Benzie County, Michigan
Natural Hazard Mitigation Plan

2023

Prepared for: Benzie County Board of Commissioners

Prepared by: Benzie County Office of Emergency Management with assistance from:

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FEMA LETTER OF APPROVAL

ACKNOWLEDGEMENTS

The Benzie County Natural Hazard Mitigation Plan is prepared for Benzie County, Michigan and all the jurisdictions within it. Each jurisdiction is invited to be a continuing participant in future regular review and updates of the Plan. This plan is the culmination of an interdisciplinary and interagency planning effort that required the participation, technical assistance and expertise of individuals within the following agencies and organizations:

Organization	Representative
Almira Twp.	Tammy Clous, Clerk
	Brad Drury, Fire Chief
	Mark Roper, Supervisor
	Mandy Gray Rineer, Trustee
	Lori Florip, Trustee
	Matt Therrien, Trustee
American Red Cross - N. MI Chapter	Meghan Powers
Benzie Conservation District	Tad Peacock, Executive Director
Benzie County Administration	Katie Zeits
Benzie County Board of Commissioners - Blaine Township, Gilmore Township, Joyfield Township, Weldon Township	Gary Sauer
Benzie County Central Dispatch/Thompsonville Fire Dept.	Michael Draeger
Benzie County Equalization	Tom Longanback
Benzie County EMS	Tom King
Benzie County Office of Emergency Management	Rebecca Hubers, EM Coordinator
Benzie County Road Commission	Mike Johnson, Shop Foreman/Facility Mgr.
	Matt Skeels, Manager
Benzie County Sheriff's Office	Kyle Rosa, Sheriff
	Gregory T Hubers, Undersheriff
Benzie-Leelanau District Health Department	Bobbi Scott
Beulah Village	
Benzonia Twp.	Diana Heller, Clerk
	Jason Barnard, Supervisor
	Karen Burns, Treasurer
	Jim Sheets, Trustee
	Shiela Priest, Trustee
Benzonia Twp. Fire Dept.	Steve Adams
Benzonia Village	
Blaine Twp.	Paul E. Crandall, Supervisor
City of Frankfort	Joshua Mills, City Superintendent
Colfax Twp.	
County Board of Commissioners - Homestead Township	Tim Markey
Crystal Lake Twp.	Amy Ferris, Supervisor
	Richard Nielsen, Trustee
	William Northway, Trustee
	Brooke Trentham Popp, Treasurer
	Sue Sullivan, Clerk
	Gregory Wright, Planning Commission Chair

Elberta Village	
Gilmore Twp.	Shannon Spencley, Clerk
	Carl Noffsinger, Supervisor
	Robin Rommell, Treasurer
	Douglas Holmes, Trustee
Graceland Fruit	Cody Allen
Grand Traverse Band of Ottawa and Chippewa Indians	Jolanda Murphy
Homestead Twp.	Karen Mallon, Clerk
	Dorene Strang, Community Member
	Mike Mead, Trustee
	Pat Delormem, Trustee
	Bess Butler, Trustee
	Tia Kurina-Cooley, Supervisor
Honor Village	
Inland Twp.	Rose Wirth, Clerk
	Paul Beechraft, Supervisor
	Linda Wilson, Treasurer
	Mary Miller, Trustee
	Sheri Poulisse, Turstee
Joyfield Twp.	Mark Evans, Trustee
	Matt Emery, Supervisor
	Patricia Daugherty, Treasurer
	Ed Kowalski, Community Member
Lake Ann Village	Craig Timm, President
Lake Twp.	Sally Casey, Trustee
	Maryanne Goodman, Trustee
	Dotty Blank Trustee
	Anna Grobe, Supervisor
MDNR Fire	Steve Cameron
Michigan Dept. of Health and Human Services	Joleen Peck
	Jennifer Savage
Michigan State Police	Lt. Frank Keck
	Lt. Matt McCaul
	Lt. Michael deCastro
Paul Oliver Memorial Hospital	Fred Craigin
Platte Twp.	Paul Solem, Supervisor
Smeltzer Orchards	Tim Brian
Weldon Twp.	Fran Griffin, Clerk
	Craig Meredith, Community Member
	Ron Hitesman, Supervisor
	Sally Bobek, Treasurer
	Sue Meredith, Trustee
	Scott Williams, Trustee

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I. INTRODUCTION

Hazard mitigation is defined as any action taken before, during, or after a disaster or emergency to permanently eliminate or reduce the long-term risk to human life and property from natural, technological and human-related hazards. Mitigation is an essential element of emergency management, along with preparedness, response and recovery.

Mitigation allows repairs and reconstruction to be completed after an incident occurs in such a way that does not just restore the damaged property as quickly as possible to pre-disaster conditions. It also ensures that such cycles are broken, that post-disaster repairs and reconstruction take place after damages are analyzed, and that sounder, less vulnerable conditions are produced. Through a combination of regulatory, administrative, and engineering approaches, losses can be limited by reducing susceptibility to damage. When successful, hazard mitigation will lessen the impact of a disaster on people, property, the environment and economy, and continuity of services through the coordination of available resources, programs, initiatives, and authorities.

A *hazard*, in the context of this plan, is an event or physical condition that has potential to cause fatalities; injuries; damage to personal property, infrastructure, or the environment; agricultural product loss; or interruption of business or civic life. The Benzie County Natural Hazard Mitigation Plan focuses on *natural* hazards such as heat, drought, wildfires, flooding, shoreline erosion, thunderstorm, high winds, hail, extreme winter weather, and invasive species. An exception is that it will also consider these technological and human-related hazards: dam failure and public illness outbreak.

The main objective of the Benzie County Natural Hazard Mitigation Plan is to permanently eliminate or reduce long-term risks to people and property from natural hazards so that county assets such as transportation, infrastructure, commerce, and tourism can be sustained and strengthened. This can be accomplished through collaborative efforts/activities amongst agencies within the county to protect the health, safety, and economic interests of the residents and businesses through planning, awareness, and implementation.

Through this Plan, a broad perspective was taken in examining multiple natural hazard mitigation activities and opportunities in Benzie County. Each natural hazard was analyzed from a historical perspective, evaluated for potential risk, and considered for possible mitigation.

Since the 2015 Plan's adoption period, the county and municipalities have achieved the following key endeavors to address their previously identified mitigation strategies; a detailed list is included in the Appendix.

- Ongoing: Enforcement of soil erosion control permitting to prevent soil erosion during construction
- Ongoing: Enforcement of building codes (permits and inspections based on State Building Code) for new construction; this includes MI EGLE floodplain verification with new builds and structural additions
- Ongoing: tree trimming by power companies
- Achieved: "Work on a multi-hazard warning plan". Benzie County now offers CodeRED free of charge to interested residents. The CodeRED system is used to send emergency notifications, from evacuations notices to missing child alerts. Residents and businesses located within Benzie county are encouraged to sign up for CodeRED to be sure they receive timely emergency notifications and other important information and instructions when alerts are issued.

Section VI of this plan provides a list of hazard mitigation strategies for each natural hazard identified. Strategies were developed based on discussions with local officials and a review of FEMA best practices for hazard mitigation. Appendix C provides a review of mitigation strategies included in the 2016 plan and their current status. Mitigation strategies are intended to be action items completed during the 5-year timeframe in which the plan is active.

Recognizing the importance of reducing community vulnerability to natural hazards, Benzie County is actively addressing the issue through the development and implementation of this plan. This process will help ensure that Benzie County remains a vibrant, safe, enjoyable place in which to live, raise a family, continue to conduct business, and maintain a tourist base. The Plan serves as the foundation for natural hazard mitigation activities and actions within Benzie County, and will be a resource for building coordination and cooperation within the community for local control of future mitigation and community preparedness around the following (Table 1).

Table 1: 2023 Benzie County Hazard Mitigation Planning Goals

Goal 1: Increase local participation in natural hazard mitigation.
Goal 2: Integrate natural hazard mitigation considerations into the County's comprehensive planning process.
Goal 3: Utilize available resources and apply for funding for natural hazards mitigation projects.
Goal 4: Develop and complete natural hazards mitigation projects in a timely manner.

II. PLANNING PROCESS

The Stafford Act, as amended by the Disaster Mitigation Act of 2000, shifted the Federal Emergency Management Agency's (FEMA) scope of work to promoting and supporting prevention, or what is referred to as hazard mitigation planning. FEMA requires government entities to have a natural hazards mitigation plan in place and updated on a 5-year cycle as a condition for applying for grant funding related to natural hazard mitigation and remediation. Benzie County has a history of mitigation planning and adopted past Natural Hazard Mitigation Plans in 2007 and 2016. The adoption of the 2022 plan will reaffirm the eligibility of the county, as well as those local municipalities who participated in the planning process and adopted the county's plan, for federal funding.

The update of the County's plan was led by the Natural Hazards Task Force comprised of the County's Local Emergency Planning Committee (LEPC). Team members consist of first responders and local, regional, and state public entities that ensure the readiness of County entities by recommending equipment purchases, training and exercises, and public education on preparedness issues. Networks Northwest staff assisted with the creation of the updated plan by providing meeting facilitation, conducting an online survey, and writing the plan. The Task Force generally met every two months, in-person, at the Benzie County Governmental Center in the Village of Beulah. The following is an outline of events for the development of the 2022 Benzie County Natural Hazard Mitigation Plan:

- An online public survey was made available from October 4, 2021 to February 4, 2022 to obtain input on community experience, concerns and priorities regarding natural hazard mitigation in Benzie County.

- LEPC and/or LPT meetings where the Natural Hazard Mitigation Plan update work was discussed:
    - June 21, 2021
    - July 1, 2021
    - September 20, 2021
    - October 18, 2021
    - January 18, 2022
    - March 21, 2022
    - April 18, 2022
    - June 20, 2022
    - July 18, 2022
    - August 15, 2022
    - October 27, 2022
    - January 17, 2023
    - February 21, 2023

Community Survey Results

The primary source of feedback was gathered through the Community Survey. The survey was shared electronically and available in an online format from December 2021 to March 2022. The survey asked sixteen questions related to hazard mitigation and received 40 responses. The majority of responses were from elected or appointed officials, emergency personnel, local citizens and other stakeholders. A copy of the survey is appended. Table 2 lists the local municipalities that did (or did not) respond to the community survey.

Table 2: Survey Responses by Local Municipality

Local Unit	Responded?	Title/Role (If Identified)
Benzie County	Yes	Central Dispatch/Deputy Director/ECS Supervisor; Sheriff and Undersheriff; Emergency Management Coordinator; EMS Director; District 2 Commissioner; District 7 Commissioner, Road Commission Manager
City of Frankfort	Yes	Chief of Police; City Superintendent (Chief Administrative Officer)
Village of Benzonia	No	
Village of Beulah	Yes	Trustees; Chair of Parks and Rec; Chair of Law and Finance;
Village of Elberta	Yes	President
Village of Honor	No	
Village of Lake Ann	Yes	President
Village of Thompsonville	Yes	Fire Chief
Almira Township	Yes	Clerk, Zoning Administrator
Benzonia Township	Yes	Treasurer
Blaine Township	Yes	Supervisor, Clerk, Trustee/Planning Commissioner
Colfax Township	No	
Crystal Lake Township	Yes	Supervisor, Treasurer, Planning Commission Chair
Gilmore Township	No	
Homestead Township	Yes	Supervisor, Fire Chief, Trustee, Treasurer
Inland Township	Yes	Supervisor, Treasurer
Joyfield Township	No	
Lake Township	Yes	Supervisor
Platte Township	No	
Weldon Township	Yes	Planning Commission Chair, Clerk, Treasurer
Grand Traverse Band Tribe	Yes	Tribal Member; Emergency Manager, Tribal Public Safety

Responses to Question 3-5 asked about participants' knowledge of local planning efforts including the current hazard mitigation plan (61% indicated they were unfamiliar with the plan), local master plans (84% yes they have an adopted Master Plan), and a local Capital Improvements Plan (CIP) (45% indicated yes, they have a CIP).

Questions 6 and 7 asked participants if there had been significant natural hazards in the past and to identify them. 35% said yes, they have experienced a significant natural hazard in the last 10 years. The following are descriptive responses to these questions:

- County-wide events
  - "Snowmageddon" snowstorm of 2012.
  - Straight line winds of August 2, 2016
  - Pandemic
- Lakeshore erosion and flooding due to high water levels in Lake MI
  - Lake MI Coastline communities: Blaine Twp., Gilmore Twp., Village of Elberta, City of Frankfort, Crystal Lake Twp., Lake Twp.
- Flooding and erosion brought on by high groundwater tables and/or high lake levels
  - City of Frankfort
  - Crystal Lake Twp.
  - Homestead Twp (also river ice over with large backup)
  - Blaine Twp (flooding and loss of shoreline along shores of Lower Herring Lake)
- Snow and wind storms causing significant tree damage
  - City of Frankfort

Questions 8 and 9 asked about community concerns for future natural hazard events and the types of natural hazard events that are likely to have the largest impact. 74% of participants are "somewhat concerned" about a future natural hazard impacting the community. When asked what type of hazard participants were most likely to cause the largest impact responses included the following: Flooding/High Lake Levels (mentioned 20 times), Illness/Pandemic (19), Wildfire (18), High Winds (7), Severe Winter Weather/Heavy Snow/Snow Storms (4), Tornado (3), Erosion/Lakeshore Erosion (3), Landslide (1) "We live at the base of an unstable hill filled with springs" [location not mentioned]. Concerns of a loss of power was mentioned 5 times.

Questions 10 asked about community concerns regarding existing infrastructure and what forms of investment might be required to mitigate impacts to infrastructure from natural hazards. Of the responses, aging bridges, dams and securing power were mentioned the most frequently. Other responses included shoreline hazards such as flooding and shoreline erosion; keeping roads clear to aid in transportation needs during an emergency/power outage (i.e., getting people to shelters). Specific areas with infrastructure concerns mentioned include:

- Village of Elberta: The M-22 Causeway over the Betsie River in Elberta was mentioned specifically five times, due to the concern of another flooding/ potential washout situation if/when lake water levels rise again like they did in 2019 and 2020.
- Blaine Township: "Somewhat concerned about structural integrity of the dam in Lower Herring Lake [adjoining Lake Michigan]. Hasn't been a functioning dam in years, but if waters receded a lot it may be something to watch."
- City of Frankfort: "Critical infrastructure concerns include the water and sanitary sewer distribution systems"; dams and rivers in the event of a flood
- The Platte and Betsie River both run through the county. The BCRC maintains 17 bridges (not counting the bridges maintained by MDOT). Losing a major bridge could have long term negative impacts to the county.
- Weldon Township: "We have a bridge that was…removed and we have hoped that it would be replaced. We have residents that live on the other side of the river. Any emergency vehicles now have to go way out of their way to get to any residents or forest area on the other side of the former bridge location (Haze Road)."
- Village of Beulah: Potential services failure due to pressures from seasonal tourists; "sustained power outages will have a significant impact on our ability to sustain major DPW responsibilities"
- Crystal Lake Township: further bluff erosion/ shoreline erosion

Questions 12 and 13 asked if participants were familiar with requests for assistance for mitigation projects in the past. 52% were unknown as to whether or not requests have been made. Similarly, Question 13 asked if those mitigation projects were granted:

- Village of Thompsonville: "Replacing the bridge after the dam on the Betsie River went out"
- Village of Beulah: "The Village requested and received a grant to do significant work on the village water/sewer system. [It] is working well right now but, for how long will this be true, with all of our out-of-town visitors?"
- "Funds were received for private property flooding – land purchase" (along Lake MI in Crystal Lake Twp.?)
- Village of Lake Ann: Guardrail replacement project, Federal Safety Grant
- "Control water run-off from storm events" (Unknown community)

Questions 13 and 14 asked participants if they had considered mitigation strategies (52% said unknown), but some answered with strategies they would like to explore:

- Benzie County: "Joint planning and/or training with the utilities companies to help them restoring power to our citizens could be beneficial." Pursue FEMA mitigation grants.
- Village of Beulah: "I am concerned about our freshwater environment – Crystal Lake, the Betsie and Platte Rivers, and, not to mention Lake Michigan."
- City of Frankfort: "Better establish a resilient shoreline to overcome high water cycles that create erosion concerns. Install check valves on storm discharge locations."
- Crystal Lake Township: "Fire, further effects of pandemic"
- Grand Traverse Band Tribe: Underground utilities, erosion and floods
- American Red Cross: [Disaster] preparedness.

Question 15 asked if there was any additional information to be considered for the County's Natural Hazard Mitigation Plan:

- City of Frankfort: Natural resiliency strategies to critical areas of our shoreline
- Village of Elberta: High water level – flooding information
- Grand Traverse Band Tribe: Underground infrastructure for continual power and erosion control along waterways

The final question, Question 16, asked survey-takers to respond with their contact information if they wish to be involved with the plan process. Several responses included a name, email address, and phone number to contact those who are interested. Many indicated no, they are not interested or they do not have the time.

Draft Plan Review and Comment

Upon approval by the Natural Hazards Task Force, the plan was released for review and comment. A notice of availability was published in the *Benzie County Record Patriot* newspaper on ___, 2023 that the County's draft Natural Hazard Mitigation Plan was available for review, and welcomed feedback before or at the schedule public hearing held on _____. A copy of the plan in its draft form was published openly on the County's website and Networks Northwest's website. Local government officials and the entire LEPC membership were encouraged to view the plan and submit suggestions and ideas for updates and changes to be considered during updates.

Additionally, the representatives from county and regional agencies that share jurisdictional boundaries with Benzie County were provided the opportunity to formally comment on the draft plan and other related materials. Those agency staff members are:

- Gregg Bird, Grand Traverse County Emergency Management Coordinator
- Jolanda Murphy, Public Safety Department 2 Manager and Emergency Manager, Grand Traverse Band of Ottawa and Chippewa Indians
- Matt Ansorge and Kelly LaCross, Leelanau County Office of Emergency Management
- Alvin Rischel, Manistee County Deputy Director/Emergency Management Coordinator
- Randy Boike, Wexford County Emergency Management Coordinator
- Robert Carson, Regional Director of Community Development, Networks Northwest

While no formal written comments were received, county staff (particularly the county Emergency Manager) received feedback via other informal means. This feedback took the form of phone calls, emails and conversations that occurred at various non-mitigation related meetings.

Below are images of the websites providing the available draft plan for review and a copy of the published public hearing notice.

Figure 1: Web Images
Source: Benzie County website (date)

Source: Networks Northwest website (date)

III. COMMUNITY PROFILE

Land Use/ Land Cover

Benzie County is located in Northwest Lower Michigan, and is bordered by Lake Michigan to the west, Leelanau County to the north, Grand Traverse County to the east, Wexford County to the southeast, and Manistee County to the south. The Environmental Features Map in Appendix A illustrates the locations of the county's roads, water bodies and jurisdictions.

The smallest county in Michigan, Benzie County is approximately 316 square miles containing pristine lakes and rivers, rolling hills and fields, thick forests, orchards, and 60 miles of Lake Michigan shoreline. The State has designated Critical Dune Protection Areas and High Risk Erosion Areas along portions of the coastline in the county, as shown in Figures 2 through 4. The county is divided into nineteen communities, including twelve townships, six villages, and the City of Frankfort. About 4%, or 19 square miles of the county is located within the Grand Traverse Bay watershed. The highest elevation point is 1,161 feet at an unnamed location in Colfax Township (44.25935, -85.830033).

Benzie County plays an important role in the region's tourist activity. Its villages and small city provide a blend of beachfront, walkable downtowns, historic character, and small town charm. Sleeping Bear Dunes National Lakeshore, partly located in the northwest portion of the county, is a national attraction; and Crystal Mountain is a popular, well-known ski/outdoor resort destination that attracts visitors year round.

There are 135 lakes are scattered across the county. Eleven of the inland lakes provide public access including Ann, Betsie, Crystal, Herendeene, Little Platte, Loon, Lower Herring, Pearl, Platte, Stephens, Turtle, and Upper Herring. Many of the lakes are of significant size, the largest being Crystal Lake, which is also the ninth largest inland lake in Michigan. Significant rivers and streams include the Betsie River, Platte River, Otter Creek, and Herring Creek, which all flow westward into Lake Michigan. All of these waters are valued for their fisheries, recreational opportunities and beauty.[1]

The 2017 USDA Census of Agriculture indicates the county had 18,516 acres of land in farms, for a total of 197 farms. This represents a 9% increase in the number of farms and a 10% decrease in the acreage of farms since the 2012 USDA Census of Agriculture. About 78% of the market value ($7,868,000) of agricultural products sold in the county is from crops. Forage (hay/hayage), tart cherries, corn for grain, cultivated Christmas trees and apples comprised the top five crops in acreage in the county. Benzie County ranks 53 out of 83 counties in the Michigan for agricultural crop sales.

The predominant land cover type is "deciduous forest" followed by "open water" and "herbaceous/grassland" (Table 1). Developed land cover is found predominantly in and around the City of Frankfort and local villages.

Table 1: Land Cover by Type, Benzie County

Classification	Acres	Percent
Developed (High Intensity)	131.6	0.1
Developed (Med. Intensity)	710.02	0.3
Developed (Low Intensity)	5,198.07	2.1
Developed (Open Space)	10,459.47	4.2
Open Water	27,243.39	11.0
Woody Wetlands	24,991.6	10.1
Emergent Herbaceous Wetlands	3,079.96	1.2
Deciduous Forest	103,000.7	41.7
Evergreen Forest	15,973.04	6.5
Mixed Forest	5,108.04	2.1
Shrub/Scrub	6,110.98	2.5
Herbaceous/Grassland	25,260.6	10.2
Cultivated Crops	15,012.57	6.1
Hay/Pasture	2,015.68	0.8
Barren Land	2,530.41	1.0

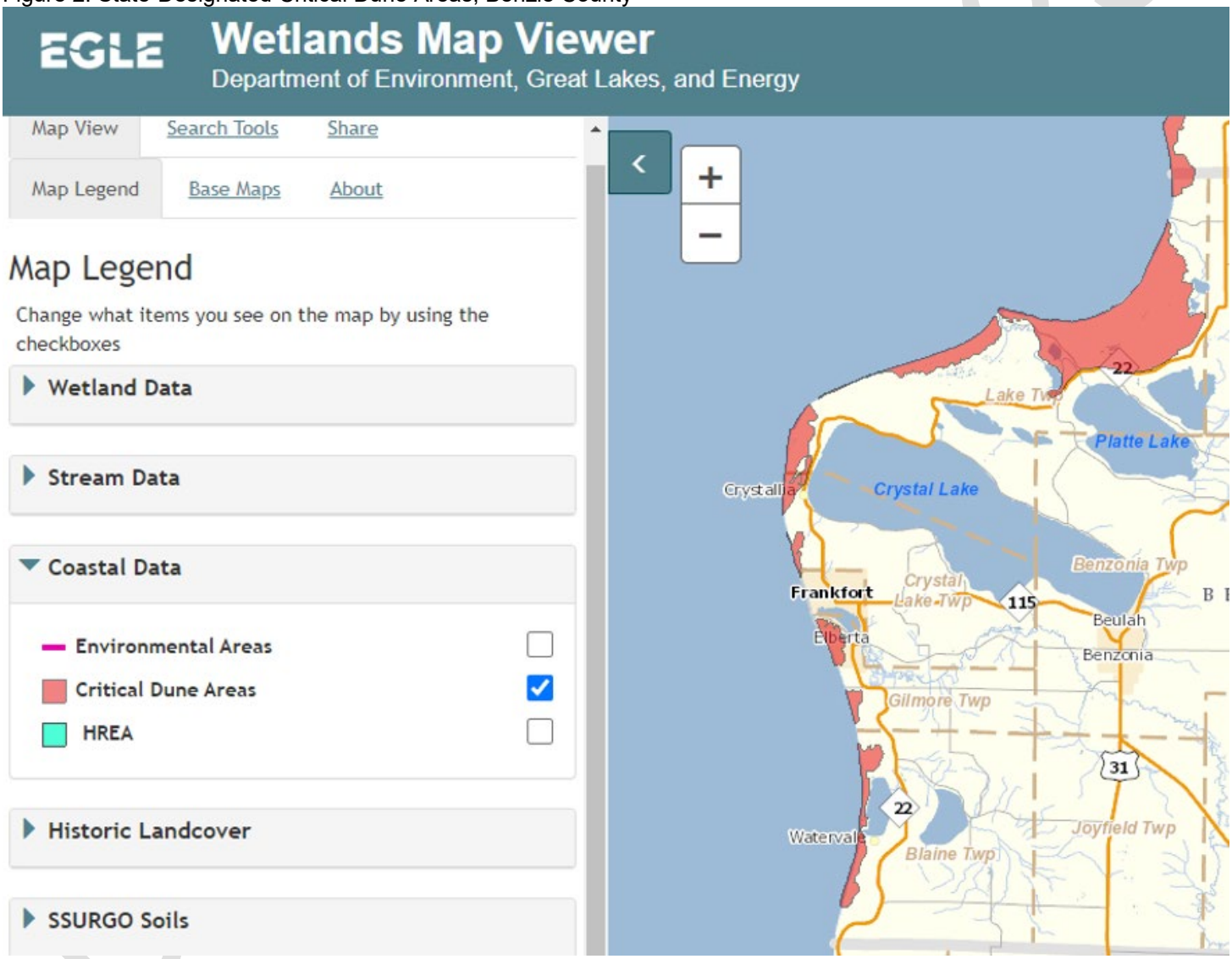
[1] *Benzie County 2017 Master Plan*, https://www.benzieco.net/departments/planning_commission/documents.php#outer-1455

TOTAL	**246,826.13**	

Source: Networks Northwest

The 2015 Hazard Mitigation Plan indicated that 146,900 acres, or 67.1%, of the county's land cover was comprised of forested lands, and 15.7% was comprised of wetlands. Current land cover data indicates these percentages have decreased since 2015. While development in the county has remained fairly steady in the past decade, it has been noted that the type of new development is changing. Office and industrial development has largely stopped, commercial development has slowed, but residential development is occurring as quickly as plans can be approved. Housing of all types and prices is in demand, but many communities desire smaller units and multiple family units. This type of housing is especially important for the senior population and will likely be in demand for many years. The Environmental Features Map in Appendix A shows the intensity of development in the county as well as natural features.

Figure 2: State-Designated Critical Dune Areas, Benzie County



Source: https://www.mcgi.state.mi.us/wetlands/mcgiMap.html#

Figure 3: High-Risk Erosion Areas, Blaine and Gilmore Townships

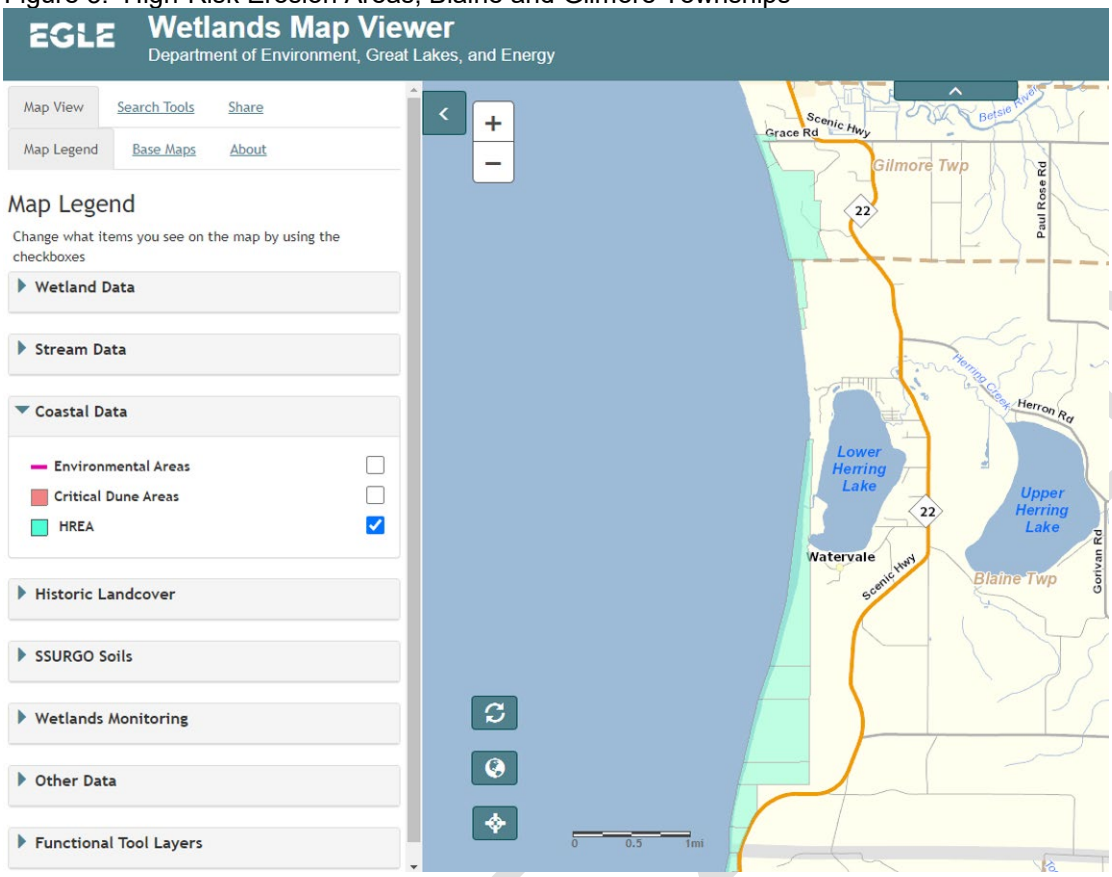
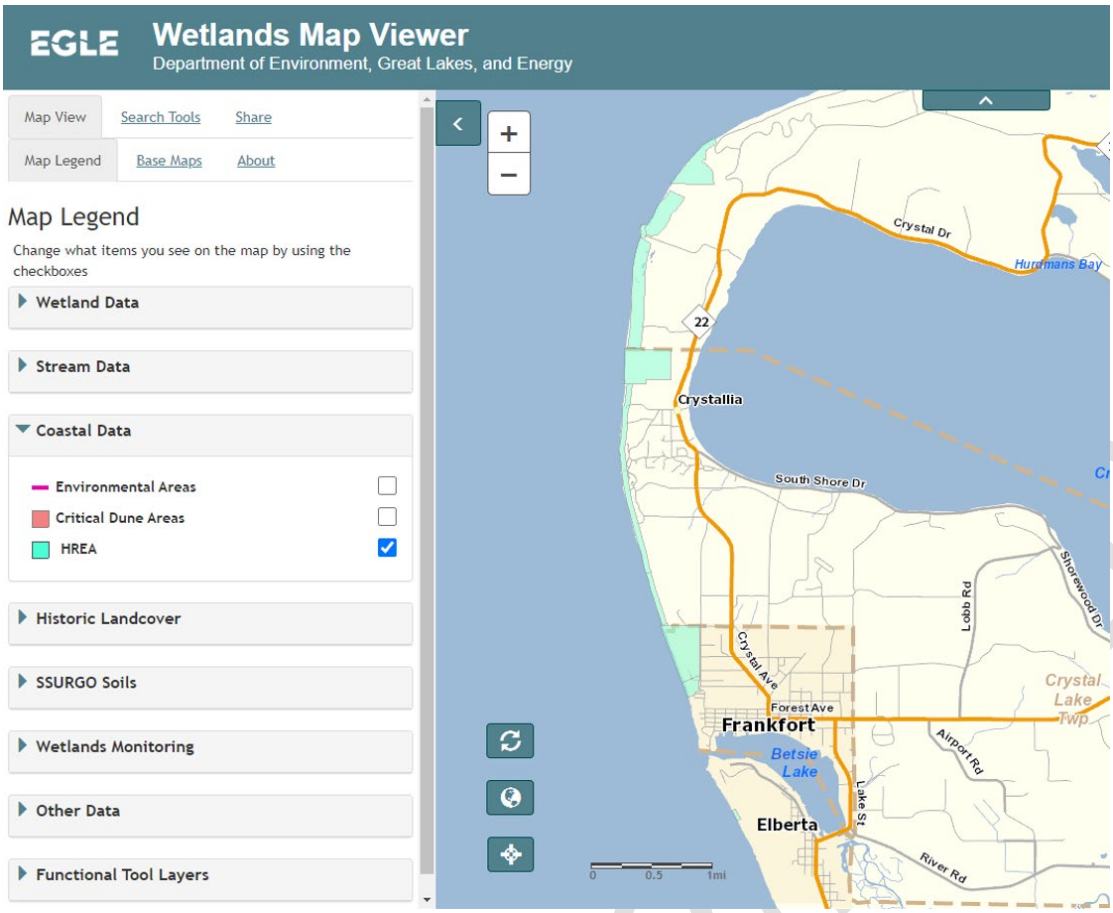


Figure 4: High-Risk Erosion Areas, Village of Elberta, City of Frankfort, Crystal Lake Twp. and Lake Twp.



Source: https://www.mcgi.state.mi.us/wetlands/mcgiMap.html#

Population

Benzie County is the 8th most populated county in the ten county region of Northwest Lower Michigan (Table 3) and is the ranked 66 out of 83 counties in the state for population.[2] The 2019 American Community Survey (ACS) estimated the county population to be 17,615 people. A comparison of the 2010 and 2019 ACS data indicates a 1% decrease in county population from 2010, when the population was an estimated 17,705 persons (Table 4). The estimated 2019 population per square mile is approximately 1.8 people.

Benzie County is comprised of twelve (12) townships, six (6) villages, of the City of Frankfort. Between 2010 and 2019, the county lost an estimated 90 persons, resulting in a -1% decrease in population. All of the villages, the City of Frankfort and the Townships of Platte, Blaine, Gilmore, Homestead and Benzonia lost population (shown in red, Table 4). Inland, Crystal Lake and Joyfield Townships were among the communities that saw the most significant increases in population (shown in green, Table 4).

Almira Township, located in the northeast portion of the county and containing the Village of Lake Ann, is the most populated community with an estimated 3,665 persons. Note that the population estimates for the villages are shown separately for informational purposes; however, those population count estimates are incorporated into the totals presented for the township in which they are located.

The second most populated community is Benzonia Township, which contains the villages of Beulah and Benzonia, at an estimated 2,735 persons. The third most populated community is Inland Township, at 2,374 persons.

[2] https://www.michigan-demographics.com/counties_by_population

Table 3: 2019 Estimated Regional Population by County, State

Jurisdiction	Population
Missaukee County	15,028
Kalkaska County	17,585
Benzie County	**17,615**
Leelanau County	21,652
Antrim County	23,206
Manistee County	24,457
Charlevoix County	26,188
Emmet County	33,104
Wexford County	33,256
Grand Traverse County	92,181
State of Michigan	9,965,265

Source: US Census, 2019 ACS 5-Year Estimates

Table 4: Population Change by Municipality, 2010 & 2019

Municipality	2010 Estimated Population	2019 Estimated Population	Numeric Change	Percent Change	% of Total County Population
Village of Elberta	283	165	(118)	-41.70%	
Village of Lake Ann	307	196	(111)	-36.16%	
Village of Beulah	491	203	(288)	-58.66%	
Village of Honor	266	222	(44)	-16.54%	
Village of Thompsonville	488	481	(7)	-1.43%	
Platte Township	392	380	(12)	-3%	2%
Blaine Township	697	493	(204)	-41%	3%
Weldon Township	596	630	34	5%	4%
Colfax Township	603	663	60	9%	4%
Gilmore Township	893	690	(203)	-29%	4%
Joyfield Township	694	836	142	17%	5%
Lake Township	778	844	66	8%	5%
City of Frankfort	1,427	1,059	(368)	-35%	6%
Crystal Lake Township	928	1,162	234	20%	7%
Homestead Township	2,352	2,084	(268)	-13%	12%
Inland Township	1,934	2,374	440	19%	13%
Benzonia Township	2,818	2,735	(83)	-3%	16%
Almira Township	3,593	3,665	72	2%	21%
Benzie County	17,705	17,615	(90)	-1%	100%
State of Michigan	9,952,687	9,965,265	12,578	0.1%	

Source: US Census, 2010 and 2019 5-Year ACS Estimates

Like many northwest Michigan communities, Benzie County experiences an influx of seasonal residents and tourists during the summer months. However, the US Census Bureau's Decennial Census and the American Community Survey only consistently and comprehensively track the permanent population. The 2022 *Seasonal Population Study for Northwest Lower Michigan* analyzed the 2020 seasonal population for ten counties in northwest Michigan. All ten counties in the Networks Northwest service area were included in the study: Antrim, Benzie, Charlevoix, Emmet, Grand Traverse, Kalkaska, Leelanau, Manistee, Missaukee, and Wexford. The study collected data for permanent and part-time residents and overnight visitors in accommodations and short-term rentals by County. Northwest Lower Michigan's permanent base population is 310,802 and expands by 118% to its largest seasonal population of 676,052 in July.

With a permanent population of 17,970, Benzie County is one of the smallest counties in the region in population. However, in the month of July, when accounting for the second-home owners and overnight visitors, Benzie County becomes the third-most populous county in the region. As indicated in Table 5, Benzie County's base population increases by as much as 138.9% in July (17,970 to 59,278). On average, the county's population grows by 33.6%, or 6,036 people, throughout the year.

Table 5: Benzie County Seasonal Population

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Permanent Population	17,970	17,970	17,970	17,970	17,970	17,970	17,970	17,970	17,970	17,970	17,970	17,970	17,970
Overnight / Part-Time Population	10,142	9,564	10,763	10,853	31,259	41,308	42,935	42,844	32,525	32,725	11,421	11,729	24,006
Total Population	28,112	27,534	28,733	28,823	49,229	59,278	60,905	60,814	50,495	50,695	29,391	29,699	41,976
Difference	7,828	8,406	7,207	7,117	13,289	23,338	24,965	24,874	14,555	14,755	6,549	6,241	6,036
% Change	43.6%	46.8%	40.1%	39.6%	74.0%	129.9%	138.9%	138.4%	81.0%	82.1%	36.4%	34.7%	33.6%

Source: 2022 Seasonal Population Study for Northwest Lower Michigan, Networks Northwest

Age, Race & Disability

Understanding the age distribution and median age of Benzie County can help identify social, economic, and public service needs in the community. The county's total estimated 2019 population is broken into age cohorts (analyzing which proportions of a municipality's population are in which stages of life). This gives a nuanced view of the makeup of a community. Figure 3 indicates the cohort group with the largest population is the 45 to 64 year old group, followed by those in 20-44 year old group and then closely by the 65-84 year old group. As shown in Figure 4, the median age (the midpoint where half the population is younger and half the population is older) of Benzie County is older (50.2 years) than the State (39.7 years). The county, like the State, is aging, but at a faster rate. The youngest community in the county is Almira Township with a median age of 37.9 years; the oldest community in the county is Lake Township with a median age of 65.8 years (Figure 5).

Figure 5: Benzie County Population by Age Cohort, 2019

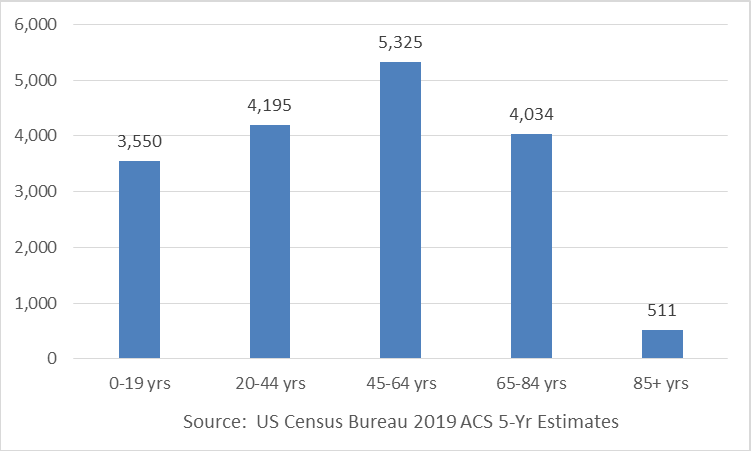


Figure 6: Median Age Trend, 2000, 2010, and 2019

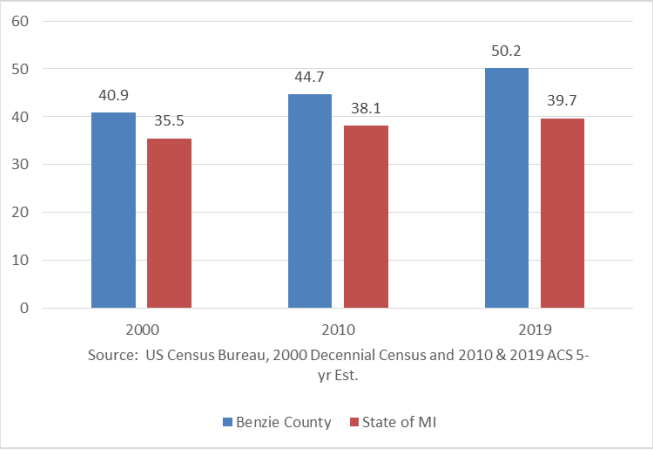
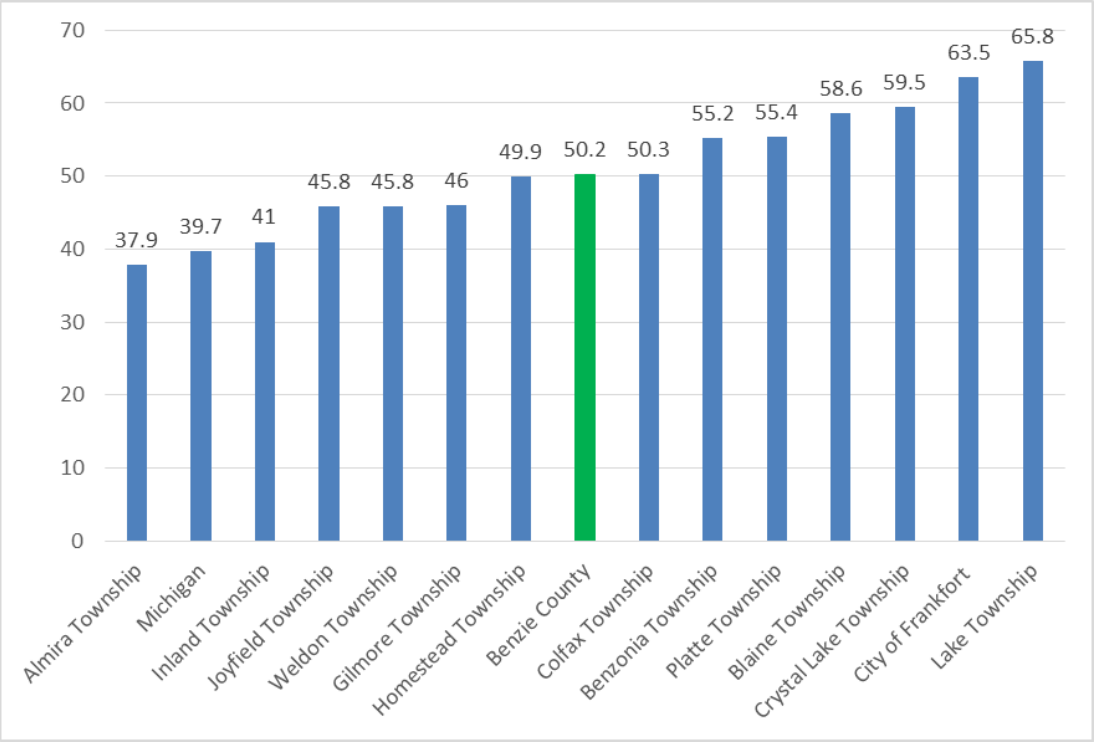


Figure 7: Median Age Comparison, Benzie County, 2019 ACS 5-yr Est.



The racial makeup of Benzie County is predominantly white (96%) (Table 6). 2.5% of the population identifies as Hispanic or Latino; this may be representative of the agricultural industry in the county. 1.7% of the population is American Indian or Alaskan Native; this is higher than representation in the State as a whole. 0.4% of the population is Asian; 0.2% is Black; 0.1% is of some other race; 0.1% is Native Hawaiian or Other Pacific Islander; and 1.8% consists of two or more races.

Table 6: Racial Composition (2019 ACS 5-yr estimates)

	White	Black	American Indian or Alaskan Native	Asian	Hispanic or Latino	Native Hawaiian or Other Pacific Islander	Some Other Race	Two or More Races
Benzie County	96%	0.2%	1.7%	0.4%	2.5%	0.1%	0.1%	1.8%
Michigan	75.0%	13.6%	0.5%	3.1%	5.1%	0.1%	0.1%	2.5%

Table 7 represents the number of persons with one or more disability and also those with a disability by age group. An estimated 2,607 (15%) of Benzie County residents have one or more type of disability. An estimated 54% of persons with one or more disabilities are aged 65 years or older.

Table 7: Persons with a Disability, 2019

Total Civilian Noninstitutionalized Population	**17,340 persons**
With one or more disability	2,607 (15%)
Age 0-17 with a disability	72 (2.2% of that age group)
18 to 64 years with a disability	1,127 (11.6% of that age group)
65 years and over with a disability	1,408 (31.6% of that age group)

Source: US Census, 2019 ACS 5-yr Estimates

Housing Characteristics and Development Trends

The average household size for Benzie County residents is 2.55 persons, which is slightly higher than the State's average of 2.46. Benzie County has an estimated 12,524 total households (Table 8). The Census defines a household as all the people who occupy a single housing unit, regardless of their relationship to one another. Benzonia Township has the largest percentage of housing units of all municipalities in the county (17%), followed by Almira Township (13%). About 49.3% of residential units were estimated to be built before 1980 (Table 9). The 2019 ACS also estimates that over 90% of the county's household units are 1-unit, detached structures, which are commonly referred to as single-family homes.

Table 8: Housing Units by Municipality, 2019

Municipality	2010 Housing Units	2019 Housing Units	Units Change	% of Total
Platte Township	284	246	-15%	2%
Colfax Township	359	399	10%	3%
Joyfield Township	389	416	6%	3%
Blaine Township	507	506	0%	4%
Gilmore Township	468	525	11%	4%
Weldon Township	644	718	10%	6%
City of Frankfort	1,057	991	-7%	8%
Inland Township	985	1,065	8%	9%
Homestead Township	1,230	1,172	-5%	9%
Crystal Lake Township	1,184	1,276	7%	10%
Lake Township	1,180	1,374	14%	11%
Almira Township	1,771	1,672	-6%	13%
Benzonia Township	2,011	2,164	7%	17%
Benzie County	12,069	12,524	4%	

Source: US Census, 2010 & 2019 ACS 5-Yr Estimates * The number of housing units for each village is incorporated into the totals for the respective township in which each village is located.

Table 9: Year Structure Built, 2019

Housing Units	Number	% of Total
Built 2010 or later	345	2.8%
Built 2000-2009	1,863	14.9%
Built 1980-1999	4,150	33.1%
Built 1960-1979	3,104	24.8%
Built 1940-1959	1,640	13.1%
Built 1939 or earlier	1,422	11.4%
Total Housing Units	**12,524**	

Source: US Census, 2019 ACS 5-Year Estimates

Housing Tenure, Table 10, summarizes the status of housing units, whether occupied or vacant, as well as the median housing value of owner-occupied units ($185,500) and the median gross rent ($699). Of the 12,524 total housing units, (90%) are occupied (indicating physically occupied, principal residence housing units).

Table 10: Housing Tenure, 2019

Total housing units	12,524	%
Occupied housing units	6,792	54%
Owner-occupied	6,093	90%
Median Housing Value	$185,500	
Renter-occupied	699	10%
Median Gross Monthly Rent	$702	
Vacant housing units	5,732	46%

Source: US Census, 2019 ACS 5-year Estimates

Economic Profile

The *2021 Comprehensive Economic Development Strategy (CEDS)* prepared by Networks Northwest is the product of a locally-based, regionally-driven economic development planning process to identify strategies for economic prosperity. The plan was prepared for the ten county region of northwest Lower Michigan. Table 11 provides a comparison of annual average wage for each county in the CEDS planning area for 2018. Kalkaska County has the highest average annual wage with $ 50,971, followed by Grand Traverse County at $44,562. Benzie County has the 8th highest average annual wage at $33,908. As a western neighbor, it is not unexpected to have residents of Benzie County travel to Grand Traverse County for work.

Table 11: Average Annual Wage by County, 2018

County	Average Annual Wage
Antrim	$33,081
Manistee	$33,821
Benzie	**$33,908**
Missaukee	$35,917
Leelanau	$36,833
Emmet	$40,258
Wexford	$40,586
Charlevoix	$44,558
Grand Traverse	$44,562
Kalkaska	$50,971

Source: 2021 Comprehensive Economic Development Strategy (CEDS) prepared by Networks Northwest

The Economic Profile of Benzie County is further described in Table 12. The table provides the county's industry makeup divided into 20 different North American Industry Classification Sectors (NAICS) as well as industry's establishments, jobs, percent distribution, and annual average wage.

The industry with the largest percent distribution is "**Accommodation and Food Service**" at 27.2%, followed by "**Other (includes private, management of business, and unallocated)**" at 14.4% of jobs, and then followed by and "**Retail Trade**" at 13.8%. The annual average wage for "Accommodation and Food Services" is $22,005; for "Other" is not available; and for "Retail Trade" is $25,294. "**Health Care, Social Assistance**" is the fourth largest industry with an average annual wage of $47,075.

The industry with the highest annual average wage is "**Finance and Insurance**" at $55,011, followed by "**Construction**" at $548,217.

Table 12: Benzie County Economic Distribution by Industry, 2018

Industry	Establishments (2018)	Jobs (2018)	% Distribution of Jobs	Annual Average Wage
Total Covered Employment	445	4,297	100.00%	$33,908
Agri., forestry, hunting	9	D	0.00%	D
Mining	1	D	0.00%	D
Construction	85	298	6.90%	$48,217
Manufacturing	19	379	8.80%	$43,086
Wholesale trade	4	D	0.00%	D
Retail trade	62	593	13.80%	$25,294
Transportation, warehousing	14	49	1.10%	$44,430
Utilities	2	D	0.00%	D
Information	10	28	0.70%	$26,091
Finance and Insurance	17	158	3.70%	$55,011
Real Estate, rental, leasing	15	43	1.00%	$26,725
Professional, technical services	29	79	1.80%	$27,778
Administrative, waste services	19	D	0.00%	D
Educational services	6	8	0.20%	$19,870
Health care, social assistance	20	386	9.00%	$47,075
Arts, entertainment, recreation	14	105	2.40%	$25,180
Accommodation and food services	55	1,168	27.20%	$22,005
Other services (except for Public admin.)	42	141	3.30%	$25,955
Public administration	18	247	5.70%	$36,572
Other Includes (private, utilities, management of business, and unallocated)	4	615	14.40%	N/A

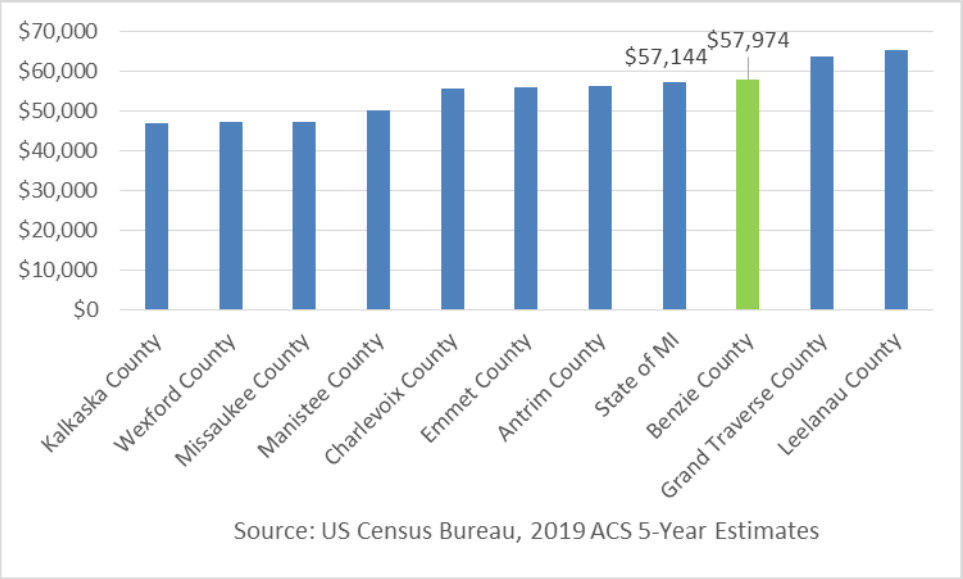
Source: 2021 Comprehensive Economic Development Strategy, Networks Northwest
**D means limited industries of a sector that would disclose confidential information*

Figures 8 and 9 present a comparison of the median household income (MHI) across the ten county region, the State of Michigan, and local jurisdictions. Benzie County has a median household income of $57,974, ranking third highest in the region, and also above that of the State. Almira Township, which is also county's most populated jurisdiction (Table 3), has the highest median household income at $80,938 (Figure 6). The county's economic profile can be further described by considering the cost of housing, transportation, and other goods and services. The budgeting rule of thumb has been that a household should spend no more than 30 percent of its income on housing costs. Considering the MHI of Benzie County over twelve months, a household is earning $4,831 per month. The US Census 2019 5-year ACS estimates that the median gross monthly rent is $702 in Benzie County, which equates to about 14.5% of the median household income.

However, according to the 2019 Northwest Michigan Target Market Analysis[3] (conducted by LandUseUSA on behalf of Housing North and Networks Northwest), rents are far higher in Benzie County than what many renters can afford. While the affordable rent for a renter earning the mean wage in the county is $800, the affordable rent for a full-time minimum wage worker earning $9.45 an hour is $491. And anecdotally, the demand for housing is driving prices higher still. Home prices are also increasing where the cost to purchase a home is often as much as $200/square foot or more.

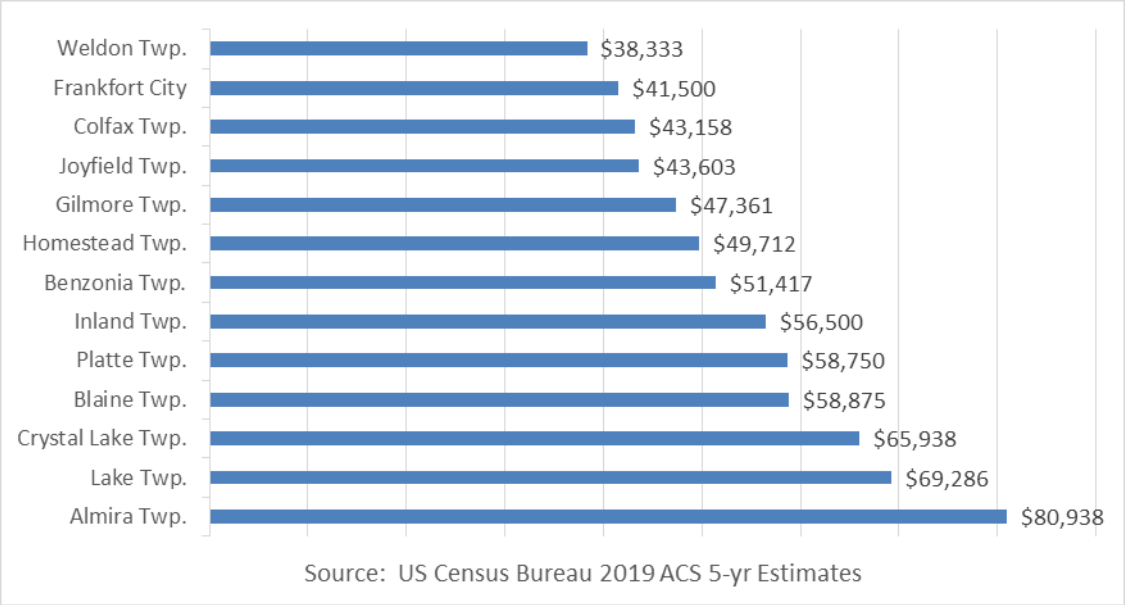
[3] https://www.housingnorth.org/target-market-analysis

Figure 8: NW Michigan Median Household Income by County, 2019



Source: US Census, 2019 ACS Estimate

Figure 9: Median Household Income by Local Jurisdiction in Benzie County, 2019



The following tables describe the population with the lowest incomes. It is estimated, in 2019, that % of all people in the county lived at or below the poverty level (Table 14). The Census describes poverty thresholds differently based on the size of the family and the number of related children living together, as illustrated in Table 13.

Table 13: 2019 Federal Poverty Level Guidelines

Persons in family/household	Poverty guideline
1	$12,490
2	$16,910
3	$21,330
4	$25,750
5	$30,170
6	$34,590
7	$39,010
8*	$43,430

**For families/households with more than 8 persons, add $4,420 for each additional person.*

Table 14: Benzie County Poverty Estimates, 2019

Poverty	Statistics
All families living below the poverty level	226 (5%)
Families with related children under age 18, in poverty	156 (11.4%)
All persons living below the poverty level	1,650 (9.5%)

Source: US Census, 2019 ACS Estimate

Financial hardship is further described in the United Ways of Michigan report entitled *ALICE in Michigan: A Financial Hardship Study*. ALICE, which is an acronym for Asset Limited, Income Constrained, Employed, are those households with income above the Federal Poverty Level, but below the basic cost of modern living, such as housing, child care, food, health care, technology and transportation. The ALICE threshold is described as, "*the average income that a household needs to afford the basic necessities… for each county in Michigan. Households earning below the ALICE Threshold include both ALICE and poverty-level households*" (ALICE, 2019). Table 15 identifies the number of ALICE and poverty households for the county and each municipality. These households likely would not have reserve savings to cover an emergency, such as impacts to their personal property from a natural hazard event.

Table 15: United Ways of Michigan ALICE Report Findings, 2019[4]

Benzie County Jurisdiction	Total Households	% of Total HH that are in Poverty & ALICE
BENZIE COUNTY	6,792	29% (State Avg. is 25%)
Almira Twp.	1,286	20%
Benzonia Twp.	1,049	44%
Blaine Twp.	225	30%
Crystal Lake	248	55%
Colfax Twp.	460	37%
Frankfort City	468	49%
Gilmore Twp.	285	46%
Homestead Twp.	786	44%
Inland Twp.	880	39%
Joyfield Twp.	305	48%
Lake Twp.	404	27%
Platte Twp.	146	43%
Weldon Twp.	250	55%

[4] Michigan Association of United Ways. *ALICE in Michigan: A Financial Hardship Study*. 2021. https://www.unitedforalice.org/county-profiles/michigan

IV. Hazard Identification and Assessments

Vulnerability Assessment

Natural hazard impact on the community can be understood by evaluating vulnerabilities for commonly agreed upon assets. A community's assets are defined broadly to include anything that is important to the character and function of a community and can be described very generally in the following categories:

- People
- Economy
- Built environment
- Natural environment

Vulnerable populations include the economically disadvantaged, elderly, homeless, and persons with a disability. Those that live unsheltered or in homeless encampments, assisted living facilities, mobile home parks, or isolated subdivisions are more susceptible to hazardous events. Vulnerable populations are represented on the *Vulnerable Populations and Hazard Areas Map* in Appendix A. Those locations included on the map were specifically discussed during public input sessions. There may be additional locations of vulnerable populations that are not listed.

The natural environment is the primary feature residents choose to live in northwest Michigan and the primary feature visitors choose to vacation in northwest Michigan. Benzie County is home to abundant forest lands, inland lakes and streams, unique sand dune areas, Lake Michigan shoreline and all of the wildlife within that are integral to the identity of the community. While natural resources are abundant they are vulnerable to all types of hazards. Northwest Lower Michigan is also home to many sensitive wildlife populations that require specific climates and habitats to survive. Damaged, destroyed, or changing natural environments may decrease the chances for certain species' survival.

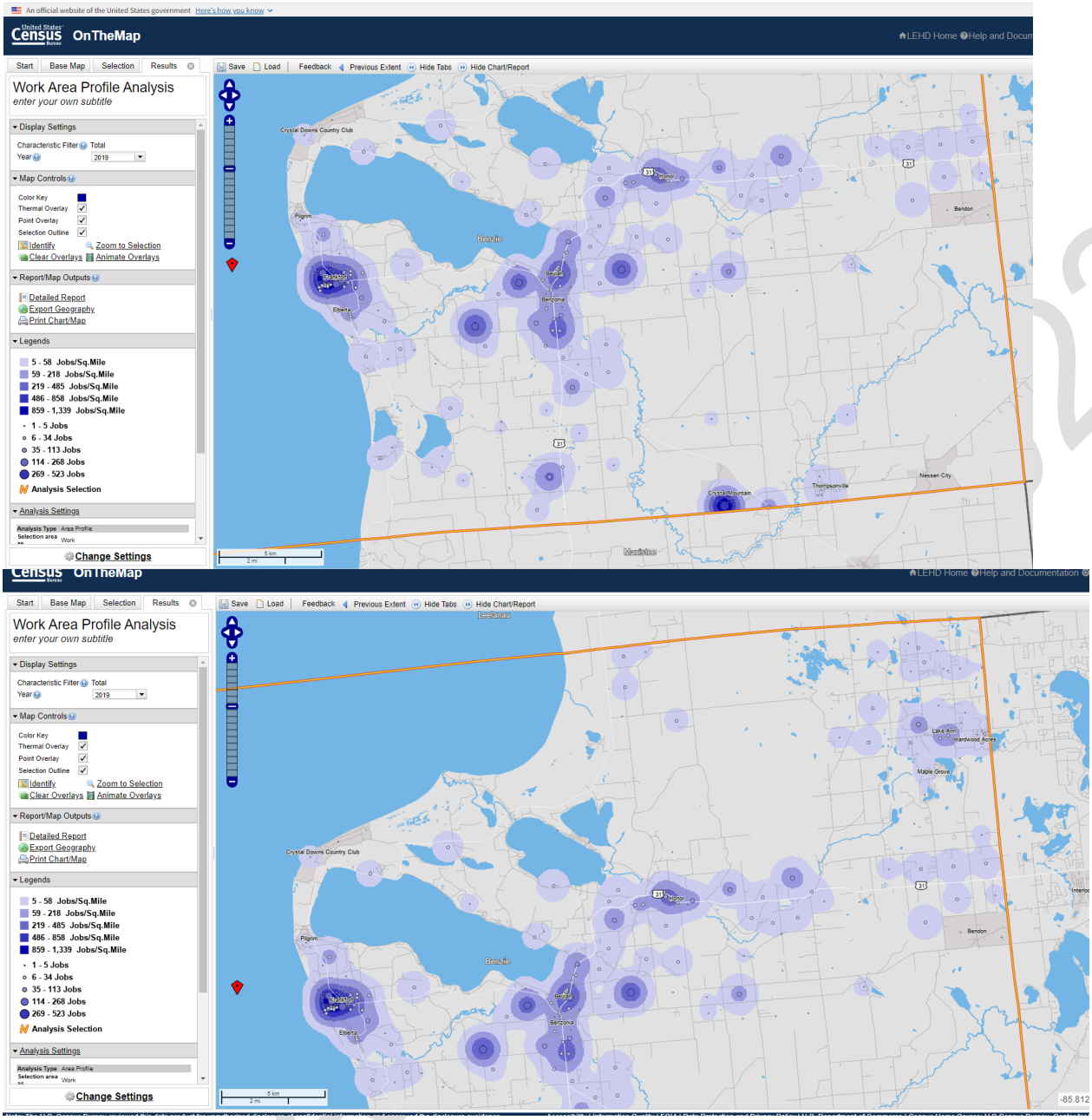
Additionally, countywide critical infrastructure is represented on the Critical Infrastructure Map, shown below. Task Force members and community stakeholders identified the critical facilities and infrastructure on the base map and provided updated GIS shape files for mapping purposes. The Critical Infrastructure Points Map is in Appendix A. Table 16 is a summary of critical infrastructure points in Benzie County:

Table 16: Critical Facilities and Infrastructure
Source: Benzie County Emergency Services

Total # of Facilities	Facility Type
5	**Commercial** • Agricultural and Food Product Distribution (1) – Graceland Fruit in Frankfort • Ag. Processing, Packaging and Production (2) – Graceland Fruit and Smeltzer Orchard Co. in Frankfort • Entertainment or Media Facility (1) – The Cherry Bowl Drive-In in Honor • Public Assembly (1) 0 The Garden Theatre in Frankfort
2	**Communications** • Information Services (1) – Benzie Central Dispatch in Beulah • Regulatory, Oversight, or Industry Organization (1) – Radio Tower in Beulah
11	**Emergency Services** • Emergency Management (1) – Office of Emergency Mgmt. in Beulah • Emergency Medical Services (EMS) (2) – Station 2 in Beulah and Station 3 in Frankfort • Fire and Emergency Services (6) – Townships of Almira, Inland, Homestead, Benzonia; Village of Thompsonville; City of Frankfort • Law Enforcement (2) – Frankfort Police and Benzie County Sheriff's Office

1	**Energy** • Natural Gas (1) – Jordon Development Pipeline, Thurman Rd., Thompsonville
20	**Government Facilities** • Dam Project (1) – Homestead Dam in Benzonia • Dam Flood Damage Reduction System (2) – Crystal Lake Outlet in Frankfort; Grass Lake Dam in Thompsonville. • Government Storage or Preservation Facility (1) – MDNR Platte River Fish Hatchery in Beulah • Military Facility (1) – USCG Station in Frankfort • Personnel-Oriented Government Facility (1) – Benzie County Govt. Center in Beulah • Service-Oriented Government Facility (8) – USPS Service Centers • Treated Water Distribution Control Center (5) – City of Frankfort and Villages of Beulah, Benzonia, Elberta, and Thompsonville • Wastewater Facility (1) – City of Frankfort
3	**Healthcare** • Extended Care Facility (1) – Maples LTC in City of Frankfort • Healthcare and Public Health (1) – Benzie-Leelanau Health Dept. in Benzonia • Hospital (1) – Paul Oliver Memorial Hospital in City of Frankfort
7	**School** • K-12 School Facilities (7)
5	**Transportation** • Aviation (2) – Frankfort Dow Memorial Airport • Maritime (1) – Point Betsie Lighthouse in Frankfort • Mass Transit (1) – Benzie Bus in Beulah • Road (1) – Benzie County Road Commission in Honor

Additionally, there is an online interactive tool available from the US Census Bureau allows for viewing of estimated job density within the county: https://onthemap.ces.census.gov/. This website may be useful for emergency preparedness planning as related to response and potential impact to local economic activity areas. It appears the greatest density of jobs are located within the along the main roads of US-31 and M-115, linking the Villages of Honor, Beulah, Benzonia, Elberta, Thompsonville, and the City of Frankfort. The Village of Lake Ann in Almira Township is also an employment center, as well as Crystal Mountain Resort, located off of M-115 in Weldon Township. Below are screenshots of the interactive map when completing an area profile analysis for all workers in all jobs in the county in 2019.


An official website of the United States government Here's how you know
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Detailed Report
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59 - 218 Jobs/Sq.Mile
219 - 485 Jobs/Sq.Mile
486 - 858 Jobs/Sq.Mile
859 - 1,339 Jobs/Sq.Mile
1 - 5 Jobs
6 - 34 Jobs
35 - 113 Jobs
114 - 268 Jobs
269 - 523 Jobs
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Beulah
Elberta
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Crystal Mountain
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219 - 485 Jobs/Sq.Mile
486 - 858 Jobs/Sq.Mile
859 - 1,339 Jobs/Sq.Mile
1 - 5 Jobs
6 - 34 Jobs
35 - 113 Jobs
114 - 268 Jobs
269 - 523 Jobs
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Lake Ann
Hardwood Acres
Maple Grove
Crystal Downs Country Club
Pilgrim
Benzie
Beulah
Elberta
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Historical Analysis

The Historical Analysis of Benzie County weather-related hazards uses information on impacts and losses from previous hazard events to predict potential impacts and losses during a similar event. Because of the frequency of these events, communities are more likely to have experience with and data on impacts and losses. Additionally, there have been seven (7) federal-or state-declared disaster incidents that have involved Benzie County (Table 17). These are included in the hazard analysis for individual event types.

Table 17: Presidential and Governor Declared Disasters for Benzie County

Date of Declaration	Type of Incident	Affected Area	Type of Declaration/ Fed ID#
March 2020	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	Flooding	Benzie and other counties; 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.	Governor Declared Disaster
9/4/2005 and 9/7/2005	Hurricane (Katrina) Evacuation	Statewide (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.)	Governor Declared Disaster and Presidential Declared Emergency (3225)
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	4 Counties: Benzie, Leelanau, Manistee and Ottawa	Presidential Declared Major Disaster (53)

Sources: FEMA https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties and Michigan State Police 2019 Michigan Hazard Analysis (MHA) pub. 103

Hazard Descriptions

Benzie County is vulnerable to a wide range of natural hazards. Hazard events have the potential to impact local residents, economic drivers in the community, critical infrastructure and the built environment, and the natural environment. The Benzie County Emergency Services Department is challenged with managing these threats to protect life and property. This plan includes a profile for each natural hazard event the county is likely to face. Each profile includes the location, extent, previous occurrences, probability of future events, and vulnerability assessment.

- Location is the geographic areas within the planning area that are affected by the hazard, such as a floodplain. The entire planning area may be uniformly affected by some hazards, such as drought or winter storm. Location may be described in narrative and or through map illustrations.
- Extent is the strength or magnitude of the hazard. Extent can be described in a combination of ways depending on the hazard.
- Previous occurrences describe the history of previous hazard events within the county. This information helps estimate the likelihood of future events and predict potential impacts. The extent of historic events may be included when the data is available. Data is collected from the National Oceanic and Atmospheric Administration's National Centers for Environmental Information data center (NOAA).
- Probability of future events is the likelihood of the hazard occurring in the future and can be described in a variety of ways. Probability may be defined using historical frequencies or statistical probabilities.
- Vulnerability assessment accounts for the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas and provides an estimate of the potential dollar losses to vulnerable assets identified.

Data for natural hazard events in Benzie County was compiled from several different sources. Weather event data was collected primarily from the National Centers for Environmental Information through the National Oceanic and Atmospheric Administration's (NOAA) website utilizing the following sections:

- Climate https://www.weather.gov/wrh/Climate?wfo=apx – Historical local observed weather data; Climate prediction and variability; local high impact event summaries

- NOAA Storm Event Database https://www.ncdc.noaa.gov/stormevents/ - Data on record from 1950 to 2021; however, information for various events is limited and non-contiguous. The database provides local storm reports, damage reports, and recorded event descriptions. The event types researched for Benzie County include: Drought (Drought); Flooding (Flash Flood, Flood); Shoreline (Lakeshore) Flood; Hail (Hail); Extreme Winter Weather (Blizzard, Extreme Cold/Wind Chill, Freezing Fog, Frost/Freeze, Heavy Snow, Ice Storm, Lake-effect Snow, Sleet, Winter Storm, Winter Weather); Rip Current; Seiche; Tornado (Tornado, Funnel Cloud); Thunderstorm and High Wind (Heavy Rain, High Wind, Lightning, Strong Wind, Thunderstorm Wind); and Wildfire (Wildfire).

The Great Lakes Current Incident Database was referenced for information about dangerous currents and current-related drownings or rescues, from 2002 to 2020. The *Michigan Hazard Analysis* report by the Michigan Department of State Police in 2019 was used to collect data on wildfires that occurred on State of Michigan owned land between 1981 and 2018. The websites for the National Inventory of Dams and MI-EGLE's Michigan Dam Inventory were used to collect information on dams in the county.

The NOAA storm events database search results indicate a total of 180 events were reported between 01/01/1950 and 10/31/2022 in Benzie County, which resulted in 3 related deaths and 31 injuries. (One event on record that has a large temporal gap between recorded events were excluded from this analysis: a hail event on record for 1955 was excluded because the next recorded hail event occurred almost three decades later, in 1982.) These events, including State and Federal emergency or disaster declarations, wildfires on MDNR land, and dangerous lake current incidents, result in a total of 372 events in the hazard analysis, as illustrated in Table 18.

Extreme Winter Weather events include lake effect snow, heavy snow, winter storm, blizzard, ice storm, and frost/freeze. These events include reported property damage, crop damage, extreme wind chills, high winds, economic disruption and/or up to/over 12 in. of snow for Benzie County.

Thunderstorm/Wind and *High Winds* include reported 50+ knot winds and/or property damage figures. *Lightning* incidents are those that resulted in a reported fatality, injury, and/or property or crop damage.

The Event Narratives for these events recorded in the NOAA NCEI database are included in the Appendix.

Table 18: Reported Benzie County Hazard Events by Type

Type of Event	# of Events	Event Location	Time Interval/ Year Event Recorded
Wildfire (on MDNR land)	184	County	1981-2018
Extreme Winter Weather	106	County/Region	1978*; 1996-2022
Thunderstorm/Wind & High Wind	45	County and Region	1975-2021
Hail	18	Countywide	1982-2021
Coastal Hazards (Lakeshore Flooding, Rip Current)	6	Benzie County Lake MI coastline	2010, 2012, 2019, 2020
Tornadoes	4	Countywide	1956*, 1983, 1986, 1989
Extreme Cold / Wind Chill	2	Region; Statewide	2007, 2019*
Heat/Excessive Heat	2	Region	2001, 2018
Drought	1	Countywide and Region	1977*
Flash Flood / Flooding	2	Countywide and Region	2000, 2013*
Lightning	1	County/Region	2000
Public Health Emergency (COVID-19 Pandemic)	1	Statewide/National	March 2020*
Invasive Species (Terrestrial/Aquatic)	-	Countywide	Ongoing
TOTAL	**372**		

Sources: NOAA National Centers for Environmental Information Storm Events Database; Michigan State Police-Dept. of Homeland Security 2020 MI Hazard Analysis; FEMA Disaster Declarations for States and Counties
Note: * indicates a state or federal event designation

Economic Impact Analysis

The estimated economic impact of the previously described Benzie County natural hazard events that were *reported* to NOAA is $ in property damages and $ in crop damages (Table 19). It should be noted that many events likely cause numerous small amounts in property damage, such as hailstorms, but this often goes unreported. The total reported Damaging Events' Costs recorded with NOAA for Benzie County are as follows:

Table 19: Damage Estimates by Event Type

Event	Property Damage Estimate	Crop Damage Estimate	Directly Related Deaths	Directly Related Rescues, Injuries or Illness
Winter Weather	$600,000 (3/2/2012 snowstorm)	$17,000,000 (2012 snowstorm and freeze events)	-	-
T-Storm with Wind	$188,000	-	-	6
High Wind	$49,000	-	-	-
Tornado	$277,750	-	2	24
Hail	-	-	-	-
Coastal Hazards	$145,000 (lakeshore flooding in 2019-2020)	-	3	11
Heat	-	-	-	-
Extreme Cold/Wind Chill	-	-	-	-
Drought	-	-	-	-
Flood/Flash Flood	-	-	-	-
Lightning	-	-	-	-
COVID-19/Pandemic	-	-	78*	4,121*

Source: NOAA's National Centers for Environmental Information; https://www.michigan.gov/coronavirus/stats
* This is the total of confirmed and probable deaths for COVID-19 in Benzie County as of 2/14/2023

Table 20 provides an overview of each potential hazard's impact on the permanent population and the estimated impact on the State Equalized Values (SEV) for real and personal property (residential and commercial). Population data is collected from the US Census, 2019 ACS data. According to the 2022 Seasonal Population Study for Northwest Lower Michigan, apply a 33.6% increase to account for the estimated annual average seasonal population within the county.

Table 20: Geographic Economic Impact by Event

Potential Hazard Event	Geography	Population Estimates	State Equalized Value
Extreme Winter Weather, Thunderstorm, Wind, Hail, Lightning, Tornado, Extreme Temperatures, Drought, Public Health Emergency	Benzie County	17,615	$839,071,400
Riverine and Urban Flooding			$13,172,250
Road Washout Problem Areas			$7,011,205
Shoreline Erosion	Lake Twp., Crystal Lake Twp., City of Frankfort, Village of Elberta, Gilmore Twp., Blaine Twp.		$17,453,093
Wildfire	Areas with Pine Forest Areas		$105,734,704

Sources: 2019 ACS Estimates from the U.S. Census Bureau; Benzie County Equalization

Extreme Winter Weather

National Weather Service defined as: *phenomenon (such as snow, sleet, ice, wind chill) that impacts public safety, transportation, and/or commerce.* The Extreme Winter Weather category includes the following subcategories: winter weather, winter storm, ice storm, heavy snow, blizzard, frost/freeze, and lake effect snow. Blizzards are the most perilous snowstorms and are characterized by low temperatures, strong winds, and enormous amounts of fine, powdery snow. Snowstorms have the potential to reduce visibility, cause property damage, and loss of life.

According to the 2019 Michigan Hazard Analysis, Michigan has 360 snowstorms with 0.1 average annual deaths, 0.1 average annual injuries, and $1.9 million in average annual property and crop damage. Michigan experiences large differences in snowfall over short distances due to the Great Lakes. The average annual snowfall accumulation ranges from 30 to 200 inches with the highest accumulations in the northern and western parts of the Upper Peninsula. In Lower Michigan, the highest snowfall accumulations occur near Lake Michigan and in the higher elevations of northern Lower Michigan. For example, the average snowfall ranges from 141 inches in the Gaylord area to 101 inches in Traverse City in the northwest region of the Lower Peninsula.

Ice and Sleet Storms are storms that generate sufficient quantities of ice or sleet that result in hazardous conditions and/or property damage. Ice storms occur when cold rain freezes on contact with the surface and coats the ground, trees, buildings, and overhead wires with ice. Often times, ice storms are accompanied by snowfall, which sometimes causes extensive damage, treacherous conditions, and power loss. On the other hand, sleet storms are small ice pellets that bounce when hitting the ground or other objects. It does not stick to trees or wires, but can cause hazardous driving conditions. When electric lines are down, households are inconvenienced, and communities experience economic loss and the disruption of essential services.

According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 16 average annual ice and sleet storm events with 0.2 average annual deaths, 0.5 average annual injuries, and $11.4 million in average annual property and crop damage.

Location
Extreme winter weather events are regional events that are not confined to geographic boundaries and can affect several areas at one time with varying severity depending on factors such as elevation and wind patterns. All of Benzie County is at risk to the occurrence and impacts from extreme winter weather; the county is more susceptible to lake-effect snow due to proximity to Lake Michigan.

One of the highest-impact snowstorms in recent memory pounded Northern Michigan on the night of March 2, 2012. Low pressure tracked from Missouri, to southern Lower Michigan, and on to eastern Canada, while rapidly strengthening. Precipitation surged northward into the region on the evening of the 2nd. This was primarily snow, except in parts of east central Lower Michigan (especially near Lake Huron), where temperatures were mild enough for rain. Snow wound down on the morning of the 3rd, and though somewhat blustery winds occurred behind the system on the 3rd, blowing snow was limited because the snowfall was so wet. Snow totals ranged from 6 to 14 inches across most of Northern Michigan. Higher amounts fell near and west of Grand Traverse Bay, with a maximum amount of 20 inches near Lake Ann. With relatively warm temperatures, the snow was very wet; Traverse City saw around a foot of snow during the night, with a low temperature of 33 degrees. The snow stuck to everything, with the weight of the snow downing many, many trees and power lines. Power outages were widespread, with an outright majority of Northern Michigan residents losing power at some time during or after the storm. In Benzie County, 95 percent of residents lost power. Outages lasted up to a week in some spots. Great Lakes Energy described it as the worst snowstorm (in regards to power outages) in 30 years. A number of counties and communities opened shelters to aid those without power or heat. Also included in the tree damage was substantial damage to fruit trees in the Grand Traverse Bay region, particularly cherry trees. This event accounted for $600,000 in property damages and $2 million in crop damages.

The frost/freeze event on listed in Table 21 took place on April 27, 2012 across Northwest Lower Michigan, but especially in the Traverse City region. A killing freeze caused extreme damage to agriculture, particularly in the fruit belt of Northwest Lower Michigan. Traverse City saw low temperatures of 25 degrees on the 27th, 31 degrees on the 28th, and 26 degrees on the 29th. These values were not exceptionally colder than normal lows, which are in the middle 30s. Ultimately, the main culprit was a stretch of unprecedented warmth in mid-March, which included five consecutive 80-degree days (17th-21st). This caused fruit trees to bud out far, far ahead of schedule, and left them vulnerable to even relatively normal weather as the spring progressed. The tart cherry crop was a total loss, while other orchard fruits such as sweet cherries, apples, pears, and peaches saw losses in excess of 90% of the expected crop. Total crop losses for were estimated at $15 million dollars.

Extent
Snowstorms can be measured based on snowfall accumulations or damages. According to the Benzie County Road Commission's annual snowfall records dating from the 1966-67 season to the 2020-21 season, the average annual snowfall in Benzie County is 126.6 inches. Extreme winter weather events on record with NOAA in total caused $600,000 in property damages during the March 2012 heavy snowstorm, and $17,000,000 in crop damages (2012 heavy snowstorm and 2012 frost/freeze).

Previous Occurrences
Since 1996, there have been 105 extreme winter weather events, including heavy snowstorms, ice storms, frost/freeze, lake-effect snow, blizzards, and winter storms reported in Benzie County (Table 21).

During the January 28 to February 2, 2019 Statewide Winter Emergency, many rivers experienced ice jams that threatened some areas with floods as well; Benzie County's Platte River near the Village of Honor threatened 20 homes and cottages.

Additionally, in 1978, Benzie County, along with the rest of the state of Michigan, received a Presidential Emergency Declaration for a snowstorm and blizzard. In recent years, the more common events are winter storms with moderate snowfall of 5-10 inches. Heavy snow, blizzards, and lake-effect snows have been less common. Nonetheless, extreme winter weather events are the second most frequently recorded natural hazard event in the county, with the potential to impact the entire county and cause widespread damage. With combined property and crop damages, winter weather events are also the most costly events to occur in the county.

Table 21: Benzie County Historic Extreme Winter Weather Events
Source: NOAA: National Centers for Environmental Information

Event Type	Total Events	Property Damage	Crop Damage	Event Years
Winter Storm	47	-	-	1997-2022
Heavy Snow	35	$600,000	$2,000,000	1996-2016
Ice Storm	4	-	-	2001, 2002, 2005, 2008
Lake-Effect Snow	12	-	-	2006, 2008, 2009, 2010, 2013, 2016, 2019
Blizzard	6	-	-	1978, 1997, 1998, 1999, 2002, 2019
Frost/Freeze	1	-	$15,000,000	2012
Winter Weather	1	-	-	2006
TOTAL	**106**	**$600,000**	**$17,000,000**	**1978, 1996-2022**

Probability of Future Events and Vulnerability Assessment
Since 1996, Benzie County has had 105 extreme winter weather events. This averages to about to about 3.9 events every year. The probability of an extreme winter weather event occurring in future years is 100 percent. Heavy snow events have the potential of shutting down towns and businesses for a significant period of time. Blowing and drifting snow with blizzard conditions cause driving hazards. Ice damage may occur when high winds push lake water and ice past the shoreline, causing damage to public infrastructure and residential property. Benzie County remains a leading producer in the state of fruits, tree nuts, and berries with over $5 million in these products sold (*2017 USDA Census of Agriculture*). A frost/freeze event of the magnitude in 2012 would decimate more than three quarters of the products sold today. This would be a huge impact to an economy that is also heavily reliant on agriculture and agri-tourism (wineries, orchards, etc.).

During the winter months, the population is largely made up of the base permanent residents. However, there is increasing demand from seasonal residents to purchase property and retire or work remotely from highly desirable northern and coastal communities like those in Benzie County. Many aspects of Benzie County, including natural wooded areas and proximity to lakes/rivers, are attractive to prospective buyers and the permanent population is expected to continue to grow. New residents, especially those locating in remote areas, increase the chance of risk to life and property during severe weather events. Winter-related events cause difficult driving conditions and in the event of an emergency, can make travel increasingly difficult for emergency personnel who may be more frequently dispatched to rural areas.

Thunderstorms and Severe Winds

Severe thunderstorms are weather systems accompanied by strong winds (at least 50 knots, or 58 mph), lightning, heavy rain (that could cause flash flooding), hail (at least 3/4" diameter), or tornadoes. Severe thunderstorms can occur at any time in Michigan, although they are most frequent during the warm spring and summer months from May through September.

High wind events are included in this category. Long-lived wind events associated with fast-moving severe thunderstorms are known as a *derecho* (pronounced similar to "deh-REY-cho"). According to the National Weather Service, a derecho is a widespread, long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction similar to the strength of tornadoes, the damage typically is directed in one direction along a relatively straight swath. As a result, the term "*straight-line wind damage*" sometimes is used to describe derecho damage. By definition, if the wind damage swath extends more than 240 miles (about 400 kilometers) and includes wind gusts of at least 58 mph (93 km/h) or greater along most of its length, then the event may be classified as a derecho. A derecho often occurs during the spring or summer; however, it can occur any time of the year.

Severe windstorms can cause damage to homes and businesses, power lines, trees and agricultural crops, and may require temporary sheltering of individuals without power for extended periods of time.

Location
Thunderstorms and severe wind are regional events that are not confined to geographic boundaries and can affect several areas at one time with varying severity depending on factors such as elevation and wind patterns. All of Benzie County is at risk to the occurrence and impacts from thunderstorms and severe winds.

The most damaging event occurred on November 10, 1998. One of the strongest storms ever recorded in the Great Lakes crossed the region on the 10th and 11th. The storm originated over the Central Plains and lifted across western portions of Lake Superior. The wind shifted to the southwest during the afternoon...with the strongest winds generally developing along the Lake Michigan shoreline. During the afternoon and evening of the 10th wind gusts of 70 to 80 mph were common along the Lake Michigan shoreline...with 50 to 60 mph gusts across the rest of the region.

A large number of trees were uprooted or snapped off with many branches also torn off. Many of the trees and branches fell on power lines resulting in widespread power outages regionwide. Many roads were also blocked by falling trees and several accidents were reported as cars collided with debris on the roadways. Several homes and cars received damage from falling trees and branches. The strong winds generated 15 to 20 foot waves on Lake Michigan. Most ships took shelter with the approach of the storm and rode out the storm in protected waters.

In Frankfort...located on the Lake Michigan shoreline of Benzie County...80 to 90 mph wind gusts destroyed a hangar at the City-County airport and damaged 6 private planes. Damage to the hangar was estimated at around $500,000 dollars.

Extent
Thunderstorms can be measured based on wind speed or damages. The average wind speed for events in Benzie is 53.2 knots. Benzie County had a reported $237,000 in property damages caused by thunderstorms and severe winds.

Previous Occurrences
Since 1991, there have been a total of 41 thunderstorm/wind and 8 high wind events reported in Benzie County. These are the third-most frequently occurring type of severe weather events in the county.

Table 22: Benzie County Historic Thunderstorm and Wind Events

Event Type	Number of Events	Property Damage	Crop Damage	Injuries	Event Year(s)
Thunderstorm Wind	33	$ 188,000	$ -	6 (1987 event)	1975-2021
High Wind	8	$ 49,000	$ -		1998, 2001, 2003, 2005, 2010, 2015, 2021
TOTAL	**41**	**$237,000**	**$ -**		

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Between 1975 and 2021, Benzie County has had 41 thunderstorm/wind and high wind events. The probability of an event occurring in a future year is 87 percent. Damage from straight line winds usually affects multiple counties through the loss of electricity from trees/tree limbs downing power lines; causing widespread property damage; and potentially exposing the public to severe injury or fatality due to flying debris. The magnitude and severity depend on the county population, seasonal activity, and the spread of development. During the warm or summer months, the base population expands by up to 138% to include both the seasonal short-term population. Residents and visitors are attracted to both rural, sparsely populated rural areas and village centers. Mobile home parks, campgrounds, institutions (schools, places of worship, etc.), and numerous annual events that draw a large number of tourists to outdoor recreation areas were identified as specific areas of concern.

Campgrounds and mobile homes are areas where people and property are particularly vulnerable to thunderstorm/wind events; these areas are mapped in Appendix A. The State Equalized Value of the approximate area of these properties, based on the US Census Bureau's 2019 ACS 5-year estimates and Benzie County Equalization data, is as follows:

- Campgrounds: $3,622,117
- Mobile homes: $199,741

Hail

Hailstorms occur when a severe thunderstorm produces hail that falls to the ground. Hail is formed when the updrafts of the storm carries water droplets above the freezing level, where they form into rounded or irregular lumps of ice that range from the size of a pea to the size of a grapefruit. When the weight of the hail is no longer supported by the air, it falls to the ground and has the potential to batter crops, dent automobiles, and injure people and wildlife. Sometimes, large hail appears before a tornado since it is formed in the area of a thunderstorm that tornadoes are most likely to form.

According to the *2019 Michigan Hazard Mitigation Plan*, Michigan has on average 191 hail storms, an expected annual statewide loss of about $16.6 million, no deaths, and approximately 1 injury per year. Despite damaging hail occurring in every part of Michigan, the areas of the state most prone to severe thunderstorms (e.g. the Southern half of the Lower Peninsula) are also most prone to large and damaging hail. The majority of the hailstorms occur during the growing season from May through August when crops have the greatest potential to be damaged by hail.

The National Weather Service issues forecasts for severe thunderstorms with sufficient warning time to allow residents to take appropriate action to reduce the effects of hail damage to vehicles and some property. However, little can be done to prevent damage to crops. For example, during September 26-27, 1998, a line of severe thunderstorms moved across northern Lower Michigan producing hail up to 2" in diameter in Manistee County and destroying an estimated 30,000-35,000 bushels of apples at area farms, and damaging several homes and vehicles.

Location
Hailstorms are regional events that frequently accompany thunderstorms, and are not confined to geographic boundaries. The severity of hailstorms may range across the affected areas. All of Benzie County is at risk to the occurrence and impacts from hailstorms. According to the National Weather Service, Benzie County is in an area of the United States that has on average two days of hailstorm events per year.

During one particularly strong event on July 17, 2006, hail damage was significant within Benzie County and the region. A strong cold front ran headlong into warm and humid air in place over Michigan. Thunderstorms ignited by midday in Eastern Upper Michigan, and became widespread by late afternoon in Northern Lower Michigan. A large number of storms became severe, as this became the largest severe weather outbreak in Northern Michigan in several years. Millions of pounds of fruit crops were destroyed by hail and wind.

Extent
According to the NOAA National Centers for Environmental Information, the approximate size of hail is described as follows in Table 23. If a thunderstorm produces hail that is 1 inch in diameter (quarter size) or larger, it is considered to be a severe thunderstorm.

Table 23: NOAA Hail Size Description

Diameter	Size Description
1/4"	Pea Size
1/2"	Mothball Size
3/4"	Penny Size
7/8"	Nickel Size
1" (Severe Criteria)	Quarter Size
1 1/4"	Half Dollar Size
1 1/2"	Walnut or Ping Pong Ball Size
1 3/4"	Golf Ball Size
2"	Hen Egg Size
2 1/2"	Tennis Ball Size
2 3/4"	Baseball Size
3"	Teacup Size
4"	Grapefruit Size
4 1/2"	Softball Size

The greatest size of hail reported in Benzie County was 3.25 inches on October 3, 2006 in Benzonia. According to the scale, hailstones of this size are slightly larger than a tea cup.

Previous Occurrences
Between 1982 and 2021, Benzie County had 18 hailstorms reported to NOAA (Table 24). There are no reported property/crop damages, injuries or deaths attributed to hail.

Table 24: Benzie County Hail Events, 1982-2021
Source: NOAA: National Centers for Environmental Information

Location	Date	Magnitude
Benzie County	7/17/1982	1.75
Benzie County	7/9/1987	0.75
Frankfort	4/24/1993	0.75
HONOR	5/30/2002	1.25
LAKE ANN	8/3/2003	0.75
LAKE ANN	8/28/2003	0.88
FRANKFORT	9/15/2003	0.75
LAKE ANN	9/7/2005	0.75
ELBERTA	9/7/2005	0.75
LAKE ANN	6/28/2006	0.75
HONOR	7/17/2006	1
BENZONIA	10/3/2006	3.25
HONOR	10/3/2006	1
BENZONIA	6/20/2007	1
LAKE ANN	10/17/2016	1
BENZONIA	5/31/2019	0.75
NESSEN CITY	5/31/2019	0.88
BEULAH	9/7/2021	0.75

Probability of Future Events and Vulnerability Assessment
With 18 events reported in the past 40 years, Benzie County has a 45% chance of a major hailstorm every year. All existing and future buildings, exposed infrastructure, and populations are at risk from hailstorms since hail causes damage to roofs, brick walls, glass, landscaping, crops, and cars. Manufactured homes and campground populations located throughout the county and are more susceptible to hail damage. Hail can also damage roads, sidewalks, bridges, and above ground utilities. Hail has the potential to cause injury and death, and populations are advised to take shelter when an event occurs.

Campgrounds and mobile homes are considered vulnerable population areas, which these are mapped in Appendix A. The State Equalized Value of the approximate area of these properties, based on Benzie County Equalization data, is as follows:
- Campgrounds: $3,622,117
- Mobile homes: $199,741

Riverine and Urban Flooding

Fluvial, or Riverine flooding occurs when rivers, streams, and lakes overflow into adjacent floodplains due to prolonged, intense rainfall, rapid snowmelt or ice jams. Flooding can damage or destroy property, disable utilities, destroy crops and agricultural lands, make roads and bridges impassable, and cause public health and safety concerns. Floods occur in the early spring, but also occur in the winter due to ice jams, and during the summer or fall from severe thunderstorms. Flooding caused by severe thunderstorms has a greater impact on watercourses with smaller drainage areas.

Pluvial, or *Urban flooding* occurs when water flows into low-lying areas because it does not have a place to go, due to impervious surface coverage. This flooding occurs from a combination of excessive rainfall, snowmelt, saturated ground, and inadequate drainage, and is becoming more common in Michigan. Since development is occurring in floodplains, the natural landscape is unable to properly disperse the water. Urban flooding also has the potential to overflow onto docks or other structures with electricity running to them, which increases the risk for an electric shock drowning. Additionally, storm and sanitary sewers are unable to handle the water flows associated with storm events, which can result in sewer overflows and affect the water quality of nearby lakes and rivers, as well as structures with basements or shallow groundwater tables.

Dam failure is also a potential source of flooding. There are four (4) existing publicly owned/operated dams in Benzie County. The Homestead Dam in Benzonia Township is the only one that has a "significant" hazard potential; meaning that if the dam were to fail, there would be a significant impact on life and property downstream of the dam.

According to the 2019 Michigan Hazard Analysis, the most damaging hazard in Michigan, based upon estimated physical damages and known response/recovery costs, appears to be floods. The MSP reports that flooding events have a statewide expected annual loss estimated at more than $100 million ($25.69 million had previously been estimated in the 2014 Michigan Hazard Mitigation Plan, but Federal Disaster 4195 confirmed a higher magnitude more in line with earlier MDEQ estimates, as that Metro Detroit flood event was quite similar to Federal Disaster 1346 during the previous decade).

The MSP's 2019 Michigan Hazard Analysis indicates that the Northern Lower Peninsula averages 0.3 annual flooding events, with average annual property and crop damages of $2,591,244 due to flooding.

Location

The City of Frankfort and the adjoining Village of Elberta comprise an urbanized area of the county and is the most likely location to experience both riverine and urban flooding, due to the presence of impervious surfaces and the presence of the Benzie River it ends at Lake Michigan.

The Betsie River and the Platte River are the two major rivers in the county. There are also multiple inland lakes. The major lakes are Crystal Lake, Platte Lake, Little Platte Lake, Upper Herring and Lower Herring Lakes, and Lake Ann.

The following communities are likely to experience riverine flooding from the Betsie River and its tributaries: the southeast part of Inland Township, Colfax Township, The Village of Thompsonville, Weldon Township, Benzonia Township, Crystal Lake Township, Gilmore Township, the Village of Elberta and the City of Frankfort.

The following communities are likely to be at risk from riverine flooding from the Platte River and its tributaries: Lake Ann Township, Inland Township, Homestead Township, the Village of Honor, Platte Township, Benzonia Township (northern part) and Lake Township.

High groundwater tables are prevalent within the Villages of Benzonia and Beulah, which are in the Crystal Lake watershed. The Village of Beulah recently completed a municipal water and sewer system. A study is underway to evaluate expansion of those systems to the Village of Benzonia and parts of Benzonia Township.

Blaine Township experienced flooding within neighborhoods surrounding Lower Herring Lake in 2020, when exceptionally high Lake Michigan water levels resulted in Lake Michigan waters flowing into Lower Herring Lake. Combined with a high groundwater table, residential backyards and some roads surrounding the lake were flooded, and residential septic systems were affected as well.

In Homestead Township/Village of Beulah, ice dams on the Platte River caused localized flooding on adjoining properties in 2019.

Other flooding may involve low-lying areas that collect runoff waters; flaws or shortcomings in existing sewer infrastructure; undersized or poorly designed storm water control practices; collective effects of land use and development trends; illegal diversion of water, or actions that interfere with system function.

There are four existing publicly-owned dams in Benzie County that are regulated by MI Dept. of EGLE, as indicated in Table 25 and Figure 12. (Note that the Thompsonville Dam was removed in 1989 after it failed.) The Homestead Dam on the Betsie River in Benzonia Township is the only one that has a "significant" hazard potential; meaning that if the dam were to fail, there would be a significant impact on life and property downstream of the dam. The remaining have a low hazard potential and are therefore not required to have an Emergency Action Plan on file with the State of MI/ Benzie County Emergency Management.

The most recent Emergency Action Plan for the Homestead Dam was received by the MDNR on January 14, 2008, and indicates the following:

> The dam was constructed in 1974 at the site of a former powerhouse barrier. It consists of a 60 foot wide fixed crest steel sheet piling spillway, with 25 foot earth fill sections on either side. The total length of the dam is 110 feet. There are two spillway crests within the spillway section, each 29.5 feet. There is no auxiliary spillway. The low head dam now functions as a lamprey barrier for the Betsie River. The dam is considered to have adequate spillway capacity based on hydraulic calculations on file with the MI EGLE Dam Safety Program.
>
> The dam is a very popular fishing area during the spring and fall. The State of Michigan owns the dam and 75% of the stream frontage from the dam downstream to the US 31 Bridge (approximately 2 miles.) The dam hazard area in case of dam failure would be most severe within 1 mile of the dam. Below this area only minor flooding should occur.

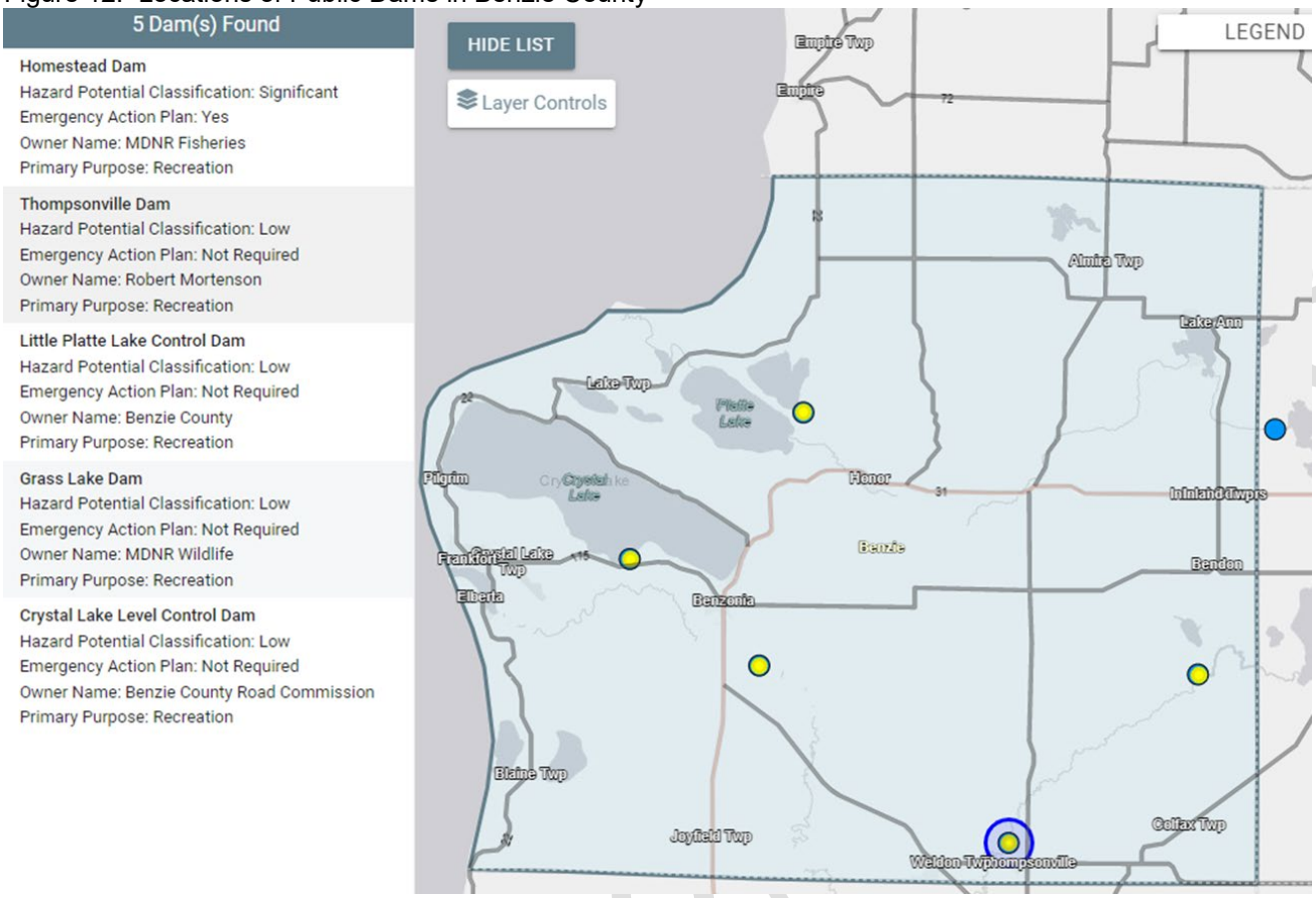
The most recent Operation and Maintenance Plan for the Dam was completed July 27, 2006, and indicates that formal inspections should be made periodically at intervals not to exceed 10 years. The dam was last inspected May 1, 2016 and has a "satisfactory" rating. Should there be an update to the EAP or O&M Plan, the Benzie County Emergency Manager should provide those documents to the EGLE Dam Safety Unit.

Table 25. Public Dams in Benzie County

Name	Height (ft)	Storage (acre-feet)	Location	Owner	Dam Type	Year Completed	Dam Purpose	Hazard Potential
Crystal Lake Level Control Dam	7	27,190	Crystal Lake Outlet	Benzie County Road Commission	Gravity	1977	Recreation, Other	Low
Grass Lake Dam	8.4	5,200	Betsie River	MDNR Wildlife	Gravity	1951	Recreation	Low
Homestead Dam	14	1,800	Betsie River	MDNR Fisheries	Other	1974	Recreation	Significant
Little Platte Lake Control Dam	10	3,400	N. Branch Platte River	Benzie County	Other	1969	Recreation, Other	Low
Thompsonville Dam (removed in 1989 after it failed)	20	165	Betsie River	Robert Mortenson	Earth, Gravity	1901	Recreation	Low

Source: EGLE Michigan Dam Inventory

Figure 12. Locations of Public Dams in Benzie County



Source: National Inventory of Dams

Extent

There are no reported property damages associated with inland flooding events for Benzie County. There are no reported deaths or injuries occurred from these events (Table 26).

Table 26: Fluvial and Pluvial Flood Events

LOCATION	DATE	EVENT TYPE	PROPERTY DAMAGE	CROP DAMAGE	FLOOD CAUSE
Countywide/Region	9/1/2000	Flash Flood of Road	-	-	Thunderstorm producing 2-6 inches of rain within four hours
Countywide/Region	April - May 2013	Flooding	-	-	Extensive rainfall during a spring thaw.
TOTAL			-		

Sources: NOAA National Centers for Environmental Information; *Michigan State Police *2019 Michigan Hazard Analysis*

Previous Occurrences

On September 1, 2000, flash flooding of roadways occurred in northern Benzie County and surrounding counties. An area of thunderstorms formed over northern Benzie County and surrounding Leelanau County and the Traverse City metropolitan area and persisted until from about 7:00 pm to 11:30 pm, continually affecting the same areas. Over the 4 to 5 hour period of rainfall, much of Leelanau County reported rainfall amounts ranging from 4 to 8 inches, while amounts ranged from 2 to 6 inches in Benzie and Grand Traverse counties. These storms led to flooding of roadways across the northern half of Benzie County as well as Leelanau and Grand Traverse counties.

On May 7, 2013, Governor Snyder issued a State of Disaster Declaration for Benzie County and 18 other counties and two cities in Michigan that were impacted by severe flooding that occurred between April 9 and May 3, 2013. Some homes along the Crystal Lake Outlet Creek (Crystal Lake Township) were flooded, along with several homes on Rhodes Road (Inland Township), and Demerly Road and Wallaker Road (Joyfield Township). Some of these homes were not located in floodplains. The water table rose so high in some places that it flooded foundations and caused the floors to buckle.

Though not a common occurrence in the county, riverine flooding has occurred when spring snowmelt coincides with prolonged, intense rains.

The county may see an increase in flood events from an increase in rain and snowfall, and the backwater effect from fluctuating high water levels of the Great Lakes.

Probability of Future Events and Vulnerability Assessment

Floods can damage or destroy public and private property, disable utilities, make roads and bridges impassable, destroy crops and agricultural lands, cause disruption to emergency services, and result in fatalities. People may be stranded in their homes for several days without power or heat, or they may be unable to reach their homes at all. Long-term collateral dangers include the outbreak of disease, widespread animal death, broken sewer lines causing water supply pollution, downed power lines, broken gas lines, fires, and the release of hazardous materials.

Between 2000 and 2021, Benzie County has had two major inland flooding events. This represents a 9% chance of an annual major fluvial or pluvial flood event. The magnitude and severity depend on the county population, seasonal activity, and the spread of development. During the warm or summer months, the population expands to include both the permanent resident base population and the seasonal short- and long-term population. The seasonal population is attracted to both rural, sparsely populated rural areas and urban activity centers. The City of Frankfort's Business District is located at the mouth of the Betsie River. City infrastructure is also vulnerable where it intersects with the Betsie River.

High groundwater tables are prevalent in many areas of the county, which poses a compatibility issue with the use of ineffective on-site septic disposal systems resulting potential groundwater contamination. The Village of Lake Ann does not have a local sewer or water supply system. The Village of Honor has sewer, but not municipal water. The Village of Thompsonville has municipal water, but not sewer. The Villages of Elberta, Beulah, and the City of Frankfort each have municipal water and sewer systems. A study is underway to evaluate expansion of those systems to the Village of Benzonia and parts of Benzonia Township. Concerns were expressed in the community survey about how well the existing sewer system in Beulah will keep up with demands placed on it by the seasonal population.

The following comments from the community survey and stakeholder meetings were provided regarding inland flooding/erosion concerns:

- Village of Elberta: The M-22 Causeway over the Betsie River in Elberta was mentioned specifically five times in the survey due to the concern of another flooding/ potential washout situation if/when lake water levels rise again like they did in 2019 and 2020.
- Blaine Township: "Somewhat concerned about structural integrity of the dam in Lower Herring Lake [adjoining Lake Michigan]. Hasn't been a functioning dam in years, but if waters receded a lot it may be something to watch." The lake flooded in 2020 due to high Lake MI water levels and excessive rain.
- City of Frankfort: "Critical infrastructure concerns include the water and sanitary sewer distribution systems"; "dams and rivers in the event of a flood"; and the need to "install check valves on storm discharge locations".
- The Platte and Betsie River both run through the county. The BCRC maintains 17 bridges (not counting the bridges maintained by MDOT). Losing a major bridge could have long term negative impacts to the county.
- Village of Beulah: Potential services failure due to pressures from seasonal tourists; "sustained power outages will have a significant impact on our ability to sustain major DPW responsibilities"
- Village of Thompsonville/Colfax Twp.: Spring runoff issues north of Lindy Road from a natural drain that runs from Thurman Road in Colfax Township and combined with a high water table.
- Weldon Township: ice backups along Little Betsie River crossing Wallin Road and Thompsonville Highway and along the Betsie River north of Lindy Road.
- Platte Township: sometime have high water/flooding along the North Branch Platte River along Gudemoos Road. High water table in low ground areas on the north end of the Little Platte Lake and Saffron Road.
- Homestead Township: Dirt road washouts on hilly roads at Weldon and Brownell and Valley Road north of US 31. Ice dams along Platte River.

- Almira Township: the Pinewoods subdivision off of Lake Ann Road has a high groundwater table and has experienced flooding.
- Benzonia Township: Dirt road washouts on the north side of Hidden Hollow Road and the south side of Crystal Lake on Lake Street. High water area could impact businesses/multi-unit housing along US-31 between Narrow Guage and Eldridge Road on the north side of US-31, toward Crystal Drive.
- Crystal Lake Township: Betsie River and Crystal Lake outlet area is a flood zone. Have had beach erosion and road washout at the end of Figg Road and the end of Bellows Road, on the south side of Crystal Lake. Also a culvert/possible road washout at Thomas Road east of Bellows Road.
- Gilmore Township: high water near M-22 causeway; concerns about the [structural] soundness of the steel wall along the Betsie Lake in Elberta.

Specific flood hazard areas were identified during public input meetings and are identified on the Hazard Areas Map provided in Appendix A. Flood hazard information may be obtained from the Flood Rate Insurance Maps (FIRM) available for jurisdictions. In order to delineate potential flood plain areas (seasonal floodplains) for each jurisdiction, Networks Northwest overlaid wetland, soils, and elevation data to determine the most likely flood prone areas. Once overlaid; isolated polygons (areas) were deleted in order to show a more accurate representation of potential flood prone areas along lakes, rivers, and streams. *Sources: Temporary/Seasonally Flooded Areas data are from the National Wetland Inventory of the US Fish and Wildlife Service; Hydric soils data are from the county digital soil surveys (were available); and Digital Elevation Model data are from the Center for Geographic Information, Michigan Department of Information Technology.*

NFIP Participation Status

Table 27 indicates the communities in Benzie County that currently participate in FEMA's National Flood Insurance Program, and available Flood Insurance Rate Maps. Benzie County participating communities are scheduled to receive their updated flood maps digitally in 2023.

Table 27: Communities Participating in the National Flood Insurance Program

Municipality	FIRM	Effective	Number
Almira Township	**Y**	3/23/2021	261921
Benzonia Township	N		
Blaine Township	**Y**	3/23/2021	260027A
Colfax Township	N		
Crystal Lake Township	**Y**	3/23/2021	260028A
City of Frankfort	**Y**	3/23/2021	260029A
Gilmore Township	**Y**	3/23/2021	261920A
Homestead Township	N		
Inland Township	N		
Joyfield Township	N		
Lake Township	**Y**	3/23/2021	260030A
Platte Township	N		
Weldon Township	N		
Village of Benzonia	N		
Village of Beulah	N		
Village of Elberta	**Y**	3/23/2021	260553A
Village of Honor	N		
Village of Lake Ann	N		
Village of Thompsonville	N		

Source: FEMA Community Status Book Report

The 2019 *Michigan Hazard Analysis* by the Michigan State Police reports the following flood insurance policy and claim data for Benzie County (Table 28).

Table 28: National Flood Insurance Statistics for Benzie County

Total Premium	Policies	A-Zone Policies	Total Coverage	Claims since 1978	Total paid since 1978
$48,653	34	22	$7,862,600	7	$54,860

Source: Michigan State Police

FEMA defines a "repetitive loss property" as any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period since 1978 (the year at which consistent claims data collection began). The county has __ property(ies) that has been identified by the National Flood Insurance Program as having suffered repetitive flood losses. This property should be prioritized for flood mitigation activities, in order to prevent or reduce such losses in the future.

Lightning

Lightning is a random and unpredictable discharge of electricity in the atmosphere between the clouds, air, or ground to equalize the charged regions in the atmosphere. It is still being debated how the electrical charges build up in the clouds. Lightning generally occurs during thunderstorms; however, it can occur without a thunderstorm, such as during intense forest fires and heavy snowstorms. Lightning that occurs without nearby rain is most likely to cause forest fires.

Location
Lightning is not confined to geographic boundaries and is a regional event. Since lightning occurs randomly, it is impossible to predict where lightning will occur and how severe it will be. All of Benzie County is at risk to the occurrence and impacts from lightning.

Extent
Only one lightning event has been reported to NOAA for Benzie County. That event occurred in conjunction with a flash flood event in the county on September 1, 2000. While no property damages, injuries or fatalities were reported for Benzie County, the NOAA Episode Narrative describes there was one injury and one fatality in the region from that lightning event. A father and son were exposed on a hillside viewing the lightning storm. The 40 year old father was struck and killed by a lightning bolt. His son was thrown to the ground, but only sustained minor injuries. Emergency crews performed CPR on the father immediately and a police officer arrived with a defibrillator. However attempts to revive the man failed.

During the same event, lightning later that Friday night also disrupted numerous high school football games. Many games were cancelled or postponed until the following Saturday morning. Many of the schools which began paly had lengthy delays and many waited an hour or more before fans and players could return to the field.

Previous Occurrences
There has been one lightning event reported to NOAA for Benzie County since 1950 (Table 29). There was one injury and one fatality that occurred associated with this event, outside of Benzie County.

Table 29: Lightning Events

LOCATION	DATE	DEATHS	INJURIES	PROPERTY DAMAGE
Countywide/Region	9/1/2000	0	0	$-

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since there have been one lightning event reported in the last 22 years, this indicates a 4.5% chance an impactful lightning event would occur every year. However, not all lightning events been reported to NOAA, since events with injuries, deaths, and extensive damages/disruptions tend to be the only ones reported. Therefore, the number of lightning events and damages may be higher.

All existing and future buildings, exposed infrastructure, and populations are at risk from lightning events since it may cause structural and wildland fires, loss of electrical and telecommunications equipment, and damage to buildings or vehicles from falling trees struck by lightning. People that work outside or participate in outdoor recreation activities are at a higher risk to be struck by lightning.

Campgrounds are mapped in Appendix A. The State Equalized Value of the approximate area of these properties, based on Benzie County Equalization data, is $3,622,117.

Tornado

A tornado is a violently rotating column of air that extends from a thunderstorm to the ground, and can occur anytime during the day and throughout the year. It can only be seen if water droplets, dust, and debris form a funnel. The funnel cloud can have winds that reach up to 300 miles per hour with an interior air pressure that is 10-20% below the surrounding atmosphere's pressure. The length of a tornado path has been reported up to 200 miles. Tornado path widths are generally less than one-quarter mile wide. These storms are the most violent of the atmospheric storms since they have the potential to destroy buildings, uproot trees, hurl objects, and cause loss of life.

According to the National Oceanic and Atmospheric Administration/National Weather Service's Storm Prediction Center, tornadoes cause approximately 60 deaths and hundreds of millions of dollars in property damage each year. According to the 2019 Michigan Hazards Plan, Michigan is located on the northern fringe of the nation's tornado belt and has a statewide expected annual loss of about $19.6 million due to tornadoes. Michigan also has an average of 18 tornadoes, approximately 4 deaths, and approximately 50 injuries per year. Between 1999 and 2019, Michigan has had 314 reported tornado events with 52.9% as EF0 (weak) or EF1 (moderate), 38.9% reported as F0 or F1 (weak), 6.7% as EF2 (significant) or EF3 (severe), and 1.6% as F2 (strong). In Northern Michigan, tornados are most likely in the summer months, although some have occurred in the spring and fall.

Location
Tornadoes are a regional event that are not confined to geographic boundaries and can affect several areas at one time. Also, the magnitude of tornadoes may range across the affected areas. All of Benzie County is at risk to the occurrence and impacts from tornadoes. It is impossible to predict where and with what magnitude a tornado will touchdown.

The EF4 tornado that occurred in 1956 began near Wallaker Road in southern Joyfield Township and continued northeast through Weldon, Homestead, Inland and Almira Townships for 19.4 miles before ending just east of Lake Ann in Grand Traverse County.

The EF1 tornado that occurred in 1983 was located near Lamerson Lane, between St. Johns Rd. and US-31, in Inland Township.

The EF1 tornado that occurred in 1986 was located in the Village of Thompsonville.

The EF1 tornado that occurred in 1989 began near the Crystal Downs Country Club and traveled 12 miles southeast across Crystal Lake, ending southwest of Narrow Gauge Rd and S. Marshall Rd. in Benzonia Township.

Extent
The Fujita Scale (Table 30) categorizes tornado severity based on observed damage. The six-step scale ranges from F0 (light damage) to F5 (incredible damage). As of February 2007, the National Weather Service uses the Enhanced Fujita Scale (EF Scale). This new scale ranges from EF0 to EF5. Based on the Fujita Scale, Benzie County's most damaging tornado occurred in 1956 with winds ranging from 210-261 mph.

Table 30: Fujita and Enhanced Fujita Scale Comparison

Fujita Scale (Old)		EF Scale (Current)	
Fujita Scale	**3-Second Gust Speed (mph)**	**EF Scale**	**3-Second Gust Speed (mph)**
F0	45-78	EF0	65-85
F1	79-117	EF1	86-109
F2	118-161	EF2	110-137
F3	162-209	EF3	138-167
F4	210-261	EF4	168-199
F5	262-317	EF5	200-234

Source: FEMA

Previous Occurrences
Between 1950 and 2021, Benzie County has had four (4) reported tornadoes touchdown, causing $277,750 in property damage (Table 31). The most destructive tornado occurred in 1956. It was a category F-4, causing two (2) deaths, twenty-four (24) injuries and $250,000 in property damage. The remaining three tornadoes were category E-1 tornados.

Table 31: Tornado Events, 1950-2021

Begin Location	Date	Deaths	Injuries	Scale	Property Damage	Crop Damage
Joyfield Township	4/3/1956	2	24	F4	$250,000	
Inland Township	7/21/1983	0	0	F1	$250	
Village of Thompsonville	6/26/1986	0	0	F1	$2,500	
Lake Township	10/15/1989	0	0	F1	$25,000	
TOTAL	**4**	**2**	**24**		**$277,750**	$

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since there have been four tornadoes events reported in the last 72 years, the data shows that there is a 5.6% chance a tornado would occur every year. While the chance for a tornado is low, if an event occurs, there is potential for a high magnitude tornado to touch down. All of the reported historic events have caused property damage.

Campgrounds and mobile homes are considered vulnerable population areas, which these are mapped in Appendix A. The State Equalized Value of the approximate area of these properties, based on Benzie County Equalization data, is as follows:
- Campgrounds: $3,622,117
- Mobile homes: $199,741

Benzie County Office of Emergency Management utilizes CodeRED or NWS messaging to notify citizens of events and emergencies in the community. CodeRED enables real-time, communication through text, email, voice messages, social media, and the CodeRED mobile app. There are no operable tornado sirens in the county. Additionally, the Grand Traverse Band Tribe of Ottawa and Chippewa Indians has underground tornado shelters on their property at Four Seasons Drive in Benzonia.

Extreme Temperatures

Prolonged periods of very high or very low temperatures are often accompanied by other extreme meteorological conditions, such as high humidity, drought, heavy snowfall, or high winds. Extreme heat or extreme cold primarily affect the most vulnerable segments of the population, such as the elderly, children, impoverished individuals, and people in poor health.

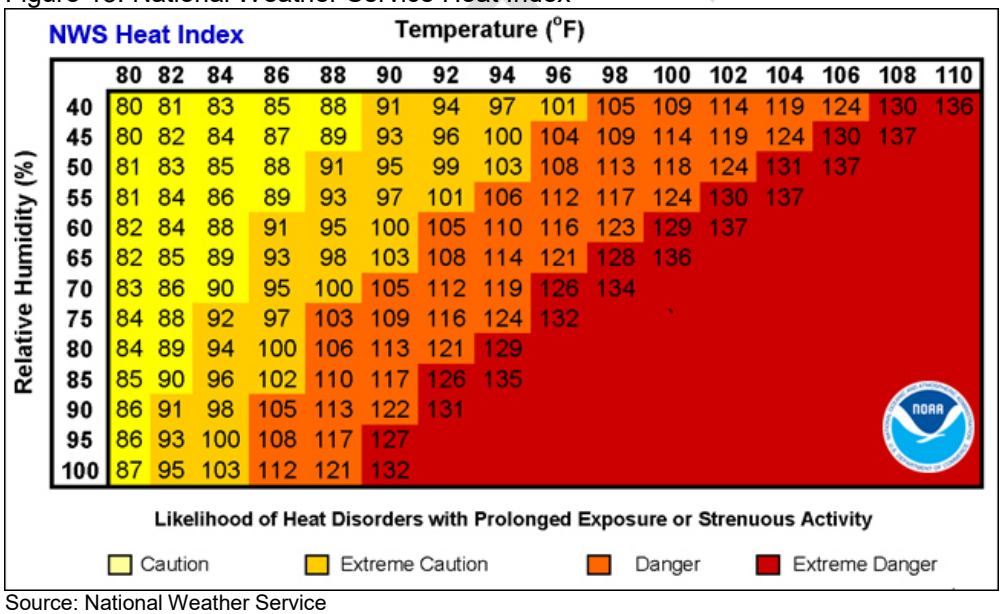
Nationwide, there have been approximately 175 deaths per year that are attributable to extreme heat according to the 2019 Michigan Hazard Analysis. The threats from extreme heat are heatstroke, sunstroke, muscle cramps, heat exhaustion, and fatigue. It is hazardous to livestock and agricultural crops, causes water shortages, exacerbates fire hazards, exacerbates respiratory problems, prompts excessive electrical energy demands, and causes infrastructure failures. Urban areas experience the most serious extreme heat with the combined high temperatures and high humidity that produce a heat-island effect.

According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 11 average annual extreme heat events with 0.4 average annual deaths and 41 average annual injuries.

In the United States, approximately 700 people die each year as a result of severe cold temperature-related causes according to the 2019 Michigan Hazard Analysis, with a significant number of deaths occurring due to illnesses or disease that are negatively impacted by severe cold weather, such as stroke, heart disease, and pneumonia. Exposure to extreme cold temperatures can be life threatening and can cause hypothermia and frostbite. According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 35 average annual extreme cold events with 1 death, 9.4 average annual injuries, and $6.4 million in average annual property and crop damage. Extreme cold affects transportation modes and power utilities, resulting in dead vehicle batteries and loss of power/heat.

Measuring Extreme Temperatures (Extreme Heat and Extreme Cold)
Extreme heat is measured with the National Weather Service's Heat Index Chart (Figure 13). The chart uses relative humidity and air temperature to determine the likelihood of heat disorders with prolonged exposure or strenuous activity. Individuals are unable to shed excess heat from their bodies when they experience prolonged exposure to hot temperatures, which results in heat disorders.

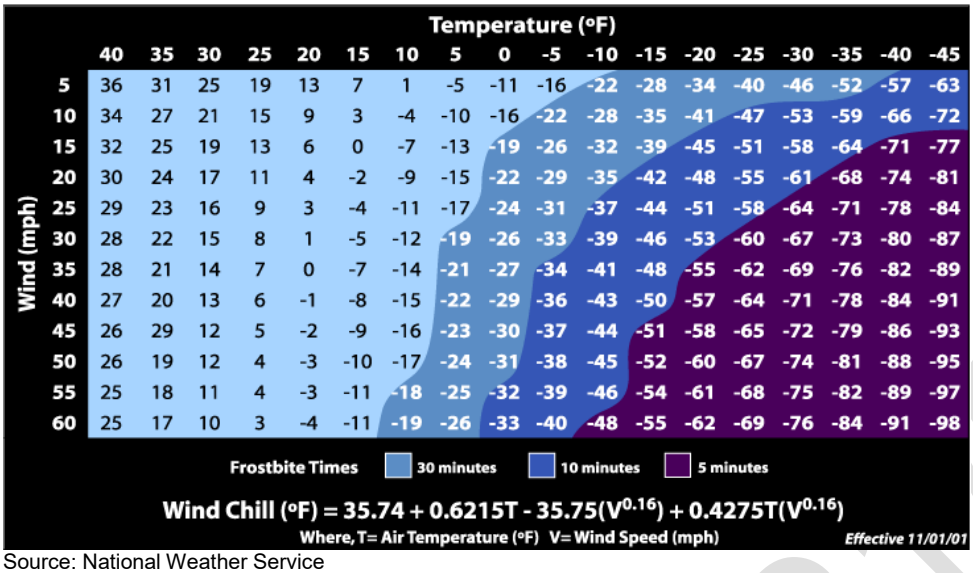
Figure 13: National Weather Service Heat Index



Source: National Weather Service

Extreme cold is measured with the wind chill index, which is a measure of the rate of heat loss from exposed skin caused by the combined effects of wind and cold. As the wind increases, heat is carried away from the body and reduces the external and internal body temperatures. Figure 14 shows the NOAA Wind Chill Chart as it corresponds to various temperatures and wind speeds.

Figure 14: National Weather Service Wind Chill Chart



Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Source: National Weather Service

Figures 15 and 16 are the observed temperatures at Frankfort and Beulah for 2021. The dark blue line shows temperatures recorded between January 1 2021 and December 21, 2021. The red line above shows record high temperatures for that day, and the light blue line below indicates record low temperatures for that day. Frankfort's proximity to Lake Michigan results in a higher observed temperature range between April and October compared to the inland location of Beulah.

Figure 15: Daily Temperature Data for Frankfort

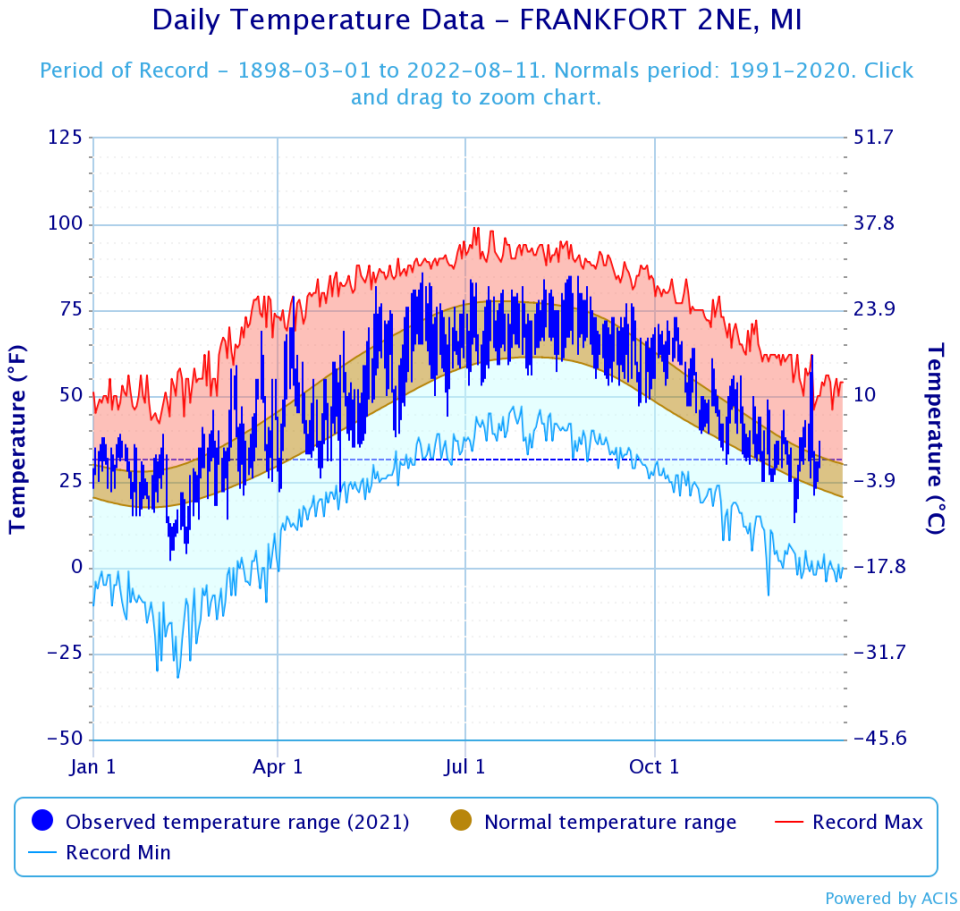
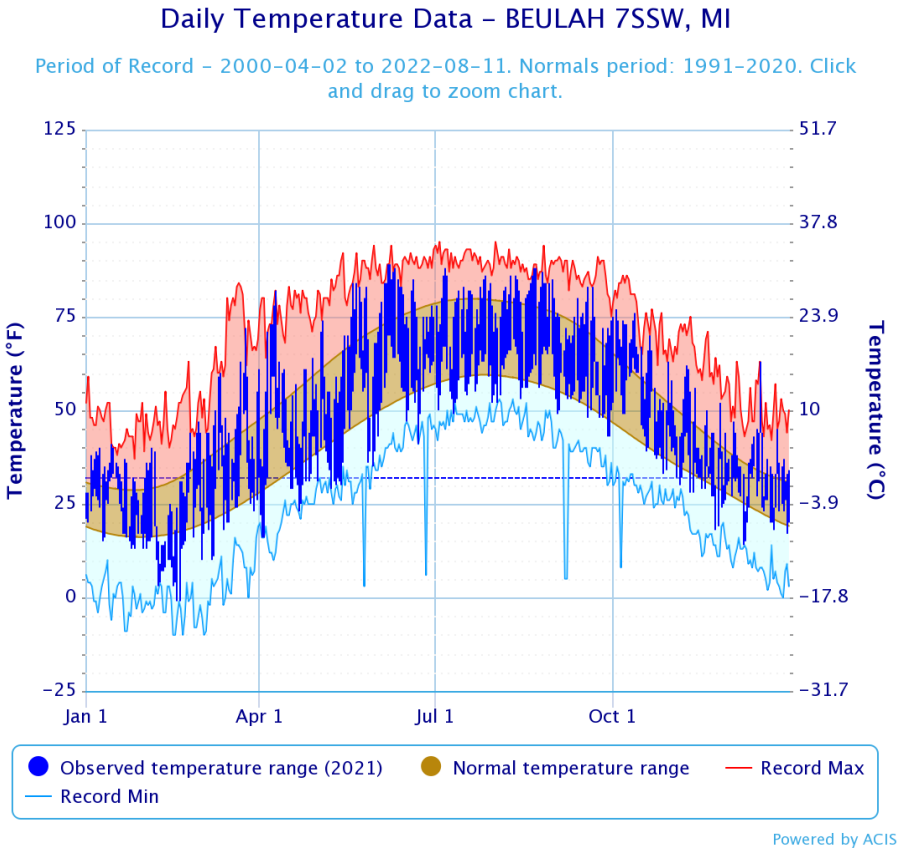


Figure 16: Daily Temperature Data for Beulah



Source: NOAA Climate Data Online

Location and Extent

Extreme temperatures are a regional event that are not confined to geographic boundaries and range in severity across the affected areas. All of Benzie County is at risk to the occurrence and impacts from extreme temperatures.

There have been two heat/extreme heat events recorded in Benzie County. The first occurred on August 1, 2001. Excessive heat was a problem the first two weeks that 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. This period of excessive heat also brought on a drought event at the same time.

The second instance of reported excessive heat occurred on June 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. An estimated 25 and 30 individuals visited local hospitals due to heat-related illnesses.

There have been two extreme cold events reported in Benzie County. The first occurred on February 4, 2007. Exceptionally cold air surged into Northern Michigan. High temperatures on the 4th (Super Bowl Sunday) were around zero, with low temperatures that night from five to ten below zero. Gusty northwest winds produced hazardous wind chills of 20 to 30 below zero, along with blowing and drifting snow. Many area schools closed on the 5th, due to the extreme cold and poor road conditions.

The second instance of extreme cold is the Governor Declared Emergency that occurred on January 29, 2019. Wind chills of 15 to 30 below zero were common in northern lower Michigan. Wind chills were much colder in eastern upper Michigan, including -51 at Kinross, and -42 at Sault Ste Marie and Mackinac Island.

Previous Occurrences

Benzie County has had two extreme heat events in 2001 and 2018 (Table 32). The events did not have any deaths, injuries, or property/crop damages. The events consisted of hot and humid conditions that caused outdoor events to be modified and attendance at outdoor events to be lower than normal.

Table 32: Heat Related Events

	DATE	EVENT TYPE	INJURIES, DEATHS, DAMAGES	EVENT DESCRIPTION
BENZIE (ZONE)	8/1/2001	Heat	0	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. 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.
BENZIE (ZONE)	6/30/2018	Excessive Heat	0	Highs were well into the 90s, including 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.

Source: NOAA: National Centers for Environmental Information

There have been three extreme cold events reported in Benzie County (Table 33). These events did not have any deaths, injuries, or property/crop damages for the county. The low temperatures caused schools to close. However, since very cold temperatures/wind chills typically occur during winter months, many events may have gone unrecorded.

A Governor-declared emergency for extreme cold in the State was enacted in January 2019 and included Benzie County.

Table 33: Extreme Cold Related Events

	DATE	EVENT TYPE	INJURIES, DEATHS, DAMAGES	EVENT DESCRIPTION
BENZIE (ZONE)	2/4/2007	Extreme Cold/Wind Chill	0	High temperatures on the 4th (Super Bowl Sunday) were around zero, with low temperatures that night from five to ten below zero. Gusty northwest winds produced hazardous wind chills of 20 to 30 below zero, along with blowing and drifting snow. Many area schools closed on the 5th, due to the extreme cold and poor road conditions.
BENZIE (ZONE)	2/19/2015	Extreme Cold/Wind Chill	0	Wind chills reached 30 to 40 below zero across part of northern Michigan, bottoming out at -43 near Cadillac early in the morning on the 19th.
BENZIE (ZONE)	1/29/2019	Extreme Cold/Wind Chill		Governor Declared Emergency – Wind chills of 15 to 30 below zero were common in northern lower Michigan. Wind chills were much colder in eastern upper Michigan, including -51 at Kinross, and -42 at Sault Ste Marie and Mackinac Island.

Sources: NOAA: National Centers for Environmental Information; MSP 2019 Michigan Hazard Mitigation Plan

Probability of Future Events and Vulnerability Assessment

Since 2001, there have been two extreme heat events in Benzie County. This indicates an approximate 9.5% chance of an annual extreme heat event occurring.

Since 2007, there have been three extreme cold/wind chill events in Benzie County. This indicates an approximate 20% chance of an extreme cold event occurring in a year. Since these events tend to occur during the winter months and are coupled with blustery winds and snowstorms, these events may have been reported as other hazards or not at all, which means there may have been more extreme cold events in the county.

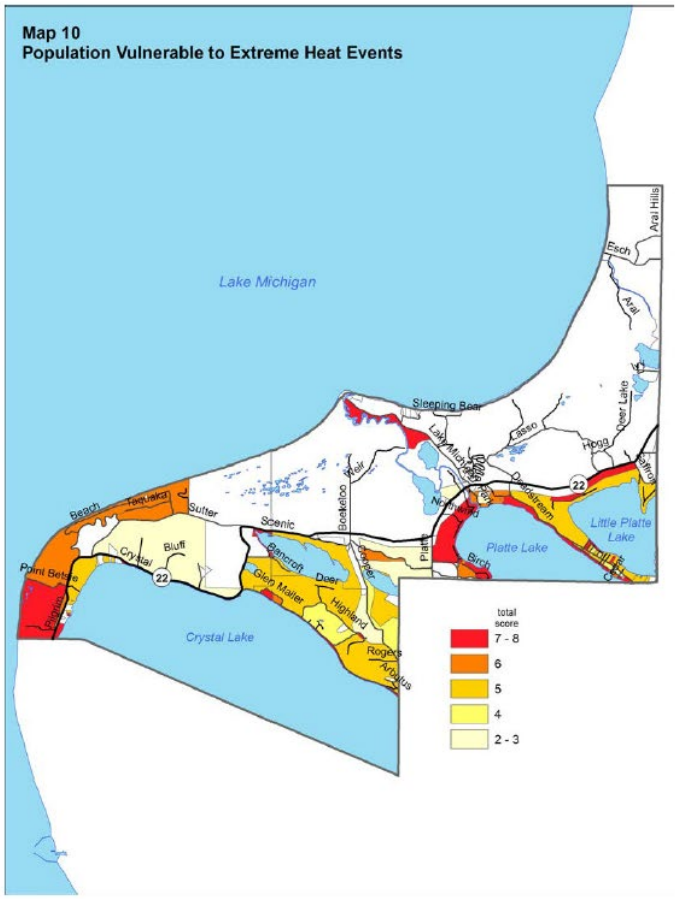
Extreme heat and cold events are more likely to impact unsheltered populations. The county's homeless population is especially vulnerable. Seasonal emergency shelters are essential services for the community. The *Northwest Lower Michigan Coastal Resilience Atlas* written by the Land Information Access Association completed a Heat Vulnerability Assessment[5] of coastal communities. A community's vulnerability is their exposure to the hazard (determined by tree canopy and impervious surface coverage) + their sensitivity. Sensitivity is determined by the folowing factors:

- Persons > 65 years
- Persons living alone
- Minority (non-white) persons
- Persons living below the poverty threshold
- People > age 25 with less than a high school education
- Disability status (i.e., ambulatory difficulty, mental disability)

Lake Township has the highest median age (65.8 yrs) of all Benzie County communities. Figure 17, taken from the *NW MI Coastal Resilience* Atlas, shows the populations in Lake Township that are vulnerable to extreme heat events.

[5] Land Information Access Association. (2019). *Northwest Lower Michigan Coastal Resilience Atlas.* http://www.resilientmichigan.org/nw_atlas.asp

Figure 17: Lake Township Relative Sensitivity of Population to Extreme Heat Events



Drought

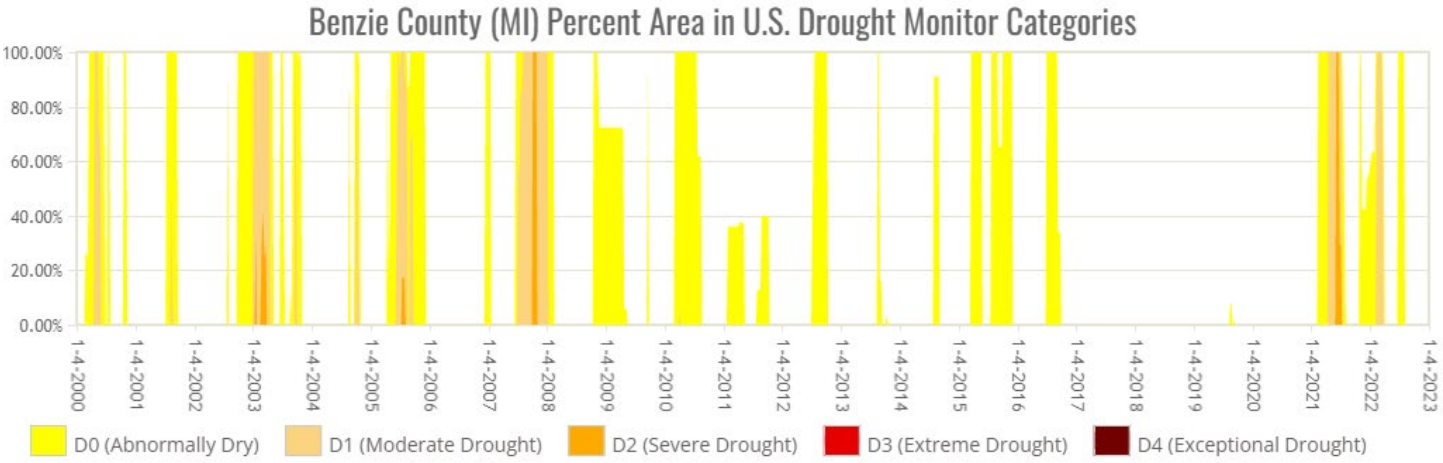
Drought is a normal part of the climate cycle. It is a slow-moving hazard, which causes people to underestimate the damage it can do, but losses from drought are as substantial as those from hurricanes, tornadoes and other faster-moving disasters. Drought causes losses to agriculture; affects domestic water supply, energy production, public health, and wildlife; and contributes to wildfire, to name a few of its effects.

Location
Drought is a regional event that is not confined to geographic boundaries and range in severity across the affected areas. All of Benzie County is at risk to the occurrence and impacts from drought.

Extent
The Palmer Drought Severity Index (PDSI) uses readily available temperature and precipitation data to estimate relative dryness. It is a standardized index that generally spans -10 (dry) to +10 (wet). Maps of operational agencies like NOAA typically show a range of -4 to +4, but more extreme values are possible. The PDSI has been reasonably successful at quantifying long-term drought.

The U.S. Drought Monitor (Figure 18) combines several input sources including the PDSI and the Standardized Precipitation Index to prepare a weekly map showing parts of the U.S. that are in drought. The map uses five classifications: abnormally dry (D0), showing areas that may be going into or are coming out of drought, and four levels of drought: moderate (D1), severe (D2), extreme (D3) and exceptional (D4) (Figure 19).

Figure 18: Benzie County Historical Drought Levels



Source: US Drought Monitor

Figure 19: U.S. Drought Categories and Historically Observed Impacts

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

Source: US Drought Monitor

Previous Occurrences

There has been one recorded incident of drought in Benzie County. In March 1977 there was a Presidential Declared Emergency for drought problems plaguing counties in the Upper Peninsula and Northern Lower Peninsula, which included Benzie County. This event was part of the 1976-77 drought in the Great Plains, Upper Midwest, and West of the United State. At a statewide level, the drought lasted for 11 consecutive months, from September 1976 to July 1977, and reached a low point in January 1977, with a Palmer Index value of -5.29 (within the D4 exceptional drought classification).[6]

Probability of Future Events and Vulnerability Assessment

There is a 2.2% annual chance for a drought event in Benzie County. In Northern Michigan's forested regions, drought can adversely impact timber production and some tourism and recreational enterprises. This can also cause a drop in income, which impacts other economic sectors. The biggest problem drought presents, however, is the increased threat of wildfire. The western portions of Benzie County are at highest risk for wildfire due to the presence of grasslands amongst the sand dune environment. Additionally, the threat to water sources should also be considered. Many county residents rely on ground water wells for drinking water. Even drought events in category D1 experience water well level decline. Drought events combined with excessive heat can have severe impacts on elderly and low income people.

[6] MSP *2019 Michigan Hazard Analysis*

Wildfire

A wildfire is an unplanned, uncontrolled fire in grassland, brushland, or forested areas. Wildfires can occur in any forest or grassland type under dry conditions; however, some forest types are more susceptible to wildland fires. For example, jack and red pine forest stands have a high risk for wildfires, as they dependent on fire to provide all the right conditions for regeneration, while aspen and white pine forest stands have a moderate risk. The primary cause of wildfires is from human activities, specifically burning outdoor debris. Wildfires cause destruction to property and timber resources, and injuries or loss of life to wildlife and persons living or recreating in wildfire prone areas. Long-term effects include scorched and barren land, soil erosion, landslides/mudflows, water sedimentation, and loss of recreational opportunities.

Approximately 55% (20.4 million acres) of Michigan's total land area is forest cover. The vast forests provide Michigan with the largest state-owned forest system in the United States. In addition, Michigan has the fifth largest quantity of timberland acreage, with 19.3 million acres (including hardwoods and softwoods). That vast forest cover is a boon for both industry and recreation, and these areas have been gradually increasing in recent years. However, it also means that many areas of Michigan are vulnerable to wildfires.

Michigan's fire season starts in early spring, when leaves and grasses remain dry from fall and winter and trees are not yet green. Wildfires are often accompanied by drought where dry conditions increase the potential to burn. Often a thunderstorm will roll through and lightning will strike causing sparking of dry leaves and dead wood. High winds can then spread wildfire. Wildfires can become unpredictable in windy conditions or when the wind changes direction suddenly. Cooler nighttime temperatures often help suppress wildfires and the potential for wildfire; however Michigan has had several major fire events.

According to MDNR and U.S. Forest Service records, between 1910 and 1949, over 5.8 million acres of forest were burned in Michigan, an average of 145,000 acres per year. By comparison, it was reported that between 1950 and 1996, the MDNR and U.S. Forest Service were involved in suppressing over 46,100 wildfires that burned 390,000 acres of forest, which averages only 8,300 acres burned per year. This drastic reduction in the acres of timber burned was largely the result of increased use of specialized equipment to suppress the fires, and intensified efforts toward fire prevention.

However, lightning strikes are not the primary cause of wildfires in Michigan. Recently, only about 4% of all wildfire in Michigan were caused by lightning strikes, and most other causes have been attributed to human activity. Outdoor debris burning is the leading cause of wildfires in Michigan. Most Michigan wildfires occur close to where people live and recreate, which puts both people and property at risk. The immediate danger from wildfires is the destruction of property, timber, wildlife, and injury or loss of life of persons who live in or are are using recreational facilities in the area.

Location
All of the county's communities and developed areas are vulnerable to wildfires since the community centers and rural residential developments interface with areas of pine forest that are prone to fire (Red Pine, Eastern White Pine, and Jack Pine). Approximately 159,469.7 acres, or 64.6% of Benzie County is forested. Red Pine forest comprises 25,005.99 acres of forested land (15.7%); Jack Pine forests comprise 4,938.69 acres (3.1%); and Eastern White Pine comprises 9.56 acres (0%). As shown on the Environmental Features Map in Appendix A, pine forests are scattered throughout various portions of the entire county, and are present in every jurisdiction.

Extent and Previous Occurrences
Extent can be measured by the number of acres burned and the cost of property damage. Between 1981 and 2018 there were 184 wildfires on lands under MDNR jurisdiction, or 4.8 wildfires per year. This resulted in a total of 396.8 acres burned and 10.4 acres burned per year. No property damages were recorded. NOAA records do not indicate any wildfire incidents within Benzie County.

Probability of Future Events and Vulnerability Assessment

There is a 100% chance there will be a wildfire on MDNR lands, and a small chance there will be a wildfire on lands outside of MDNR jurisdiction. Forest types (Red Pine, Eastern White Pine, and Jack Pine) and grasslands within Benzie County are susceptible to wildfires. Additional factors that increase fire risk include dead or dying trees as a result of disease/invasive species, lightning strikes, and human factors such as the number of persons residing, camping, or traveling through the County. Historically, Michigan's landscape has been shaped by wildfire; however, over the last several decades, the current landscape has transformed from wildland to residential development. With the increase in residential development in and around rural areas prone to wildfires, there is an increase in the potential for loss of life and property damage. Unfortunately, rural areas do not have enough fire suppression forces available to protect every structure from wildfires. Residential development in rural Benzie County is often isolated from town centers and

emergency services. Those subdivisions that are located in rural areas near Jack Pine forests or sand dunes/grasslands are identified on the Vulnerable Populations and Hazard Areas Map in Appendix A.

Additionally, a Weldon Township representative indicating the following concern in the community survey pertaining to access in the event of an emergency, which could include a wildfire: "We have a bridge that was…removed and we have hoped that it would be replaced. We have residents that live on the other side of the river. Any emergency vehicles now have to go way out of their way to get to any residents or forest area on the other side of the former bridge location (Haze Road)."

Shoreline Hazards (Coastal Flooding, Coastal Recession, Rip Currents and Seiches)

Shoreline hazards also include coastal flooding and coastal recession. Coastal recession (subsidence) is the wearing away of land, such as loss of riverbank, beach, shoreline, or dune material. It is measured as the rate of change in the position or displacement of a riverbank or shoreline over a period of time. Short-term erosion typically results from periodic natural events, such as flooding, hurricanes, storm surge, and windstorms, but may be intensified by human activities. Long-term erosion is a result of multi-year impacts such as repetitive flooding, wave action, sea level rise, sediment loss, subsidence, and climate change. Death and injury are not typically associated with erosion; however, it can destroy buildings and infrastructure.

Shoreline flooding results when water levels rise and push inland or during rainfall or snowmelt accumulates and is not able to drain properly. Shoreline flooding may also be caused during storms and wind events with high-energy waves. In developing the *Northwest Lower Michigan Coastal Resilience Atlas,* scenario planning was used to determine the potential impact of three differing levels of storms combined with high waters. The three scenarios are described as follows:

The first scenario, **"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.

Currents along the shoreline of Lake Michigan represent another type of coastal hazard in Benzie County. Currents in the Great Lakes can form from any combination of wind, waves, bottom formation, beach slope, water temperature, man-made structures, and natural outlets. For example, during rip currents, the water "piles up" between a sandbar and the beach. It has to find a way back out to sea. After the pressure builds up, the water creates a pathway and gushes from the shore back out to open water. That's a rip current: a narrow but powerful stream of water and sand moving (ripping) swiftly away from shore. Rip currents vary in size and speed and can be found on many beaches every day.[7]

The types of currents reported for incidents in Benzie County include a "Classic Rip", "Longshore Current", and "Structural". Definitions of these are provided in theAppendix .

Location

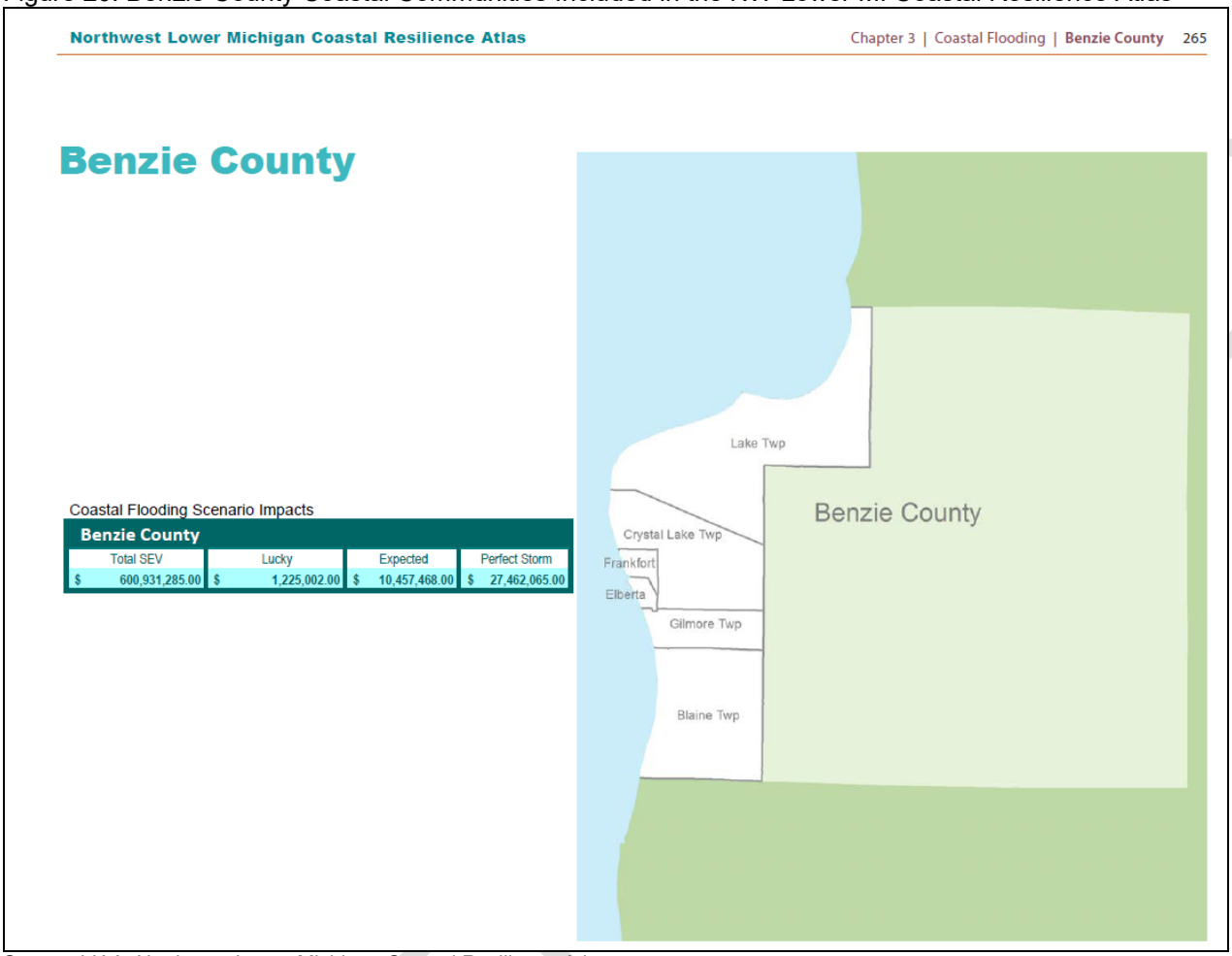
To reference the *Northwest Lower Michigan Coastal Resilience Atlas*, "Climate scientists predict that northwest Lower Michigan can expect more frequent storms of increasing severity in the decades ahead. The total amount of rainfall per year in also likely to increase. The potential for substantially larger rain events and severe storms raises concerns of harm to human health and damage to buildings and infrastructure, especially for areas along the Lake Michigan coastline."

Jurisdictions located on the Lake Michigan coast that are impacted by shoreline hazards include: Lake Township, Crystal Lake Township, the City of Frankfort, the Village of Elberta, Gilmore Township and Blaine Township (Figure 20). The Land Information Access Association documented potential shoreline hazards for these communities in the *Northwest Lower*

[7] https://www.michiganseagrant.org/topics/coastal-hazards-and-safety/dangerous-currents/

Michigan Coastal Resilience Atlas. Additionally, specific areas of shoreline hazards were identified during the hazard mitigation planning public input sessions. These are marked as a hazard area on the Hazard Area Map in Appendix A.

Figure 20: Benzie County Coastal Communities Included in the NW Lower MI Coastal Resilience Atlas



Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

While there have been Governor-Declared Disasters for shoreline problems in the State in 1985-1986, these declarations did not include Benzie County. However, NOAA's National Centers for Environmental Information storm event database indicates that there have been four (4) lakeshore flood incidents; two occurred in 2019 in and two occurred in 2020, during a time of very high Great Lakes water levels. Three out of the four event narratives described the presence of shoreline erosion. Two of these events occurred within the City of Frankfort; one occurred "several miles north of Frankfort", and one occurred around the border of the Village of Elberta and the City of Frankfort, on M-22 causeway over the Betsie River.

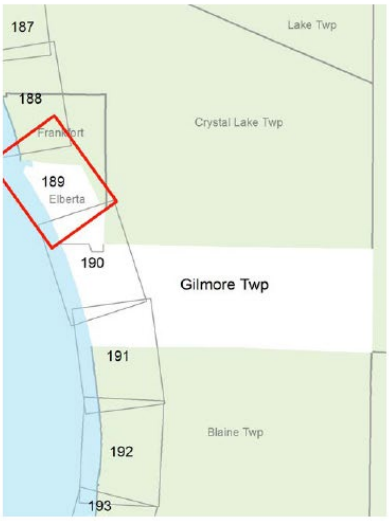
Figures 21 through 24 illustrate the three potential flooding scenarios in the City of Frankfort, the Village of Elberta and Gilmore Township. The "Lucky" scenario flooding is shown in green, "Expected" flooding scenario is shown in yellow, and "Perfect Storm" future scenario is shown in red.

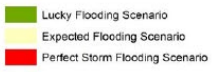
Coastal recession or erosion to Lake Michigan communities is a constant, but very small wearing away of the shoreline. The Great Lakes are estimated to lose one foot of shoreline per year to normal wave and wind activity. However, storms and increased wave activity have caused increased coastal recession to varying degrees in Grand Traverse's coastal communities. Chapter 4 of the *Northwest Lower Michigan Coastal Resilience Atlas* describes bluffline recession since its recorded shoreline in 1938. The blue line indicates the shoreline in 1938, the green line indicates the bluffline in 1938, the yellow line is the bluffline in 2016, and the red line is the predicted 30 year bluffline.

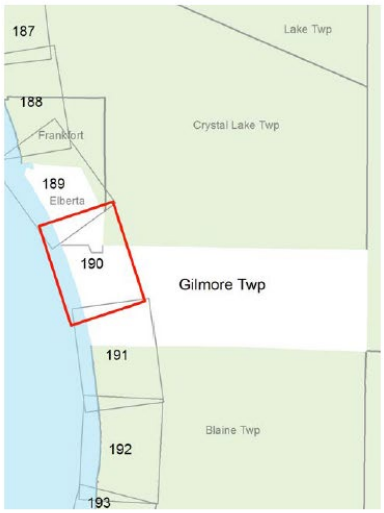
The varying lines shown in Figures 25-27 depict the recession of the bluffline in Frankfort and Crystal Lake Township. There are several structures located near or on the predicted 30-year bluffline.

Figures 21 & 22: Panels #188 & 189 - Flooding Hazards, City of Frankfort

Figures 23 & 24: Panels #189-190 - Flooding Hazards, Gilmore Twp. & Village of Elberta







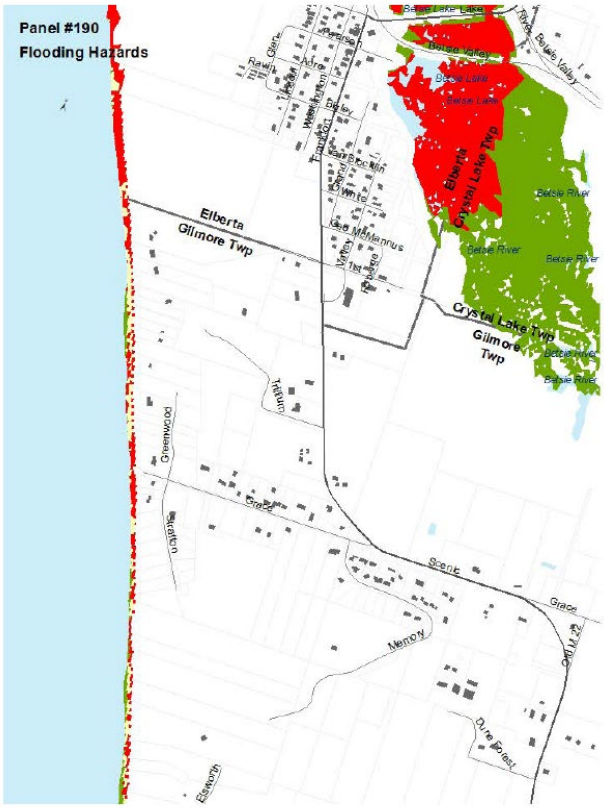
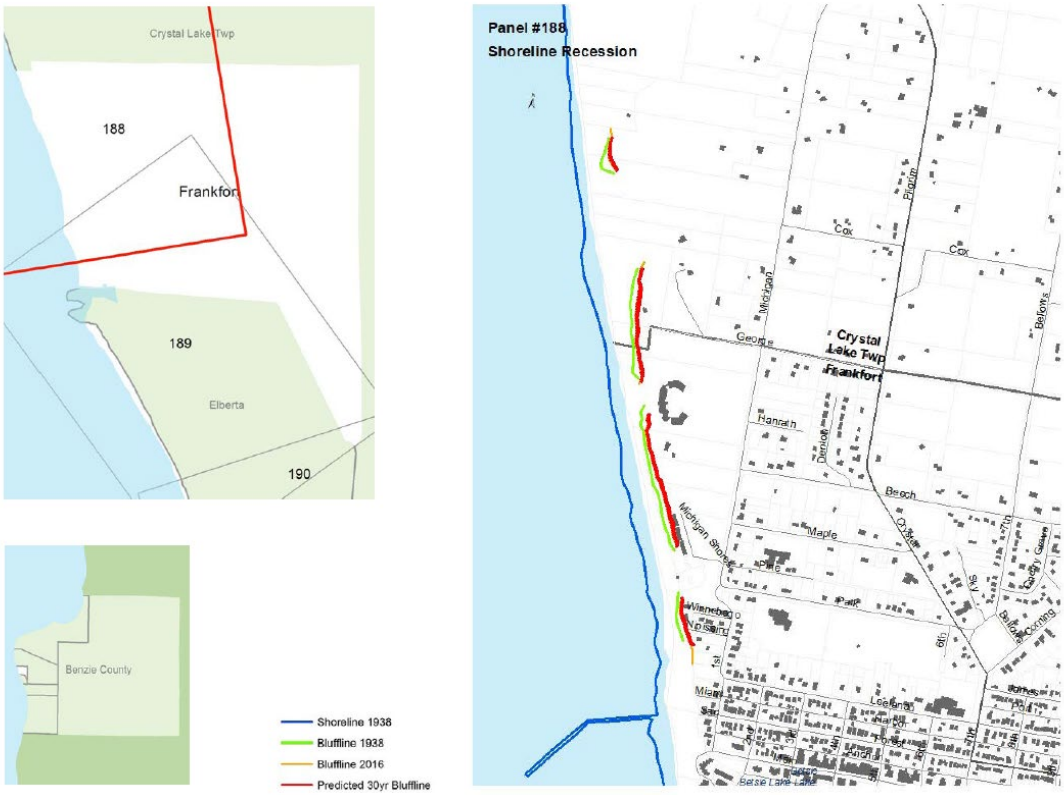


Figure 25: Panel #188 Shoreline Recession, City of Frankfort



Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

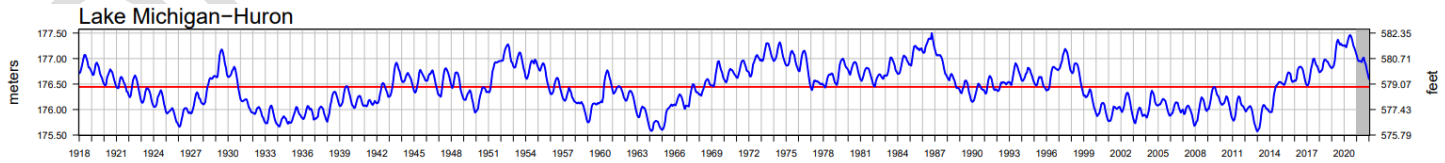
Figures 26 & 27: Panel #187-188, Shoreline Recession in Crystal Lake Township

Extent

Shoreline recession can be measured by feet of bluffline retreat and property damages. Bluffline retreat distances vary across the county, and there are no reported damages from bluffline recession. Shoreline flooding can be measured by flood water levels, inches of rainfall, lake water levels (shown in Figure 28), and damages. The four (4) Lakeshore Flooding events in 2019 and 2020 caused $145,000 in property damages within and near the City of Frankfort (Table _).

In recent years, the swings in water levels have been unprecedented. In January 2013, Lake Michigan-Huron set an all-time record low of 576.02 feet, and seven years later in July of 2020 Lake Michigan-Huron reached a monthly record high of 582.22, only second to the October 1986 monthly record high of 582.35.

Figure 28: Lake Michigan-Huron Historic Water Levels, 1918-2021



LAKES MICHIGAN-HURON

2021	*580.94*	*580.68*	*580.54*	*580.54*	*580.54*	*580.48*	*580.71*	*580.77*	*580.48*	*580.41*	*579.95*	*579.69*	*580.48*
Mean	**578.48**	**578.44**	**578.48**	**578.77**	**579.07**	**579.30**	**579.40**	**579.33**	**579.17**	**578.94**	**578.77**	**578.61**	**578.90**
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	

Source: US Army Corps of Engineers

Previous Occurrences
The Great Lakes experienced record high lake levels in 1985-86, 1997-98, and most recently in 2019-2020. Issues of erosion and high lake levels, causing rivers, lakes and tributaries to back up have caused infrastructure damage and failures throughout Benzie County and many other areas in Michigan.

There have been four (4) lakeshore floods on record with the NOAA Storm Events database, as indicated in Table 34.

Table 34. Lakeshore Flooding Events, Benzie County

Date	Property Damage	Event Narrative	Episode Narrative
10/16/2019	$8,000	Severe beach erosion threatened to destroy a home several miles north of Frankfort.	Northwest to north winds produced high waves and elevated water levels along the northwest lower Michigan coastline. With Great Lakes water levels at near-record levels, significant coastal flooding and beach erosion resulted.
10/22/2019	$129,000	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.	Strong northerly to easterly winds resulted in another round of substantial coastal flooding and beach erosion, this time on both Lake Michigan and Lake Huron, for the 21st into the 22nd.
4/13/2020	$8,000		Strong low pressure passed just north of eastern upper Michigan on the morning of the 13th. Gusty west to northwest winds of 40-50 mph were common. Lakeshore flooding also occurred along portions of the Lake Michigan coastline of northwest lower Michigan. The city boat launch in Frankfort experienced flooding of docks and the parking lot.
6/10/2020	$0	M-22 was closed across the Betsie Lake Causeway near Elberta due to high water.	The remnants of Atlantic Tropical Cyclone Cristobal lifted across Lake Superior and into northern Ontario, producing multiple rounds of showers and thunderstorms. Some lakeshore flooding occurred on the northwest lower Michigan coastline, thanks to gusty onshore winds.
	$145,000		

While there are no storm surge (seiche) events listed in the NOAA NCEI database for Benzie County from 1950 until present, there does remain a small possibility that a seiche may occur along the Lake Michigan coastline.

Input received from the community survey and stakeholder meetings included the followings site specific concerns related to past shoreline hazard incidents in 2019-2020:

Gilmore Township: Lake Michigan erosion prevented beach access for emergency vehicles; high water flooded the M-22 causeway.

Crystal Lake Township: Bluff erosion along Lake Michigan at Golf Lane and Ness Roads

Blaine Township: Lake Michigan waters flowed into Lower Herring Lake in 2020

City of Frankfort: Would like to pursue mitigation strategies to "better establish a resilient shoreline to overcome high water cycles that create erosion concerns".

According to the Great Lakes Current Incident Database search, and the NOAA Storm Events database, Benzie County has had seven (7) lake current incidents along Lake Michigan between 2002 and 2020 (Table 35). This has resulted in 12 rescues and 3 fatalities.

Table 35. Lake Michigan Current Incidents, Benzie County

Date	Fatalities	Rescues	NOAA Event Narrative	NOAA Episode Narrative	Type Of Current	Wave Direction	Wave Height (ft)
8/17/2010	0	1	A 14-year-old male was caught in a rip current while swimming in Lake Michigan, near Frankfort. He was carried away from the beach, and eventually was submerged for 5 to 10 minutes. When rescued, he was not breathing and had no pulse. He was revived by CPR, and taken to a Frankfort hospital, then eventually transported to Traverse City and from there to Grand Rapids. The victim was unconscious and on a respirator for two days, before coming to. At this time, he is not expected to suffer any long-term damage.	Rip currents produced a near-fatality on Lake Michigan.	Rip Current		
8/12/2011	0	4			STRUCTURAL	SW	3 TO 4
8/5/2012	1	3	A rip current fatality occurred near Peterson Beach, in the Sleeping Bear Dunes National Lakeshore. During a family outing, a 40 year old male from Cincinnati went into the water to pull out two nephews who were struggling with waves and strong currents. He was able to get them to safety, but was unable to himself escape the water. A park ranger retrieved his body from about five feet water a half-hour later, and CPR was performed on site, but he was pronounced dead soon after arrival at a local hospital. Rescue personnel estimated waves of 3 to 5 feet at the time of the incident.	Wave action produced by onshore winds of 15 to 20 mph contributed to rip current development on Lake Michigan.	CLASSIC RIP	NW	5 TO 6
8/5/2012	0	2			CLASSIC RIP	NW	5 TO 6
8/25/2018	1	0			STRUCTURAL	SW	5 TO 6
7/3/2019	0	2			CLASSIC RIP	NW	0 TO 2
7/4/2020	1	0			Longshore Current	NW	0 TO 2

Probability of Future Events and Vulnerability Assessment

Considering that the data on record from 1950-2021 (72 years) indicates four (4) shoreline flooding events, there would be a 5.6% chance that shoreline flooding/erosion would occur in a given year. Shoreline or soil erosion hazards involve the loss of property or necessitate the relocation of homes as sand or soil is removed by flowing water (lake, river, etc.) and carried away over time. The foundation of a structure, or underground utility pipes in the area, may become fully exposed and vulnerable to weather, extreme temperatures, water damage, or other sources of risk. Shoreline banks that support roadways may erode and cause the road surface to crack, become unstable, or more prone to deposits of sand, snow, water, and ice. This hazard is especially relevant to those municipalities that contain residential and commercial development along Lake Michigan (Lake, Crystal Lake, Gilmore, and Blaine Townships; Village of Elberta; and City of Frankfort) that experience seasonal shifts in water levels and possible ice erosion hazards.

As lake water levels fluctuate and increased storminess occurs, shoreline recession and flooding will continue. In 2021 the levels of Lake Michigan-Huron began to decline, however, as historic data shows us, the water will begin to rise again.

Those communities that have already faced shoreline hazards are likely to experience issues in the future. Changes in land use practices and improvements to the shoreline such as natural vegetation plantings or shoreline armoring may reinforce the shoreline for a period of time, but is likely not a permanent solution.

There have been seven (7) current incidents on Lake Michigan between 2002 and 2020. In that time period of 19 years, that equates to a 36.8% chance that another current incident will occur. Shoreline communities with public (or private) Lake Michigan access are expected to receive a continuous, if not an increase in, seasonal visitors. According to the National Weather Service Great Lakes Current Incident Database, dangerous current-related incidents in the Great Lakes most often occur when:

- Winds are blowing towards the shore
- Wave heights reach 3 to 6 feet
- A cold weather front is passing through

People may feel comfortable swimming in seemingly moderate wind and wave conditions, but it's important to keep in mind that when there are onshore winds and breaking waves dangerous currents may be present. The highest number of deaths and rescues happen in Michigan, specifically along the eastern shore of Lake Michigan. Additionally, swimmers near structures are more likely to die, and dangerous currents can exceed 5 mph — faster than an Olympic swimmer can swim (2 mph and faster are considered dangerous).

Public Health Emergency (Infectious Disease)

Public health emergencies occur when there is a widespread and/or severe epidemic, contamination incident, bioterrorist attacks, or other situation that negatively impacts the health and welfare of the public. These emergencies include disease epidemics, large-scale food or water contamination incidents, extended periods without adequate water and sewer services, harmful exposure to chemical, radiological or biological agents, and large-scale infestations of disease-carrying insects or rodents. A common characteristic of public health emergencies is that they impact or have the potential to impact a large number of people either statewide, regionally, or locally in scope and magnitude. These health emergencies can occur as primary events or as secondary events from another hazard or emergency (e.g. flood, tornado, or hazardous material incident).

Location
Public Health Emergency can be a worldwide, national, state or regional event that is not confined to geographic boundaries and range in severity across the affected areas. All of Benzie County is at risk to the occurrence and impacts from an infectious disease. Depending on the type of disease, different populations are more susceptible.

Extent
The extent of a public health emergency can be determined by the number of cases and deaths, and the amount of money spent to prepare for and respond to public health threats. In Grand Traverse County, the Grand Traverse County Health Department works with local, state, and federal agencies to prepare for and respond to public health threats. It developed a comprehensive emergency preparedness program capable of responding to a variety of emergency situations with funds from the Centers for Disease Control.

State of Michigan (https://www.michigan.gov/coronavirus/stats) reports, as of February 14, 2023 there have been 4,121 cumulative cases of COVID-19 and 78 deaths (total confirmed and probably cases) related to COVID-19 in Benzie County. Of the deaths with details provided, those in the age 70+ category years and older have the most deaths of any age range. All of the deaths reported were persons for persons aged 50 years and above. COVID-19 originally appeared in January 2020.

Previous Occurrences
Throughout the years, there have been many pandemics. For example, there was an outbreak of severe acute respiratory syndrome (SARS) in 2003. This virus was a new coronavirus that resulted in over 8,000 illnesses worldwide. Of these, 774 died. Since 2012, Middle East respiratory syndrome (MERS), a coronavirus, has been reported in 27 countries where there have been approximately 2,494 people infected and 858 deaths. In 2017, the World Health Organization (WHO) put SARS and MERS on its priority pathogen list to spur further research into coronaviruses. More recently in 2020, a Presidential and Governor Emergency was declared for COVID-19 Pandemic in Michigan.

Probability of Future Events and Vulnerability Assessment
Naturally occurring pandemics may result in widespread precautions around the world. The Benzie-Leelanau Health Department created a pandemic plan that serves as a template for responding to a large-scale outbreak of influenza and other highly infectious respiratory diseases. That plan is being tested currently since COVID-19 appeared in January 2020. The response is ongoing to this pandemic. The elderly, immune-compromised, and low income populations are most vulnerable to public health emergencies. Additionally, the community survey results indicated that a pandemic/illness was the second most frequently mentioned hazard event that would have the largest impact on their community.

Invasive Species

The National Invasive Species Council defines an invasive species as, "A species that is not native and whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health." The Council was formed under Presidential Executive Orders 13112 and 13751 to prevent the introduction and spread of invasive species, and to support efforts to eradicate and control invasive species that are established throughout the United States. NOAA's National Ocean Service identifies invasive species as "capable of causing extinctions of native plants and animals, reducing biodiversity, competing with native organisms for limited resources, and altering habitats." There are a wide variety of species considered invasive. Known and monitored species include:

- Mammals
- Birds
- Insects
- Fish
- Crustaceans
- Mollusks
- Worms
- Plants
- Diseases

The Department of Environment, Great Lakes, and Energy oversees invasive species programs for the State. The State has produced prohibited and restricted species lists, watch lists, and state management plans for terrestrial and aquatic species. Many of the species listed in this plan are also listed as a prohibited or restricted species: it is unlawful to possess, introduce, import, sell, or offer that species for sale as a live organism, except under certain circumstances. A full list of prohibited and restricted species can be found at http://www.Michigan.gov/invasives.

Invasive species harmful to Michigan and Manistee County may be either terrestrial invasive species (TIS) or aquatic invasive species (AIS). Terrestrial invasive include non-native, land-based plants, insects, animals and diseases that harm Michigan's environment, economy, and human health. Aquatic invasive include non-native, water-dwelling plants, animals, and other organisms that have evolved to live primarily in water (aquatic habitats) rather than on land. Aquatic habitats are habitats that are covered with water all or part of every year. Michigan State Departments cooperated to prepare the Terrestrial Invasive Species State Management Plan and the 2013 Aquatic Invasive Species State Management Plan Update: Prevention, Detection, and Management in Michigan Waters. Each plan outlines a statewide strategy to reduce the environmental and economic damages caused by either TIS or AIS.

Non-native terrestrial and aquatic species are introduced to Michigan and the Great Lakes both intentionally and unintentionally. Aquatic invasive species are the result of unwanted fish and aquatic plants released from home aquariums, travelled across the ocean in ballast water carried by freighters, or entered from the ocean through human-built channels such as the Welland Canal[8].

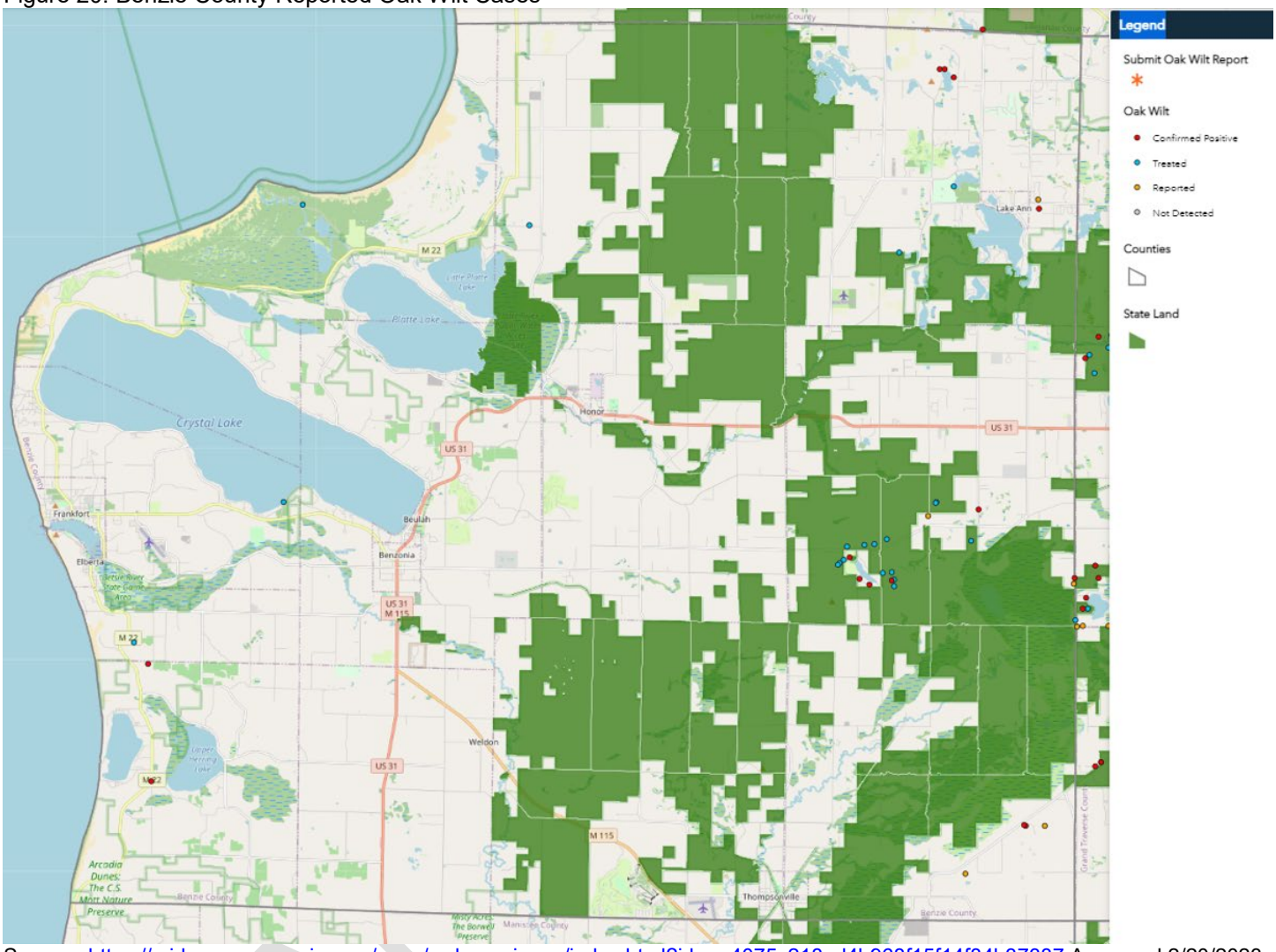
The Midwest Invasive Species Network (MISIN) is a regional effort to develop and provide early detection and response resources for invasive species. Among many tools and resources, the website (misin.msu.edu) provides a catalog of species information and a report of occurrences submitted within each state. Animals, plants, and diseases are included in the catalog. The top five reported species in Michigan are: phragmites (invasive) with 63,018, garlic mustard with 18,368, autumn olive with 16,042, spotted knapweed with 15,436, and brown marmorated stink bug with 13,351.

Location
Combined, terrestrial and aquatic invasive species may be present in Benzie County forest, wetland, farmland, grassland, aquatic, shoreline, and urban environments. "A Field Guide to Invasive Plants of Aquatic and Wetland Habitats for Michigan" (Campbell, Higman, Slaughter, Schools) identifies the Lake Michigan coastline as particularly vulnerable. "Lake-moderated climates along the Lake Michigan shoreline, Saginaw Bay, the Thumb, Lake St. Clair, and western Lake Erie are much milder than those in the state's interior… These areas have the potential to harbor species typically found far south of Michigan." Regular monitoring and reporting introductions detected is the only way to know where an invasive species has infested. The MISIN Species Data Viewer https://www.misin.msu.edu/mapviewer/ shares reported detections by species name (common and scientific) and family type.

[8] The Welland Canal is a ship canal in Ontario, Canada, connecting Lake Ontario and Lake Erie.

Figure 20 is from the MDNR interactive mapping resource “Look for Oak Wilt,” which allows users to submit an Oak Wilt Report throughout Michigan. Multiple Oak Wilt cases have been reported throughout Manistee County. These include trees confirmed positive for the disease and trees that are reported cases.

Figure 20: Benzie County Reported Oak Wilt Cases



Source: https://midnr.maps.arcgis.com/apps/webappviewer/index.html?id=aa4075c218ad4b968f15f14f84b37387 Accessed 2/20/2023

Extent

Invasive species impact can be measured by its damaging effects. TIS cause billions of dollars in damage annually, are extremely costly to control, and often have irreversible ecological effects. Native habitats, agriculture lands and livestock, and the outdoor recreation economy are threatened or damaged by invasive species. *Michigan’s Terrestrial Invasive Species State Management Plan* lists these state impacts:

- The State of Michigan estimates 42% of threatened or endangered species are considered at risk due to non-native species.
- Visitors spent over $22 billion dollars in Michigan in 2014, supporting nearly 327,000 jobs (Tourism Economics 2014). Invasive species impact the use and beauty of Michigan’s shorelines, trails and parks, which may result in a reduction in visitor spending and citizen enjoyment
- Michigan’s Forest Products Industry supports 96,000 jobs and contributes more than $20 billion to the state’s economy each year (Michigan DNR 2015). Invasive forest pests including emerald ash borer, oak wilt and beech bark disease kill trees and significantly impact the value of urban properties, forests and timber resources. The

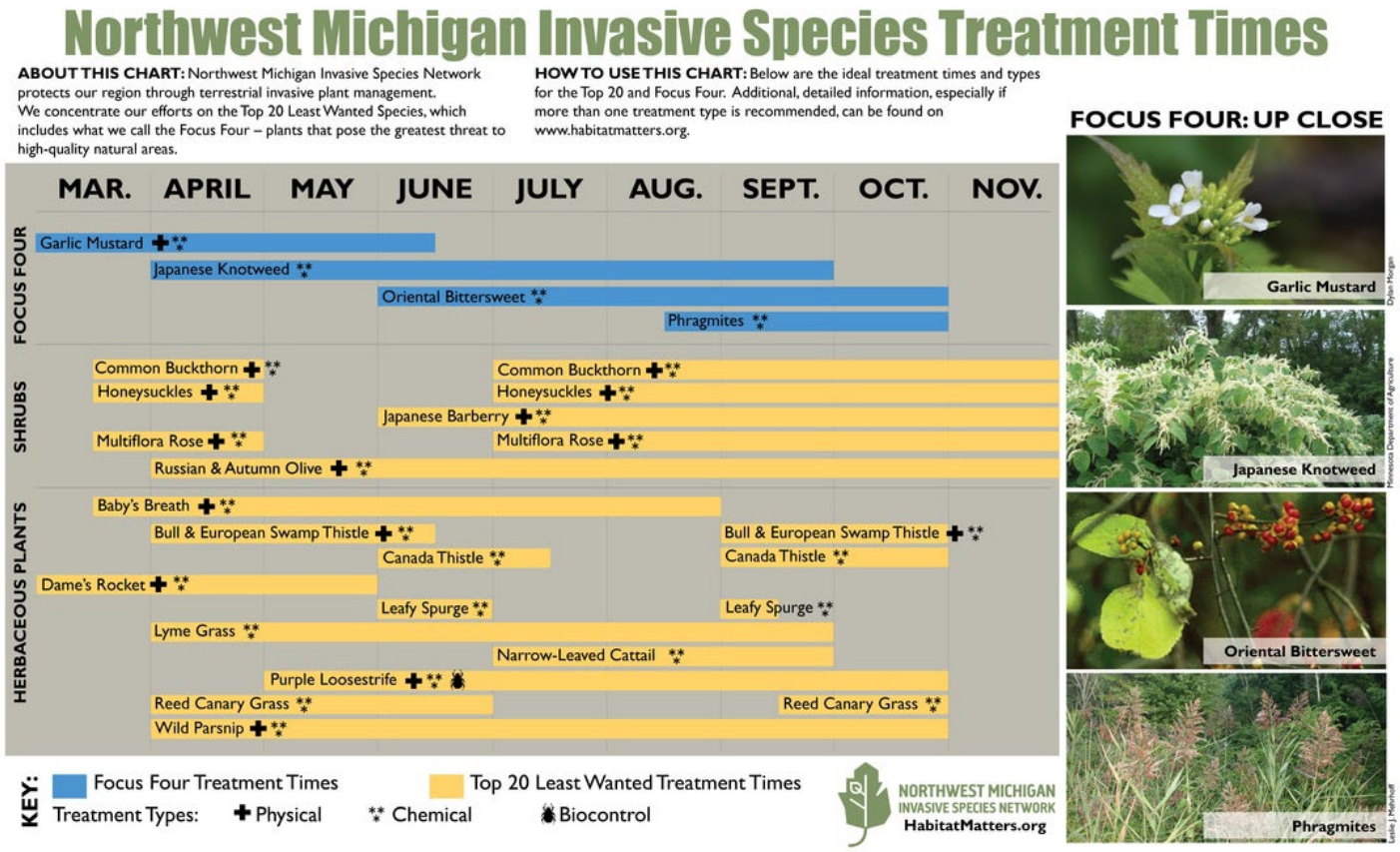
estimated cost of treating or removing dead ash within developed land in Michigan's communities due to emerald ash borer was $230 million in 2009[9]. A map of oak wilt cases in Manistee County is shown as Figure 20.

- Bear Lake Improvement Board's estimated budget for management of Eurasian milfoil: Bear Lake EWM Program Proposed Cost Estimates for 2023 through 2027 are in the annual range of $46,200 to $46,750.
- The proposed 2022 budget for the PLWF Water Quality and Environmental Monitoring Committee was $83,600.

Previous Occurrences

The Northwest Michigan Invasive Species Network (ISN) works directly with over 60 partners in Benzie, Grand Traverse, Leelanau, and Manistee Counties to manage populations of terrestrial invasive species that threaten northwest Michigan's high-quality natural areas, such as around Lake Michigan coastal dunes and waterways & riparian areas. Figure 21 below indicates the treatment methods and schedules for the "focus four" priority plants (Phragmites, Oriental Bittersweet, Japanese Knotweed and Garlic Mustard) and the other "top 20 least wanted" plants in the ISN management area.

Figure 21. ISN's Invasive Species Treatment Chart



One of our most beloved evergreens, the eastern hemlock (*Tsuga canadensis*) is also a critical part of our local ecosystems. Often found along ravines, hillsides, and stream banks, eastern hemlock offer habitat for wildlife and provide shade for streams, effectively lowering stream temperatures and increasing oxygen for fish and other aquatic species. Hemlocks provide aesthetic value and are loved by homeowners. It is estimated that Michigan is home to 170 million eastern hemlock trees. Unfortunately, this beautiful tree is now threatened by an invasive species: hemlock woolly adelgid (HWA) (*Adelges tsugae*). Areas near the Lake Michigan shoreline are the most probable for new infestations, as the adelgids tend to favor the temperatures and conditions found near the lake more than those inland.

In 2018, ISN and regional partners established a map that narrowed down areas that were expected to be denser with hemlock – following the current trajectory of HWA movement in Michigan. Winter surveys took place to minimize any potential spread of the invasive and because it is easier to locate the woolly mass of HWA ovisacs underneath hemlock needles. ISN's focus was on easier-to-access locations such as public land and conservation easements. The following

[9] Kovacs, K.F., R.G. Haight, D.G. McCullough, R.J. Mercader, N.W. Siegert and A.M. Liebhold. 2010. Cost of potential emerald ash borer damage in U.S. communities, 2009−2019. Ecological Economics 69: 569-578.

winter, the focus shifted to private land surveys. Landowners and Homeowner Associations meeting the following requirements are encouraged to complete a landowner survey from ISN (on their website):

- Property is in Benzie, Grand Traverse, Leelanau or Manistee County *(required)*
- Located within 10 miles of the Lake Michigan shoreline *(required)*
- A hemlock tree you planted was purchased from an online retailer

In 2021, a single tree infested with HWA was found at a campsite at the Sleeping Bear Dunes National Lakeshore in Benzie County. The tree's infested branches were removed, and no signs of the insect have been found in subsequent surveys of that property.

On January 27, 2023, the USDA Animal and Plant Health Inspection Service confirmed a sample taken from hemlock trees at Crystal Downs Country Club in Frankfort as positive for HWA. The ISN is undertaking a delimitation survey of the country club and surrounding properties to determine the extent of the infestation and mark the trees for treatment in the summer of 2023.

One of the highest priorities of the Crystal Lake and Watershed Association (CLWA) is preventing the spread of aquatic invasives into the Crystal Lake watershed environment. Since these nuisances are commonly introduced into a new lake by hitchhiking on watercraft that have picked them up elsewhere in infested waters, the CLWA has promoted boat washing on Crystal Lake. CLWA has also focused on regular monitoring of the watershed to identify potential threats at an early stage, followed by rapid action to control or eliminate the intrusive plant or animal before it becomes widespread. In the summer of 2008, as part of the Cooperative Lakes Monitoring Program (CLMP) the CLWA sampled, identified, and mapped aquatic plant species for comparison with previous studies. It launched a new comprehensive aquatic plant identification and mapping survey in the summer of 2016, again under the auspices of the CLMP. This survey was completed in the summer of 2018, with the assistance of aerial drone observation.

Eurasian watermilfoil was the only invasive aquatic nuisance plant detected during the survey. It is well established and extensive at the east end of the lake, in the area of the Beulah public boat launch. Smaller patches occur at the eastern parts of the north and south shores, again in the vicinity of public boat launches (for example, at the Mollineaux Road DNR launch and the Lobb road end). The CLWA is now developing a treatment and control plan to prevent this problem from becoming more severe.

Two other identified invasive species in Crystal Lake are Phragmites australis (Common Reed) and the Round Goby (Apollonia melanostomus). CLWA requests that occurrences be reported to info@crystallakewatershed.org so that prompt control measures can be taken.
Other Lake Improvement Board Efforts?

Probability of Future Events and Vulnerability Assessment

The Great Lakes and connecting channels and rivers form the largest surface freshwater system in the world. This freshwater system, along with Michigan's inland lakes, streams, rivers, and wetlands represent an invaluable resource and are therefore justifiably a top natural resource management priority. The State of Michigan estimates 42% of threatened or endangered species are considered at risk due to non-native species. The services provided by the Northwest Michigan Invasive Species Network, Benzie Conservation District and other land and water management agencies are crucial to continuous invasive species management and prevention.

Michigan's Invasive Species "Watch List" are priority species that have been identified as posing an immediate and significant threat to Michigan's natural resources. These species have either never been confirmed in Michigan or have very limited distribution or are localized. Early detection and timely reporting of occurrences of these species is crucial for increasing the likelihood of stopping an invasion and limiting negative ecological and economic impacts. The invasive species below should be reported immediately and directly to State of MI staff. This list is reviewed and updated periodically, and the most current list is available at www.michigan.gov/invasives.

Insects and Tree Diseases (Tree diseases list the scientific name for the pathogen or fungus associated with the disease)
• Asian longhorned beetle (Anoplophora glabripennis)
• Balsam woolly adelgid (Adelges piceae)
• Hemlock woolly adelgid (Adelges tsugae)
• Thousand cankers disease (Geosmithia morbida)
• Beech leaf disease (Litylenchus crenatae and potential associates)
• Spotted lanternfly (Lycorma delicatula)

Mammals
• Nutria (Myocastor coypus)

Terrestrial Plants
• Asiatic sand sedge (Carex kobomugi Ohwi)
• Chinese yam (Dioscorea oppositifolia L.)
• Himalayan balsam (Impatiens glandulifera)
• Japanese stiltgrass (Microstegium vimineum (Trin.) A. Camus)
• Kudzu (Pueraria montana var. lobata)
• Mile-a-minute weed (Persicaria perfoliata)
• Japanese chaff flower (Achyranthes japonica)

Aquatic Plants
• Parrot feather (Myriophyllum aquaticum)
• Yellow floating heart (Nymphoides peltata)
• European frog-bit (Hydrocharis morsus-ranae)
• European water-clover (Marsilea quadrifolia)
• Brazilian elodea (Egeria densa)
• Hydrilla (Hydrilla verticillata)
• Water chestnut (Trapa natans)
• Water hyacinth (Eichhornia crassipes)
• Water lettuce (Pistia stratiotes)
• Water soldier (Stratiotes aloides)

Fish and other Aquatic Animals
• Invasive carps
    Silver carp (Hypophthalmicthys molitrix)
    Bighead carp (Hypophthalmichthys noblis)
    Grass carp (Ctenopharyngodon idella)
    Black carp (Mylopharyngodon piceus)
• Northern snakehead (Channa argus)
• Marbled crayfish (Procambarus virginalis)
• Red swamp crayfish (Procambarus clarkii)
• New Zealand mud snail (Potamopyrgus antipodarum)

Potential impact from the species listed on watch list could be catastrophic for Benaie County's natural resources, agriculture, recreation, tourism, and economy.

Impacts from Climate Change

Climate describes the average weather conditions for a particular location and over a long period of time. The changing climate impacts society and ecosystems in a broad variety of ways. For example, climate change can alter rainfall, influence crop yields, affect human health, cause changes to forests and other ecosystems, and even impact our energy supply. Climate-related impacts are occurring across the country by increasing the severity of storms and weather-related events. Natural disasters then have a direct impact on our economy.

According to a new comprehensive report from the World Meteorological Organization (WMO), "A disaster related to a weather, climate or water hazard occurred every day on average over the past 50 years – killing 115 people and causing $202 million (US $) in losses daily The number of disasters has increased by a factor of five over the 50-year period, driven by climate change, more extreme weather and improved reporting. But, thanks to improved early warnings and disaster management, the number of deaths decreased almost three-fold[10]" (World Meteorological Organization, 2021).

The impacts of climate change already are, and continue to be, deep and widespread in the Great Lakes Region and Michigan as a whole. The National Climate Assessment (NCA) assesses the science of climate change and variability and its impacts across the United States, now and throughout this century. Chapter 21 of the NCA *Fourth National Climate Assessment Volume II: Impacts Risks, and Adaptation in the United States reports,* the Great Lakes influence regional weather and climate conditions and impact climate variability and change across the region. The lakes influence daily weather by:

1) Moderating maximum and minimum temperatures of the region in all seasons,
2) Increasing cloud cover and precipitation over and just downwind of the lakes during winter, and
3) Decreasing summertime convective clouds and rainfall over the lakes.

The Great Lakes Integrated Sciences and Assessments (GLISA) is one of 11 NOAA Regional Integrated Sciences and Assessments teams that focus on helping the nation prepare for and adapt to climate variability and change. A summary of findings from NCA and the GLISA report, *Climate Change in the Great Lakes Region*[11], are provided to show the impacts of climate change throughout the state of Michigan.

Temperature
Warm-season temperatures are projected to increase more in the Midwest than any other region of the United States.[12] Since 1951, annual average air temperatures have increased by 2.3°F (1.3°C) in the U.S., Great Lakes region. By mid-century (2050), average air temperatures are projected to increase by 3°F to 6°F (1.7°C to 3.3°C). By end of century (2100), average air temperatures are projected to increase by 6°F to 11°F (3.3°C to 6.1°C).

The frost-free season is projected to increase 10 days by early this century (2016–2045), 20 days by mid-century (2036–2065), and possibly a month by late century (2070–2099) compared to the period 1976–2005 according to the higher scenario (RCP8.5).[13]

Precipitation
Since 1951, total annual precipitation has increased by 14% in the U.S., Great Lakes Region. Future projections suggest more precipitation on average, but not necessarily during all seasons (summer to be drier) and not for all locations depending on which model is used. Reduced lake ice cover and enhanced evaporation may lead to increased lake-effect snowfall in the near-term, but rising temperatures will cause more winter precipitation to fall as rain as opposed to snow across the region by late century.

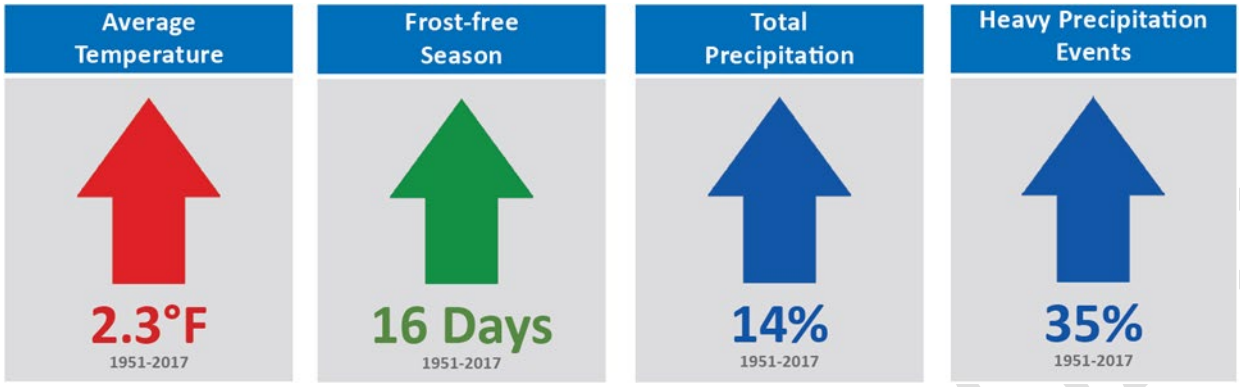
[10] *World Meteorological Organization*. (2021, August 31). Retrieved from Weather-related disasters increase over past 50 years, causing more damage but fewer deaths: https://public.wmo.int/en/media/press-release/weather-related-disasters-increase-over-past-50-years-causing-more-damage-fewer

[11] (2019, February 14). Retrieved from Climate Change in the Great Lakes Region: https://glisa.umich.edu/wp-content/uploads/2021/04/GLISA-2-Pager.pdf

[12] Vose, R. S., D. R. Easterling, K. E. Kunkel, A. N. LeGrande, and M. F. Wehner, 2017: Temperature Changes in the United States. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 185–206. doi:10.7930/J0N29V45.

[13] Hibbard, K. A., F. M. Hoffman, D. Huntzinger, and T. O. West, 2017: Changes in Land Cover and Terrestrial Biogeochemistry. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 277–302. doi:10.7930/J0416V6X.

From 1951-2017, the United States, Great Lakes Region, overall, has seen increases in average temperature, frost-free season, total precipitation, and heavy precipitation events.



Snow, Ice Cover and Lake Temperature
Summer lake surface temperatures have been increasing faster than the surrounding air temperatures, with Lake Superior increasing by 4.5°F between 1979 and 2006. Annual average ice cover on the Great Lakes shifted from higher amounts prior to the 1990s to lower amounts in recent decades. There remains strong year-to-year variability, and high ice years are still possible. Lake-effect snowfall has increased in northern areas and may continue to increase through mid-century.

Extreme Weather
The frequency and intensity of severe storms has increased. This trend will likely continue as the effects of climate change become more pronounced. The amount of precipitation falling in the heaviest 1% of storms increased by 35% in the U.S. Great Lakes region from 1951 through 2017. More severe storms may have a negative economic impact due to resulting damages and increased costs of preparation, clean up, and business disruption.

The NCA *Fourth National Climate Assessment Volume II: Impacts Risks, and Adaptation in the United States states, "*Climate change is transforming where and how we live and presents growing challenges to human health and quality of life, the economy, and the natural systems that support us. Risks posed by climate variability and change vary by region and sector and by the vulnerability of people experiencing impacts. Social, economic, and geographic factors shape the exposure of people and communities to climate-related impacts and their capacity to respond. Risks are often highest for those that are already vulnerable, including low-income communities, some communities of color, children, and the elderly" (*Ch. 14: Human Health, KM 2*; *Ch. 15: Tribes, KM 1–3*; *Ch. 28: Adaptation, Introduction*).

A vulnerability assessment can be found in the two-page report: *Climate Change in the Great Lakes Region* by GLISA. The report identifies key challenges from climate change such as:

- **Public Health**
  - Increased risk of heat waves and increased humidity may amplify the number of heat-related deaths and illnesses.
  - More storm activity and flooding, resulting in increased point- and non-point source pollution, will likely increase watershed contamination and water-borne illnesses, while warmer surface waters amplify the risk of toxic algal blooms and fish contamination.
- **Tourism and Recreation**
  - *Winter recreation/tourism are likely to suffer* due to reduced snow cover and shorter winters. Reduced lake ice cover and enhanced evaporation may lead to increased lake-effect snowfall in the near-term, but rising temperatures will cause more winter precipitation to fall as rain as opposed to snow across the region by late century.
  - Increasing temperatures and a longer summer season may *increase the demand for lake and beach use*.
  - Overall, *summer tourism may grow before temperature rise becomes unfavorable* for outdoor recreation.
  - *The fishing industry* (commercial and recreation) is likely to be impacted by the *decline of coldwater species of fish, such as lake trout and whitefish*.

- **Natural Environment**
  - Despite increasing precipitation, land surfaces in the region are expected to become drier overall due to increasing temperatures and evaporation rates.
  - More frequent summer droughts could affect soil moisture, surface water, and groundwater supply.
  - Increased evaporation rates and sustained levels of high or low water levels may change wetland areas in the region.
  - The rate of warming may *outpace the rate at which ecosystems are able to migrate and adapt*.
  - *Wildlife populations better adapted to cold temperatures will continue to decline* as competing species migrate into the region with rising air and surface water temperatures.
  - *Forest productivity will likely increase in the short term*, until other impacts of climate change such as increased drought, fire and invasive species present additional stressors to forests.

The full two-page report can be found here.

V. Goals and Objectives

The mission of the Benzie County Natural Hazards Mitigation Plan is to protect the health and safety of the public and property in the County which includes prevention of injury, loss of life, property damage, breakdown in vital services like transportation and infrastructure, economic slumps, maintain tourist base, and liability issues. This is done by taking action to permanently eliminate or reduce the long-term risks from natural hazards.

Specific goals and objectives have been established based upon the community's natural hazards analysis, as well as input from the Task Force participants and the public through meetings, request for comments on the draft plan, and the presentation of the plan to the Local Emergency Planning Team.

Goal 1: Increase local awareness and participation in natural hazards mitigation strategies

Strategies

- Encourage cooperation and communication between planning and emergency management officials
- Encourage additional local governmental agencies to participate in the natural hazards mitigation process
- Encourage public and private organizations to participate, including organizations who advocate for individuals with functional or access needs

Goal 2: Integrate natural hazards mitigation considerations into the community's comprehensive planning and operational processes

Strategies

- Enforce and/or incorporate natural hazards mitigation provisions in building code standards, ordinances, and procedures
- Create or update ordinances to reflect building codes, shoreline protection rules, etc.
- Incorporate natural hazards mitigation into basic land use regulation mechanisms
- Develop community education programs and public warning systems
- Strengthen the role of the Local Emergency Planning Committee in the land development process
- Integrate natural hazards mitigation into the capital improvement planning process so that public infrastructure does not lead to development in natural hazards areas
- Encourage county agencies to assess local roads, bridges, dams, and related transportation infrastructure for natural hazards vulnerability

Goal 3: Utilize available resources and apply for additional funding for natural hazards mitigation projects

Strategies

- Identify desired community mitigation measures and provide them to the State
- Encourage the application for project funding from diverse entities (i.e., Homeland Security grants for EOC equipment needs or training; Tribal government partnerships for emergency services; invasive species management and treatment efforts)

Goal 4: Develop and complete natural hazards mitigation projects in a timely manner

Strategies

- Encourage public and business involvement in natural hazards mitigation projects

VI. Mitigation Strategies and Priorities

Types of Mitigation Actions

The mitigation planning regulations requires that each participating jurisdiction identify and analyze a comprehensive range of specific mitigation actions and projects to reduce the impacts of the hazards identified in the risk assessment. The emphasis is on mitigating the impacts or vulnerabilities identified in the risk assessment, not on the hazards themselves. The types of mitigation actions can be classified into the following types:

- Local Plans and Regulations
- Structure and Infrastructure Projects
- Natural Systems Protection
- Education and Awareness Programs

Furthermore, a set of evaluation criteria was developed to determine which mitigation strategies were best suited to address the identified problems in Benzie County.

- The measure must be technically feasible.
- The measure must be financially feasible.
- The measure must be environmentally sound and not cause any permanent, significant environmental concerns.
- The measure must be acceptable to those participating in the strategy and/or primarily affected by the strategy.

By anticipating future problems, the County can reduce potential injury, structure losses, loss of power, such as electric and gas, and prevent wasteful public and private expenditures. The County Infrastructure, Vulnerability, and Hazard Maps in Appendix A can assist with the determining future problem areas.

Emergency Warning System Coverage

Mobile warning system: Benzie County uses the CodeRED Emergency Communications Network, which is an electronic high-speed outbound notification service available to the general public.

The FEMA Mobile App is also a publicly available mobile warning system providing real-time weather alerts, locations of emergency shelters, and allows for notifications to be sent to loved ones.

The National Weather Service may concurrently utilize their mobile warning notification system when deemed necessary in severe weather event situations to send phone notifications to users within signal of a cellular tower.

Radio warning system: NOAA Weather Radio All Hazards is a nationwide network of radio stations broadcasting continuous weather information directly from the nearest National Weather Service office. NWR broadcasts official Weather Service warnings, watches, forecasts and other hazard information 24 hours a day, 7 days a wee

Benzie County uses radio channels ___AM and ___ FM for emergency weather alerts.
Weather alert radios were purchased and distributed to all the schools, nursery schools, and senior homes (?)

Tornado/Severe Weather Systems: The CodeRed Emergency Communications Network is utilized for severe weather/tornado alerts.

Flood warning system: For dam failures/flooding downstream an active warning system is pre-determined utilizing geographic boundary information and the CodeRED Emergency Communications Network.

Website and Social Media Platforms

Shelters

The Benzie County Office of Emergency Management (OEM) maintains use agreements with the following organizations to utilize their facilities for temporary emergency shelters:
- Benzie Central Schools
- Frankfort Elberta Schools
- Elberta Lifesaving Station
- Garden Theatre (Frankfort)

Memorandums of Understanding need to be renewed with “GROW Benzie” in Blaine Twp. and “New Covenant” for emergency food provision services.

The Grand Traverse Band Tribe of Ottawa and Chippewa Indians has underground tornado shelters on their property at Four Seasons Drive in Benozna.

Benzie Bus service can provide transportation of the public to emergency shelter sites.

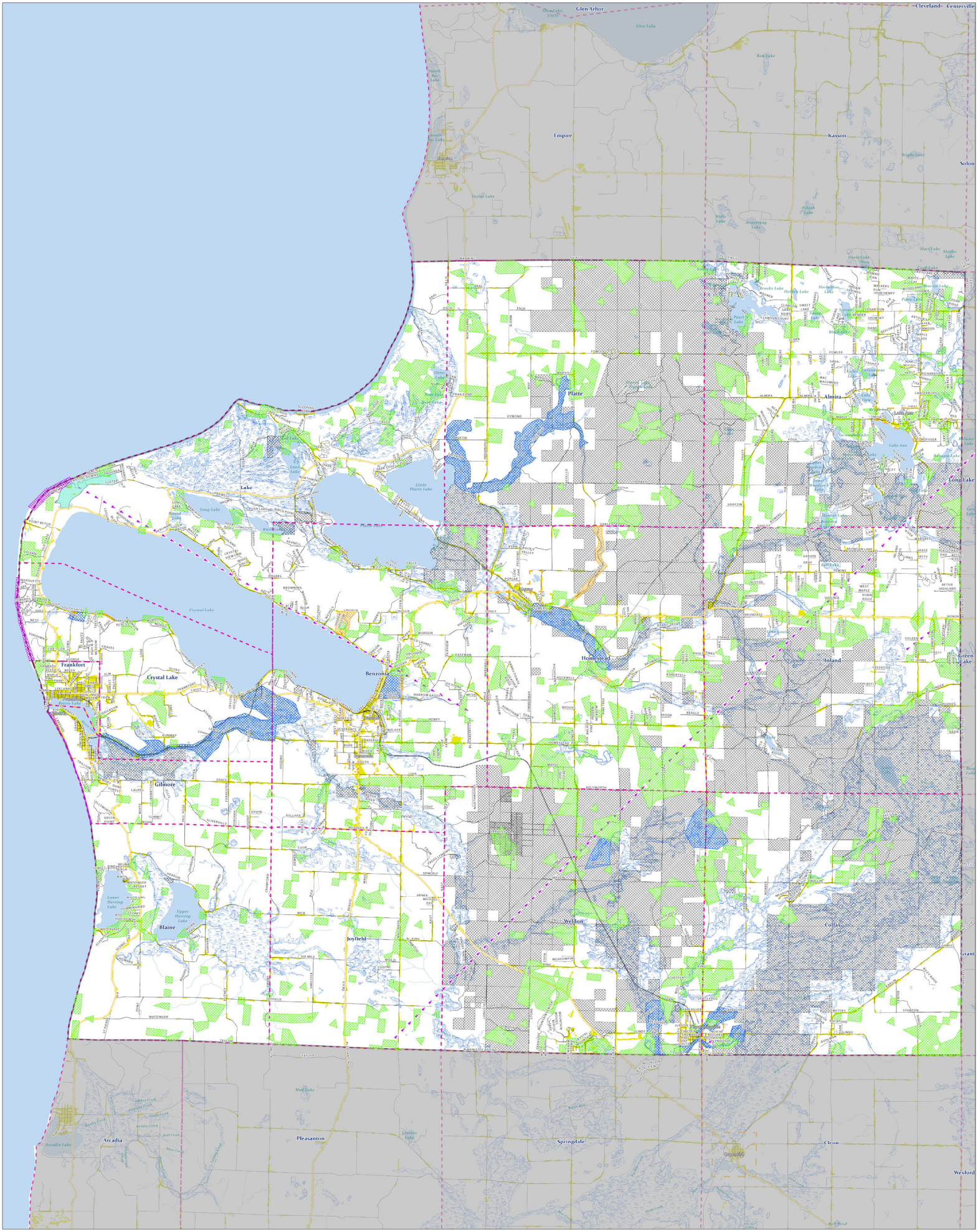
The OEM also maintains “soft” agreements with municipalities to use their city, village or township halls as shelter sites.

The American Red Cross can provide resources to create a long-term shelter if needed.

I. IMPLEMENTATION

The hazard mitigation strategies for Manistee County are presented on the following table. Strategies are grouped by theme, as identified on the far left column of the table: Awareness & Preparation, Shelters, Buildings & Infrastructure, Utilities & Technology, and Environment & Natural Resources. The table also includes: a description of each strategy; what natural hazards it addresses; where the strategy applies; who is responsible for implementing the strategy; how the strategy will be implemented (what resources are available to apply the strategy); the level of priority; and what type of strategy it is (per FEMA HM Plan review requirements).

APPENDIX A: BENZIE COUNTY ENVIRONMENT, INFRASTRUCTURE, VULNERABILITY, AND HAZARD AREA MAPS



Benzie County Hazard Areas

2023 Hazard Mitigation Plan

Legend

Hazard Areas

Type
- Flood
- Road Washout
- Shoreline Erosion
- Pine Forest Hazard Area
- Invasive Species
- Tornado Path

Highways
Roads
Railroad

Rivers/Streams
Water Bodies
Part 303 Wetlands

Public Land

Developed Land
- High, Medium & Low Intensity

Township Boundaries
Villages
Cities
Benzie County
Adjacent Counties

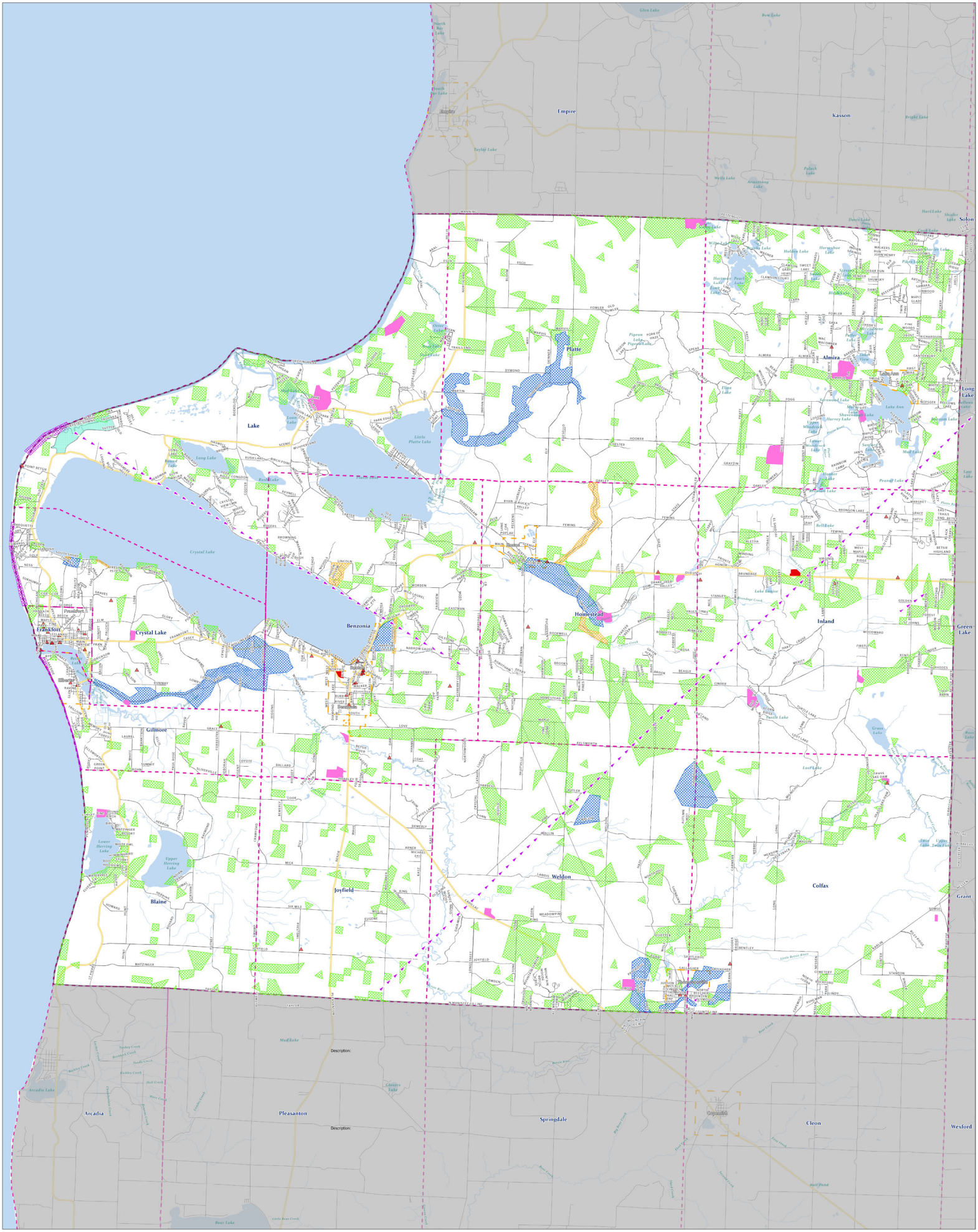
0 2,000 4,000 8,000 12,000 16,000 Feet

0 0.5 1 1.5 2 4 6 8 Miles

N W E S

Benzie County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2022.
Map data sources: State of Michigan, ESRI, NRCS, USDA, USGS, Benzie County Emergency Management

Networks Northwest
Talent / Business / Community



Benzie County Vulnerable Populations & Hazard Areas

2023 Hazard Mitigation Plan

Legend

Vulnerable Populations
- Campground
- Mobile Home

Hazard Areas
Type
- Flood
- Road Washout
- Shoreline Erosion
- Pine Forest Hazard Area

- Highways
- Roads
- Railroad
- Critical Infrastructure
- Tornado Path
- Invasive Species
- Rivers/Streams
- Water Bodies
- Township Boundaries
- Villages
- Cities
- Benzie County
- Adjacent Counties

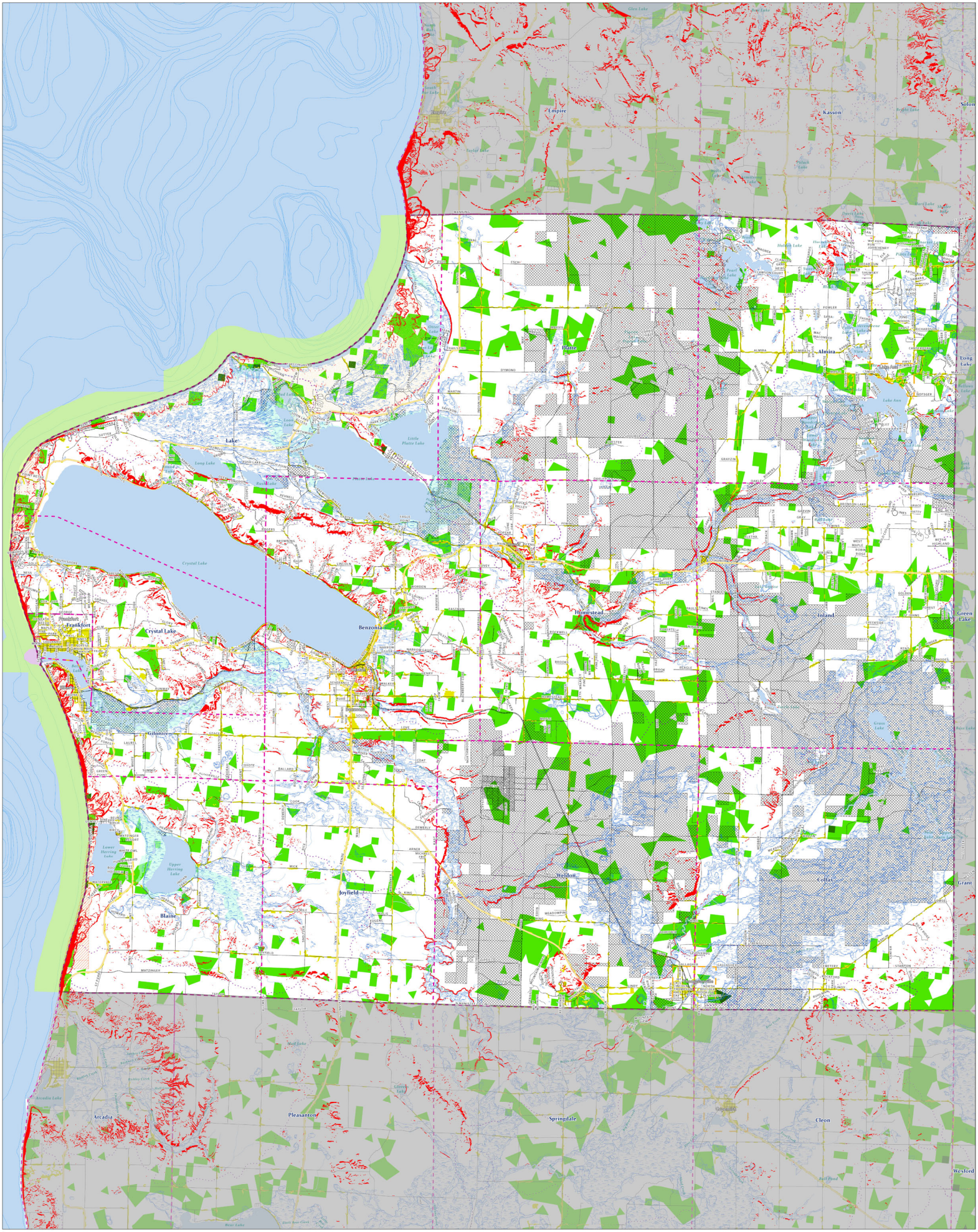
0 2,000 4,000 8,000 12,000 16,000 Feet

0 0.5 1 1.5 2 4 6 8 Miles

N W E S

Benzie County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2022.
Map data sources: State of Michigan, ESRI, NRCS, USDA, USGS, Benzie County Emergency Management

Networks Northwest
Talent / Business / Community



Benzie County Environmental Features

2022 Hazard Mitigation Plan

Legend

- Highways
- Roads
- Railroad
- Rivers/Streams
- Water Bodies
- Part 303 Wetlands
- Bathymetric Contours
- Watershed Boundary 12 Digit
- High Risk Erosion
- Critical Dunes
- Slope 30% or Greater
- Flood Zone
  - A
  - AE
  - VE
- Developed Land
  - High, Medium & Low Intensity
- Pine Forest
  - Jack Pine
  - Red Pine; Eastern White Pine
- Public Land
- Villages
- Cities
- Township Boundaries
- Benzie County
- Adjacent Counties

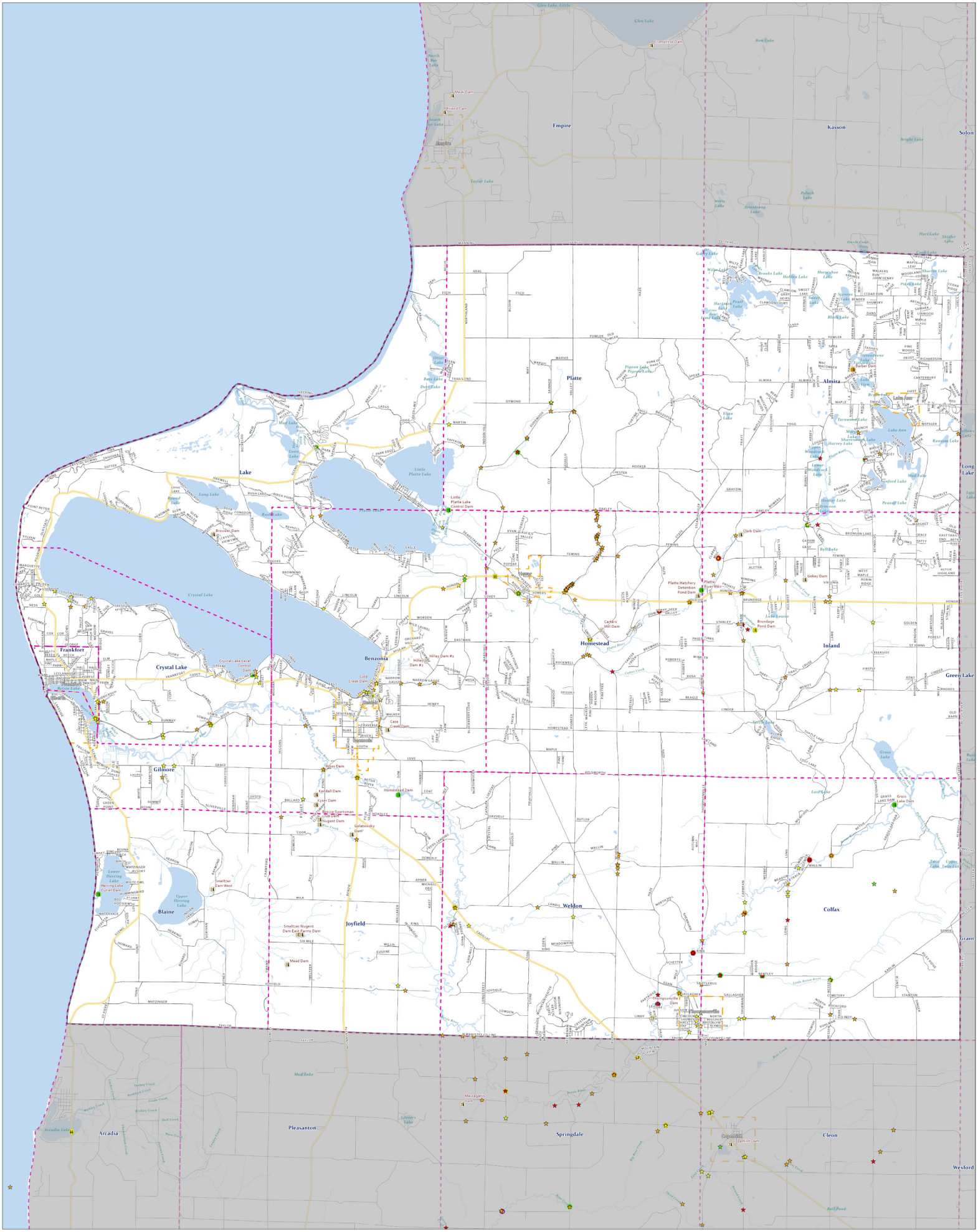
0 2,000 4,000 8,000 12,000 16,000 Feet

0 0.5 1 1.5 2 4 6 8 Miles

N W E S

Benzie County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2022.
Map data sources: State of Michigan, ESRI, NRCS, USDA, USGS

Networks Northwest
Talent / Business / Community



Benzie County Infrastructure

2022 Hazard Mitigation Plan

Legend

Highways
Roads
Railroad
Rivers/Streams
Water Bodies

Stream Crossings (CRA)
Severity
Restored
Minor
Moderate
Severe
Unknown

Bridge Condition
Rating
Good
Fair
Poor
Serious
Critical
Closed

MI Dam Inventory
Condition
Satisfactory
Fair
Poor
Unsatisfactory
Not Rated

Villages
Cities
Township Boundaries
Benzie County
Adjacent Counties

0 2,000 4,000 8,000 12,000 16,000 Feet
0 0.5 1 1.5 2 4 6 8 Miles

N
W E
S

Benzie County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2022.
Map data sources: State of Michigan, ESRI, NRCS, USDA, USGS, CRA, MDOT

Networks Northwest
Talent / Business / Community

APPENDIX B: COMMUNITY SURVEY RESULTS

APPENDIX C: LOCAL PLANNING TEAM MEETING DOCUMENTATION

2015 Hazard Mitigation Plan Strategies

Inland Flooding Mitigation Strategies (Platte, Betsie, and Herring River Basins)
Honor/Platte River flash flooding area (U.S. Highway 31)
Platte River Bridge (M-22)
South Street Bridge (U.S. Highway 31)
Betsie Lake (M-22)
East side of Upper Herring Lake (Mick and Garvan Roads)
Crystal Lake Outlet (M-115)

Flood Mitigation Strategies

- Mapping of flood prone areas (Blueberry Creek/Trout Pond area off of US 31 west of Honor
- Wetland protection
- Enforcement of storm water/drainage control statutes/ordinances and other state and county ordinances – The County is working on creating a new 50 foot and 100 foot building/septic development setback for residential and commercial entities on all water bodies in The Sanitary Code and proposed as 50 to 75 feet for Crystal Lake and the Betsie River; presently only a 25 foot set back
- Enforcement of building codes
- Public education

Lake Michigan Coastal Erosion Area (located in the Crystal Downs development, Michabou Shores, and Village of Elberta, Lake, Crystal Lake, Gilmore, Blaine Townships, Village of Elberta; Other Erosion Areas include the Village of Honor area (Village of Honor, Homestead Township)
Erosion Mitigation Strategies

- Repair roadways susceptible to erosion (see Appendix G)
- Promote the relocation of structures
- Drainage control and placement of vegetation, utilizing native vegetation
- Enforcement of soil erosion statutes/permits
- Enforcement of building codes
- Public Education

Potential Wildfire Areas (Lake Ann Area, Sleeping Bear Dunes National Lakeshore, Crystal Lake, and Eastern Benzie County)
Wildfire Mitigation Strategies

- Develop new building and zoning codes such as a 25 foot cleared space between houses/structures; defensible space
- Adjustments in the planning, design, and development process for area structures
- Public education, awareness, and alertness – become a FIREWISE community; fuel management, diversity of and native vegetation; homeowner property maintenance
- Visit campgrounds to advise campers of critical fire levels
- Building code enforcement on new construction

Severe Winter Weather potential each year throughout the County – heavy snow, extreme temperatures, ice damage occurrences on Crystal Lake (Lake Benzonia, Crystal Lake Townships, Village of Beulah)
Snow Load and Ice Build Up Mitigation Strategies

- Adoption of stricter snow load building codes
- Public education
- Building code enforcement (only for new construction)

High Wind potential throughout the County which cause downed trees over roads and downed power lines.
High Winds Mitigation Strategies:

- Shelters for Campground areas – Betsie River Campground, Lake Michigan Campground on the Platte River in Sleeping Bear Dunes National Lakeshore; Lake Ann Baptist Camp
- Public Education for structural elements and tree management and promoting anchoring and tie downs for structures that need it
- Building code enforcement for new construction
- Building code enforcement for pavilions
- Tree management by power companies on power line easements