

# Benzie County Hazard Mitigation Plan Update

March 21, 2022



**Networks  
Northwest**

Talent / Business / Community



# Welcome

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

# Purpose

## Hazard Mitigation Planning

**“The effort to reduce loss of life and property by lessening the impact of disasters”**

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## Billion-Dollar Disasters Shattered U.S. Record in 2020

The 22 events that each caused at least \$1 billion in damage show the increasing costs of climate change

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By Thomas Frank, E&E News on January 11, 2021



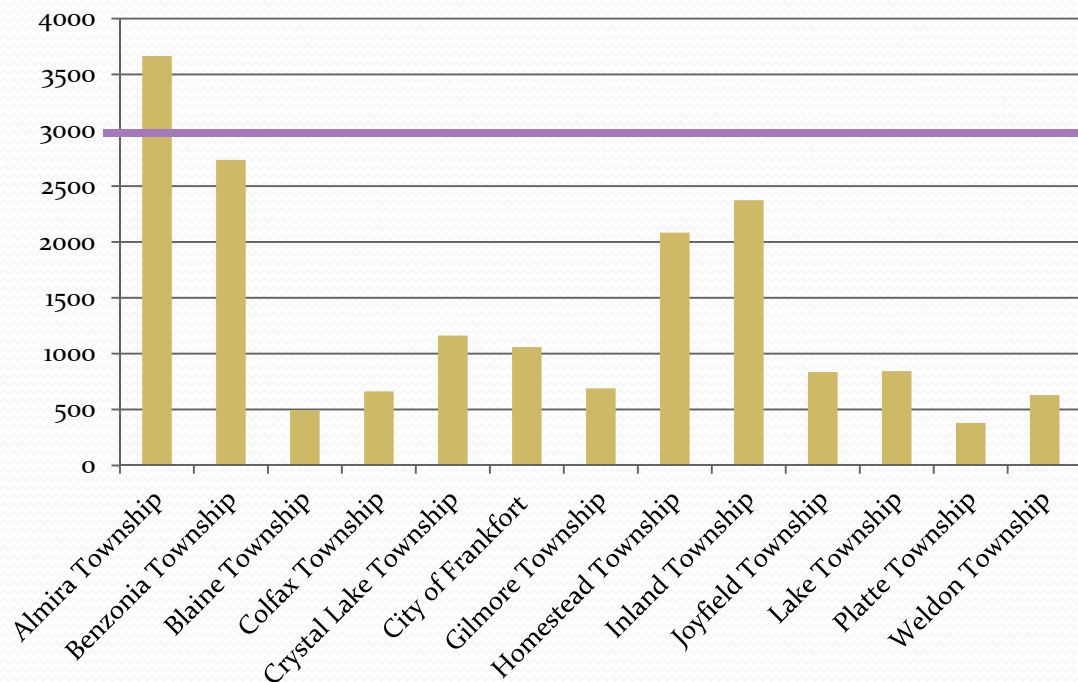
An aerial view of flood waters from Hurricane Delta surrounding structures destroyed by Hurricane Laura on October 10, 2020 in Creole, Louisiana. Credit: Mario Tama Getty Images



# 2020 FEMA Grant Awards

## Building Resilient Infrastructure & Communities (BRIC) Funding Program

- \$700 million available for FY 2020
- Awards for small impoverished communities
  - 3,000 or fewer individuals







# 2020 FEMA Grant Awards

## Building Resilient Infrastructure & Communities (BRIC) Funding Program

- Income not to exceed 80% of the national per capita income
- In 2019, US per capita income was \$34,103. 80% = \$27,282
- Benzie County 2019 per capita income is \$29,425
- 77% of small impoverished applications were awarded



# Potential *Natural* Hazard Events

Drought

Excessive Precipitation (*may cause dam failure, high lake and river water levels, lakeshore and streambank erosion, flooding, contaminated water, etc.*)

Extreme temperatures (*heat/cold*)

Hail

High winds/Straight-line winds /Derecho (*may contribute to shoreline flooding, strong rip currents, seiche, etc.*)

Invasive species (*can cause damage to forests, crops, native species, etc.*)

Public health emergency (i.e., *pandemic; contaminated water supply*)

Severe thunderstorms (*can produce hail, lightning, high winds, flooding, seiche, etc.*)

Tornado

Wildfire

Winter Storm (*can produce ice, sleet, heavy snowfall, high winds...*)

Wildlife or zoonotic diseases (i.e., *Bovine TB, Avian Influenza, Swine Flu*)

# Historic Federal and Governor Declared Emergencies/Disasters

Then, learn about the **43** disasters that have occurred in **Michigan** since 1953.

Click on an incident or county to filter the visualization. Click again to reset.



12 Flood

10 Severe Storm(s)

6 Tornado

5 Snow

2 Biological

2 Dam/Levee Break

1 Drought

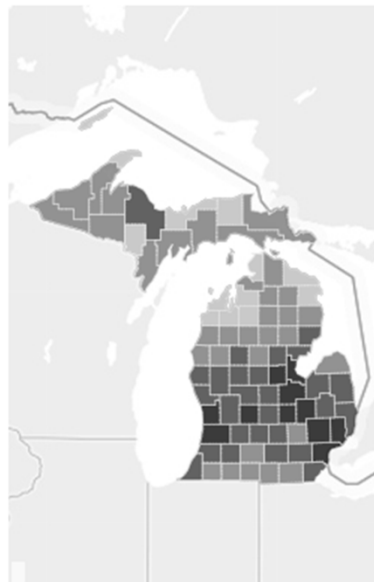
1 Fire

1 Freezing

1 Hurricane

1 Other

1 Toxic Substances



EMHSD PUB-103  
April 2019  
EMERGENCY MANAGEMENT AND  
HOMELAND SECURITY DIVISION  
Michigan Department of State Police

## Michigan Hazard Analysis





# Historic Federal and Governor Declared Emergencies/Disasters

Date of Incident	Type of Incident	Affected Area	Type of Declaration/ Fed ID #	Notes
March 2020	COVID-19; COVID-19 Pandemic	Statewide & National	State of Emergency, National Emergency (3455), and Governor and Presidential Declared Major Disaster (4494)	
1/29/2019	Extreme Cold	Statewide	Governor Declared Emergency	
5/7/2013 and 6/18/2013	Flooding	Benzie and other counties	Governor Declared Disaster	Some homes along the Crystal Lake Outlet Creek were flooded, along with several homes on Rhodes Road, Demerly Road and Wallaker Road. Some of these homes were not in flood plains.
9/4/2005 and 9/7/2005	Hurricane (Katrina) Evacuation	Statewide	Governor Declared Disaster and Presidential Declared Emergency (3225)	Declared due to the emergency conditions in the State of Michigan, resulting from the influx of evacuees from states impacted by Hurricane Katrina beginning on August 29, 2005.
1/26-27/1978	Blizzard, Snowstorm	Statewide	Presidential Declared Emergency (3057); Governor Declared Disaster	
3/2/1977	Drought	Benzie and 43 other counties	Presidential Declared Emergency (3035)	
4/5/1956	Tornado	Benzie County along with Leelanau, Manistee and Ottawa Counties	Presidential Declared Major Disaster (53)	

# Historic Weather Events

- Extreme Winter Weather Events (9) 2012-2021\*  
(events with ice covering, property damage, and/or up to/over 12 in. of snow)

Start Date	Event Type	Effect	Damage
3/2/2012	Heavy Snow	20" snow total near Lake Ann. Most areas saw 6-14" snow. 95% of Benzie County residents lost power.	\$600,000 Property; \$2,000,000 Crop
4/27/2012	Killing Freeze	Extreme damage to fruit trees after unseasonal early warm temperatures	\$15,000,000
3/9/2013	Lake Effect Snow	12" snow at Lake Ann	
1/24/2014	Winter Storm	12-16" snow	
1/17/2016	Lake Effect Snow	+ 18" snow at Lake Ann	
4/13/2018	Winter Storm	Multi-day event; Totals 14" to 23" snow and 1-5" sleet	
2/24/2019	Blizzard	Wind gusts 40-60 mph;. Many roads (especially north-south roads) were rendered impassable by blowing and drifting snow, and drifts as high as 6 feet.	
11/11/2019	Lake Effect Snow	24" snow in Beulah	
2/19/2021	Winter Storm	Heavy snowfall > 12" in L. MI shoreline communities	

\* 29 total severe winter weather events on record since 1993

# Historic Weather Events

- Severe Thunderstorms/High Winds, (10) 2012-2021\*

Date	Event Type	Location	Winds (kts)	Effect	Damage
8/7/2013	T-Storm/Wind	Frankfort Airport	54	Numerous trees were downed between Frankfort and Benzonia.	\$8,000
12/24/2015	High Wind	Region	50	Scattered tree damage and power outages.	\$12,000
6/10/2016	T-Storm/Wind	Lake Ann	50	Several large tree limbs were downed.	\$2,000
6/10/2016	T-Storm/Wind	Frankfort	52	Several trees and a few power lines were downed.	\$9,000
7/21/2016	T-Storm/Wind	Watervale	54	Several trees were downed near Lower Herring Lake.	\$8,000
7/19/2019	T-Storm/Wind	Thompsonville Airport	51	Two trees were downed across M-115 near King Rd.	\$3,000
7/19/2019	T-Storm/Wind	Beulah to Homestead	52	Scattered trees were downed from the Beulah area to near Cinder and Homestead Roads.	\$9,000
6/9/2021	T-Storm/Wind	Thompsonville Airport	50	Downed trees and damage to artwork at Michigan Legacy Art Park.	\$10,000
8/10/2021	T-Storm/Wind	Lake Ann	50	Trees and powerlines downed.	\$5,000
12/16/2021	High Wind	Region	52	An impressive sub-980mb cyclone tracked across western Lake Superior into Ontario during the morning of 12/16, bringing widespread wind gusts of 60-70mph across all of northern Michigan. The highest gust recorded was 70mph at Traverse City Cherry Capitol airport. Widespread downed trees, limbs and powerlines were seen across the County Warning Area, leaving many with power outages that extended for several days.	\$20,000

\* 24 total severe t-storm/wind events on record



# Historic Weather Events

- Hail (19)

Date	Diameter (in.)	Location
6/20/1955	1.75	
7/17/1982	1.75	
7/9/1987	0.75	
4/24/1993	0.75	Frankfort
5/30/2002	1.25	Honor
8/3/2003	0.75	Lake Ann
8/28/2003	0.88	Lake Ann
9/15/2003	0.75	Frankfort
9/7/2005	0.75	Lake Ann
9/7/2005	0.75	Elberta
6/28/2006	0.75	Lake Ann
7/17/2006	1	Honor
10/3/2006	3.25	Benzonia
10/3/2006	1	Honor
6/20/2007	1	Benzonia
10/17/2016	1	Lake Ann
5/31/2019	0.75	Benzonia
5/31/2019	0.88	Nessen City (Colfax Twp.)
9/7/2021	0.75	Beulah

# Historic Weather Events (cont'd)

- 4 Tornadoes

Date	Description	Damage
4/3/1956	EF-4, 19 miles long, 400 yards wide, 2 deaths and 24 injuries	\$250,000
7/21/1983	EF-1	NA
6/26/1986	EF-1, 1 mile long, 20 yards wide	\$3,000
10/15/1989	EF-1, 12 miles long, 20 yards wide	\$25,000



# Historic Weather Events

- Lakeshore Flood (4)

Date	Effect	Damage
10/16/2019	Severe beach erosion threatened to destroy a home several miles north of Frankfort.	\$8,000
10/22/2019	A parking lot next to Betsie Lake in Frankfort flooded. A large field of debris, including entire trees and large tree limbs, was deposited along the beach at Point Betsie Lighthouse.	\$129,000
4/13/2020	The city boat launch in Frankfort experienced flooding of docks and the parking lot.	\$8,000
6/10/2020	M-22 was closed across the Betsie Lake Causeway near Elberta due to high water.	N/A

- Rip Current (2)

Date	Location	Description
8/17/2010	Frankfort	Rip currents produced a near-fatality on Lake Michigan. A 14-year old male was caught in a rip current while swimming in Lake Michigan. He was carried away from the beach, and eventually was submerged for 5 to 10 minutes before being rescued.
8/4/2012	Peterson Beach, Sleeping Bear Dunes National Lakeshore, Lake Township	Wave action produced by onshore winds of 15 to 20 mph contributed to rip current development on Lake Michigan. One fatality occurred. Rescue personnel estimated waves of 3 to 5 feet at the time of the incident.





# Historic Weather Events

- Flood/Flash Flood (1) and Lightning (1)

Date	Event Type	Location	Effect	Damage
9/1/2000	Flash Flood, Lightning	Countywide/Grand Traverse Region	Over the 4 to 5 hour period of rainfall, amounts ranged from 2 to 6 inches in Benzie County, leading to flooding across the northern half of the County. Lightning associated with the storms was almost continuous during the event and resulted in many high school football games being cancelled or delayed.	N/A

- Wildfire

- None on record with NOAA as a major event
- MSP's 2019 *Michigan Hazard Analysis*:
  - MDNR Jurisdiction from 1981-2018
    - 184 wildfires, 396.8 acres burned
    - 4.8 fires/year; 10.4 acres burned/year



# Historic Weather Events (cont'd)

- Extreme Heat/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.



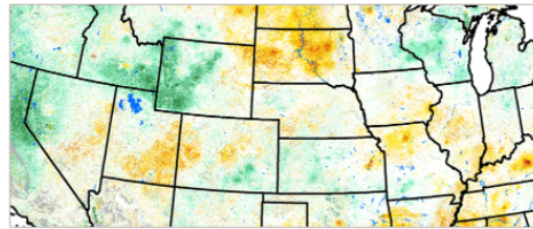
# Drought Risk

- U.S. Drought Monitor  
<https://droughtmonitor.unl.edu>

## U.S. Drought Monitor

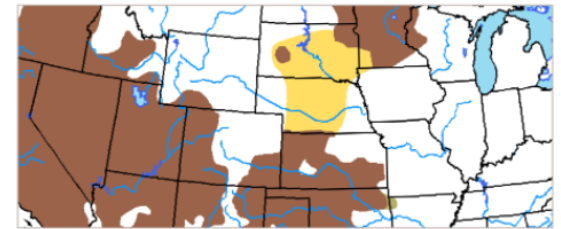
[Current Map](#)[Maps](#)[Data](#)[Summary](#)[About](#)[Conditions & Outlooks](#)[En Español](#)[NADM](#)[Home](#) > [Conditions & Outlooks](#)

### Conditions & Outlooks



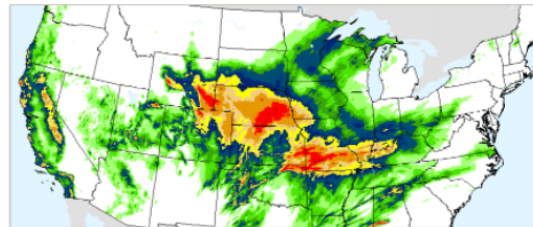
#### Current Conditions

Access various products showing current climate conditions, which inform the USDAM map.



#### Outlooks

Find forecast and outlook products related to drought from our regional and federal partners.



#### Weekly Drought Indices

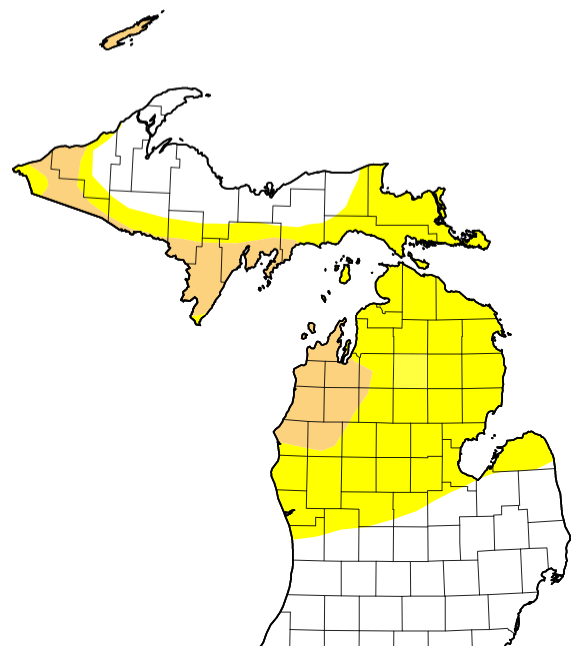
A series of maps are produced weekly and contain a large number of the inputs used in the making of the weekly United States Drought Monitor. Most updates are provided on the Tuesday of each week.



# Drought Risk

## Michigan

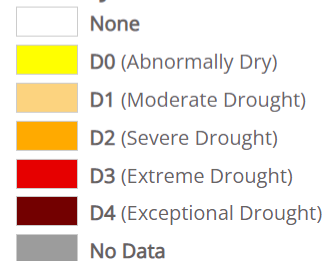
[Home](#) > Michigan



**Map released: Thurs. March 17, 2022**

**Data valid: March 15, 2022 at 8 a.m. EDT**

### Intensity



### Authors

**United States and Puerto Rico Author(s):**

**Adam Hartman**, NOAA/NWS/NCEP/CPC

**Pacific Islands and Virgin Islands Author(s):**

**Brad Rippey**, U.S. Department of Agriculture

*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying [text summary](#) for forecast statements.*

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

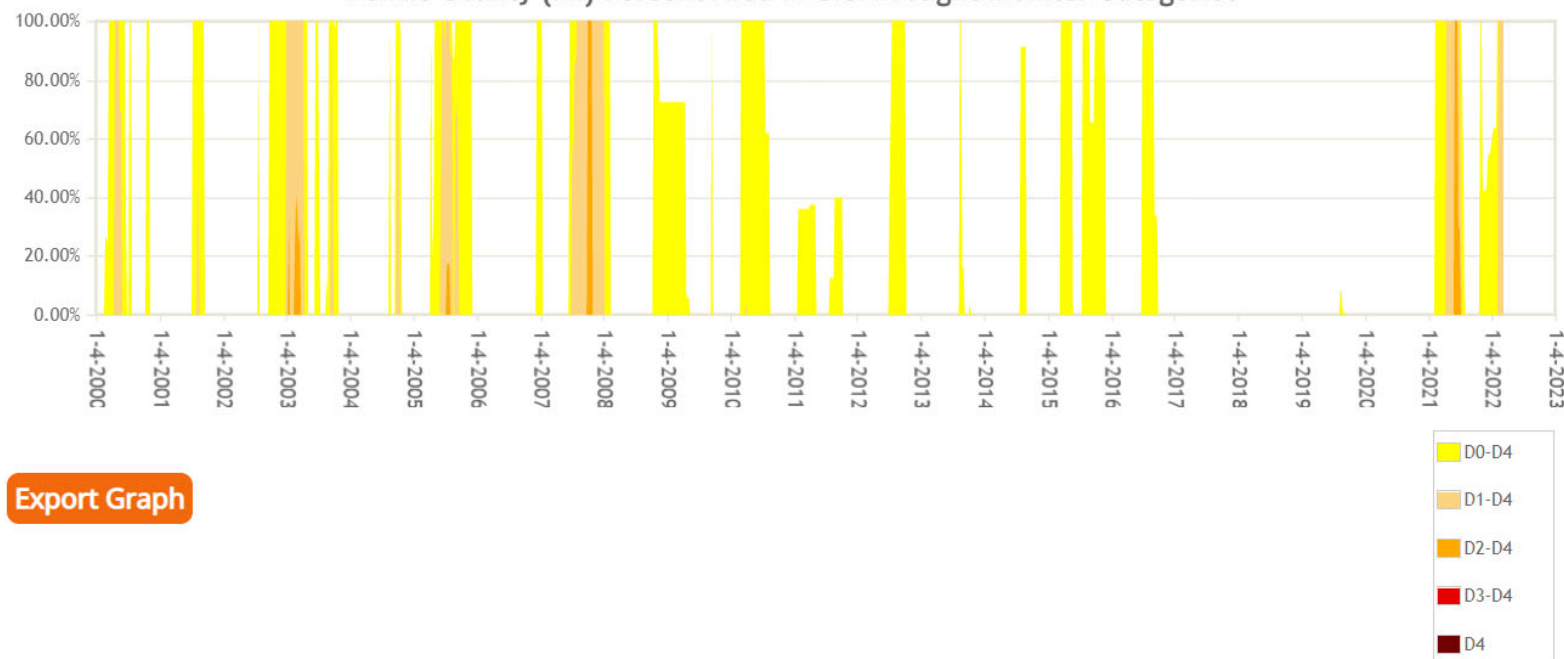
# Historic Drought Risk

## Benzie County, 2000-present

To zoom in, click and drag the cursor. To return to the full time series, double-click anywhere in the chart.

Area type: County Area: Benzie County (MI) Index: USDM Fill area: ☒ Show:   
 D0: ☒ D1: ☒ D2: ☒ D3: ☒ D4: ☒

Benzie County (MI) Percent Area in U.S. Drought Monitor Categories

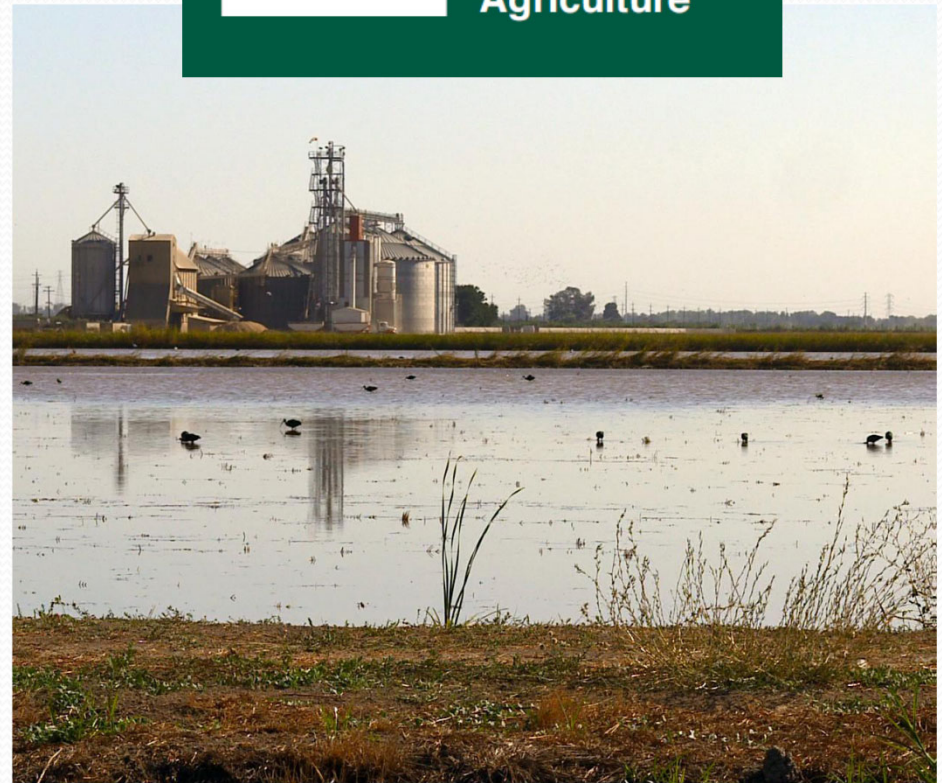


Export Graph



# Disaster Impacts on Agriculture

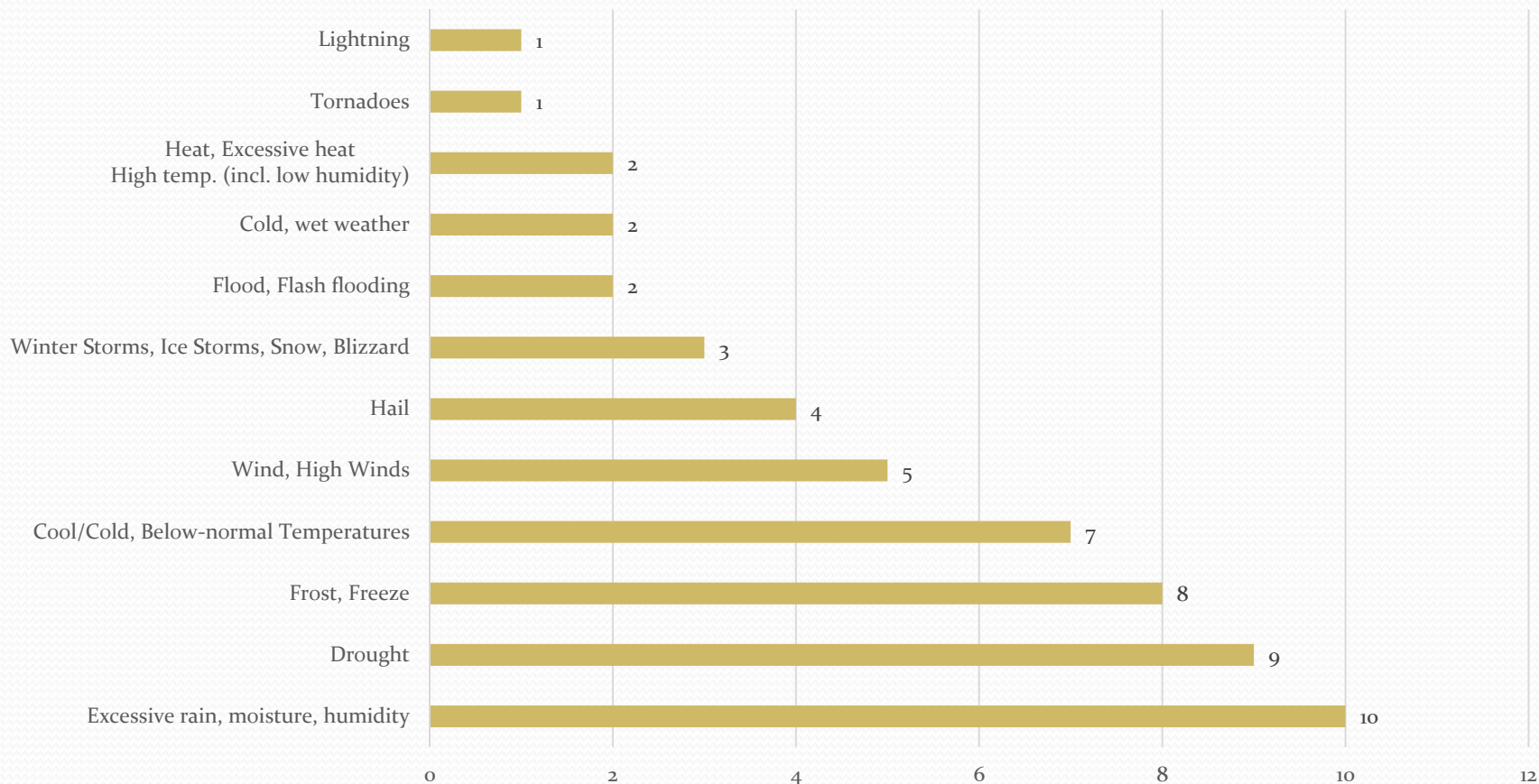
- The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency (EM) loans available to producers suffering losses in those counties and in counties that are contiguous to a designated county.
- In addition to EM loan eligibility, other emergency assistance programs, such as Farm Service Agency (FSA) disaster assistance programs, have historically used disaster designations as an eligibility trigger.
- Agriculture-related disasters and disaster designations are quite common. Many counties in the United States have been designated as disaster areas in the past several years, even in years of record crop production.
- The USDA Farm Service Agency (FSA) administers four types of disaster designations:
  - U.S. Department of Agriculture (USDA) Secretarial disaster designation;
  - Presidential major disaster and Presidential emergency declaration;
  - FSA Administrator's Physical Loss Notification (APLN); and
  - Quarantine designation by the Secretary under the Plant Protection Act or animal quarantine laws.





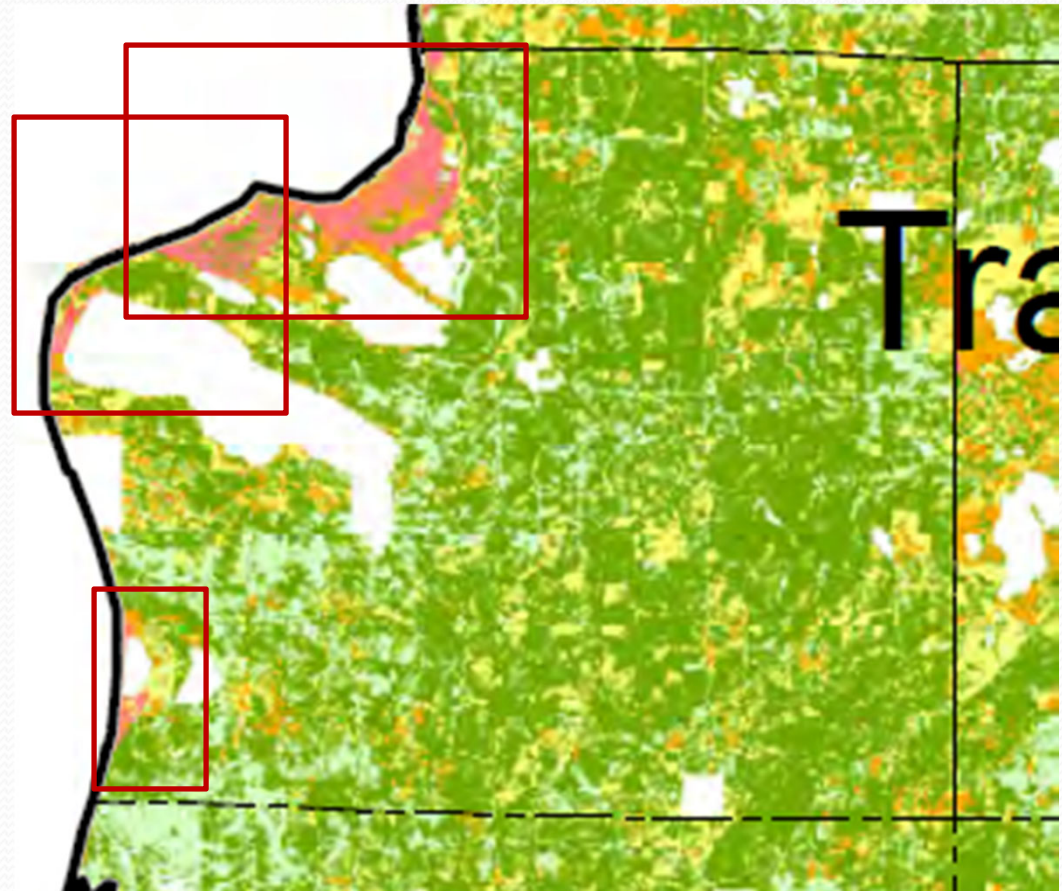
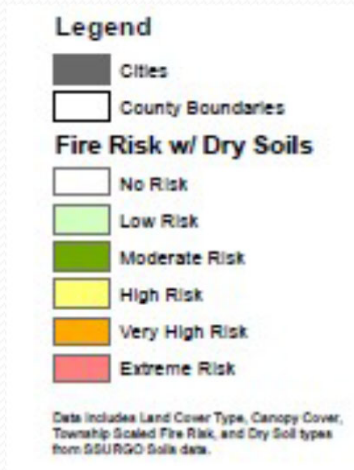
# Disaster Impacts on Agriculture

USDA Disaster Designations - Event Types  
Benzie County, 2012-2021\*



\*There were 25 Disaster Designations from the US Secretary of Agriculture for Benzie County between 2012-2021.

# Wildfire Risk



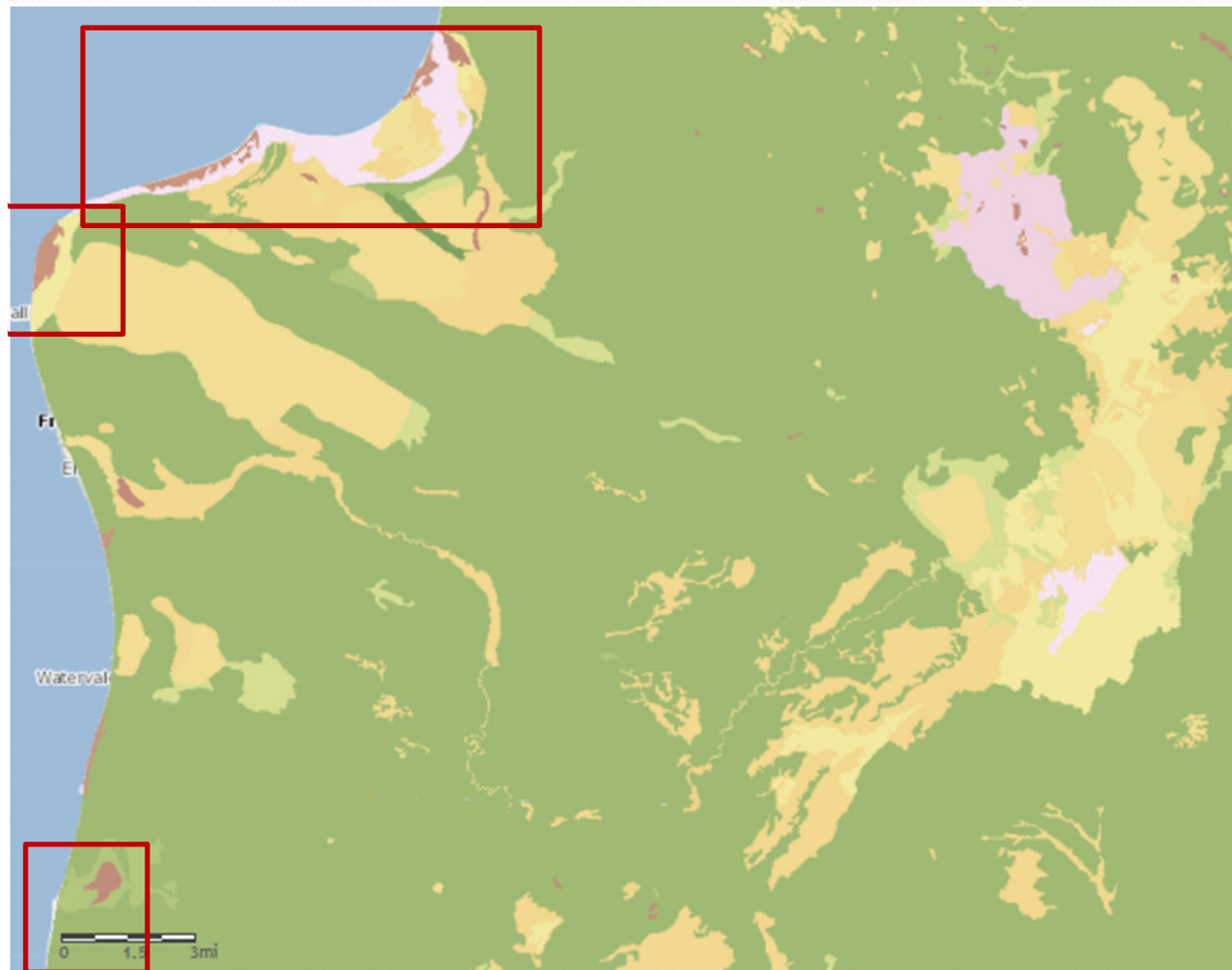
Source: Wildfire Risk Map - MDNR Forest Resources Division



# County Forests

MNFI Landcover Circa 1800

- ASPEN-BIRCH FOREST
- BEECH-SUGAR MAPLE FOREST
- BEECH-SUGAR MAPLE-HEMLOCK FOREST
- BLACK ASH SWAMP
- BLACK OAK BARREN
- CEDAR SWAMP
- EXPOSED BEDROCK
- GRASSLAND
- HEMLOCK-WHITE PINE FOREST
- HEMLOCK-YELLOW BIRCH FOREST
- JACK PINE-RED PINE FOREST
- LAKE/RIVER
- MIXED CONIFER SWAMP
- MIXED HARDWOOD SWAMP
- MIXED OAK FOREST
- MIXED OAK SAVANNA
- MIXED PINE-OAK FOREST
- MUSKEG/BOG
- OAK-HICKORY FOREST
- OAK/PINE BARRENS
- PINE BARRENS
- SAND DUNE
- SHRUB SWAMP/EMERGENT MARSH
- SPRUCE-FIR-CEDAR FOREST
- SUGAR MAPLE-BASSWOOD FOREST
- SUGAR MAPLE-HEMLOCK FOREST
- SUGAR MAPLE-YELLOW BIRCH FOREST
- WET PRAIRIE
- WHITE PINE-MIXED HARDWOOD FOREST
- WHITE PINE-RED PINE FOREST
- WHITE PINE-WHITE OAK FOREST
- Undetermined





# Wildland Fire - 2019

## Map Views

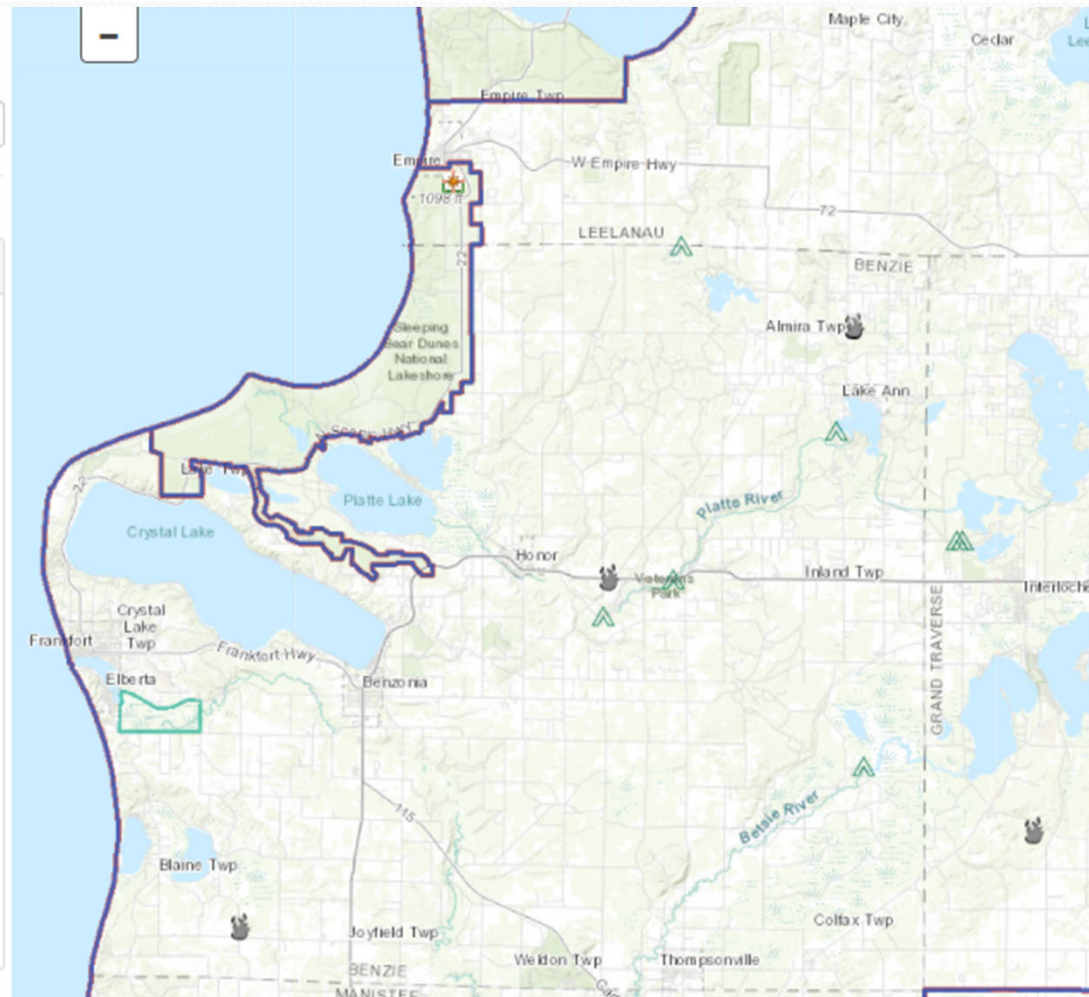
Display Fire Incidents by Year

2019

Change the map items using the checkboxes

### Wildland Fire Incidents

- ☒ Fire Incident - Active
- ☒ Fire Incident - Closed
- ☒ Prescribed Burn - State
- ☒ Prescribed Burn - Federal
- ☒ Prescribed Burn - Contractor
- ☒ Prescribed Burn - Closed
- ☒ Weather Stations
- ☒ MDNR Fire Offices
- ☒ DNR Campgrounds
- ☒ MDNR Fire Protection
- ☒ MDNR Fire Management Boundaries
- ☐ USFS National Forest
- ☒ MDNR Wildlife Boundary
- ☐ DNR Ownership Parcels
- ☐ Has Concern



Source: Wildland Fires - <https://www.mcgi.state.mi.us/wildfire/mcgi.html#>

# County Wetlands

## Wetland Data

☐ Wetland (Hydric) Soils

☐ National Wetlands Inventory 2005

### Potential Wetland Restoration

☐ Highest Potential - Hydric and  
Presettlement Wetland Overlay

☐ High Potential - Hydric Soils Only

☐ Moderate Potential - Presettlement  
Wetlands Only

### Part 303 Final Wetlands Inventory

☒ Wetlands as identified on NWI and MIRIS  
maps

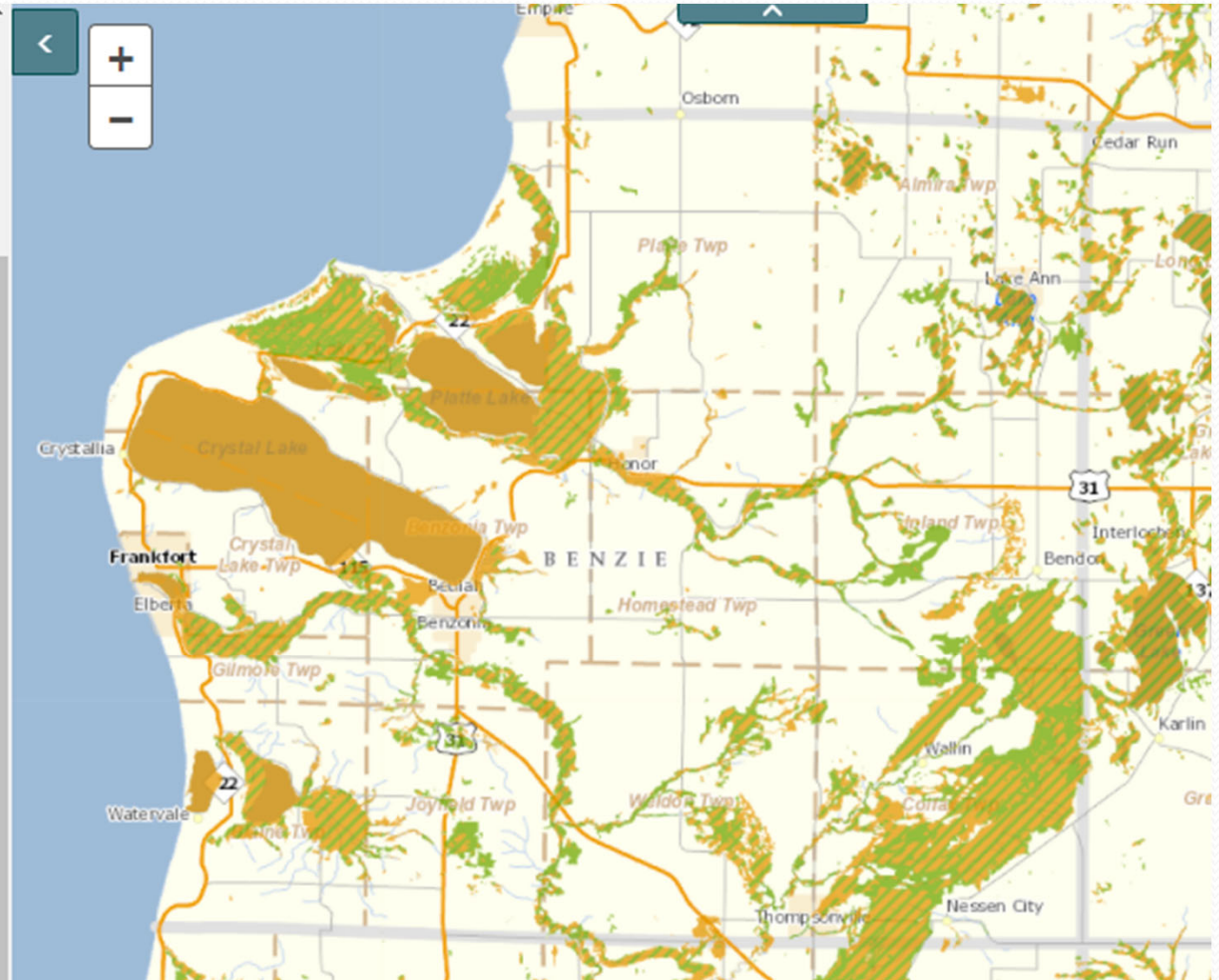
☐ Soil areas which include wetland soils

☐ Wetlands as identified on NWI and MIRIS  
maps and soil areas which include wetland soils

## Stream Data

## Coastal Data

## Historic Landcover





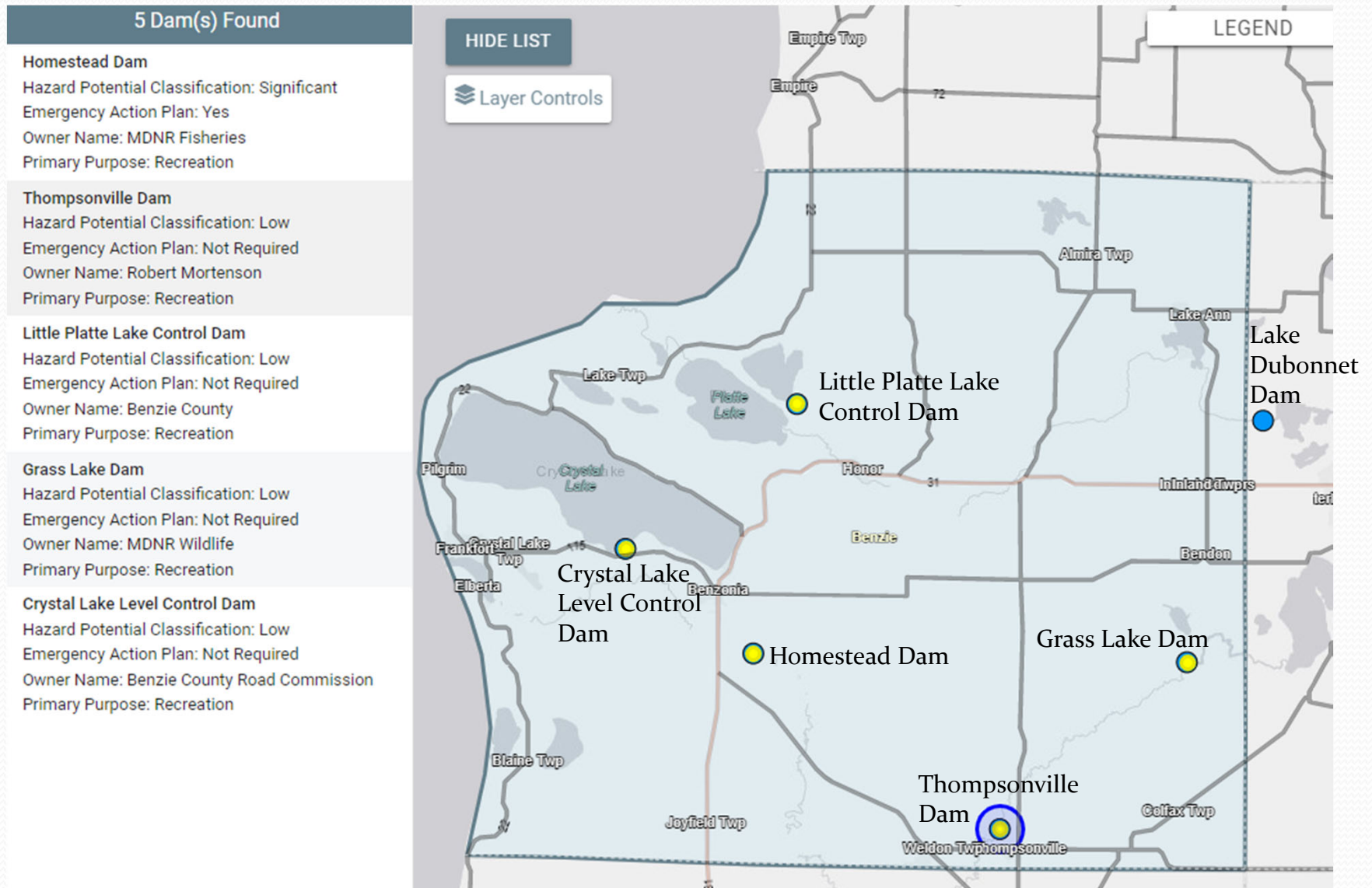


# Benzie County Dams

	Name	Height (ft)	Storage (acre-feet)	Location	Owner	Regulatory Agency	Dam Type	Year Completed	Dam Purpose	Hazard Potential
1	Crystal Lake Level Control Dam	7	27,190	Crystal Lake Outlet	Benzie County Road Commission	-	Gravity	1977	Recreation, Other	Low
2	Grass Lake Dam	8.4	5,200	Betsie River	MDNR Wildlife	-	Gravity	1951	Recreation	Low
3	Homestead Dam	14	1,800	Betsie River	MDNR Fisheries	State	Other	1979	Recreation	Significant
4	Little Platte Lake Control Dam	10	3,400	North Branch Platte River	Benzie County	-	Other	1969	Recreation, Other	Low
5	Thompsonville Dam	20	165	Betsie River	Robert Mortenson	-	Earth, Gravity	1901	Recreation	Low

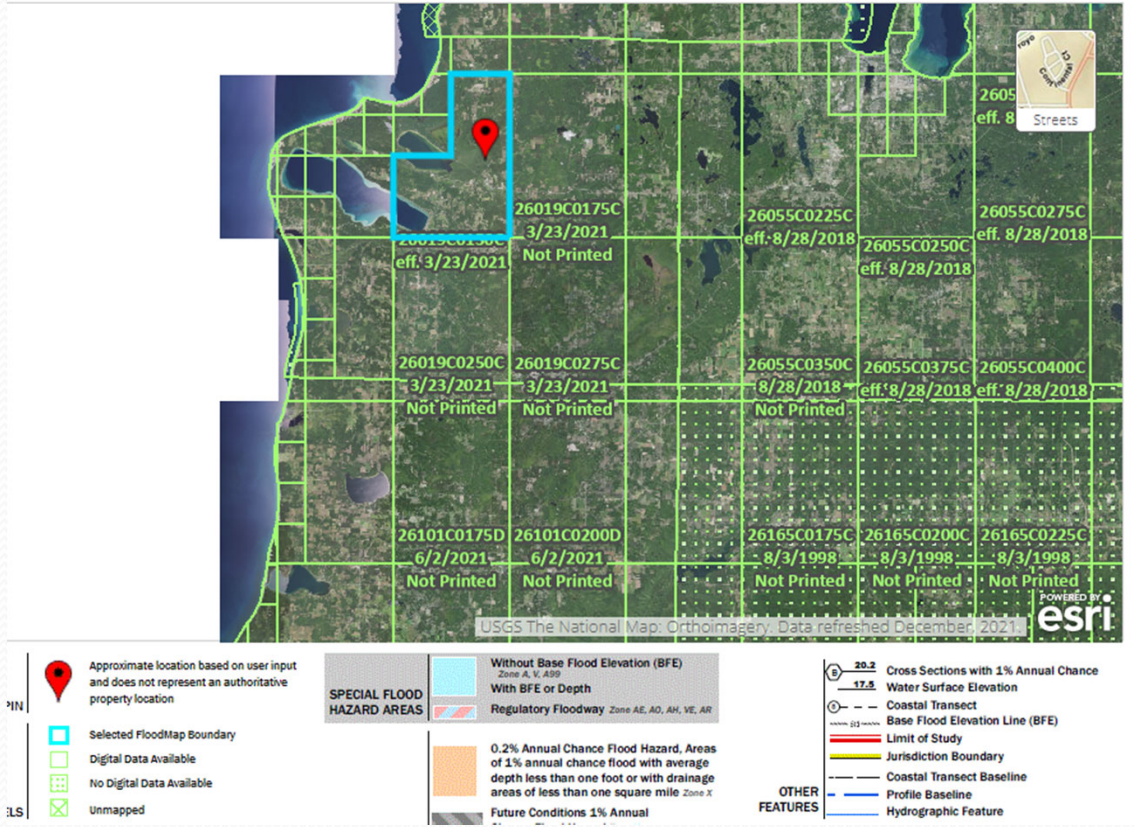


## Listed on the National Inventory of Dams



# Local NFIP Status

Municipality	FIRM	Effective Date
Almira Township	Y	3/23/2021
Benzonia Township	N	
Blaine Township	Y	3/23/2021
Colfax Township	N	
Crystal Lake Township	Y	3/23/2021
City of Frankfort	Y	3/23/2021
Gilmore Township	Y	3/23/2021
Homestead Township	N	
Inland Township	N	
Joyfield Township	N	
Lake Township	Y	3/23/2021
Platte Township	N	
Weldon Township	N	
Village of Benzonia	N	
Village of Beulah	N	
Village of Elberta	Y	3/23/2021







# CRS Participating Communities

- 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

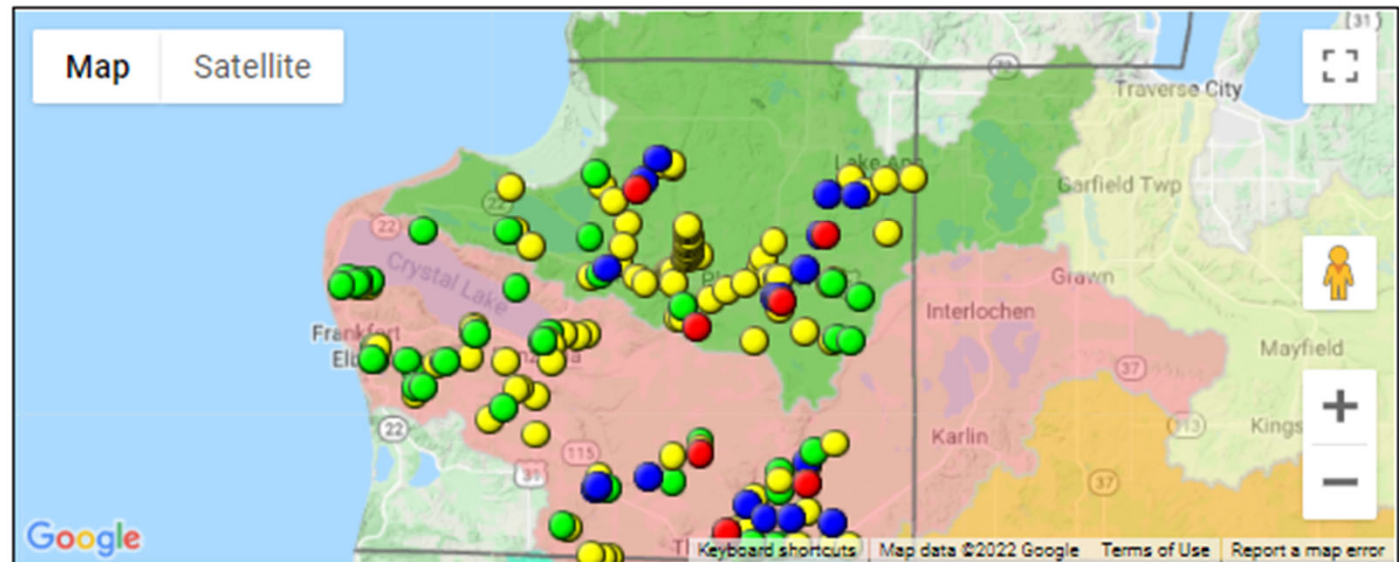


# RIVER RESTORATION

in Northern Michigan

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## Road Stream Crossings in Benzie County

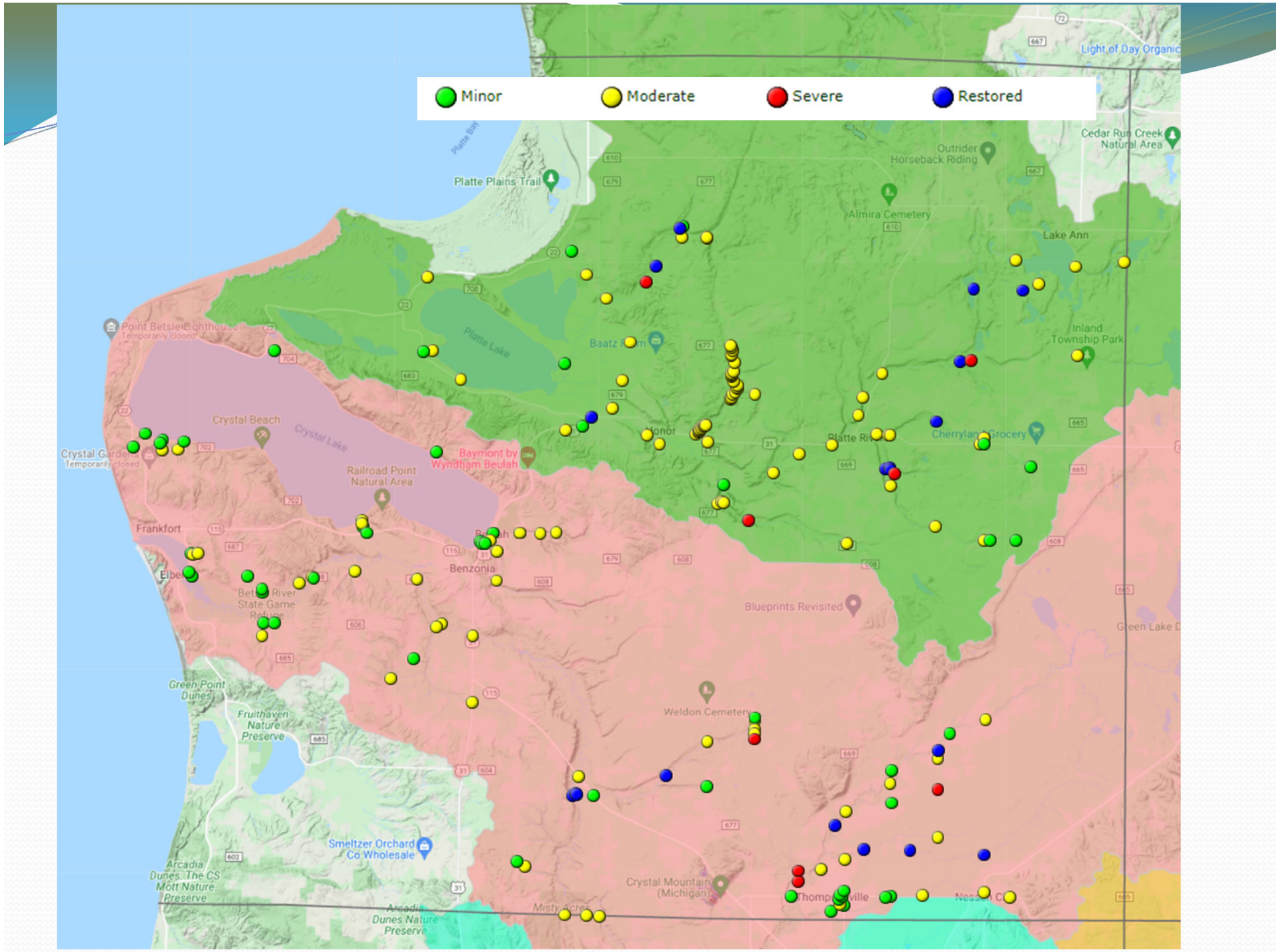
[Benzie County](#)[Road Stream Crossings](#)[Streambank Erosion](#)

● Minor

● Moderate

● Severe

● Restored





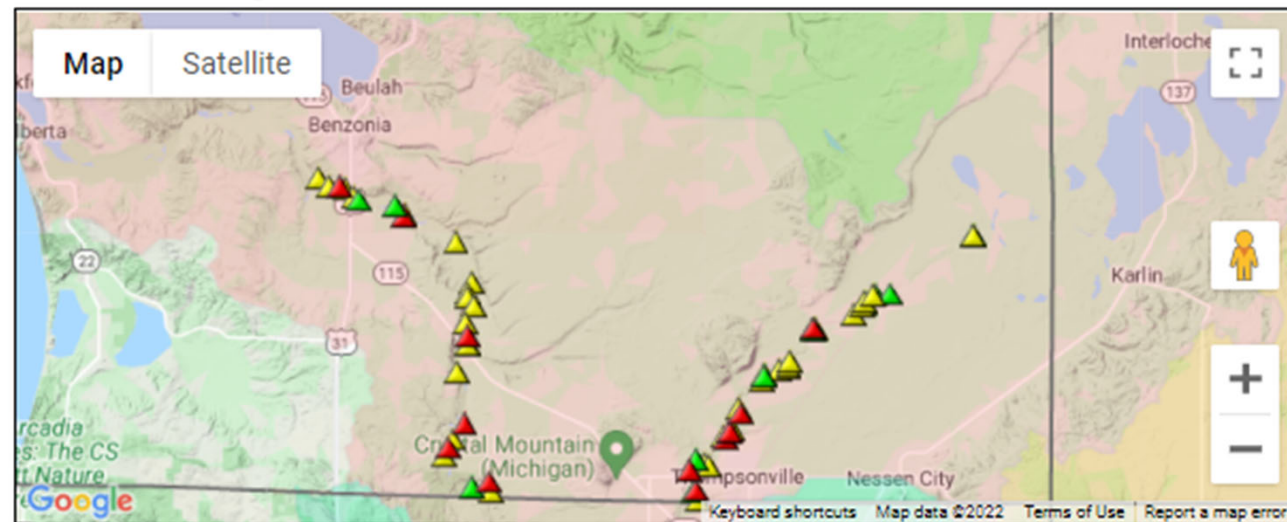
# RIVER RESTORATION

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### Benzie County Streambank Erosion Sites

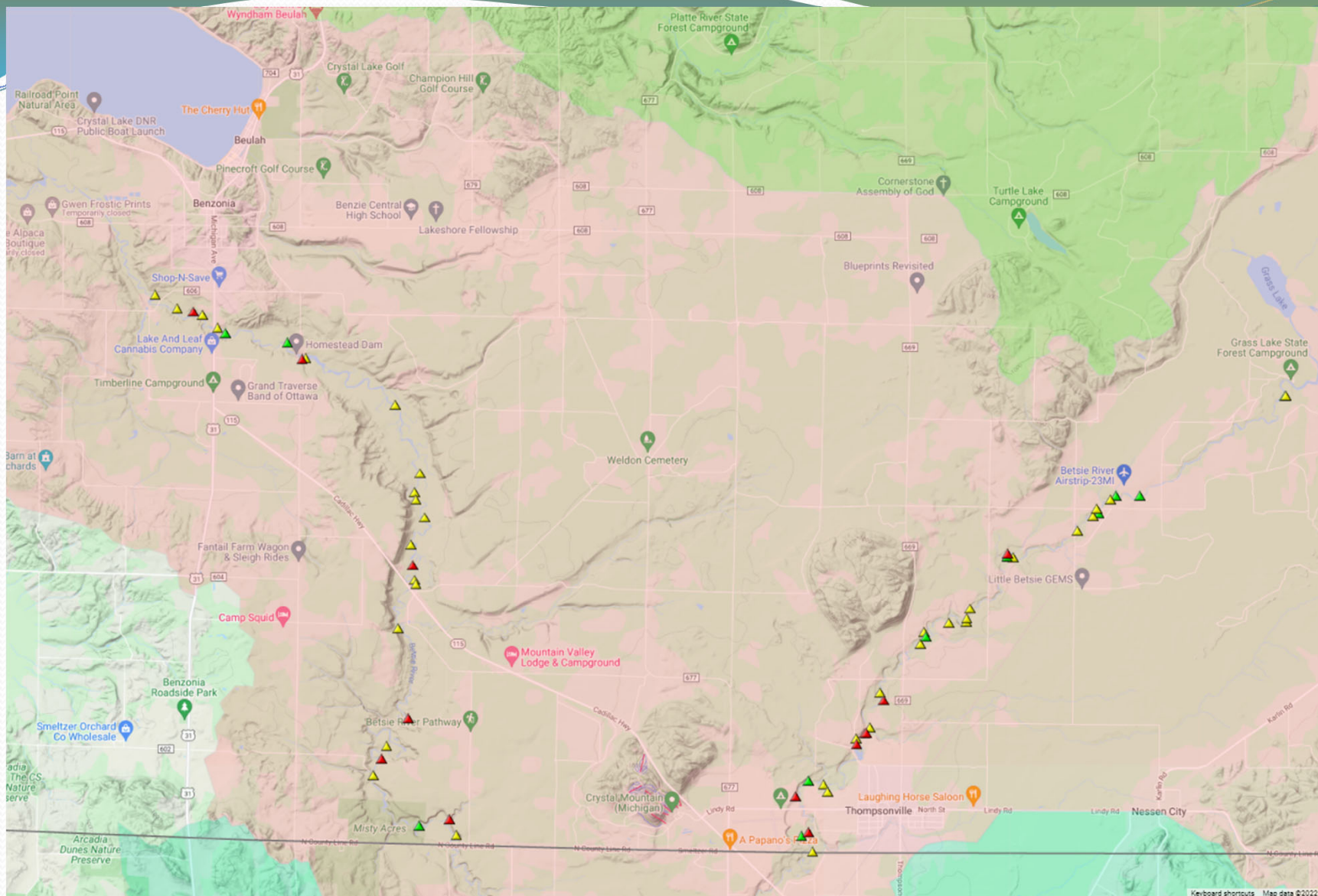
Benzie County  
Road Stream Crossings  
Streambank Erosion



▲ Minor ▲ Moderate ▲ Severe

Site No.	Township	County	Stream	Length	Texture	Treatment
▲ <a href="#">BTS-001</a>	Colfax Twp	Benzie	Betsie River	30 ft.	Sand	-Rock riprap -Tree revetments -Constructed access
▲ <a href="#">BTS-002</a>	Colfax Twp	Benzie	Betsie River	30 ft.	Sand	-Bank revegetation -Constructed access
▲ <a href="#">BTS-003</a>	Colfax Twp	Benzie	Betsie River	20 ft.	Gravel Sand	-Tree revetments
▲ <a href="#">BTS-004</a>	Colfax Twp	Benzie	Betsie River	30 ft.	Sand	-Rock riprap -Tree revetments
▲ <a href="#">BTS-005</a>	Colfax Twp	Benzie	Betsie River	35 ft.	Sand Gravel	-Rock riprap -Tree revetments
▲ <a href="#">BTS-006</a>	Colfax Twp	Benzie	Betsie River	20 ft.	Sand	-Obstruction removal -Rock riprap -Tree revetments





# Coastal Flooding / Coastal Recession

- [http://www.resilientmichigan.org/nw\\_atlas.asp](http://www.resilientmichigan.org/nw_atlas.asp)



## ACKNOWLEDGMENTS

Financial assistance for this project was provided, in part, by the Michigan Coastal Zone Management Program, Department of Environment, Great Lakes, and Energy, and is supported through a grant under the National Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration. The statements, findings, conclusions and recommendations in this report are those of the researchers and do not necessarily reflect the views of the Michigan Department of Environment, Great Lakes, and Energy and the National Oceanic and Atmospheric Administration.



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.







# Coastal Dynamics

- Climate change on the Great Lakes
  - Increased precipitation and storminess
  - Variability of lake water levels – on a decadal scale
  - Increased water temperature
- Water Volume, Wave Energy and Height
  - Erosion
  - Changing conditions: sedimentation, shallower and wider water bodies

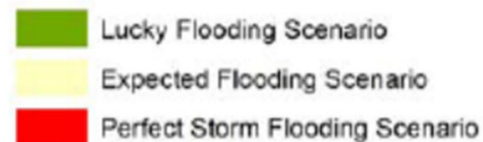


# US Army Corp of Engineers

[illegible]

# Coastal Flooding

[http://www.resilientmichigan.org/nw\\_atlas.asp](http://www.resilientmichigan.org/nw_atlas.asp)



- **“Lucky” 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: 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: 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.



# Coastal Flooding

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Northwest Lower Michigan Coastal Resilience Atlas

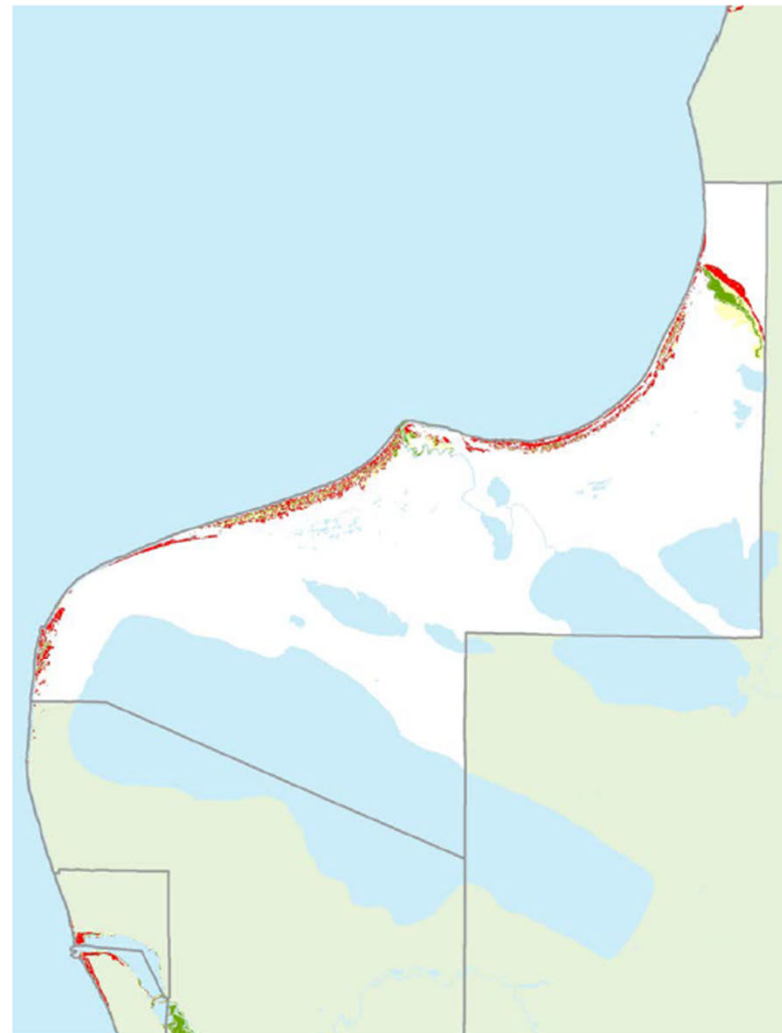
## Lake Twp.



Coastal Flooding Scenario Impacts

Lake			
Total SEV	Lucky	Expected	Perfect Storm
\$ 253,341,015.00	\$ -	\$ 22,231.00	\$ 7,982,680.00

- Lucky Flooding Scenario
- Expected Flooding Scenario
- Perfect Storm Flooding Scenario

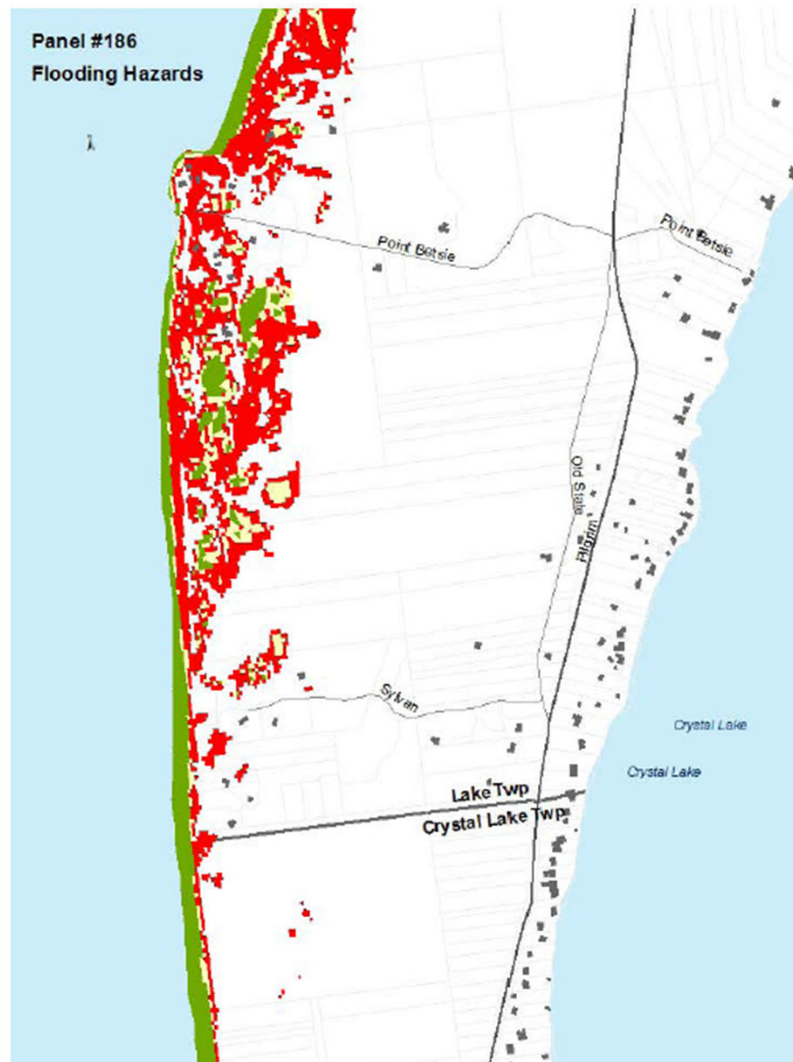




# Coastal Flooding



- Lucky Flooding Scenario
- Expected Flooding Scenario
- Perfect Storm Flooding Scenario



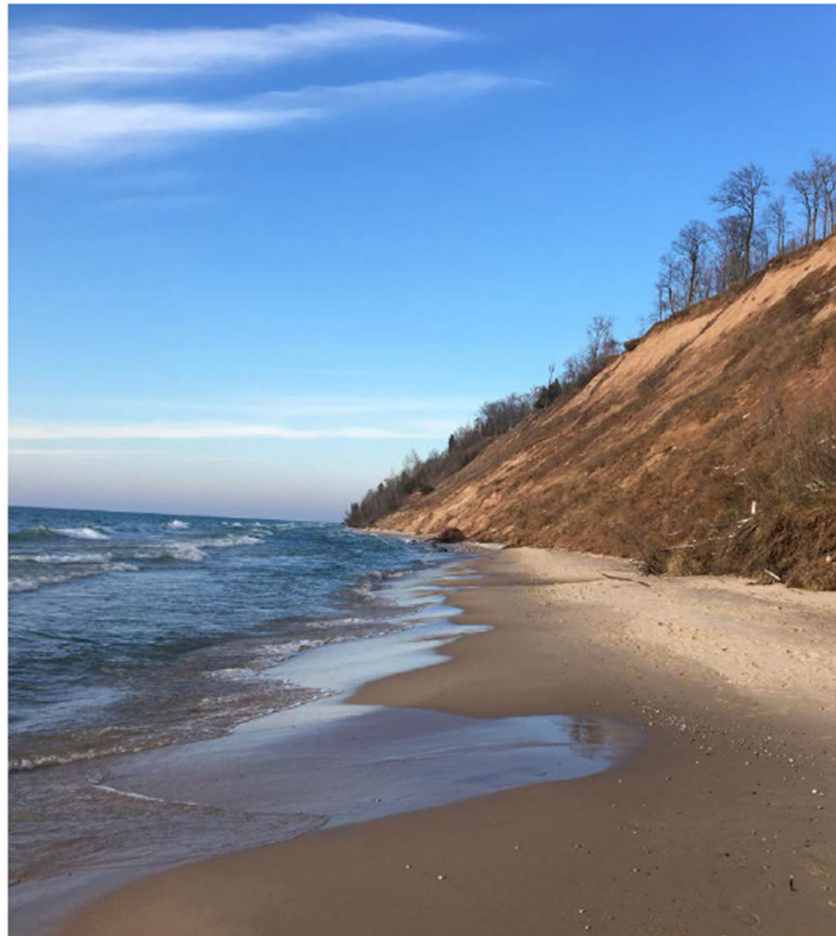
# Coastal Recession

[http://www.resilientmichigan.org/nw\\_atlas.asp](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

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## Frankfort



Shoreline 1938  
Bluffline 1938  
Bluffline 2016  
Predicted 30  
yr bluff

— Shoreline 1938  
— Bluffline 1938  
— Bluffline 2016  
— Predicted 30yr Bluffline



# Coastal Recession

[http://www.resilientmichigan.org/nw\\_atlas.asp](http://www.resilientmichigan.org/nw_atlas.asp)

Northwest Lower Michigan Coastal Resilience Atlas

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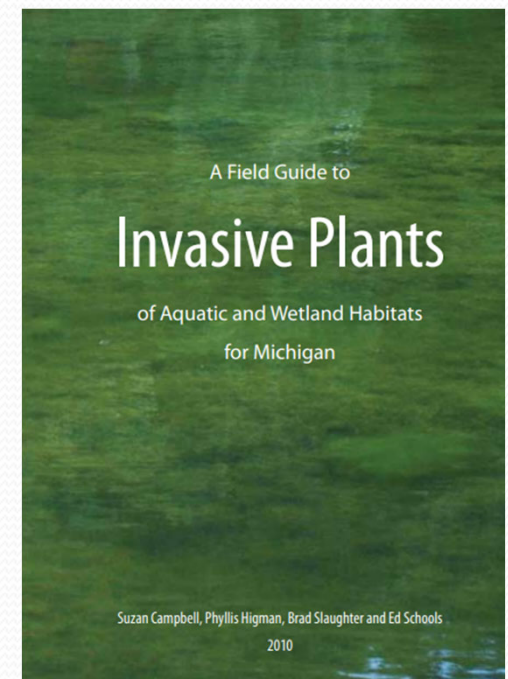
Bluff Detail, Panel 188, Frankfort



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



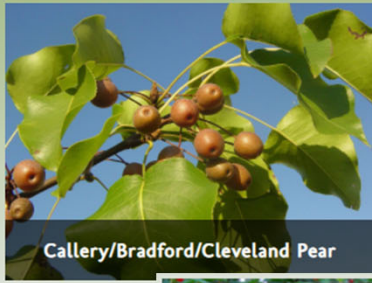
Japanese and common barberry



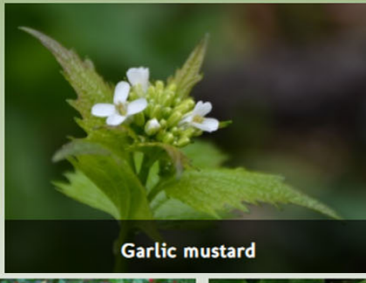
Blue lyme grass



Glossy and common buckthorn



Callery/Bradford/Cleveland Pear



Garlic mustard



Invasive honeysuckles



\*Knotweeds



Invasive bittersweet



\*Invasive Phragmites



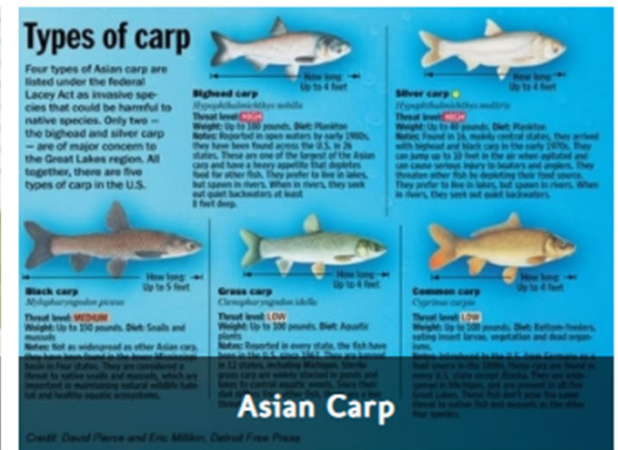
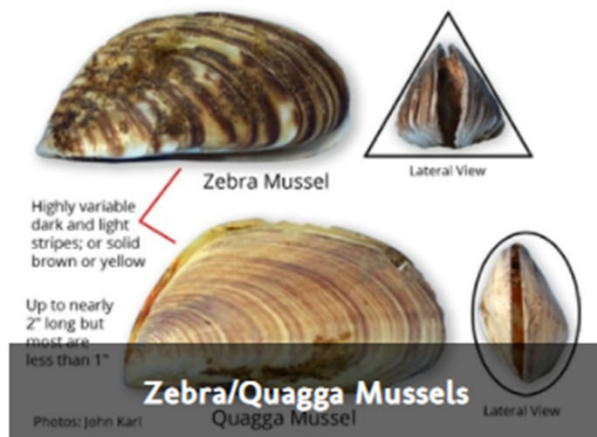
\*Purple loosestrife



Tree-of-Heaven



# Invasive Species







# Next Steps

- Hazard mapping
- Review 2016 prioritized hazards
- Prepare hazard analysis
- Small group meetings
- Field trip