	281,940,000 BU	14.4 $ / BU	$4,059,936,000
CORN						
CORN	3,400,000	3,180,000	187 BU / ACRE	594,660,000 BU	6.45 $ / BU	$3,835,557,000
HAY & HAYLAGE						
HAY & HAYLAGE	N/A	880,000	2.93 TONS / ACRE, DRY BASIS	2,580,000 TONS, DRY BASIS	N/A	$418,752,000
HAY						
HAY	N/A	830,000	2.7 TONS / ACRE	2,243,000 TONS	162 $ / TON	$360,754,000
WHEAT						
WHEAT	510,000	465,000	79 BU / ACRE	36,735,000 BU	7.85 $ / BU	$292,043,000
PUMPKINS						
PUMPKINS	4,000	3,800	175 CWT / ACRE	665,000 CWT	22.4 $ / CWT	$14,791,000
OATS						
OATS	50,000	15,000	70 BU / ACRE	1,050,000 BU	5.4 $ / BU	$5,670,000

Source: U. S. Department of Agriculture - National Agricultural Statistics Service, 2022 State Agricultural Overview for Ohio

FEMA NATIONAL RISK INDEX

In the National Risk Index, a heat wave hazard risk index score and rating represent a community's relative risk for heat waves when compared to the rest of the United States. Generally, the heat wave exposure value represents a community's agriculture and building values (in dollars), and population (in both people and population equivalence) exposed to heat waves. The Expected Annual Loss (EAL) represents the relative level of agriculture, building, and population loss each year due to heat waves. For more information on current methodology and data, refer to section 12 of the National Risk Index Technical Manual.

Table 2.15.h

FEMA National Risk Index Heat Wave Analysis, October 2023, OEMA Region 1							
County	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	EAL (Buildings)	EAL (Pop. Equiv)	EAL (Agriculture)	EAL (Total)
Allen	$ 22,716,703,979	102,191	$ 160,496,256	$ 819	$ 49,165	$ 9,878	$ 59,861
Auglaize	$ 9,860,531,608	46,399	$ 237,335,321	$ 276	$ 17,362	$ 11,361	$ 29,000
Champaign	$ 7,667,574,489	38,673	$ 137,134,143	$ 200	$ 95,809	$ 6,096	$ 102,104
Clark	$ 26,184,414,152	135,980	$ 145,090,222	$ 682	$ 336,878	$ 6,449	$ 344,009
Crawford	$ 7,313,887,213	42,015	$ 268,368,664	$ 551	$ 47,995	$ 8,258	$ 56,804
Darke	$ 14,009,127,924	51,868	$ 592,046,670	$ 1,642	$ 19,409	$ 28,341	$ 49,392
Defiance	$ 8,087,441,978	38,229	$ 123,028,714	$ 1,151	$ 82,487	$ 7,151	$ 90,790
Erie	$ 17,826,579,068	75,596	$ 108,040,692	$ 1,045	$ 67,165	$ 2,586	$ 70,796
Fulton	$ 9,458,064,062	42,713	$ 198,555,183	$ 1,267	$ 86,741	$ 10,862	$ 98,871
Hancock	$ 15,955,315,753	74,885	$ 155,722,617	$ 1,603	$ 114,057	$ 6,389	$ 122,050
Hardin	$ 5,771,778,889	30,690	$ 255,601,798	$ 150	$ 50,639	$ 11,361	$ 62,151
Henry	$ 6,671,428,521	27,662	$ 153,003,310	$ 950	$ 59,687	$ 8,894	$ 69,530
Huron	$ 12,267,907,773	58,532	$ 229,320,807	$ 822	$ 59,433	$ 6,273	$ 66,528
Logan	$ 13,072,495,063	45,835	$ 139,648,149	$ 366	$ 122,287	$ 6,685	$ 129,338
Lucas	$ 84,065,353,547	431,225	$ 58,114,456	$ 7,744	$ 602,065	$ 2,186	$ 611,994
Marion	$ 12,618,822,345	65,349	$ 155,912,944	$ 227	$ 74,650	$ 4,798	$ 79,675
Mercer	$ 13,482,824,605	42,522	$ 724,437,877	$ 1,581	$ 15,911	$ 34,678	$ 52,170
Miami	$ 24,042,803,617	108,774	$ 122,404,090	$ 674	$ 40,703	$ 5,859	$ 47,236
Ottawa	$ 13,873,314,133	40,343	$ 67,919,699	$ 1,046	$ 46,085	$ 2,090	$ 49,220
Paulding	$ 5,212,442,255	18,790	$ 198,980,415	$ 786	$ 42,929	$ 12,246	$ 55,961
Preble	$ 8,365,924,518	40,984	$ 167,747,600	$ 1,121	$ 17,527	$ 9,177	$ 27,825
Putnam	$ 6,676,183,788	34,443	$ 246,010,331	$ 1,006	$ 78,690	$ 15,141	$ 94,837
Sandusky	$ 13,863,139,112	58,813	$ 115,856,168	$ 1,045	$ 67,183	$ 3,565	$ 71,794
Seneca	$ 11,329,882,437	55,063	$ 161,581,658	$ 949	$ 69,889	$ 5,525	$ 76,362
Shelby	$ 14,107,349,800	48,215	$ 204,457,715	$ 396	$ 18,042	$ 9,787	$ 28,224
Van Wert	$ 5,627,989,417	28,929	$ 219,408,525	$ 848	$ 13,918	$ 13,504	$ 28,270
Williams	$ 9,168,318,554	37,098	$ 140,850,996	$ 1,228	$ 75,338	$ 7,706	$ 84,273
Wood	$ 34,370,106,132	132,182	$ 182,623,882	$ 3,454	$ 201,326	$ 7,493	$ 212,273
Wyandot	$ 4,936,442,675	21,893	$ 180,432,174	$ 413	$ 27,788	$ 6,169	$ 34,370
Total	$ 438,604,147,408	1,975,890	$ 5,850,131,076	$ 34,044	$ 2,601,158	$ 270,507	$ 2,905,709

Table 2.15.i

FEMA National Risk Index Heat Wave Analysis, October 2023, OEMA Region 2							
County	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	EAL (Buildings)	EAL (Pop. Equiv)	EAL (Agriculture)	EAL (Total)
Ashland	$ 13,803,678,610	52,443	$ 130,487,461	$ 166	$ 39,938	$ 2,677	$ 42,781
Butler	$ 75,012,163,121	390,244	$ 62,955,865	$ 14,448	$ 239,901	$ 4,951	$ 259,300
Clinton	$ 10,400,043,228	41,956	$ 134,061,383	$ 375	$ 143,920	$ 8,251	$ 152,546
Cuyahoga	$ 244,271,620,347	1,264,334	$ 7,139,284	$ 116	$ 2,057,309	$ 146	$ 2,057,572
Delaware	$ 54,674,879,026	213,208	$ 99,598,499	$ 1,204	$ 446,942	$ 3,746	$ 451,893
Fairfield	$ 29,693,562,383	158,878	$ 114,416,499	$ 832	$ 423,884	$ 5,477	$ 430,194
Fayette	$ 7,200,569,590	28,951	$ 145,919,280	$ 216	$ 82,758	$ 7,484	$ 90,458
Franklin	$ 236,422,364,692	1,323,446	$ 59,817,357	$ 244	$ 3,375,411	$ 2,659	$ 3,378,314
Geauga	$ 21,951,348,661	95,397	$ 41,416,609	$ 1,103	$ 72,652	$ 850	$ 74,604
Greene	$ 32,904,559,550	167,939	$ 111,374,164	$ 923	$ 448,059	$ 5,331	$ 454,312
Hamilton	$ 153,888,332,381	830,621	$ 26,421,546	$ 696	$ 4,384,352	$ 5,149	$ 4,390,198
Knox	$ 14,262,973,508	62,691	$ 155,013,155	$ 171	$ 47,742	$ 3,180	$ 51,094
Lake	$ 45,763,676,596	232,492	$ 84,443,953	$ 1,916	$ 147,554	$ 1,448	$ 150,918
Licking	$ 37,618,983,655	178,382	$ 212,638,122	$ 904	$ 651,210	$ 8,725	$ 660,838
Lorain	$ 63,415,048,848	312,902	$ 153,571,419	$ 3,717	$ 278,005	$ 3,676	$ 285,398
Madison	$ 8,575,778,256	43,789	$ 182,647,724	$ 206	$ 100,139	$ 7,494	$ 107,839
Medina	$ 38,977,305,363	182,378	$ 59,097,992	$ 1,632	$ 115,741	$ 1,010	$ 118,384
Montgomery	$ 99,451,626,775	537,192	$ 90,263,913	$ 8,365	$ 794,632	$ 12,962	$ 815,959
Morrow	$ 6,740,057,169	34,943	$ 96,569,984	$ 94	$ 31,046	$ 2,311	$ 33,452
Pickaway	$ 12,399,763,844	58,527	$ 186,562,233	$ 348	$ 156,149	$ 8,930	$ 165,427
Portage	$ 32,692,818,126	161,780	$ 39,552,855	$ 1,095	$ 82,136	$ 541	$ 83,772
Richland	$ 24,198,309,075	124,906	$ 155,034,818	$ 291	$ 95,122	$ 3,181	$ 98,593
Stark	$ 76,095,235,247	374,812	$ 109,916,533	$ 3,824	$ 285,438	$ 2,255	$ 291,516
Summit	$ 108,471,919,232	540,333	$ 14,459,158	$ 4,542	$ 342,908	$ 247	$ 347,698
Union	$ 13,980,628,662	62,265	$ 240,069,700	$ 336	$ 142,390	$ 9,850	$ 152,576
Warren	$ 49,577,832,622	242,269	$ 54,672,546	$ 2,085	$ 135,983	$ 3,926	$ 141,994
Wayne	$ 24,062,125,634	116,847	$ 376,044,644	$ 1,209	$ 88,985	$ 7,715	$ 97,908
Total	$ 1,536,507,204,200	7,833,924	$ 3,144,166,696	$ 51,060	$ 15,210,306	$ 124,172	$ 15,385,538

Table 2.15.j

FEMA National Risk Index Heat Wave Analysis, October 2023, OEMA Region 3							
County	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	EAL (Buildings)	EAL (Pop. Equiv)	EAL (Agriculture)	EAL (Total)
Adams	$ 7,250,017,139	27,463	$ 46,001,867	$ 290	$ 104,673	$ 3,146	$ 108,109
Ashtabula	$ 20,560,536,719	97,518	$ 66,415,498	$ 317	$ 108,345	$ 667	$ 109,329
Athens	$ 11,699,628,860	62,393	$ 13,104,471	$ 164	$ 83,232	$ 314	$ 83,709
Belmont	$ 13,488,466,636	66,461	$ 29,087,217	$ 2,399	$ 231,132	$ 597	$ 234,128
Brown	$ 8,791,644,984	43,652	$ 82,277,263	$ 370	$ 174,694	$ 5,908	$ 180,972
Carroll	$ 5,326,823,085	26,701	$ 55,775,343	$ 789	$ 77,382	$ 954	$ 79,125
Clermont	$ 36,078,125,690	208,527	$ 36,442,863	$ 1,734	$ 133,765	$ 2,991	$ 138,489
Columbiana	$ 21,193,341,284	101,872	$ 122,355,264	$ 887	$ 295,235	$ 2,092	$ 298,214
Coshocton	$ 7,743,404,536	36,580	$ 113,678,424	$ 93	$ 41,826	$ 2,332	$ 44,252
Gallia	$ 5,985,030,900	29,179	$ 21,771,339	$ 72	$ 33,364	$ 447	$ 33,882
Guernsey	$ 8,571,916,308	38,372	$ 30,718,163	$ 103	$ 43,875	$ 630	$ 44,609
Harrison	$ 2,837,123,823	14,475	$ 21,371,245	$ 505	$ 50,340	$ 438	$ 51,283
Highland	$ 10,507,327,608	43,282	$ 140,989,067	$ 358	$ 140,221	$ 8,195	$ 148,773
Hocking	$ 6,751,958,435	28,040	$ 5,834,953	$ 189	$ 74,810	$ 279	$ 75,279
Holmes	$ 11,951,498,604	44,196	$ 208,850,782	$ 144	$ 33,657	$ 4,285	$ 38,086
Jackson	$ 6,971,680,704	32,646	$ 12,654,530	$ 98	$ 43,550	$ 303	$ 43,950
Jefferson	$ 15,713,558,690	65,187	$ 10,548,230	$ 2,329	$ 188,918	$ 180	$ 191,427
Lawrence	$ 9,823,219,144	58,183	$ 4,625,383	$ 494	$ 203,149	$ 95	$ 203,738
Mahoning	$ 48,322,567,878	228,579	$ 78,699,686	$ 1,619	$ 529,955	$ 1,076	$ 532,650
Meigs	$ 4,709,053,511	22,183	$ 19,054,372	$ 57	$ 25,365	$ 391	$ 25,812
Monroe	$ 4,269,411,186	13,379	$ 16,020,912	$ 759	$ 46,528	$ 329	$ 47,616
Morgan	$ 2,734,311,820	13,787	$ 20,660,347	$ 38	$ 18,392	$ 494	$ 18,925
Muskingum	$ 18,106,752,065	86,374	$ 80,370,075	$ 218	$ 98,762	$ 1,649	$ 100,628
Noble	$ 4,120,330,194	14,107	$ 8,365,126	$ 733	$ 49,060	$ 172	$ 49,964
Perry	$ 5,607,927,097	35,327	$ 38,807,640	$ 79	$ 47,126	$ 929	$ 48,133
Pike	$ 6,578,325,422	27,037	$ 63,156,277	$ 250	$ 97,897	$ 4,103	$ 102,250
Ross	$ 13,696,889,485	77,071	$ 89,156,257	$ 411	$ 220,312	$ 4,573	$ 225,296
Scioto	$ 11,861,302,547	73,911	$ 20,459,899	$ 475	$ 281,705	$ 1,399	$ 283,579
Trumbull	$ 42,033,156,468	201,961	$ 64,314,882	$ 1,408	$ 468,249	$ 880	$ 470,537
Tuscarawas	$ 19,321,270,818	93,231	$ 143,573,861	$ 232	$ 71,000	$ 2,945	$ 74,178
Vinton	$ 2,259,117,031	12,767	$ 6,529,618	$ 32	$ 17,031	$ 156	$ 17,219
Washington	$ 11,589,652,639	59,732	$ 48,217,160	$ 259	$ 69,096	$ 989	$ 70,344
Total	$ 406,455,371,310	1,984,173	$ 1,719,888,014	$ 17,904	$ 4,102,645	$ 53,936	$ 4,174,485

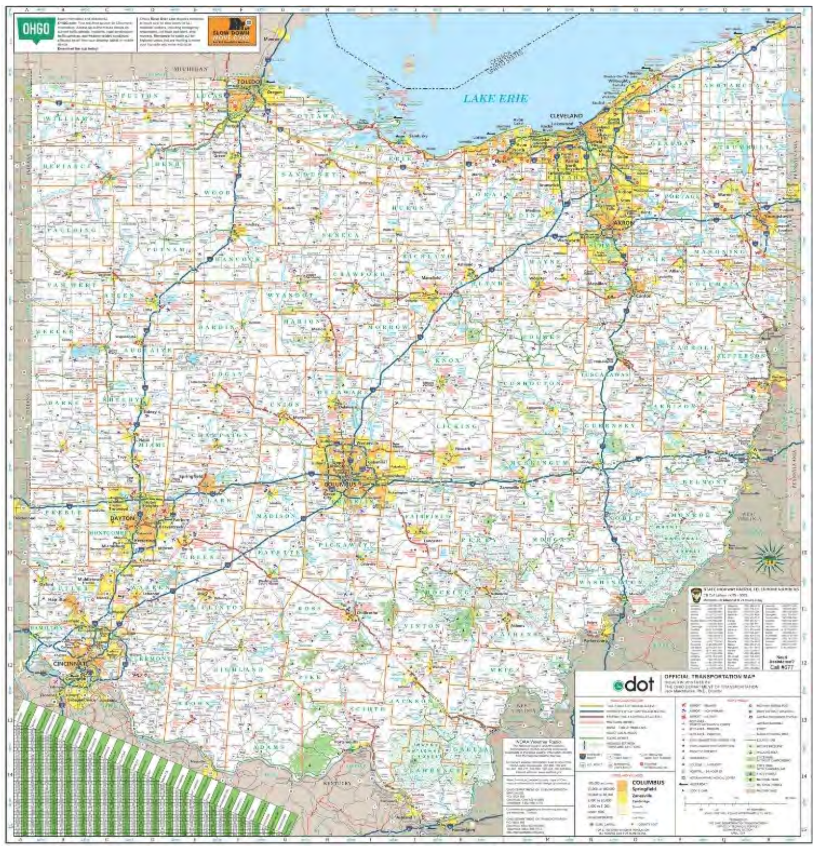
STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

As mentioned earlier in this section, extreme/excessive heat does not pose a direct threat to the structural integrity of state-owned or state-leased facilities. However, the larger threat from extreme heat to these facilities would be to their occupants, especially if they fall in a population group with increased risks. Extreme heat may also indirectly cause physical and economic damage to these facilities in regards to the maintenance of their mechanical systems such as air conditioning, plumbing, and other utilities. These impacts may be exacerbated by infrastructure failure in an event where increased stress on the electrical grid causes power outages in the form of rolling blackouts and results in losses of function. For a list of state-owned and state-leased critical facilities by county, refer to Appendix C.

Extreme heat will also impact state roads, as higher temperatures will soften and break asphalt, and cause buckling in concrete roads. Maps of local, state, and interstate roads and average annual daily traffic counts can be obtained from the Ohio Department of Transportation, and their Transportation Information Mapping System (TIMS).

Additionally, extreme heat plays a cascading role in the occurrences and impacts from drought (section 2.11) and wildfires (section 2.7). It also contributes to urban heat island effects within higher-density communities, and the emission greenhouse gases. It can be expected that vulnerabilities to state-own and state-leased facilities and infrastructure will increase as infrastructure ages and extreme heat events become more frequent.

Figure 2.15.j -- Map of select local, state, and interstate roads



Source: The Ohio Department of Transportation