Grand Traverse Band of Ottawa and Chippewa Indians Natural Hazard Mitigation Plan

March 11, 2022

Networks Northwest

Talent / Business / Community

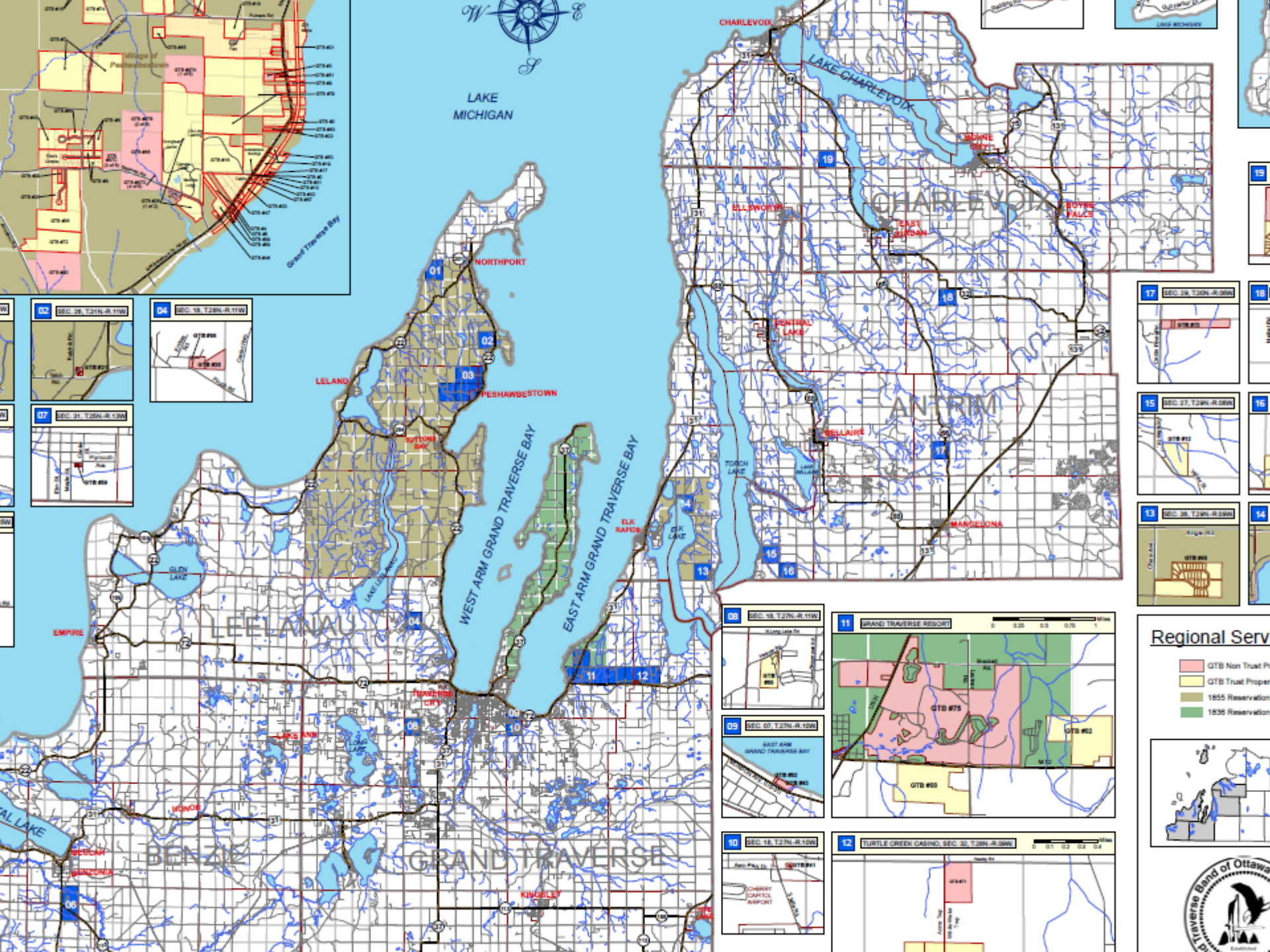
Welcome

- Thank you for joining us!
- We will be discussing the following:
  - Historic Weather Events
  - Hazard Identification

2020 FEMA Grant Awards

Building Resilient Infrastructure and Communities (BRIC) funding program

- $700 million available for FY 2020
- $20 million was set aside for federally recognized tribes.
  - For the tribal set-aside, FEMA received submittals by 40 federally recognized tribes, in which 38 tribes have been selected for further review for more than $26.1 million in total project costs.
  - Resilient Building Code Implementation
  - Drainage improvements
  - Storm shelters


LAKE MICHIGAN
LAKE CHARLEVOIX
CHARLEVOIX
ANTRIM
LEELANAU
BENZIE
GRAND TRAVERSE
WEST ARM GRAND TRAVERSE BAY
EAST ARM GRAND TRAVERSE BAY
Grand Traverse Bay
CHARLEVOIX
NORTHPORT
LELAND
SUTTONS BAY
PESHAWBESTOWN
ELLSWORTH
EAST JORDAN
BOYNE FALLS
CENTRAL LAKE
BELLAIRE
TORCH LAKE
MANCELONA
ELK RAPIDS
ELK LAKE
GLEN LAKE
EMPIRE
TRAVERSE CITY
LAKE ANN
HONOR
BEULAH
BENZONIA
KINGSLEY
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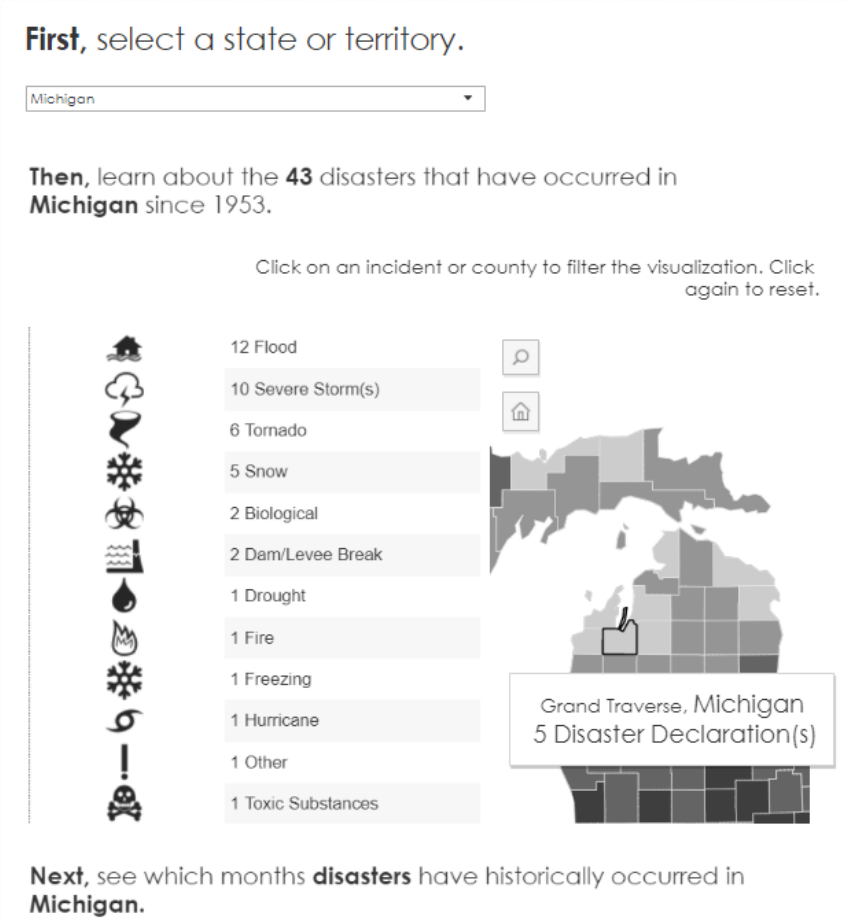
SEC. 26, T31N.-R.11W.
SEC. 18, T28N.-R.11W.
SEC. 31, T25N.-R.13W.
SEC. 18, T27N.-R.11W.
SEC. 07, T27N.-R.10W.
SEC. 18, T27N.-R.10W.
GRAND TRAVERSE RESORT
TURTLE CREEK CASINO, SEC. 32, T.28N.-R.09W.
SEC. 29, T.30N.-R.06W.
SEC. 27, T.29N.-R.08W.
SEC. 36, T.29N.-R.09W.
GTB #75
GTB #02
GTB #03
Regional Serv
GTB Non Trust Pr
GTB Trust Proper
1855 Reservation
1836 Reservation

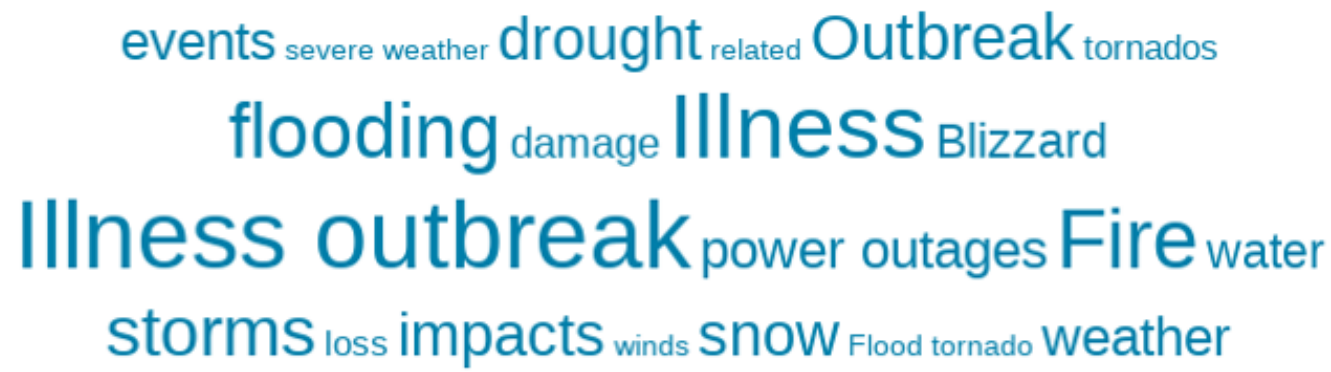
Historic Federal and Governor Declared Emergencies/Disasters



FEMA's Records of Disaster Declarations for States and Counties: https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties

Community Survey Responses

Q4 What type of natural hazard events are likely to have the largest impact on your community (for example: fire, flood, drought, illness outbreak, etc.)?



Presidential and Governor Declared Emergencies/Disasters

- **March 10, 2020: Governor Whitmer declared a State of Emergency** in Michigan to address the COVID-19 pandemic.
- **March 13, 2020:** the **U.S. made a National Emergency Declaration** regarding the COVID-19 virus outbreak. The Federal government began developing a sweeping relief package.
- **March 23, 2020: Governor Whitmer announced an order for all Michigan businesses and operations to temporarily suspend in-person operations** that are not necessary to sustain or protect life, and to stay home unless they are part of the critical infrastructure workforce, engaging in outdoor activities, or performing necessary tasks (e.g. going to the grocery store).
- **March 26, 2020: Governor Whitmer requested a Major Disaster Declaration for the State of Michigan due to the Coronavirus Disease 2019 (COVID-19) pandemic beginning on January 20, 2020, and continuing.** The Governor requested a declaration for Individual Assistance (all programs) statewide; Public Assistance (Categories A-G), including direct Federal assistance, statewide; and Hazard Mitigation statewide. The Governor also requested that the cost-sharing requirement be waived for this disaster.
- **March 27, 2020: President Trump approved Governor Whitmer's request for a Major Disaster Declaration in Michigan**, which allows Michigan to participate in FEMA programming.

Presidential and Governor Declared Emergencies/Disasters

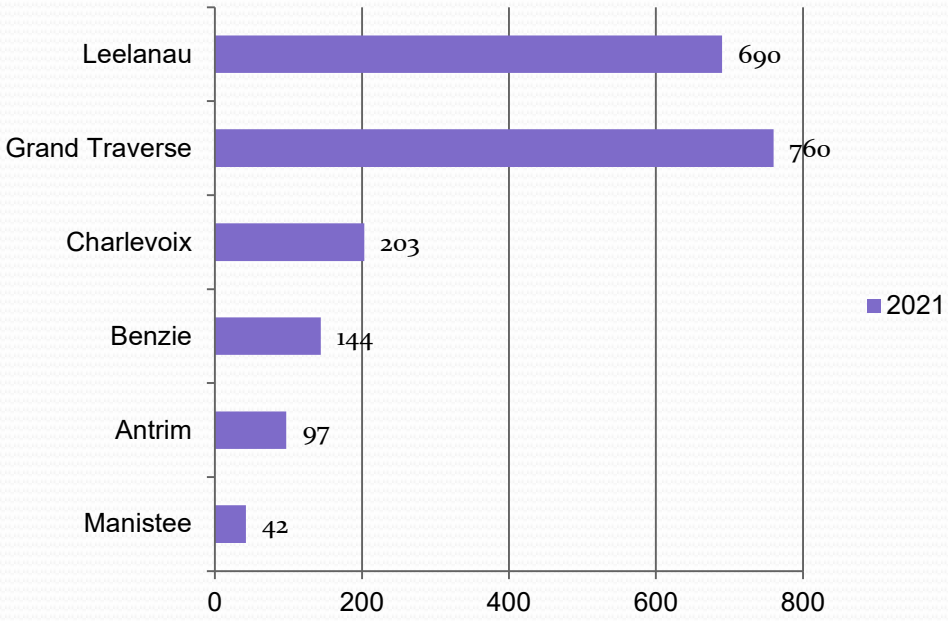
Disaster/Emergency Declarations by the Governor or President, 2019-1956, for the 6-county region for the GTB Tribe	
Incident Type	**Number of Incidents**
Flooding (1986, 2008, 2013)	3
Deep Frost/Underground Freeze (1993-94, 2014)	2
Thunderstorms (2008, 2015)	2
Tornado (1956)	1
Blizzard, Snowstorm (1978)	1
Great Lakes Flooding, Wave Action (1986)	1
Extreme Cold (2019)	1
Drought (1977)	1
Hurricane Evacuation (2005)	1

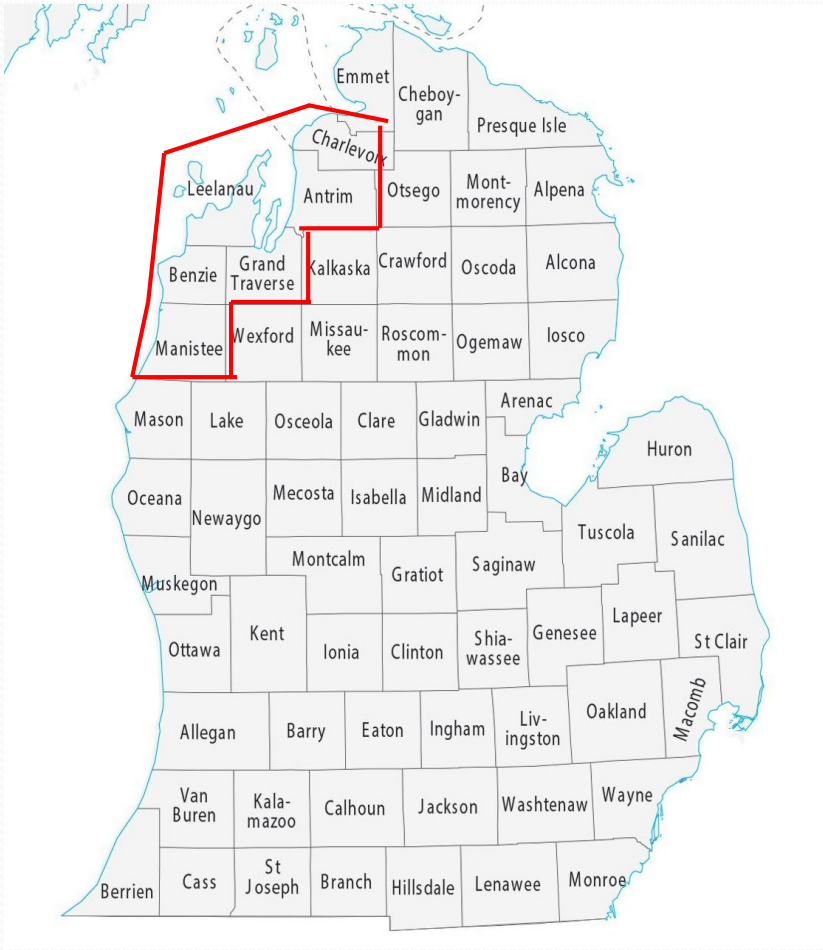
Presidential and Governor Declared Emergencies/Disasters

Date of Incident	Type of Incident	Affected Area	Type of Declaration
1/29/2019	Extreme Cold	All 83 counties	Gov. Emergency
8/2/2015	Thunderstorms	City of Traverse City (Grand Traverse Co.), Township of Acme (Grand Traverse Co.), Township of East Bay (Grand Traverse Co.), Township of Garfield (Grand Traverse Co.), Township of Long Lake (Grand Traverse Co.), Township of Peninsula (Grand Traverse Co.), and Township of Whitewater (Grand Traverse Co.); Grand Traverse, and Leelanau Co.	Gov. Disaster
2/13/2014	Deep frost	Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Gogebic, Luce, Mackinac, and Marquette Co.	Gov. Emergency
6/18/2013 5/7/13	Flooding	Allegan, Baraga, Barry, Benzie, Genesee, Gogebic, Gratiot, Houghton, Ionia, Iron, Kent, Keweenaw, Marquette, Mecosta, Midland, Muskegon, Newaygo, Ontonagon, Osceola, Ottawa and Saginaw Co.; City of Grand Rapids (Kent Co.); City of Ionia (Ionia Co.)	Gov. Disaster
7/14/2008	Thunderstorms, flooding	12 counties: Allegan, Barry, Eaton, Ingham, Lake, Manistee, Mason, Missaukee, Osceola, Ottawa, Saginaw, and Wexford Co.	Pres/ Major Disaster (1777)
9/7/2005	Hurricane evacuation	All 83 counties	Emergency (3225)
9/4/2005	Hurricane evacuation	All 83 counties	Gov. Disaster
3/10/94 3/4/94 2/23/94, 2/25/94	Underground freeze	Charlevoix, Cheboygan, Chippewa, Delta, Gogebic, Houghton, Mackinac, Marquette, Ontonagon, and Schoolcraft Co.	Gov. Emergency
12/93-5/94	Underground freeze	10 counties: Charlevoix, Cheboygan, Chippewa, Delta, Gogebic, Houghton, Mackinac, Marquette, Ontonagon, and Schoolcraft Co.	Pres. Major Disaster (1028)
10/28/86 9/15/86 9/12/86	Flooding, heavy rain	Allegan, Arenac, Bay, Clare, Clinton, Genesee, Gladwin, Gratiot, Huron, Ionia, Isabella, Kent, Lake, Lapeer, Macomb, Manistee, Mason, Mecosta, Midland, Montcalm, Muskegon, Newaygo, Oceana, Osceola, Ottawa, Saginaw, Shiawassee, Tuscola, and Van Buren Co.	Gov. Disaster
9/10-19/86	Flooding	30 counties: Allegan, Arenac, Bay, Clare, Clinton, Genesee, Gladwin, Gratiot, Huron, Ionia, Isabella, Kent, Lake, Lapeer, Macomb, Manistee, Mason, Mecosta, Midland, Montcalm, Muskegon, Newaygo, Oceana, Osceola, Ottawa, Saginaw, Sanilac, Shiawassee, Tuscola, and Van Buren Co.	Pres. Major Disaster (774)
2/21/1986	Great Lakes flooding, wave action	Allegan, Arenac, Bay, Berrien, Grand Traverse, Iosco, Macomb, Marquette, Menominee, Monroe, Muskegon, Ottawa, Saginaw, St. Clair, Tuscola, Van Buren, and Wayne Co.	Gov. Disaster
1/26-27/78	Blizzard, snowstorm	Statewide	Pres. Emergency (3057)
1/26/1978	Blizzard, snowstorm	Statewide	Gov. Disaster
3/2/1977	Drought	44 counties: Alcona, Alger, Alpena, Antrim, Arenac, Baraga, Benzie, Charlevoix, Cheboygan, Chippewa, Clare, Crawford, Delta, Dickinson, Emmet, Gladwin, Gogebic, Grand Traverse, Houghton, Iosco, Iron, Isabella, Kalkaska, Lake, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Mecosta, Menominee, Missaukee, Montmorency, Oceana, Ogemaw, Ontonagon, Osceola, Oscoda, Otsego, Presque Isle, Roscommon, Schoolcraft, and Wexford Co.	Pres. Emergency (3035)
4/5/1956	Tornado	4 counties: Benzie, Leelanau, Manistee, and Ottawa Co.	Pres. Major Disaster (53)

Historic Weather Events

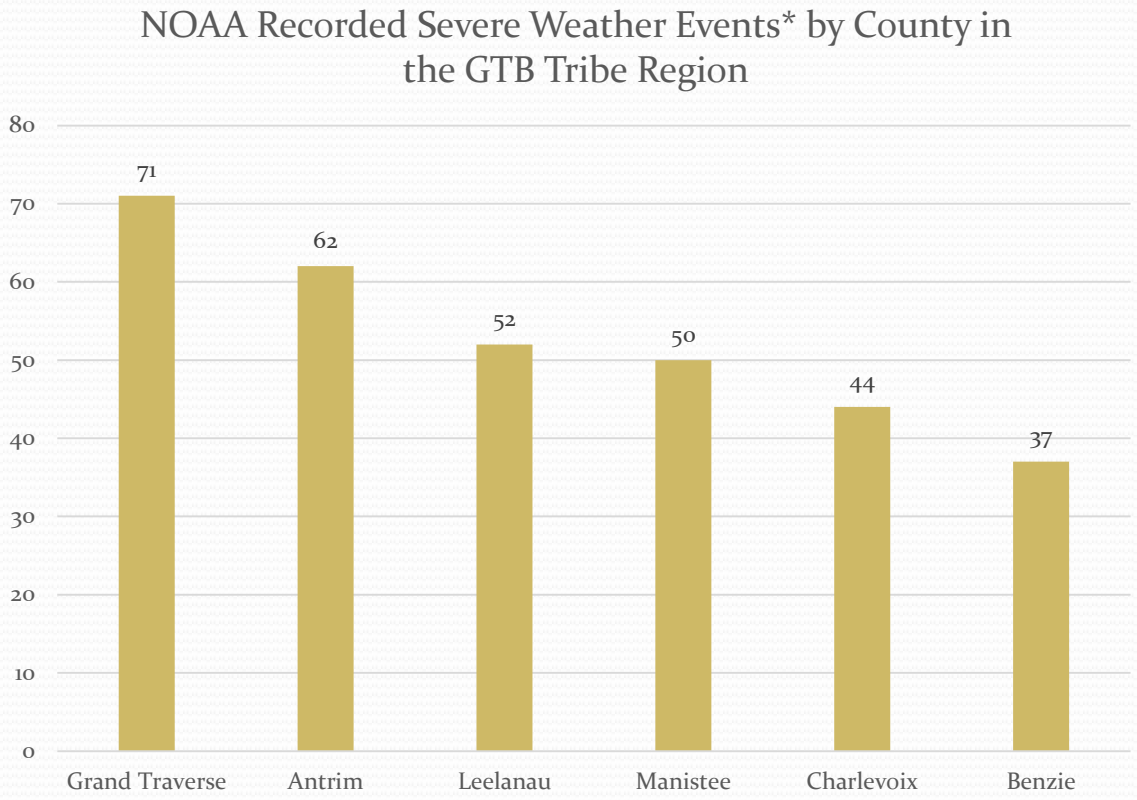
- GTB Membership Coverage Area – 6 Counties





https://gisgeography.com/michigan-county-map/

Historic Weather Events

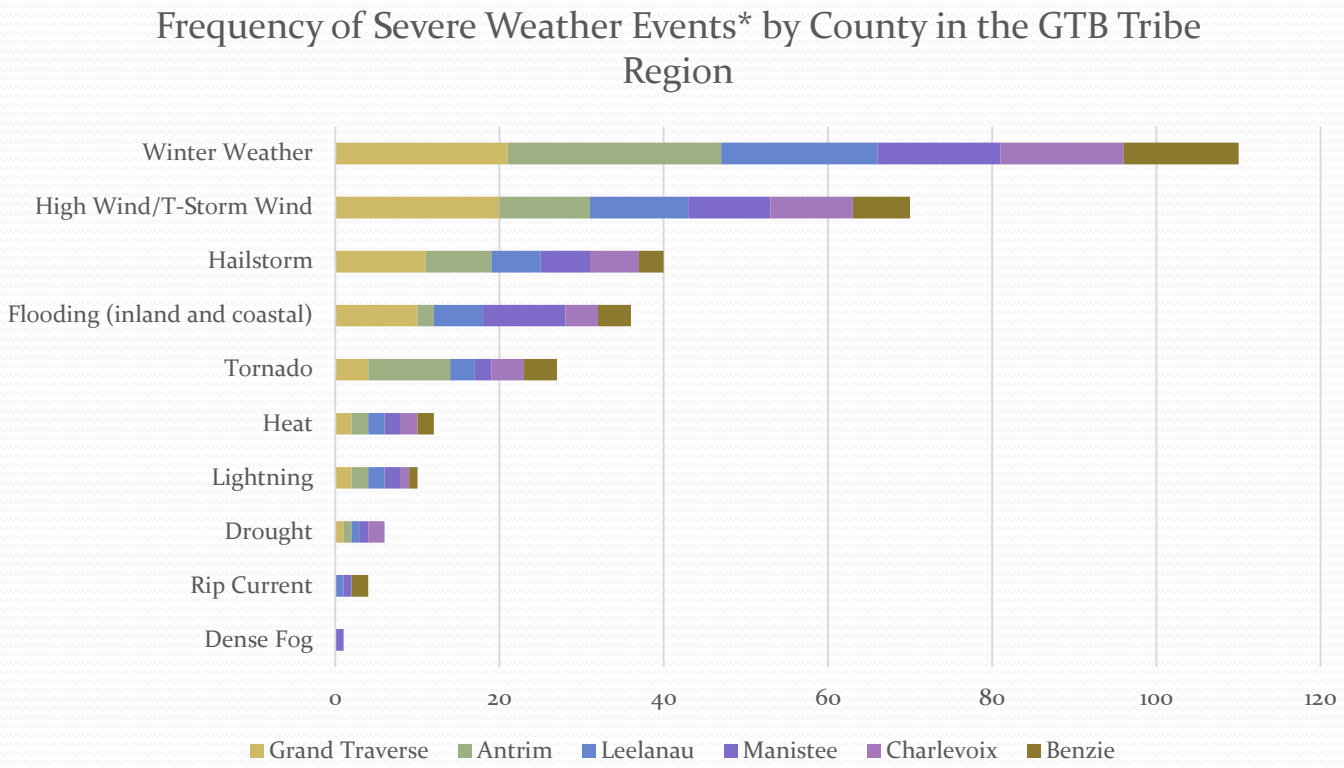


*Notes:

- Source: NOAA Storm Events Database. Data reflect non-contiguous years of records from 1950-2021. Totals represent the following: 1) Occasionally occurring events include the following types recorded from 1950-2021: dense fog, rip current, drought, lightning, heat, tornado, and flooding (inland and coastal) and 2) Frequently occurring events include the following types recorded from 2012-2021: hail, high wind/T-storm with wind, and winter weather.

- NOAA's National Centers for Environmental Information will provide weather data through Dec. 2021 by mid-March or April 2022.

Historic Weather Events



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Historic Weather Events

		Grand Traverse	Antrim	Leelanau	Manistee	Charlevoix	Benzie	Total Events
Occasionally Occurring Events (1950-2021)	**Dense Fog**	0	0	0	1	0	0	**1**
	Rip Current	0	0	1	1	0	2	**4**
	Drought	1	1	1	1	2	0	**6**
	Lightning	2	2	2	2	1	1	**10**
	Heat	2	2	2	2	2	2	**12**
	Tornado	4	10	3	2	4	4	**27**
	Flooding (inland and coastal)	10	2	6	10	4	4	**36**
Frequently Occurring Events (2012-2021)	**Hailstorm**	11	8	6	6	6	3	**40**
	High Wind/T-Storm Wind	20	11	12	10	10	7	**70**
	Winter Weather	21	26	19	15	15	14	**110**
	Total Events	**71**	**62**	**52**	**50**	**44**	**37**	

Historic Weather Events

- Extreme Heat (2)
  - **6/30/2018** The month of June closed with one of the hottest days in recent memory. Highs were well into the 90s, including 99 at Alpena, and 98 at Traverse City and Gaylord. The National Weather Service office near Gaylord also hit 98; that was (by several degrees) the warmest reading recorded at that location since observations began there in the late 1990s. Heat indices exceeded 105 degrees across most of northern lower Michigan, and some locations exceed 110. The warmest reported heat index on the day was 114 near Indian River. There were estimated to be between 25 and 30 individuals who visited local hospitals due to heat-related illnesses.
  - **08/01/2001** Excessive Heat was also a problem the first two weeks in August across all of northern Michigan. Temperatures reach the mid to upper 90s, on average, a few days each year; however, for a 5 day (8/5 - 8/9) stretch overnight low temperatures failed to fall below the lower 70s in most areas. This very humid air mass was unusual for northern Michigan, an area which typically sees cool nighttime temperatures and for this reason has very few homes with air conditioners. No heat related deaths or injuries were reported; however, most outdoor events were modified due to the forecasts of hot and humid conditions. County fairs sent animals home, yet still there were livestock losses at fairs in Otsego and Alcona counties. Attendance at county fairs was well below normal and this was attributed to the heat.

Drought Risk

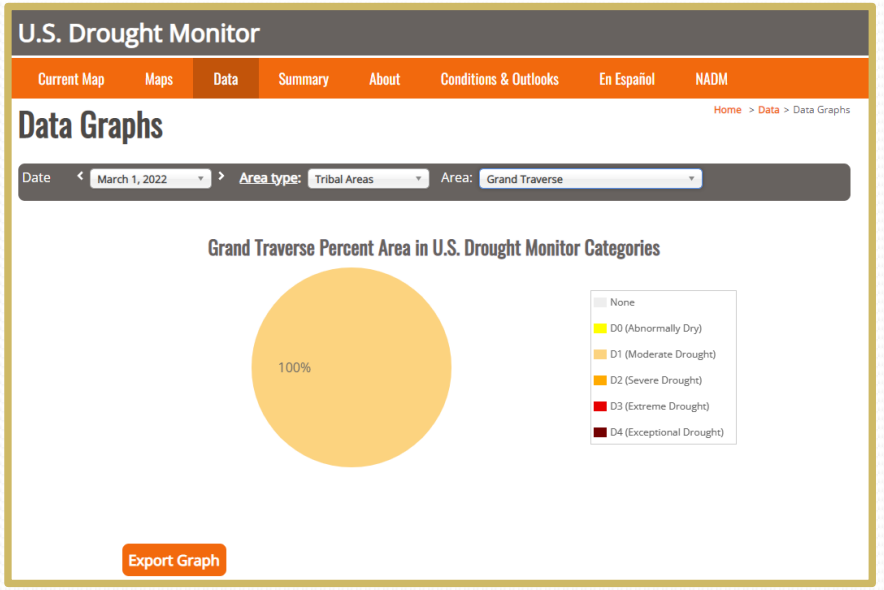
https://droughtmonitor.unl.edu/

Check the current drought monitor data for the Grand Traverse Tribe area

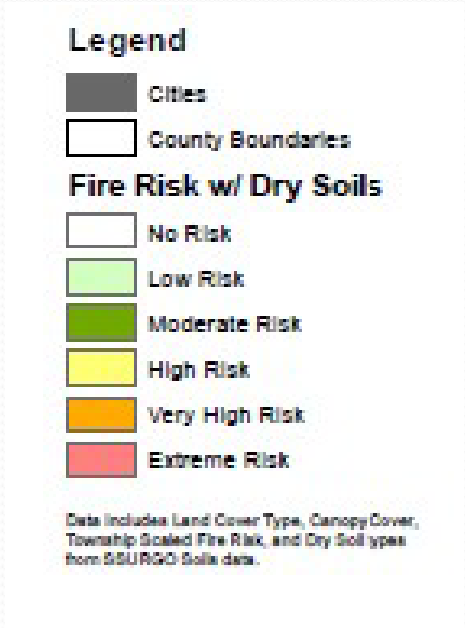
Michigan

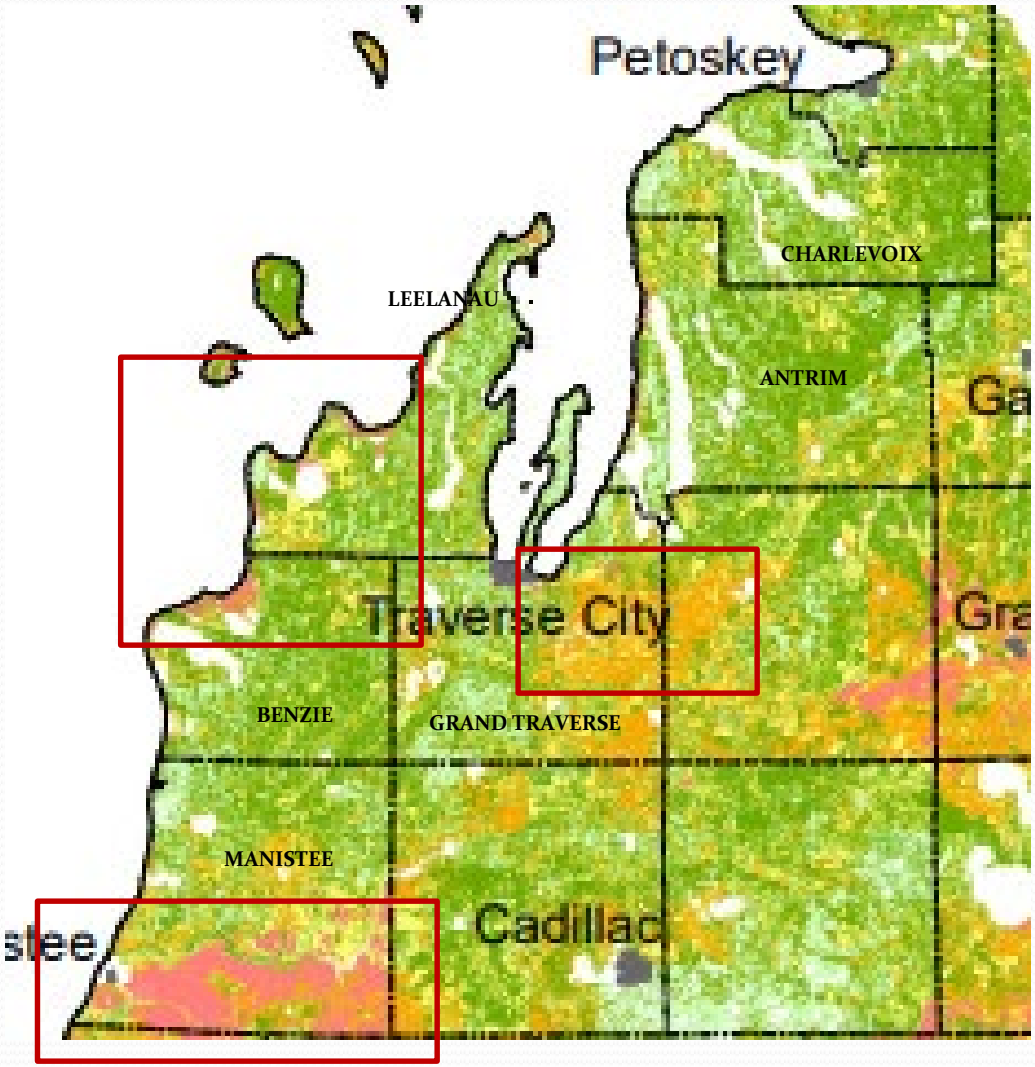
Category	Historically observed impacts
D0	Grass fires increase
	Lawns are brown; landscape and gardens are watered more frequently
D1	Most crops and vegetation are stressed; farmed Christmas trees are stressed
	Well levels decline
D2	Corn and soybean yields are low
	Mature trees are stressed
	Streamflow is extremely low, potentially too low to irrigate

Historically observed drought impacts in MI



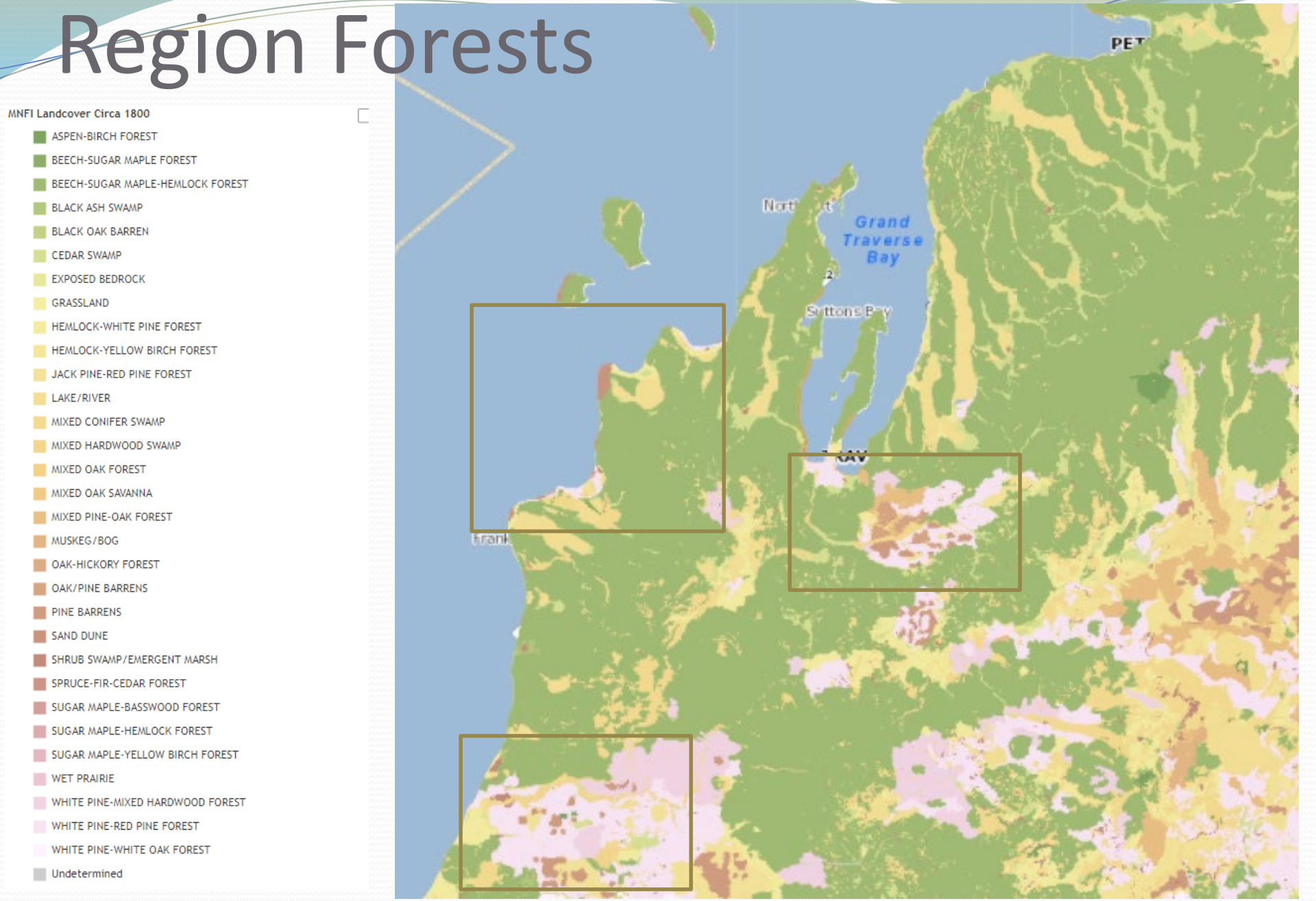
Wildfire Risk



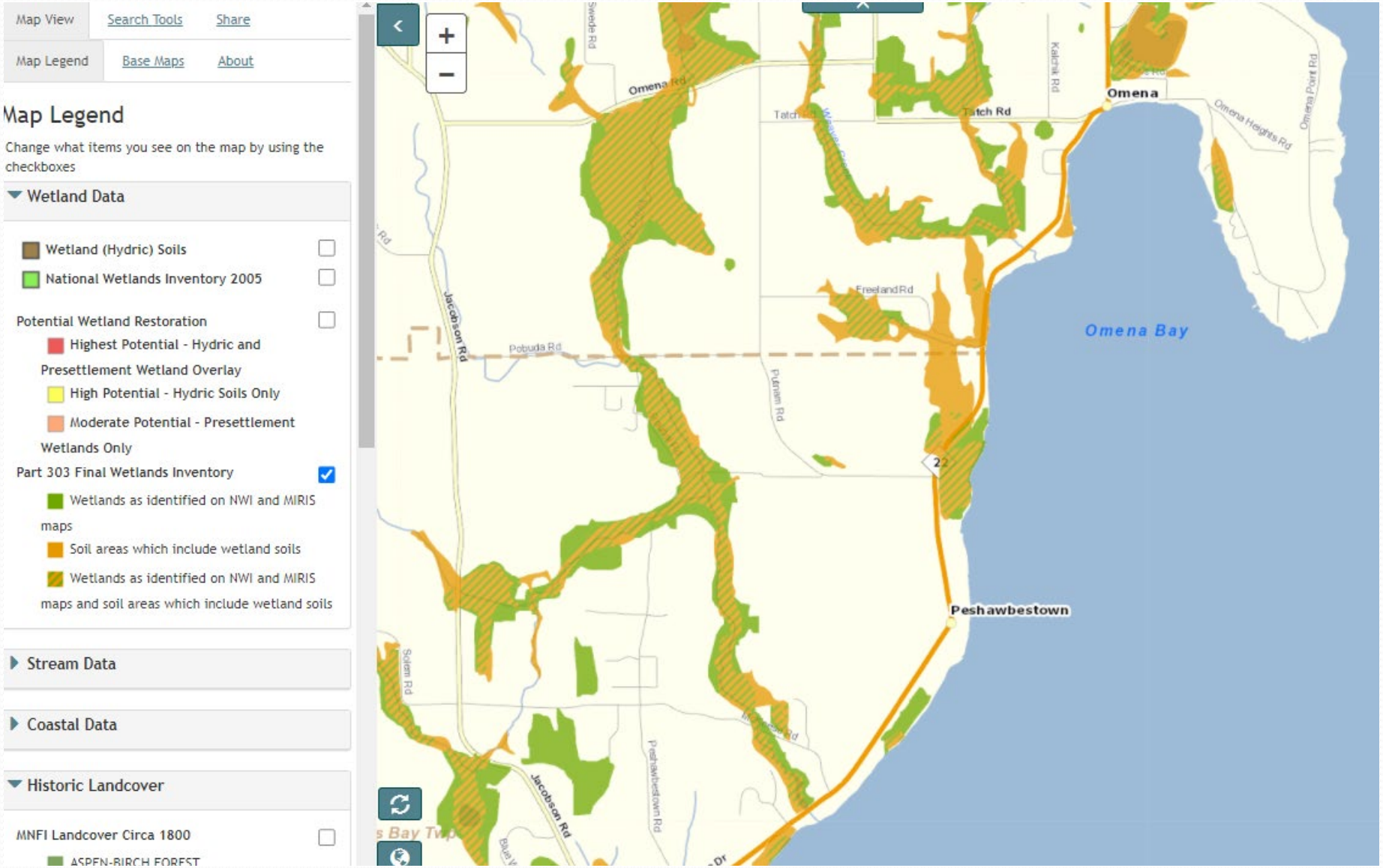


Source: Wildfire Risk Map - MDNR Forest Resources Division

Region Forests



Peshawbestown Wetlands



Leelanau and Grand Traverse County Dams

	Name	Height (ft)	Storage (acre-feet)	Location	City/Township	Owner	Regulatory Agency	Dam Type	Year Completed	Dam Purpose	Hazard Potential
1	Belanger Dam	21	50	Belangers Creek	Peshawbestown	Ignatius Belanger	-	Gravity	1864	Recreation	Low
2	Cedar Lake Dam	16	1600	Cedar Lake Outlet	Cherry Bend	Elmwood Township	State	Earth	1856	Recreation	Significant
3	Leland Dam	19	86950	Lake Michigan Tributary	Leland	Leelanau County Drain Commission	State	Concrete, Earth	1910	Recreation	High
4	Meeuwenberg Dam	42	193	Cedar Lake Tributary	Cherry Bend	Cherry Bend Lake Owners	State	Earth	1968	Recreation	High

	Name	Height (ft)	Storage (acre-feet)	Location	Owner	City	Regulatory Agency	Dam Type	Year Completed	Dam Purpose	Hazard Potential
1	Bissell Pond Dam	16	200	Williamsburg Creek	Angela Kirby	Williamsburg	State	Earth, Gravity	1852	Recreation	Significant
~~2~~	~~Boardman Dam~~	~~56~~	~~1260~~	~~Boardman River~~	~~Grand Traverse County~~	~~Traverse City~~	~~State~~	~~Earth, Gravity~~	~~1884~~	~~Recreation~~	~~High~~
3	Brown Bridge Dam	46	2800	Boardman River	City of Traverse City	Traverse City	-	Earth, Gravity	1921	Recreation	High
4	General Growth Dam	9	31	Kids Creek Tributary	General Growth Partners, Inc.	Traverse City	-	Earth	1990	Flood Risk Reduction	Significant
5	Gerhard Dam	25	86	Mitchell Creek Tributary	Philip and Dona Gerhard	Traverse City	State	Earth	1960	Recreation	Low
6	Headquarters Lake Dam	16	2146	Fife Lake Outlet	MDNR Wildlife	Smithville	State	Earth, Gravity	1955	Recreation	Low
7	Lake Dubonnet Dam	12.5	3170	Platte River	MDNR Fisheries	Lake Ann	State	Earth	1956	Recreation	Low
8	Mayfield Electric Light Plant Dam	23	3	Swainston Creek	Paradise Township	Mayfield	-	Earth, Gravity	1873	Recreation	Significant
9	Petobego Dam	10.5	1375	Tobeco Creek	MDNR Wildlife	Acme	State	Earth	1951	Recreation	Low
~~10~~	~~Sabin Dam~~	~~34~~	~~435~~	~~Boardman River~~	~~Grand Traverse County~~	~~Traverse City~~	~~State~~	~~Earth, Gravity~~	~~1906~~	~~Recreation~~	~~High~~
11	Union Street Dam	21	11200	Boardman River	City of Traverse City	Traverse City	State	Earth, Gravity	1867	Recreation	High
12	Wysong Dam	11	2	Lake Michigan Tributary	Peter Wysong	Peninsula Twp.	-	Earth	1989	Recreation	Significant

Region Dams –

Listed on the National Inventory of Dams

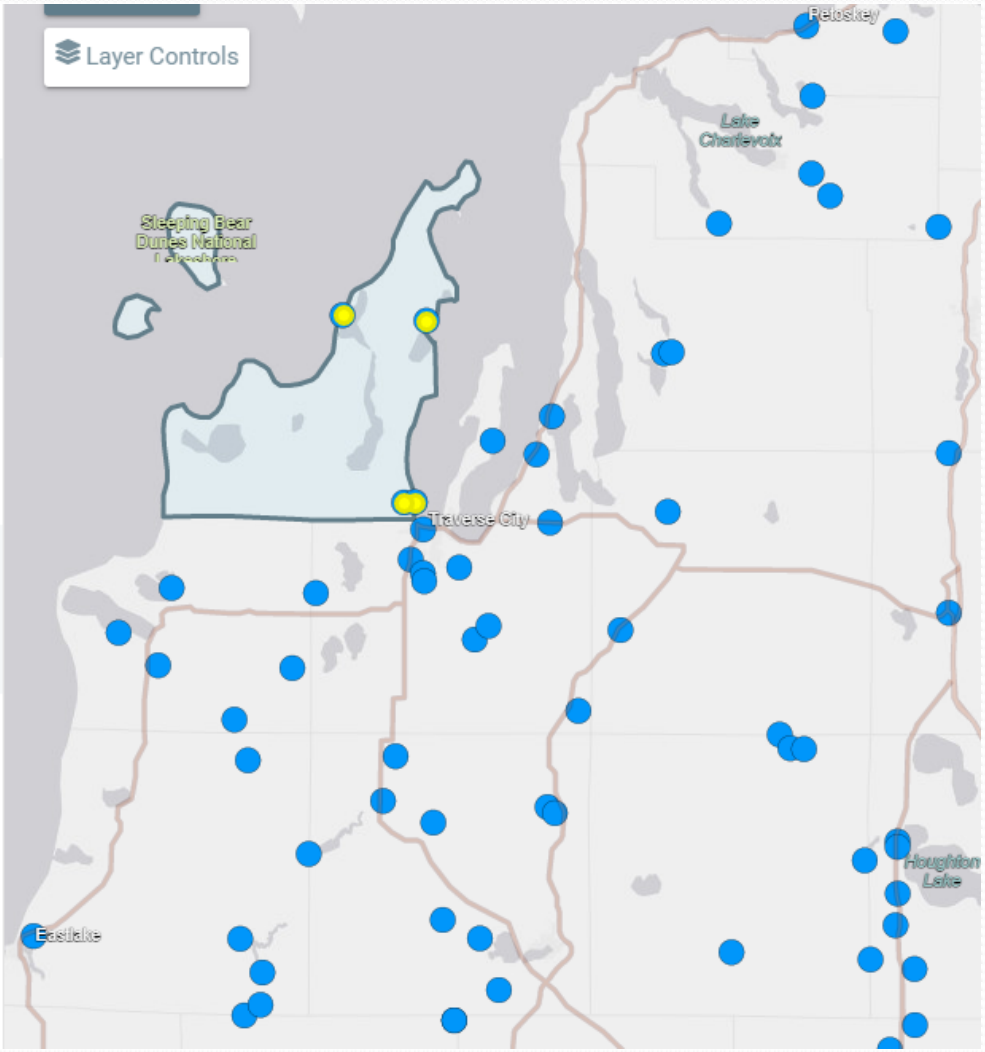
Meeuwenberg Dam
Hazard Potential Classification: High
Emergency Action Plan: Yes
Owner Name: Cherry Bend Lake Owners
Primary Purpose: Recreation

Leland Dam
Hazard Potential Classification: High
Emergency Action Plan: Yes
Owner Name: Leelanau County Drain Commissioner
Primary Purpose: Recreation

Cedar Lake Dam
Hazard Potential Classification: Significant
Emergency Action Plan: Yes
Owner Name: Elmwood Township
Primary Purpose: Recreation

Belanger Dam
Hazard Potential Classification: Low
Emergency Action Plan: Not Required
Owner Name: Ignatius Belanger
Primary Purpose: Recreation

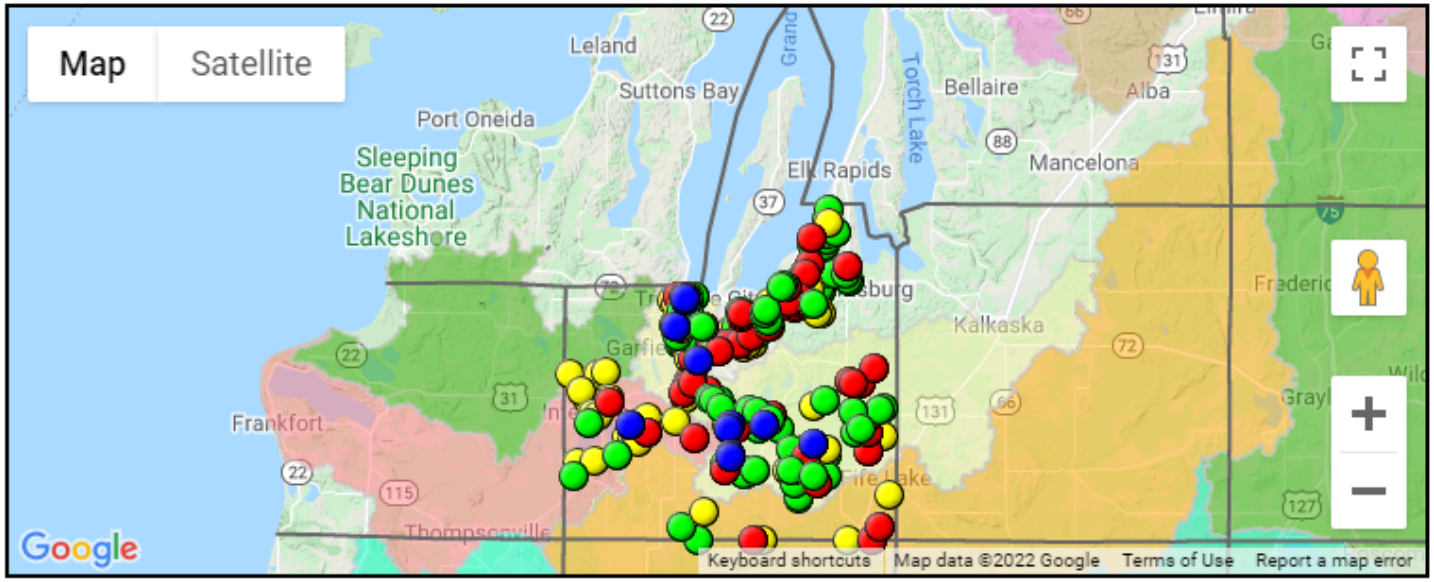
County	# of Dams	High Hazard Potential
Manistee	5	1
Antrim	3	2
Benzie	5	0
Charlevoix	4	0
Grand Traverse	10	2
Leelanau	4	2



RIVER RESTORATION
in Northern Michigan

Road Stream Crossings in Grand Traverse County

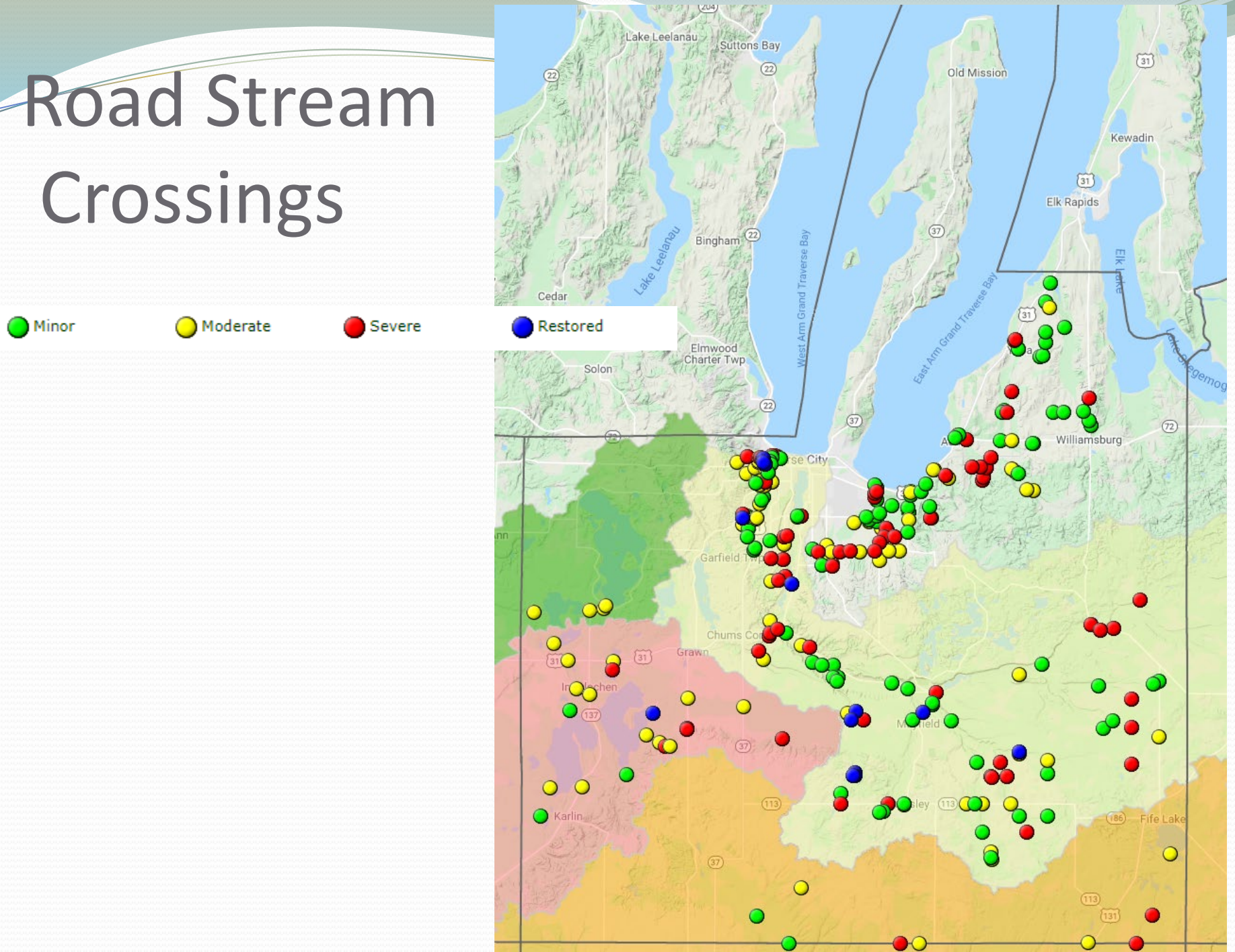
Grand Traverse County
Road Stream Crossings
Streambank Erosion



Minor Moderate Severe Restored

Site No.	Township	County	Road	Stream
BT_G005	Blair Twp	Grand Traverse	M-37	Mason Creek
BT_G006	Blair Twp	Grand Traverse	Mill Rd	Mason Creek
BT_G007	Green Lake Twp	Grand Traverse	Co. 633	Mason Creek
BT_G008A	Green Lake Twp	Grand Traverse	Co. 633	Mason Creek
BT_G008B	Green Lake Twp	Grand Traverse	Co. 633	Mason Creek
BT_G009	Green Lake Twp	Grand Traverse	E Duck Lake Rd	Brigham Creek
BT_G010	Green Lake Twp	Grand Traverse	E Duck Lake Rd	Brigham Creek
BT_G011	Green Lake Twp	Grand Traverse	Hulett Rd	Brigham Creek
BT_G012	Green Lake Twp	Grand Traverse	E Duck Lake Rd	Brigham Creek
BT_G013	Green Lake Twp	Grand Traverse	E Duck Lake Rd	Mason Creek

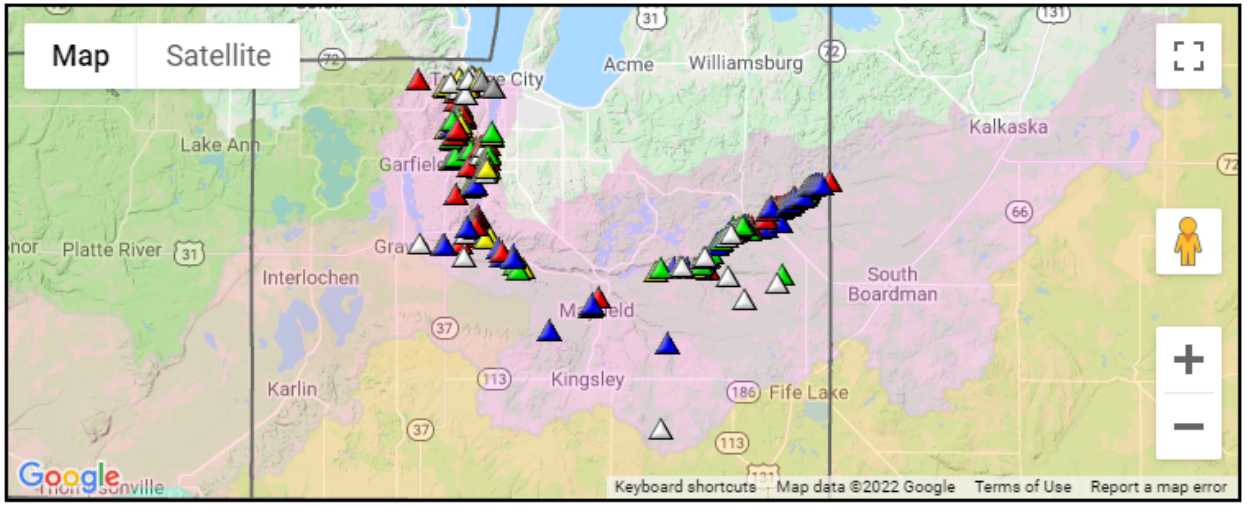
Road Stream Crossings



RIVER RESTORATION
in Northern Michigan

Streambank Erosion Sites in Grand Traverse County

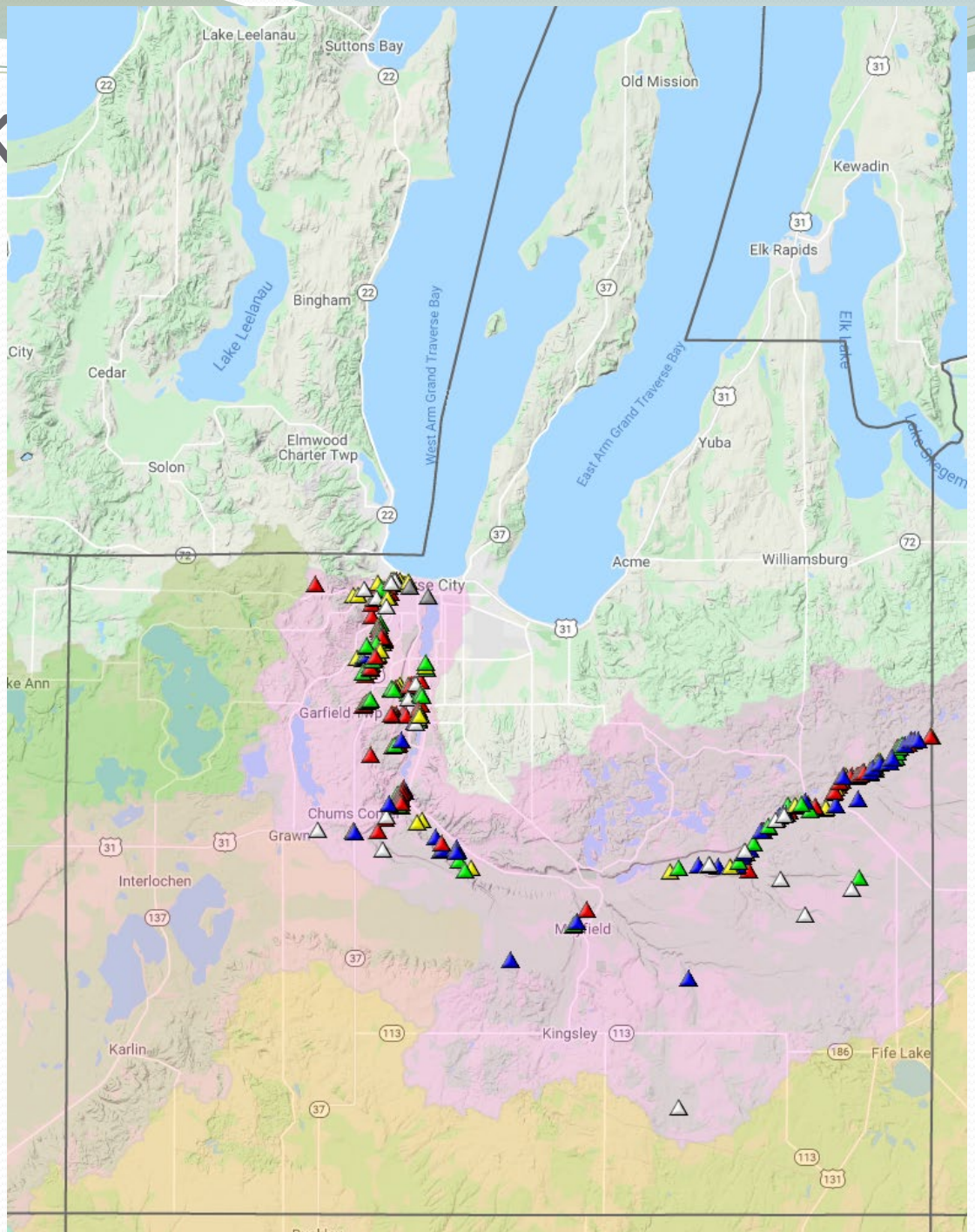
Grand Traverse County
Road Stream Crossings
Streambank Erosion



Minor | Moderate | Severe | Restored | None | Undefined

Site No.	Township	County	Stream	Length	Texture	Treatment
BRD-172	Garfield Twp	Grand Traverse	Boardman River	30 ft.	Sand	-Bank revegetation Other Treatments: topsoil, fencing
BRD-226	Traverse City	Grand Traverse	Boardman River			
BRD-G1	Garfield Twp	Grand Traverse	Boardman River	12 ft.	Sand	-Bank revegetation Other Treatments: erosion cribbing, steps
BRD-G10	Garfield Twp	Grand Traverse	Boardman River	80 ft.	Sand	Other Treatments: topsoil
BRD-G11	Garfield Twp	Grand Traverse	Boardman River	20 ft.	Sand	-Bank revegetation -Cover structure Other Treatments: fiber rolls, topsoil, shrubs
BRD-G12	Traverse City	Grand Traverse	Boardman River	40 ft.	Gravel	-Bank revegetation
BRD-G13	Traverse City	Grand Traverse	Boardman River	125 ft.	Sand	-Rock riprap Other Treatments: topsoil

Streambank Erosion

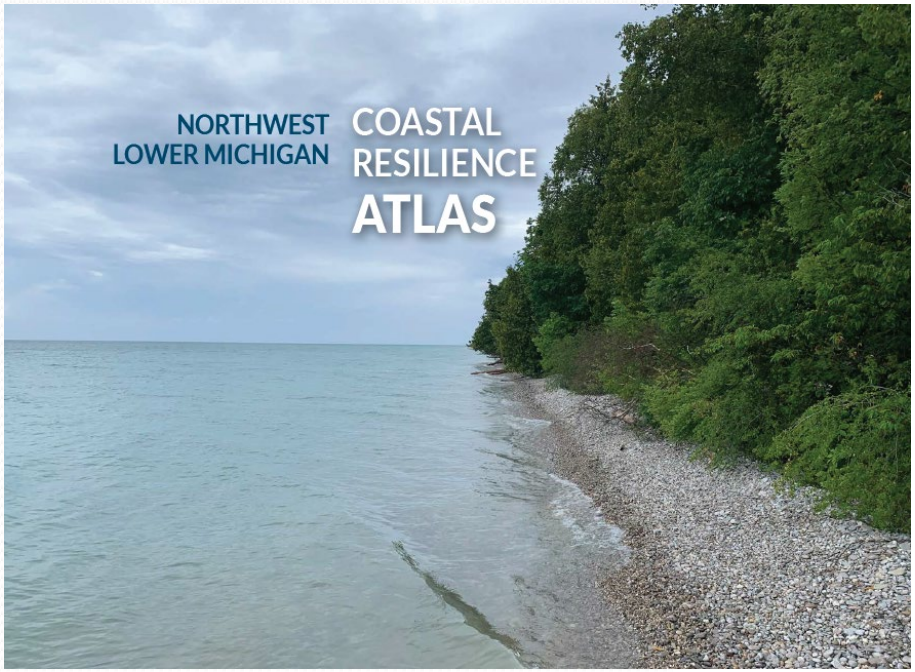


NFIP & CRS Participating Communities

- National Flood Insurance Program
- The Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management practices that exceed the minimum requirements of the NFIP
- In CRS communities, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community's efforts that address the three goals of the program:
  - Reduce and avoid flood damage to insurable property
  - Strengthen and support the insurance aspects of the National Flood Insurance Program
  - Foster comprehensive floodplain management

Coastal Flooding / Coastal Recession

- http://www.resilientmichigan.org/nw_atlas.asp



ACKNOWLEDGMENTS

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EGLE
MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

NOAA

This Atlas was prepared by the Land Information Access Association (LIAA) in cooperation with the Great Lakes Research Center at Michigan Technological University and the Taubman College of Architecture and Urban Planning at the University of Michigan, July 2019.

LIAA

Michigan Technological University

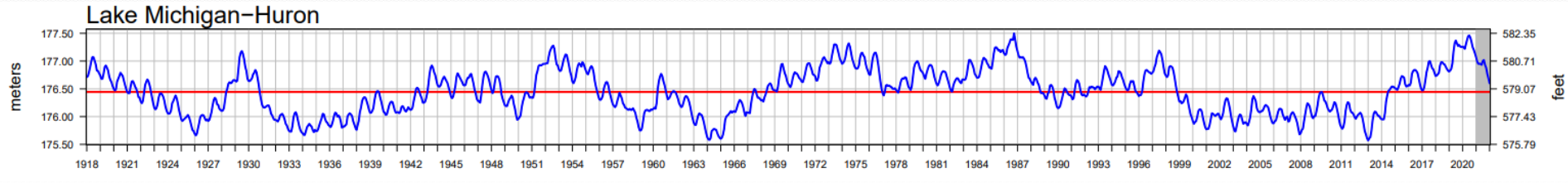
TAUBMAN COLLEGE architecture + urban planning University of Michigan

Coastal Dynamics

- Changing water levels
- Water Energy and Height
  - Erosion
  - Changing conditions
- Climate change on the Great Lakes
  - Increased precipitation and storminess
  - Variability of lake water levels
  - Water temperature

Changing Water Levels

US Army Corp of Engineers



Long Term Average Maximum Minimum

LAKES MICHIGAN-HURON

2020	*581.56*	*581.53*	*581.43*	*581.69*	*581.96*	*582.19*	*582.22*	*582.09*	*581.82*	*581.53*	*581.36*	*581.17*	*581.73*
Mean	**578.44**	**578.41**	**578.48**	**578.74**	**579.07**	**579.30**	**579.40**	**579.33**	**579.17**	**578.94**	**578.74**	**578.61**	**578.87**
Max	581.56	581.53	581.43	581.69	581.96	582.19	582.22	582.09	581.96	582.35	581.96	581.56	
	2020	2020	2020	2020	2020	2020	2020	2020	1986	1986	1986	1986	
Min	576.02	576.08	576.05	576.15	576.57	576.64	576.71	576.67	576.64	576.44	576.28	576.15	
	2013	1964	1964	1964	1964	1964	1964	1964	1964	1964	1964	2012	

Coastal Flooding

http://www.resilientmichigan.org/nw_atlas.asp

Manistee County

Coastal Flooding

http://www.resilientmichigan.org/nw_atlas.asp

To develop the scenario planning framework, the research team had to establish assumptions regarding future climate conditions that could affect northwest Lower Michigan. These varying "climate futures" — all of which are reasonably anticipated possibilities — are arranged from a least impactful ("Lucky") to a most impactful ("Perfect Storm") condition in terms of the potential for wave damage and flooding hazards they would bring.

The following descriptions outline the key assumptions made in defining each of the climate futures as compared to the others. The maps in this chapter show the estimated land areas that would be affected by waves and flooding under these three climate futures.

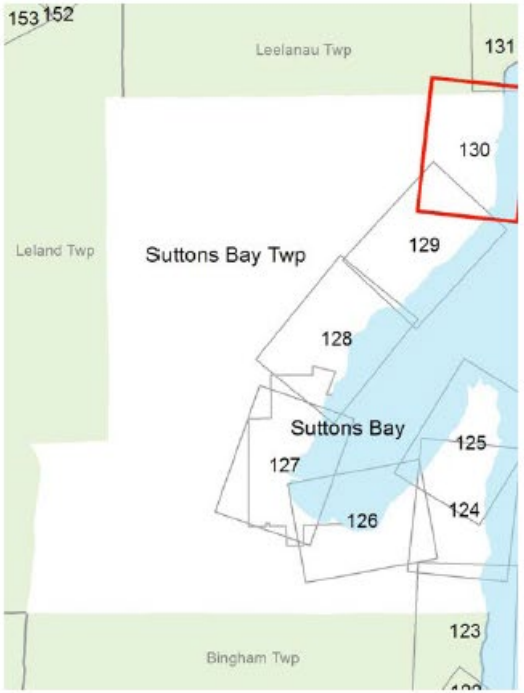
"Lucky" Future: Under the Lucky Climate Future, Great Lakes water levels will continue to stay relatively low. Although there will be wave and wind action, major storm events and wave impacts will not encroach on properties landward of current beaches. A Lucky Future projection, indicating the land areas that would be affected by high-energy waves along the shorefront and/or adjacent riverine flooding under these conditions, is shown in green on the maps.

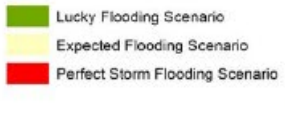
"Expected" Future: Under the Expected Climate Future, Great Lakes water levels will continue to fluctuate according to long-term decadal patterns, including recent extreme storm events incorporated into the ongoing Great Lakes Coast Flood Study being conducted by the Federal Emergency Management Agency (FEMA). Given those ongoing fluctuations, this Climate Future accounts for periods when Great Lakes still-water elevations are closer to the long-term average. In addition, this Climate Future anticipates the so-called "100-year storm event" (or 1% storm) becoming more like a 20- or 50-year storm event (i.e., an expected storm within the normal community planning time horizon) because of increased storminess. The Expected Future projection is shown in yellow on the maps.

"Perfect Storm" Future: Under the Perfect Storm Climate Future, Great Lakes water levels will continue to fluctuate according to decadal patterns, consistent with assumptions made for the Expected Future. However, for this Perfect Storm Climate Future, the estimated still-water elevation is set higher than the long-term average and closer to the long-term high (583 feet). In addition, this Climate Future anticipates the occurrence of a so-called "500-year storm event" (or 0.2% storm) occurring within the planning time horizon while lake levels are high. The Perfect Storm Future projection is shown in red on the maps.

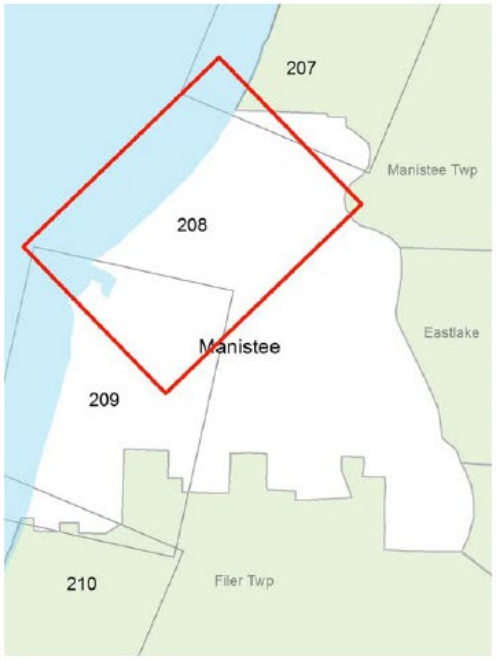
Taken together on the maps, the three climate futures are progressively cumulative; that is, the Expected Future is cumulative of all the green (Lucky) and yellow areas put together, and the Perfect Storm Future encompasses all green, yellow and red areas. It is important to note that this flooding analysis is only complete for Lake Michigan coastal areas; inland rivers, streams and other waterbodies may show little or no data.

Coastal Flooding





Coastal Flooding



Lucky Flooding Scenario
Expected Flooding Scenario
Perfect Storm Flooding Scenario

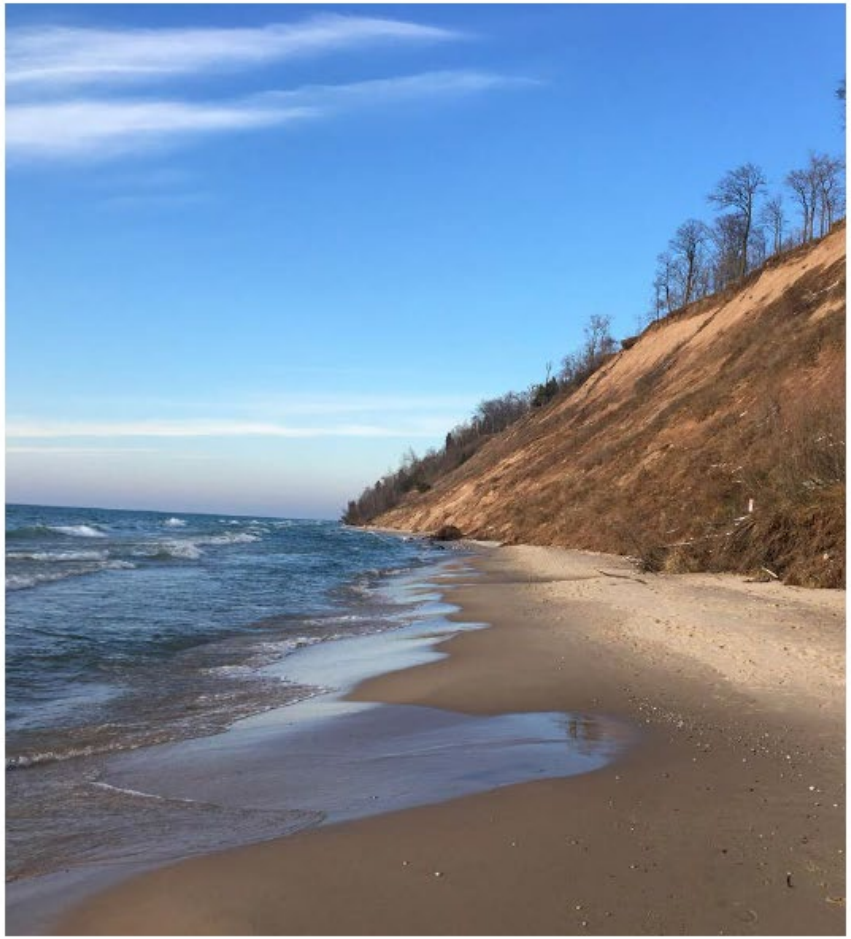
Coastal Recession

http://www.resilientmichigan.org/nw_atlas.asp

CHAPTER 4
Coastal Recession

As previously discussed, Great Lakes water level fluctuations do not result from the moon's gravitational pull like oceans, but from cyclical changes in rainfall, evaporation, and riverine and groundwater inflows. These factors work together to raise and lower the water levels of the Great Lakes in small increments daily, and larger increments seasonally and over the course of years and decades.

Unlike our nation's ocean coasts (which change in shoreline level over a 24-hour tidal period), the significantly longer time spans of mean water level change on the Great Lakes give the beach and nearshore region significant time to readjust to new water levels and wave characteristics. During multiple years of high-water levels, wave base moves landward, coastal erosion (bluff and beach) is accelerated, and the nearshore profile steepens. Conversely, during prolonged years of low water levels the reverse happens, although not completely. As the wave base moves offshore, coastal erosion decreases but it does not always stop completely, and the beach area grows larger. Because the beach readjustment from high water episodes to low water episodes is not complete (due to losses of beach sediment to offshore and into longshore sediment traps), there exists a net shoreline retreat over several cycles. For most Great Lakes shoreline, this is on the order of one foot per year of coastal retreat.



Coastal Recession

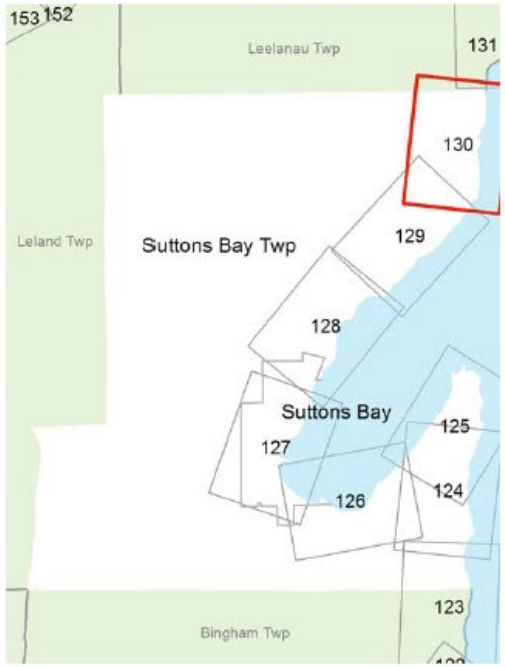
http://www.resilientmichigan.org/nw_atlas.asp

Bluff Detail, Panel 207, Manistee Twp.

Shoreline 1938
Bluffline 1938
Bluffline 2016
Predicted 30 yr bluff

Coastal Recession

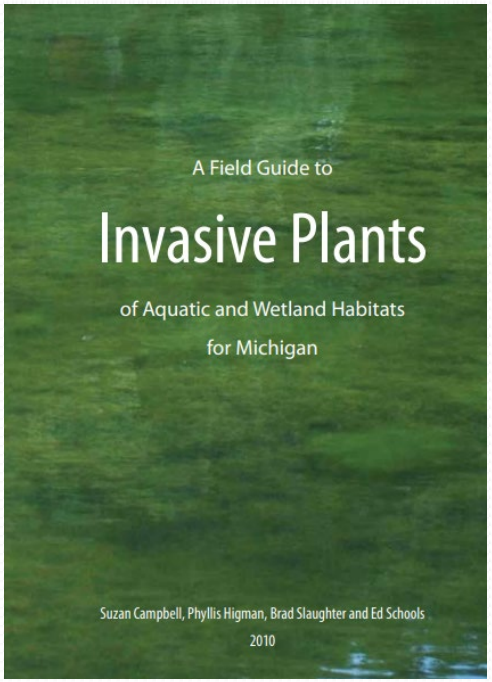
http://www.resilientmichigan.org/nw_atlas.asp



Shoreline 1938
Bluffline 1938
Bluffline 2016
Predicted 30 yr bluff

Invasive Species

- Only a small fraction of non-native plants are invasive
- Invasives is a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm
- Lake-moderated climates along Lake Michigan, Lake Erie, Saginaw Bay, Thumb, and Lake St. Clair are milder and have high potential to harbor species typically found to the south.



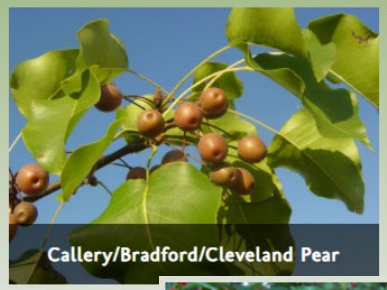
Invasive Species

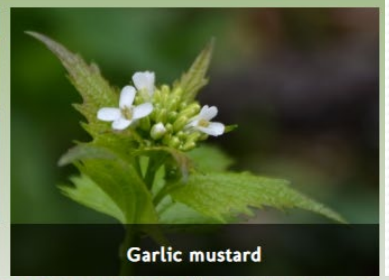

Baby's breath


Japanese and common barberry


Blue lyme grass


Glossy and common buckthorn


Callery/Bradford/Cleveland Pear


Garlic mustard


Invasive honeysuckles


*Knotweeds

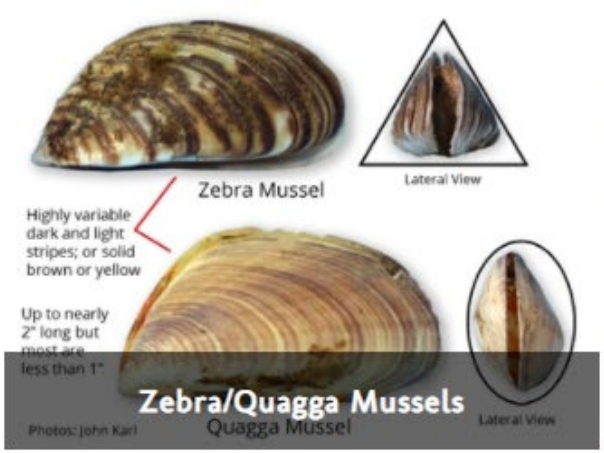

Invasive bittersweet


*Invasive Phragmites


*Purple loosestrife


Tree-of-Heaven

Invasive Species



Zebra/Quagga Mussels


Round goby


Rusty crayfish


Eurasian Ruffe


Sea Lamprey

Asian Carp

Next Steps

- Hazard mapping
- Prepare hazard analysis
- Next group meeting / field trip