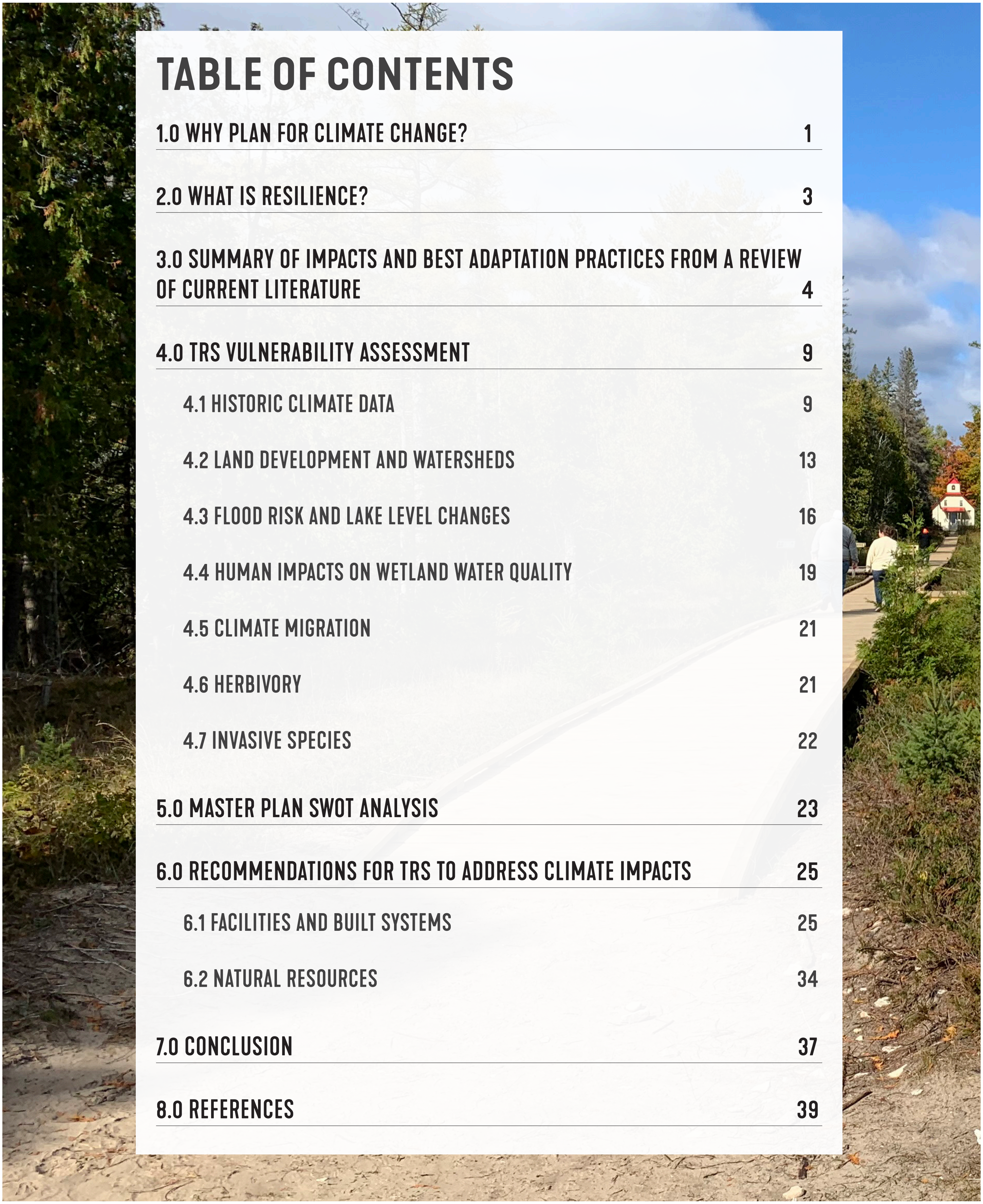
APPENDIX B | CLIMATE RESILIENCY PLAN

A document outlining The Ridges Sanctuary's commitment to addressing the climate crisis, including a review of current literature, a vulnerability assessment, and specific facility improvements and adaptation recommendations for natural resources. The information provided in this plan will inform the future development of an action plan.



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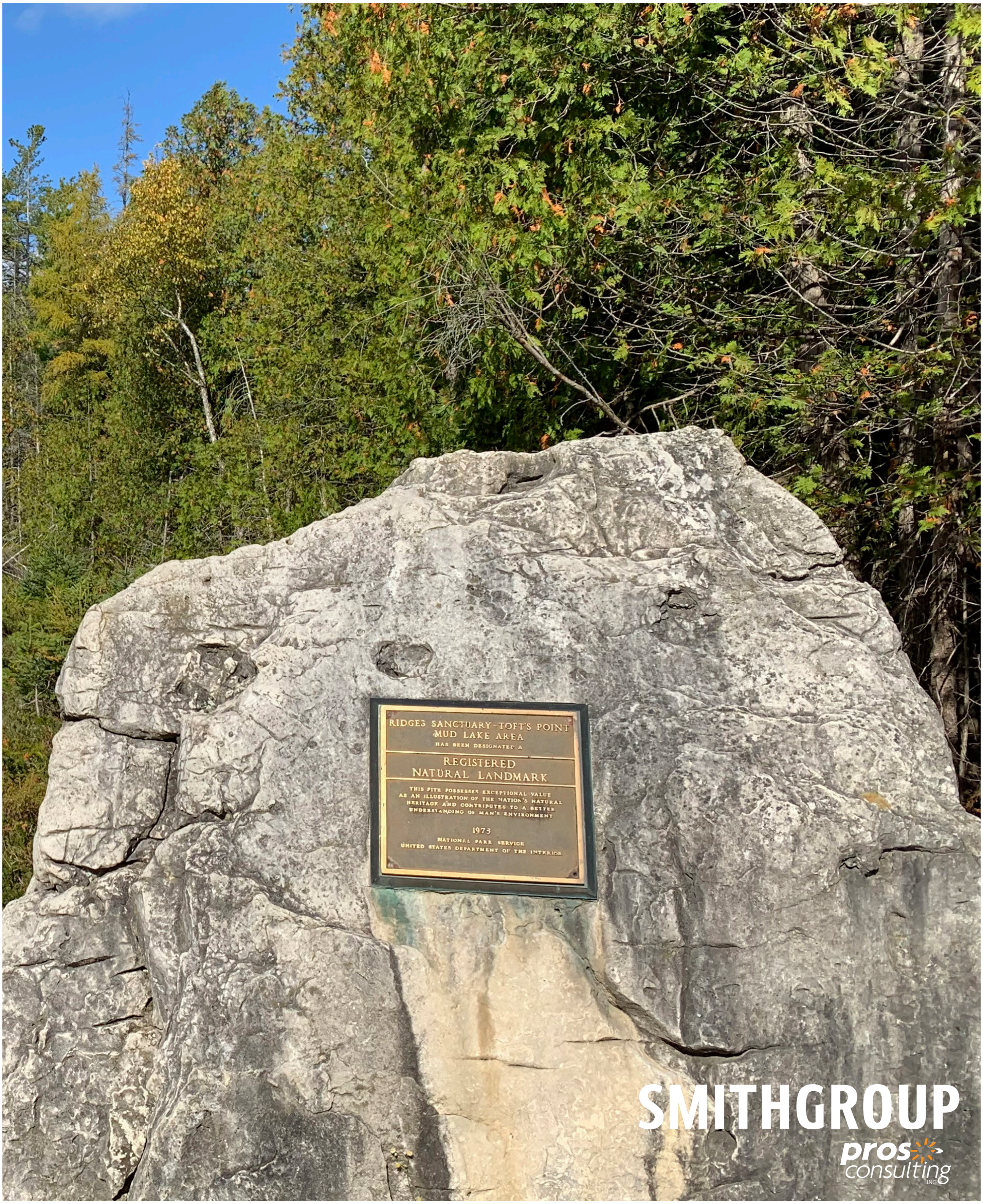

RIDGES SANCTUARY - TOFT'S POINT
MUD LAKE AREA
HAS BEEN DESIGNATED A
REGISTERED
NATURAL LANDMARK
THIS SITE POSSESSES EXCEPTIONAL VALUE
AS AN ILLUSTRATION OF THE NATION'S NATURAL
HERITAGE AND CONTRIBUTES TO A BETTER
UNDERSTANDING OF MAN'S ENVIRONMENT
1975
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR
SMITHGROUP
pros consulting

FIGURES

**All figures in this Appendix are created by SmithGroup unless otherwise stated in the caption*

1.0 WHY PLAN FOR CLIMATE CHANGE?

Although Earth's climate has varied throughout history, today's unprecedented rate of change threatens human health, infrastructure, and the global economy, as well as the survival of both individual species and natural systems. "Since systematic scientific assessments began in the 1970s, the influence of human activity on the warming of the climate system has evolved from theory to established fact." [1] As described by NASA, the evidence for global climate change is overwhelming: [2]

- Global surface temperature has risen about 2°F (1°C) since the late 19th century, with the two warmest years on record occurring in 2016 and 2020.
- Oceans have warmed more than 0.6°F (0.33°C) since 1969, and have acidified by 30% due to absorption of carbon dioxide.
- Both the Greenland and Antarctic ice sheets are melting, with a combined total loss of 427 billion tons of ice lost per year from 1993-2019.
- Snow cover worldwide in winter is decreasing, with earlier spring melt.
- Global sea level rose 8 inches (20 cm) over the past 100 years, but the rate is accelerating annually.
- Extreme weather events are increasing in frequency.

The 2015 UN Climate Change Conference culminated in the Paris Agreement, an international treaty joined by 194 countries that intends to limit global temperature rise to 2°C this century, while pursuing further efforts to cap emissions to strive for only a 1.5°C increase.[3] As noted by a BBC report, if the world exceeds a 1.5°C increase and continues towards 2°C, we risk passing several critical tipping points that would cause irreversible damage to our global climate system. The devastating consequences of climate change we're already experiencing would increase significantly, causing massive population displacement and more severe disruption to food and water supplies, among other impacts.[4]

Unfortunately, the world remains woefully behind in meeting the Paris Agreement target of limiting global warming to 1.5°C above pre-industrial levels and reaching net-zero carbon dioxide and greenhouse gas emissions globally by 2050. Decarbonization is critical to this effort, as a 50% reduction in global carbon emissions per year by 2030 achieving net zero by 2050 only has a 50% chance of meeting the target for a 1.5°C rise in temperature.

Credit: *Architecture 2030.*

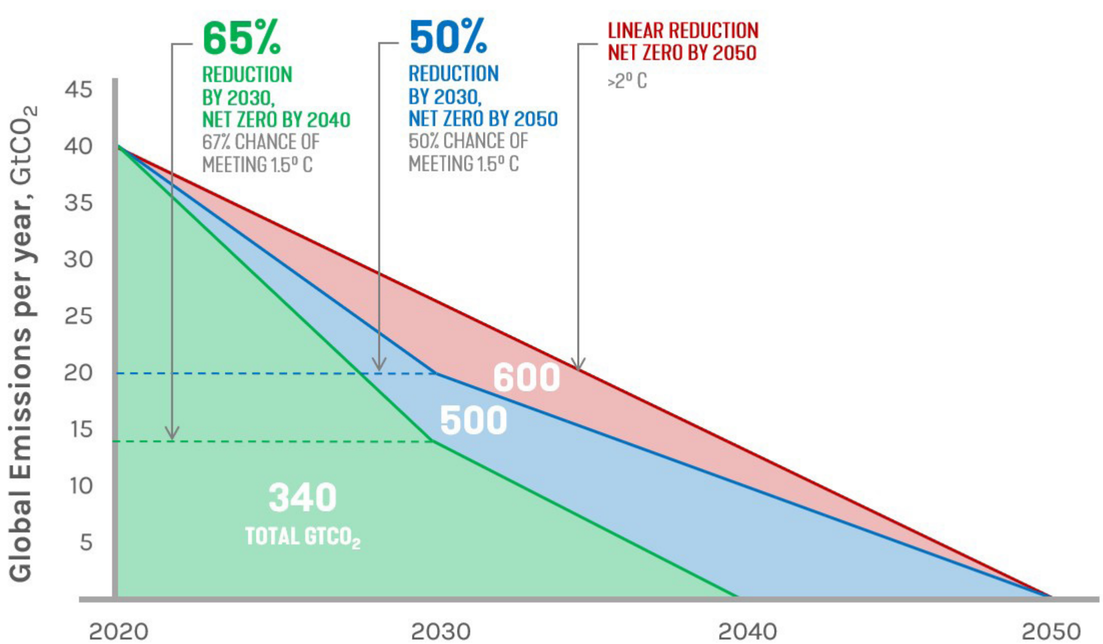


Figure B1: Impact of projected reduction in carbon emissions.

Figure B2: Storm intensities on the Great Lakes are increasing due to climate change.

TRS is committed to renewable and sustainable practices that minimize our impact on the environment and our natural resources. **At the same time, we recognize that even if the world collaborates to avoid going over the threshold 1.5°C rise, TRS needs to respond and adapt to climate impacts that have and will continue to occur, including severe storms, increased temperatures, and species migration.**

This Climate Resiliency Plan acknowledges the risks that climate change poses to the unique boreal habitat of the Sanctuary, identifies specific current and future vulnerabilities, and lays out strategies to mitigate impacts on biodiversity while also reducing the energy use and embodied carbon of our constructed facilities. Building on the completion of our LEED-certified Nature Center in 2015 as well as our commitment to environmental education, TRS is positioned to be a leader in addressing climate change for the Door County region and beyond.

Despite the magnitude of the climate crisis, Paul Hawken reminds us in his book, *Regeneration: Ending the Climate Crisis in One Generation*, that people are the solution, both through individual and collective action.[5] No single individual, organization, community, or nation can solve these issues on its own. However, individual and group commitments can and do make an impact when collectively working towards a common purpose. Based on TRS' commitment to addressing the climate crisis, this Climate Resiliency Plan address the following objectives:

- Define resilience as related to the climate crisis.
- Document a general resiliency framework, climate impacts, and best adaptation practices from a review of current literature.
- Assess climate risks and vulnerabilities specific to TRS' natural and existing systems, and identify non-climate stressors that could exacerbate climate impacts at TRS.
- Share the results of a SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats) conducted with participants in the Ridges Sustainable Citizens Symposium in September 2022.
- Identify specific building strategies to reduce climate risks and address vulnerabilities for TRS' facilities.
- Provide adaptation recommendations for TRS' natural resources, focusing on two critical species – the Hine's Emerald Dragonfly and the Ram's Head Lady Slipper Orchid.

2.0 WHAT IS RESILIENCE?

From an ecological perspective, resilience is the capacity of an ecosystem to endure a disturbance and recover in a way that maintains biological balance and function. Through resilience, a system is able to continue functioning and maintain patterns of nutrient cycling, biomass production, and ecosystem services. Features that make a system more resilient include a diversity of species, populations, and landscape features, as well as redundancy where species overlap use of niches within the ecosystem's structural web. [6]

Applying these concepts to a human perspective, "Community resilience is the ability to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions."[7] Resilience describes a community or organization's ability to plan for and recover from shocks and stressors. According to the *RRC Resiliency Toolkit* by the Michigan Economic Development Corporation, a resilient community is knowledgeable about threats and risks, actively assesses vulnerabilities and organizes plans to reduce negative impacts, creates partnerships to give and receive support, and has designed its facilities and systems for future conditions.[8] As shown by the diagram in Figure B3, with advance preparations including resilience improvements, an organization or community can reduce both losses and recovery time following a disturbance or catastrophic event. This differs from "business as usual," which fails to consider resiliency planning, and thus requires greater response efforts after a disturbance occurs.

In relation to climate change, resiliency planning recognizes that the crisis is here and the world is already changing around us. Even if every nation cooperates to cut emissions and slow the pace of change, we must adapt to changes that are already unavoidable, including patterns of precipitation and wind direction, severity of storm events, and migration of species. The overall goal is to design for flexibility. Because the impacts of climate change are dynamic, it is unknown exactly how TRS' unique habitats will respond. This Climate Resiliency Plan identifies specific vulnerabilities and potential stressors to better equip TRS to track shifting conditions and develop adaptive management strategies to help preserve the biodiversity of the Ridges ecosystem.

Credit: *Adapted from model developed by M.E. Hynes, B. Ross, and CARRI (2008), presented at the DHS University Summit, Washington, D.C.*

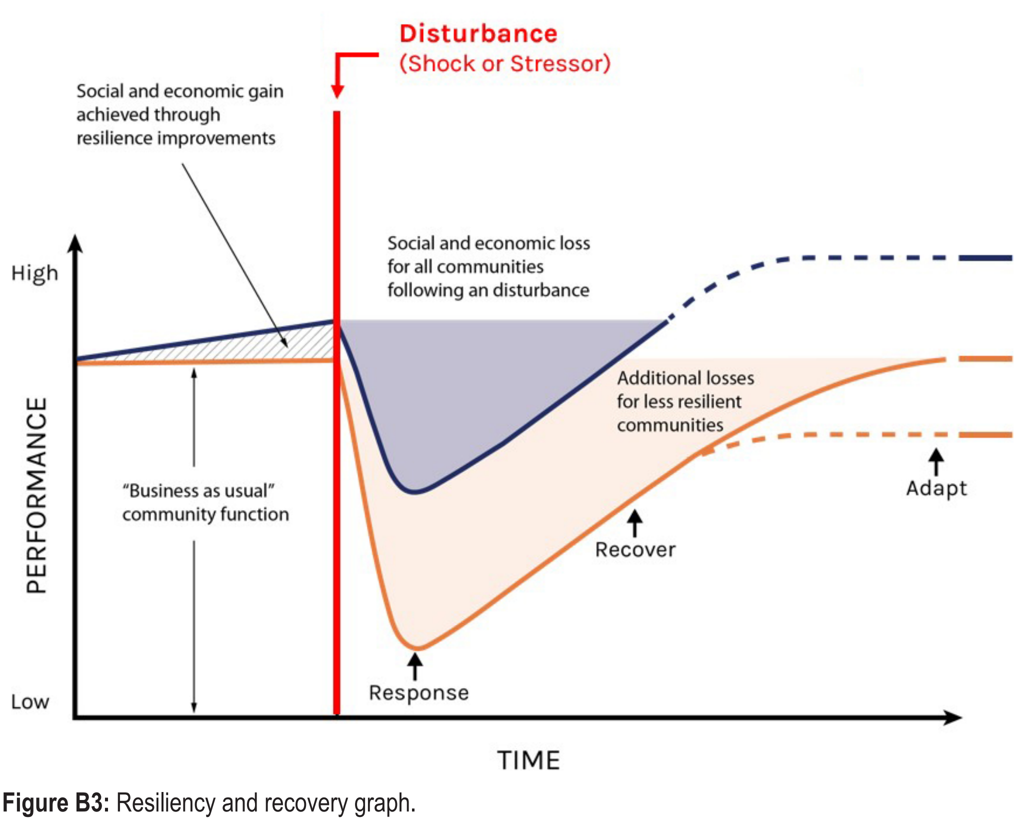


Figure B3: Resiliency and recovery graph.

3.0 SUMMARY OF IMPACTS AND BEST ADAPTATION PRACTICES FROM A REVIEW OF CURRENT LITERATURE

Given future uncertainty, the best approach is to evaluate a variety of potential scenarios, including extreme conditions, to understand the range of risks faced and TRS' adaptive capacity to address them. Even models using the highest quality and reliability of data available cannot fully account for complex meteorological processes or for the uncertainties related to future emission reductions. There are different models for climate change depending on a variety of scenarios, which is why no one can definitively say emissions need to be cut by 50% or 65% by 2030 to avoid triggering climate tipping points. Given this level of uncertainty – and the fact that the world is currently not on pace to meet either of those reduction targets – TRS needs to protect the Sanctuary as an irreplaceable ecological asset by being as aggressive as possible in targeting climate sensitive practices and developing adaptation practices. In doing so, TRS will speak to the core of their mission of stewardship and preservation, and provide leadership by example to other organizations and individuals.

First and foremost, TRS needs to stay current with the latest data, research, and innovations. New data, new technologies and design innovations continue to inform climate action. Adaptations can and ideally should have multiple outcomes and benefits. There are many effective climate action solutions that not only address mitigation and adaptation, but also provide other benefits such as healthier work and learning environments, increased habitat for local flora and fauna, more equitable access to services and amenities, and strengthening of partnerships. Although a multitude of assessments are being conducted on climate change, the following review of current literature briefly describes several studies that are directly relevant to TRS regarding climate impacts and best adaptation practices.

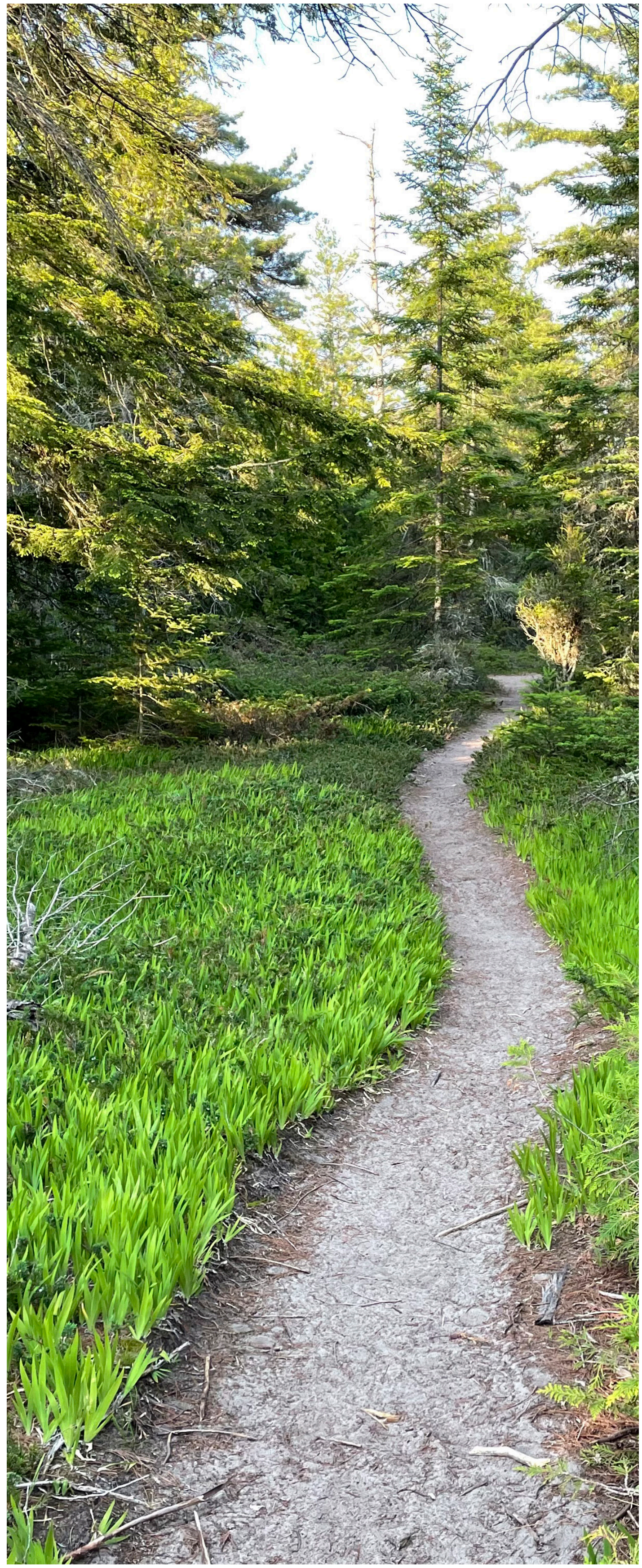


Figure B4: Federally-threatened dwarf lake iris along Sandy Ridge.

U.S. GLOBAL CHANGE RESEARCH PROGRAM - FOURTH NATIONAL CLIMATE ASSESSMENT: VOLUME II, IMPACTS, RISKS, AND ADAPTATIONS IN THE UNITED STATES [9]

The U.S. Global Change Research Program is charged with delivering a report to Congress and the President every four years that analyzes the impacts of global climate change on natural systems, social networks, and economic sectors, and assesses current trends in global change. The Fourth Assessment published in 2018 found that more frequent and intense weather patterns will continue to damage both ecosystems and human infrastructure, and that without significant worldwide mitigation efforts, climate change will result in billions of dollars of losses and severe ecological alterations.

Specific to the Midwest, the study notes that although understory plant species ranges have shifted over the past 50 years, the rate of change is not enough to keep up with increasing temperatures. Also, while both peak bird migration and plant bud-break are shifting earlier in spring, the arrival of birds is becoming out of sync with the earlier plant phenological variation. Changes such as this allow invasive species to be increasingly competitive at displacing natives. Invasive insect species in particular take advantage of extended growing seasons that result in higher impacts, while native pollinators who are dependent on few plant species may see rapid declines.

The report recommends perpetual adaptation to assess climate risks as they evolve and formulate actions to reduce impacts. This includes integrating climate considerations into all organizational decision-making processes, using a structured process of (1) awareness of the risk, (2) assessment, (3) planning, (4) implementation, and (5) monitoring and evaluation.

Figure B5: Multiple odonata species depend on TRS wetlands.

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS (WICCI) – WISCONSIN'S CHANGING CLIMATE: IMPACTS AND SOLUTIONS FOR A WARMER CLIMATE, 2021 ASSESSMENT REPORT [10]

This report summarizes observed climate impacts in Wisconsin and suggests solutions that can lessen impacts and help promote resiliency. First, the report documents the following observed changes in Wisconsin's climate:

- The last two decades are the warmest on record for Wisconsin, and the state's average daily temperature is three degrees Fahrenheit warmer than the 1950s.
- Temperatures at night and in the winter show the largest deviation from the historical record.
- Average precipitation is 17% higher than 1950.
- Forest ecosystems are stressed by warmer winters, increasing deer herds, extreme weather events, summer droughts, longer growing seasons, and new pests and diseases.
- Summer droughts, reduced snowpack, and increased flooding are amplifying non-climate stressors, resulting in loss of habitat and food sources for wildlife.
- Many species are shifting ranges or changing migration patterns to adjust to the rapidly changing conditions.

Although recognizing that many challenges and barriers exist, the report recommends multiple solutions that organizations and policymakers can implement to adapt to climate impacts. Proposals that are applicable to TRS include:

- Protect and preserve large, connected habitats to provide wildlife with corridors for movement and room to adapt to changes in range.
- "Keep forests as forests" by managing for canopy regeneration.
- Consider water control infrastructure to account for periods of high water and drought.
- Conserve water and promote infiltration to lessen impacts from both flooding and droughts.
- Embrace walkability, clean energy, and green building design.

THE NATURE CONSERVANCY – RESILIENT AND CONNECTED LANDSCAPES FOR TERRESTRIAL CONSERVATION IN THE CENTRAL UNITED STATES [11]

At a macro-level scale, The Nature Conservancy has mapped "biodiversity strongholds" – areas with greater natural landcover, more topographic variability, and increased connectivity with other green spaces that can help make them more resilient to climate changes. Although TNC anticipates that these areas may change in specific character or species assemblages, these resilient sites are more likely to retain ecosystem function and health over the long term.

The goal of the study was to identify the places most essential to conserve that have the best chance in sustaining biodiversity as the climate changes. The study assessed connectivity and climate flow, rating the permeability of the landscape to allow for species movement and range shifts. This included analyzing resistance to species movement by both human-made barriers and natural barriers in the landscape as well as diversity of topography and landscape position. The resulting maps are published online at https://maps.tnc.org/resilientland/.

The majority of TRS property at both Baileys Harbor and Logan Creek is recognized for its high biodiversity and is categorized as slightly more resilient, with average to high flow for species movement – likely based on connectivity with regional native landcover networks. However, given the scale of the study, this tool may not have the resolution necessary to recognize the disconnect between the Door County pocket of boreal forest from locations far distant in northern Wisconsin and Michigan. However, it does strengthen the importance for TRS to maximize connectivity both within its own land holdings and throughout Door County overall.

NORTHERN INSTITUTE OF APPLIED CLIMATE SCIENCE – CLIMATE CHANGE FIELD GUIDE FOR NORTHERN WISCONSIN FORESTS: SITE-LEVEL CONSIDERATIONS AND ADAPTATIONS [12]

Published by a multi-agency collaboration led by the U.S. Forest Service, this field guide summarizes climate change effects on northern Wisconsin's forests and identifies conditions that could increase or reduce risks of climate impacts. The guide notes that forests are considered vulnerable to climate changes if they are at risk of significant change in the composition of species and/or of substantial decline in health. A key takeaway is that a range of forest management adaptation strategies are suggested to respond to climate change, including managing deer browse to promote regeneration of desired species, establishing artificial reserves for at-risk or sensitive species, guiding changes in species composition at early stages of forest regeneration after disturbance, and moving at-risk species to locations that are expected to provide habitat.

Credit: *The Nature Conservancy Resilient Land Mapping Tool, https://maps.tnc.org/resilientland/*

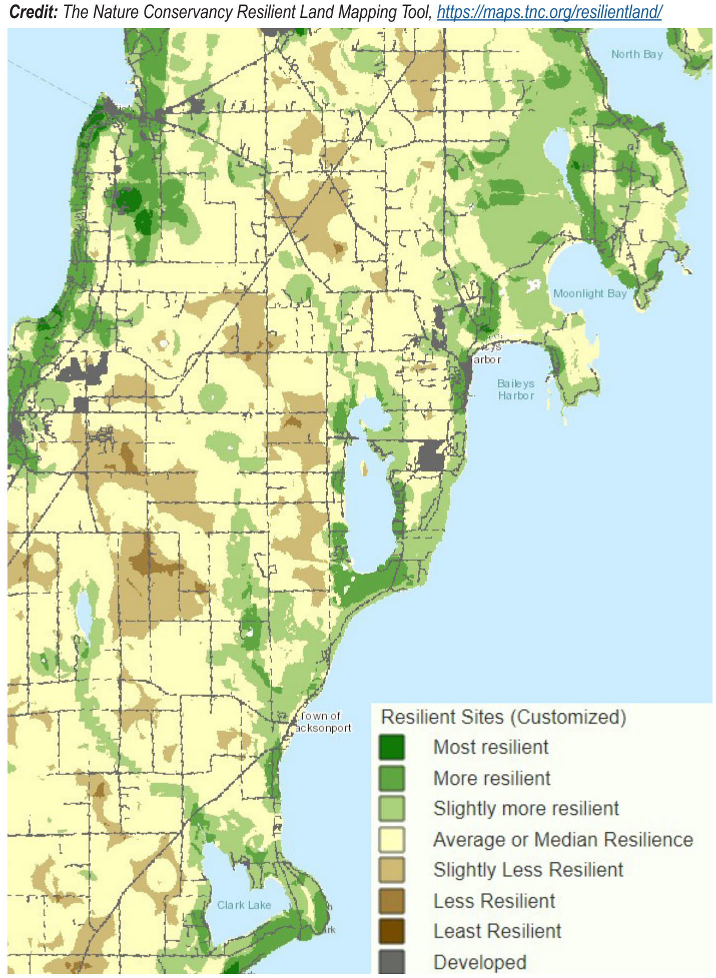


Figure B6: Resilient Land Mapping Tool developed by TNC.

WISCONSIN DEPARTMENT OF AGRICULTURE, TRADE, AND CONSUMER PROTECTION – THE WISCONSIN POLLINATOR PROTECTION PLAN [13]

DATCP partnered with researchers at UW-Madison to propose strategies to address pollinator species declines throughout the State of Wisconsin. The study notes that over 87% of flowering plants rely on pollinators, including bees, butterflies, moths, flies, beetles, wasps, and hummingbirds. Although there is no data for the vast majority of wild pollinators regarding population trends, dramatic bee species declines have been observed in both the U.S. and Europe and other species like the monarch butterfly have been listed as endangered by the IUCN Red List of Threatened Species. TRS can promote education on pollinator-friendly practices such as integrated pest management, providing nesting habitat, planting to provide overlapping bloom times for the entire growing season, and avoiding pesticides.

Figure B7: TRS can educate visitors on pollinator-friendly practices.

MINISTRY OF NATURAL RESOURCES AND FORESTRY – CLIMATE CHANGE VULNERABILITY ASSESSMENT OF SPECIES IN THE ONTARIO GREAT LAKES BASIN [14]

A consortium of Canadian agencies performed an assessment on species vulnerability to rapid climate change in Ontario. This study used NatureServe's Climate Change Vulnerability Index to evaluate impacts on a representative subset of species including several species of concern. Results found that over 60% of the species were vulnerable to climate change, with the dune and coastal wetland complexes of Lakes Erie and Huron having one of the highest concentrations of vulnerable species. The purpose of this study was to provide baseline data to inform policy and strategy development, not recommend actions. However, TRS may lean on this vulnerability assessment methodology as applicable to a similar study for Door County.

GREAT LAKES COMMISSION – BEST PRACTICES FOR CLIMATE CHANGE ADAPTATION: SPOTLIGHT ON MICHIGAN COASTAL WETLANDS [15]

The Great Lakes Commission in partnership with the National Wildlife Federation developed a toolkit for managing Michigan's coastal wetlands, highlighting both institutional-level best practices that are policy focused and project-level best practices that can be used by wetland managers. Strategies that could be used by TRS include:

- Use historic information on water levels and vegetative community composition to inform future wetland management including target water levels and prioritizing acquisitions to support adaptation. Potential sources of information to map wetland changes include aerial photographs, interviews, and historical documents.
- Develop a system to keep records and report on annual management practices, identifying both successes and failures to adapt to future activities.
- Incorporate regular data analysis in monitoring programs to look for trends and variation in the data to allow for a more rapid response to adverse impacts.

PAUL HAWKEN – REGENERATION: ENDING THE CLIMATE CRISIS IN ONE GENERATION [5]

Regeneration describes how humanity can join together in an inclusive movement to bring about climate solutions. Strategies address current human needs by providing for the poor and under-included populations, with initiatives that include technologies such as solar energy and electric vehicles, but go beyond standard solutions with proposals including food localization, decommodification, forests as farms, and electrification. Regeneration seeks to engage the majority of humanity in the solution, by creating opportunities for all through a healing approach. Six basic frameworks for action are outlined, including:

- Equity – Providing fairness in social systems and how we treat each other and the living world. Create respect for the environment by addressing violence, injustice, and availability of resources.
- Reduce – End emissions from agriculture, transportation, deforestation and ecosystem destruction.
- Sequester – Increase the carbon sequestered in the natural cycle, through regenerative agriculture, reforestation, managed grazing, and restoration of natural ecosystems.
- Influence – Advocate for policy changes that protect people and natural systems, as well as those that disfavor degenerative processes and products.
- Support – Connect with organizations and citizens undertaking efforts that address climate change through actions dealing with pollution, species, social justice, water, and more, from the local level to international.
- Protect – Protect natural systems that hold carbon in forests, wetlands, and grasslands.

For TRS, this framework allows a critical analysis of how much carbon the Sanctuary is sequestering, the capacity being protected through alternate adaptation strategies, and the influence of support networks that can be cultivated.

Credit: *Paul Hawken, Regeneration: Ending the Climate Crisis in One Generation.*

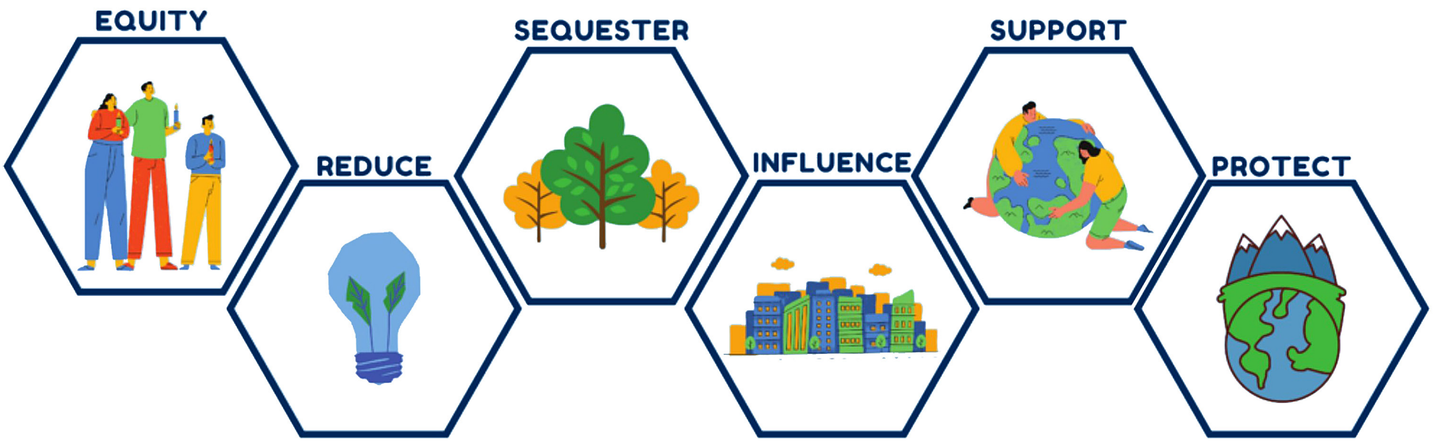


Figure B8: The 6 Frameworks of Regeneration.

4.0 TRS VULNERABILITY ASSESSMENT

Climate change vulnerability is the likelihood of being adversely affected by climate change, and applies not only to impacts on natural systems but also to human comfort and survival. This includes both sensitivity to specific harms as well as a lack of ability to adapt to changing conditions. Vulnerability assessments provide valuable information to develop strategies to respond to change, by providing a baseline for the local ecosystem or feature of interest, and an analysis of potential impacts from climate models and other human induced stressors. This assessment considers the vulnerability of TRS' natural systems including the ridge-swale wetland complex and boreal forest, as well as climate threats to TRS facilities and human use of the site.

4.1 HISTORIC CLIMATE DATA

Cool and damp breezes from Lake Michigan allow for a pocket of boreal forest to survive at TRS, far south of the typical range of this natural community. The effect of these lake breezes on vegetation is highly dependent on the difference between air temperature and water temperature of the lake and wind speed. A lake water-surface temperature increase of 1 to 3°C has been shown to directly link to near-surface air temperature increases of 1 to 2°C in studies from Lake Superior and Lake Erie, leading to changes in evaporation and precipitation patterns.[16] With temperatures warming over the Great Lakes region, seasonal ice cover decreased and summer surface water temperatures rose between 1973 and 2013.[9]

Historic climate data collected at the Ephraim-Gibraltar Airport is summarized in the graphics at right. Winds are primarily out of the south off Lake Michigan, with night flush winds most prevalent coming from the southeast over the water. Based on the period from 1981-2010, annual precipitation generally peaks in June, but is relatively stable above 2.5 inches per month from April through November. Snowfall is generally heaviest in December and January at 13 to 15 inches average per month. Changes in these historic wind and precipitation patterns due to climate change will negatively impact the species and ecosystems that rely on the cool, wet weather.

The predicted HVAC mode diagram – a psychometric chart – illustrates that the energy to heat buildings is the largest portion of their energy use, and so pursuing desirable solar heat gain (heat from the sun to reduce heating demand from mechanical systems) is beneficial. This is best accomplished using south facing glazing designed to let in winter sun but shielded with sunshades to prevent summer solar heat gain. The diagram also shows that the building can be in "economizer" mode for 16% of the year – meaning that 16% of the year, the outdoor temperature supports comfort without any need for heating or cooling.

Credit: *USGCRP. 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.*

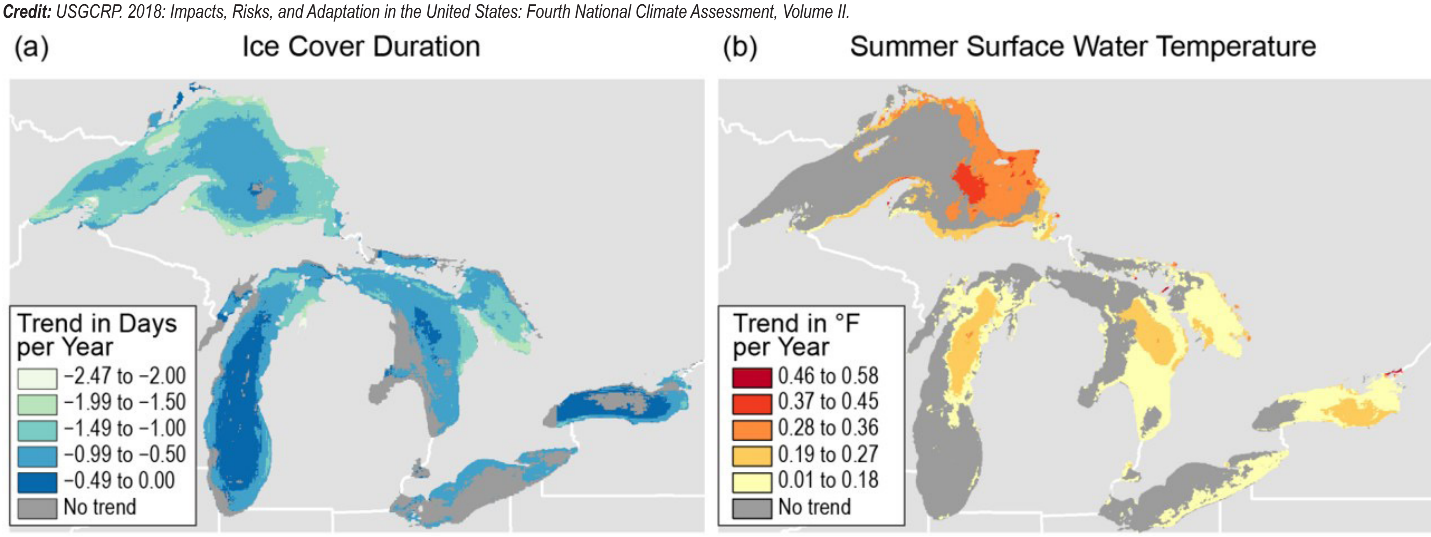


Figure B9: Rate of change in ice cover duration and summer surface water temperature.
(a) Ice cover duration decrease between 1973 and 2013. (b) Summer surface water termperature increase from 1994 to 2013.

Source: *TMY3 Weather Data collected at the Ephraim-Gibraltar Airport, Door County, WI.*

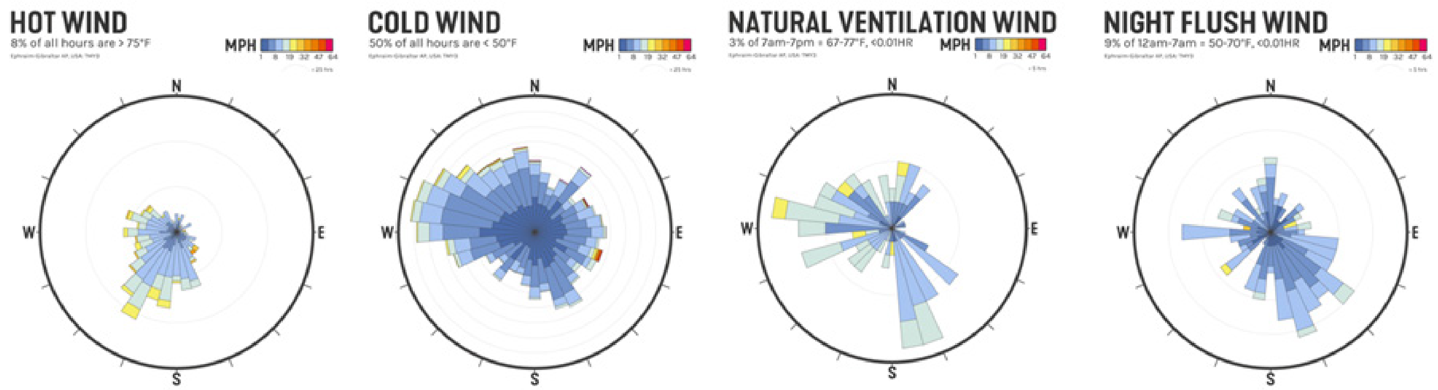


Figure B10: Summary of historic wind data at the Ephraim-Gibraltar Airport.

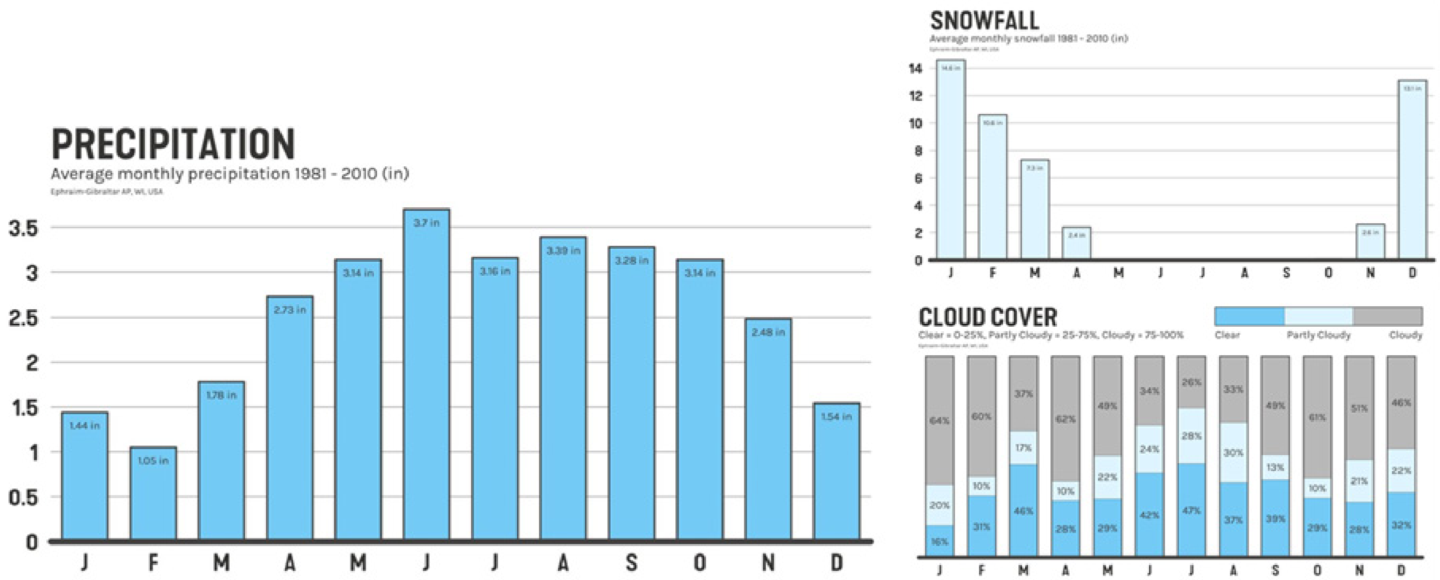


Figure B11: Summary of historic precipitation, snowfall, and cloud cover data at the Ephraim-Gibraltar Airport.

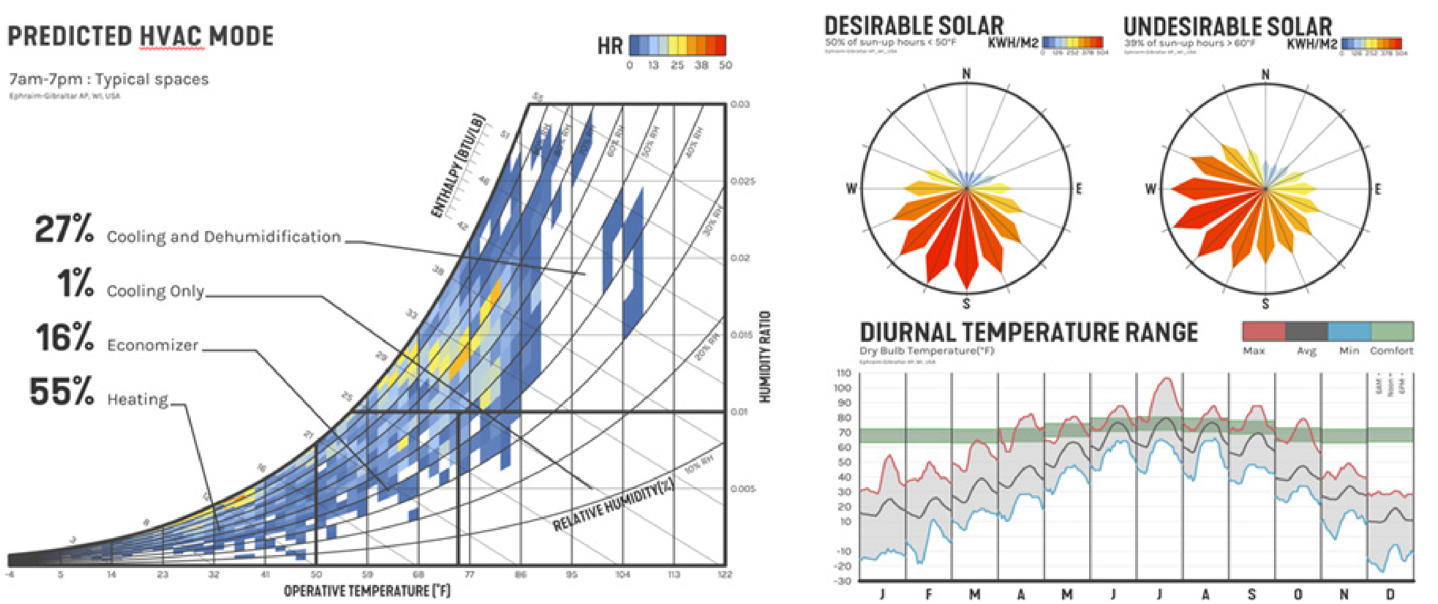


Figure B12: Predicted HVAC mode diagram for TRS based on historic solar and temperature data at the Ephraim-Gibraltar Airport.

Credit: *The Climate Explorer, https://crt-climate-explorer.nemac.org/.*

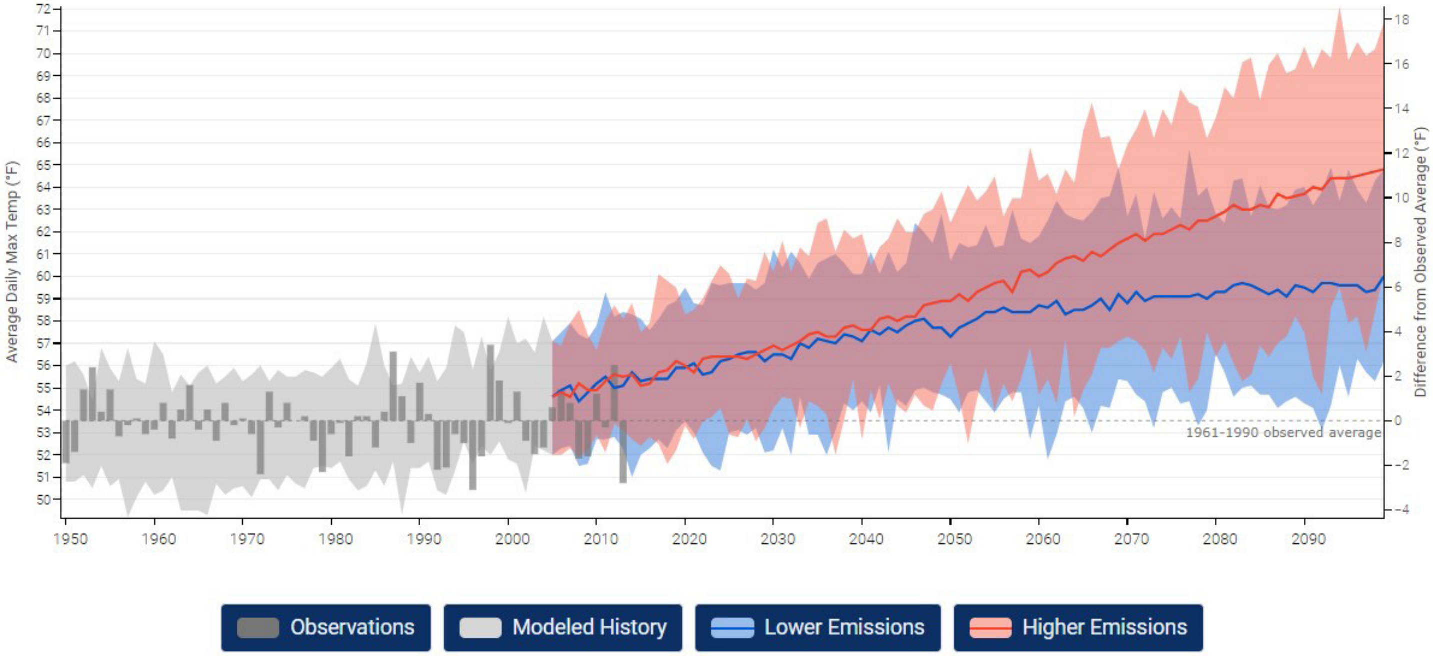


Figure B13: Projected average daily maximum temperature (° F) for Baileys Harbor under lower and higher carbon emission models.

To leverage this climate asset, buildings should be designed with operable windows, facing the prevalent direction of breezes on mild days, which come from the south-southeast for TRS. These windows not only support daytime natural ventilation, but also can be automated to open on certain nights to flush out the interior, precooling the interior on warmer days, extending the potential for natural ventilation. Operable windows also support climate resiliency by providing ventilation in case of power loss from severe weather. Creating more weather-tight, opaque exterior building envelopes in the west-northwest facades will reduce undesirable infiltration from cold winds.

Cloud cover patterns show predominantly cloudy days, beneficial for daylighting strategies, although limiting for solar photovoltaics. Photovoltaic output will be significantly reduced in the winter months, between cloud cover and snowfall, but can still provide good output during the spring, summer, and fall seasons, when TRS sees the greatest number of visitors and also with increased potential for intense storms that could disrupt the power grid.

Average daily temperatures are already observed to be increasing because of climate change. As noted by the Climate Change Field Guide for Northern Wisconsin Forests,[12] "winters have warmed about twice as much as other seasons, and minimum temperatures are increasing faster than maximum temperatures." The charts above and on the facing page show modeled predictions specific to Baileys Harbor for the increase in daily maximum temperature, the number of days with a maximum temperature greater than 95 ° F, and the number of days with a minimum temperature below 32 ° F. These changes will have an unpredictable impact on the survival of the boreal forest habitat at TRS.

Credit: *The Climate Explorer, https://crt-climate-explorer.nemac.org/.*

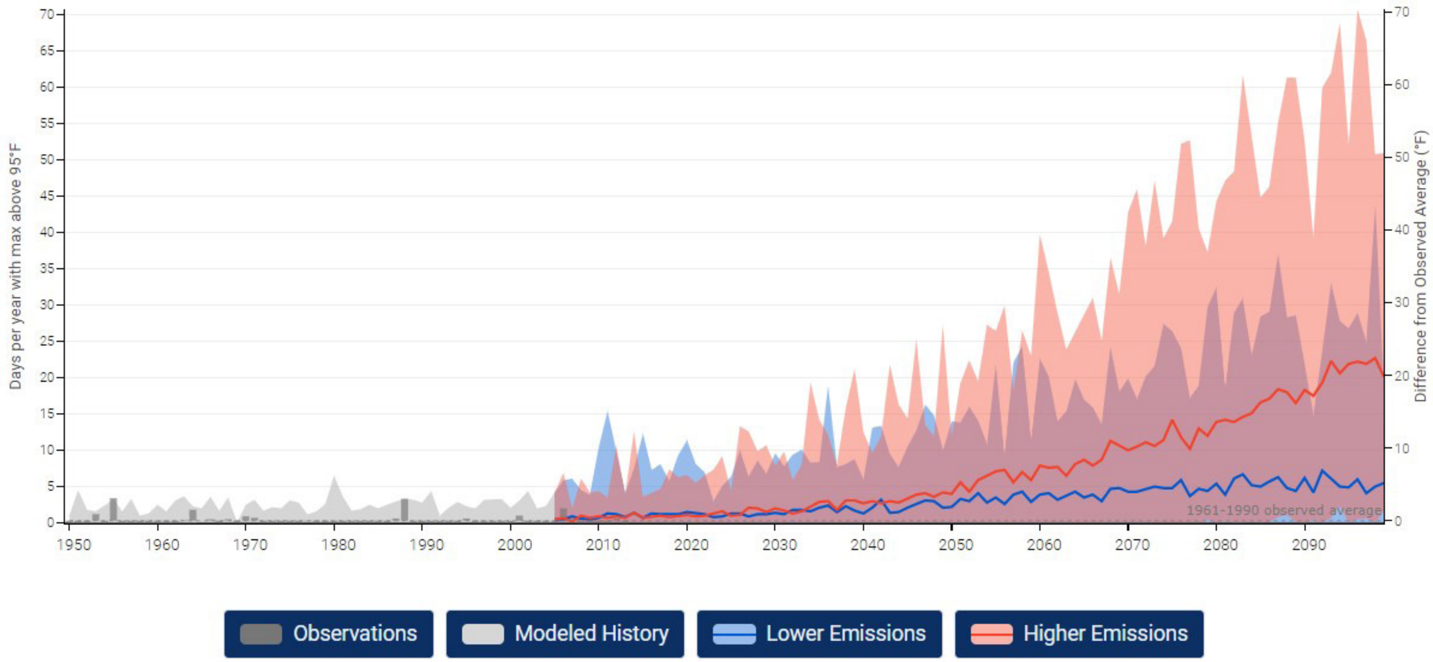


Figure B14: Projected number of days for Baileys Harbor with a maximum temperature over 95 ° F under lower and higher carbon emission models.

Credit: *The Climate Explorer, https://crt-climate-explorer.nemac.org/.*

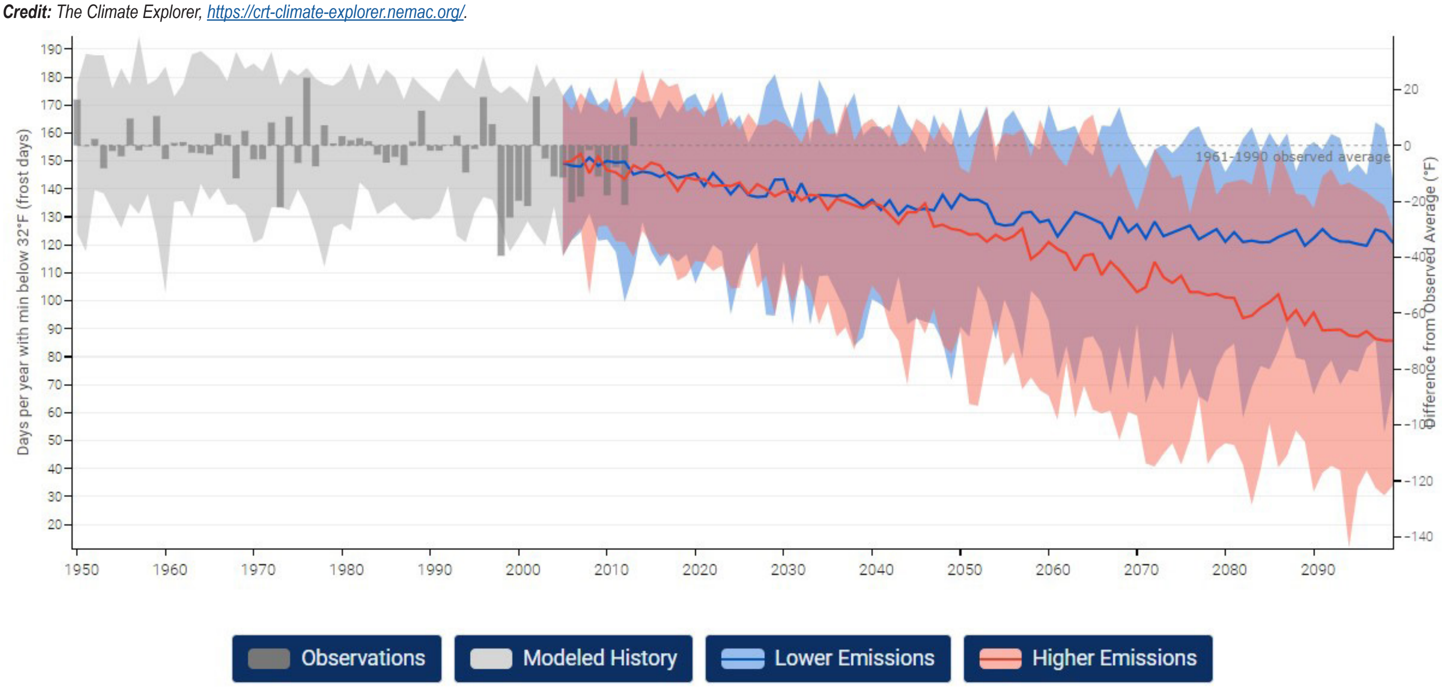


Figure B15: Projected number of days for Baileys Harbor with a minimum temperature under 32 ° F under lower and higher carbon emission models.

4.2 LAND DEVELOPMENT AND WATERSHEDS

Since TRS was established in 1937, the surrounding land use has changed dramatically. By the 1930s, substantial areas within the landscapes around both the Baileys Harbor and Logan Creek properties had been cleared for agriculture. However, aerial photographs show that several areas that had been cleared for logging, row crops, or pasture as visible in the older photos have since regrown with canopy trees. For Baileys Harbor, this includes the area around North Campus, parts of the Family Discovery Trail, and fingers of vegetation north towards Pickerel Pond (See Figures B18-B19). At Logan Creek, these historically cleared areas included large properties along Highway 57 and an area that appears to be pasture at the southeast edge of the property near Clark Lake (See Figures B16-B17). This reforestation promotes carbon sequestration, through biological storage of carbon in forests and wetlands, but could be threatened by invasive insects and disease as noted below.

Figure B16: Aerial Photo of Logan Creek, 1938.

Figure B17: Aerial Photo of Logan Creek, 2021.

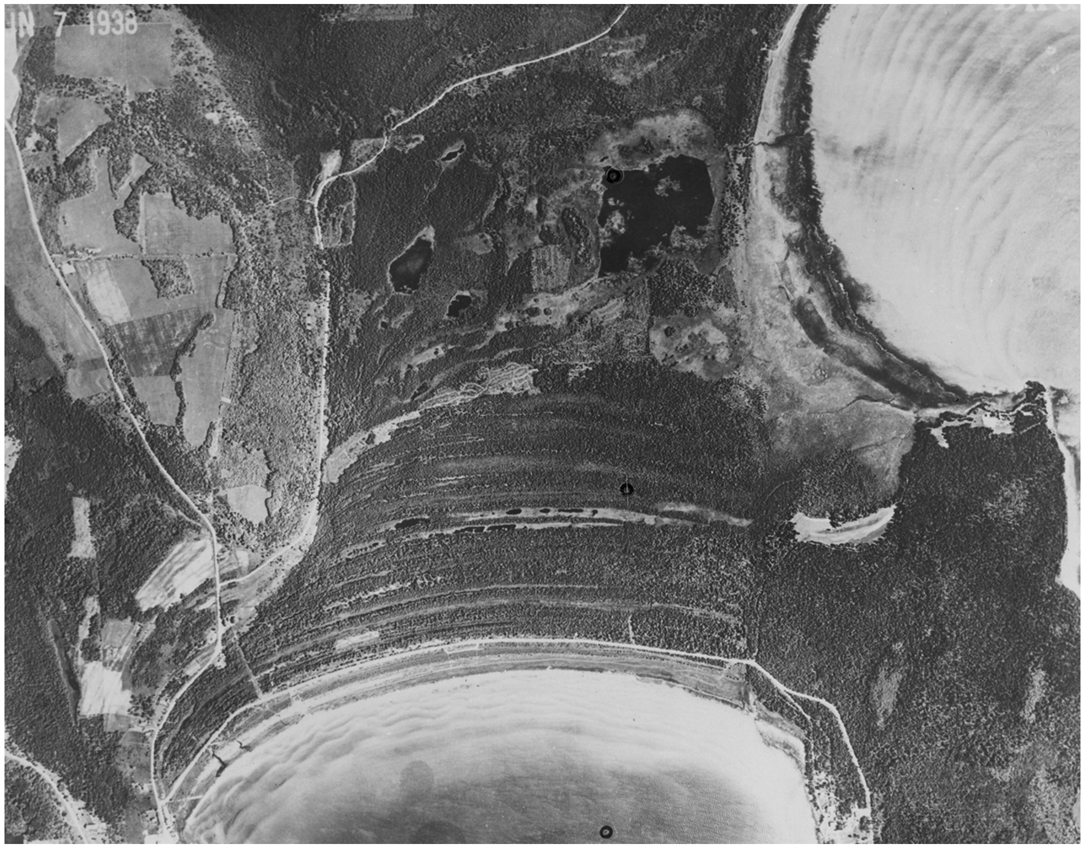


Figure B18: Aerial Photo of Baileys Harbor, 1938.

Figure B19: Aerial Photo of Baileys Harbor, 2021.

***Credit:** The Ridges Sanctuary Watershed Study – 2006-2007, University of Wisconsin - Green Bay Cofrin Center for Biodiversity and Door County Soil and Water Conservation Department*

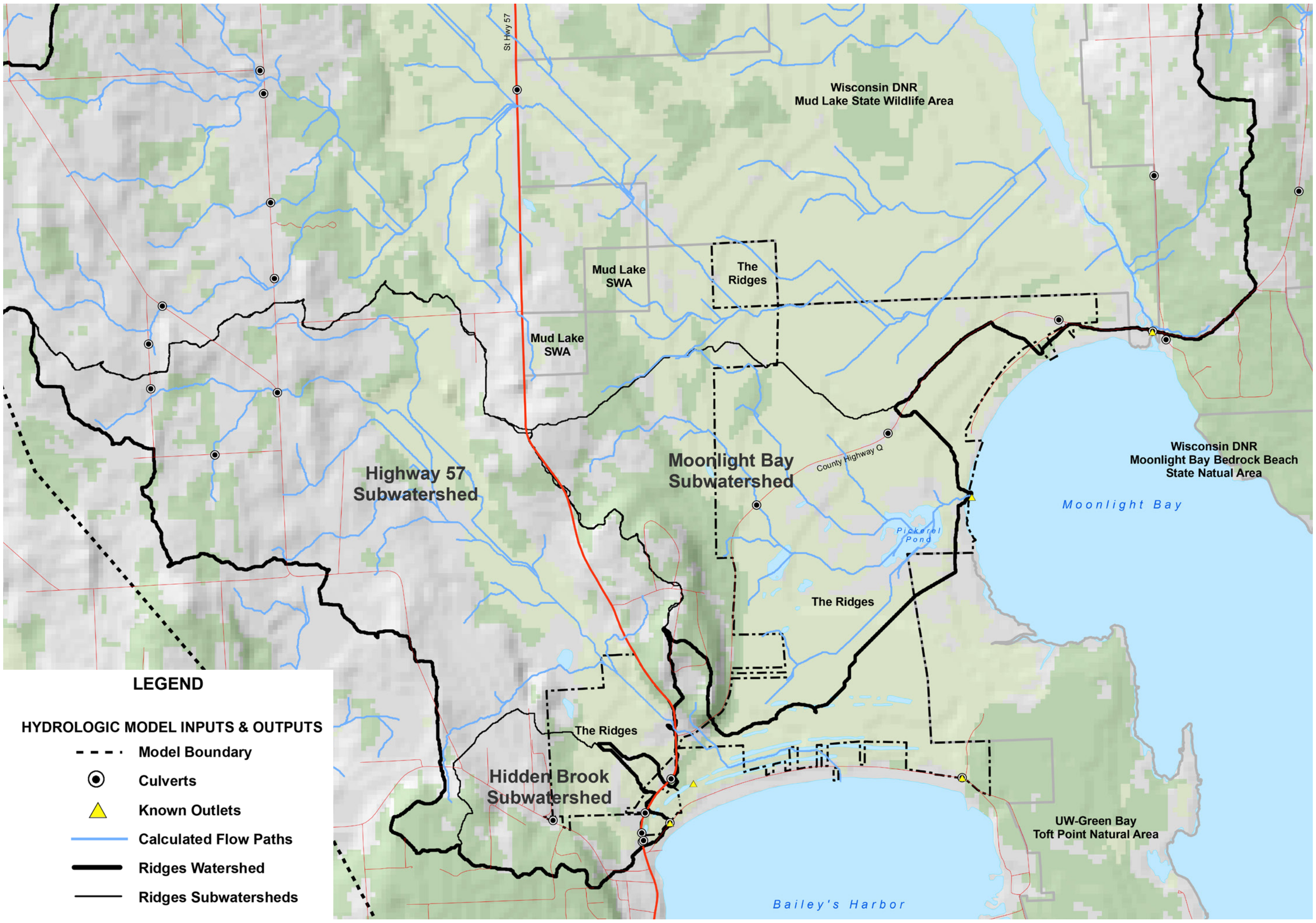


Figure B20: Surface watersheds of The Ridges Sanctuary.

However, the photos also show that extensive development has occurred since the 1930s, especially along shorelines, road corridors, and ridgetops. As shown in Figure B20, three primary subwatersheds provide surface drainage to TRS, the largest of which is the Highway 57 subwatershed that drains to Hidden Brook at the Ridges Inn. This drainage basin includes potential contamination from highway runoff, agriculture, and gravel mining operations. The Moonlight Bay subwatershed drains towards Pickerel Pond, and retains a more natural character with limited development along Highway Q and on top of Appel's Bluff. The smallest of the watersheds is also the most highly developed, including parts of Baileys Harbor along County Highway F.

Several vulnerabilities are created by this observed residential and commercial development within the surface watershed and groundwater recharge area.

Development increases impervious surfaces from roofs, roads, and driveways, which both increases surface runoff from intense storm events and prevents infiltration of groundwater needed to supply base flow to wetlands and streams throughout the growing season. Development also creates a potential risk of aquifer depletion in prolonged periods of drought. Population growth not only adversely impacts infiltration that is critical to recharge, but construction of additional wells can also significantly draw down the groundwater needed to sustain human activities and drinking water sources.

4.3 FLOOD RISK AND LAKE LEVEL CHANGES

Door County Emergency Management Department drafted a Hazard Mitigation Plan for 2022-2026 that assesses risks to the community from natural hazards including severe weather such as heavy rain events, high winds and lightning, coastal erosion and flooding, and winter storms and extreme cold. For TRS, the most applicable parts of the plan address flooding and shoreline erosion. Baileys Harbor has experienced both flooding from storms and high lake levels in the past decade. In 2014, a storm dropped up to 9 inches of rain on the peninsula in less than 24 hours, causing widespread flooding and power outages. Many businesses and homeowners in Baileys Harbor saw damage with flooded basements and downed trees.[17]

Water level changes in Lake Michigan follow a cyclical high/low pattern over time, with a number of recent changes occurring more quickly than the historic average. As shown by Figure B21, from 1917 to 2022, periods of high water occurred approximately every thirteen years. However, based on recent weather events, the historic averages are no longer reliable indicators of future risk as there is an acceleration between high and low levels from changes in winter ice cover, cloud cover, and precipitation patterns.

Record high water levels in 2019-2020 resulted in property damage all along the Lake Michigan shoreline, destroying the youngest ridges found along the shoreline in Baileys Harbor. As noted by Guy Meadows with Michigan Technological University's Marine Engineering Laboratory, increasing storm intensity and frequency from climate change combined with high water levels can result in dramatic escalation in erosion rates.[18] From interviews with residents along the shoreline in Baileys Harbor, previous high water levels prompted them to build a seawall to protect their homes, which is now buried under sand. These hardened edges at the water's edge, as well as the presence of the houses and driveways on these lakeshore lots, forever alter the ridge-swale formation process that created the unique landscape.

The current FEMA flood map for Baileys Harbor (2009) is shown in Figure B22; however, the Hazard Mitigation Plan notes that these maps for the county are currently being updated based on the recent flood events. Much of Ridges Road and the area surrounding Pickerel Pond are currently in inundation Zone AE, which is the 100-year flood zone for Lake Michigan. Access plans should be developed for these areas if long duration flooding occurs. TRS should remain aware of when the updated FEMA maps are released to evaluate any changes for their properties. Until then, resiliency planning should consider the 500-year flood zone or data from recent flood events as a minimum flood level from a risk assessment standpoint, and should understand the potential for increased groundwater inundation from lake level rise.

Source: *NOAA Great Lakes Water Level Dashboard; USACE Great Lakes Information Website: https://coast.noaa.gov/digitalcoast/tools/glwld.html*

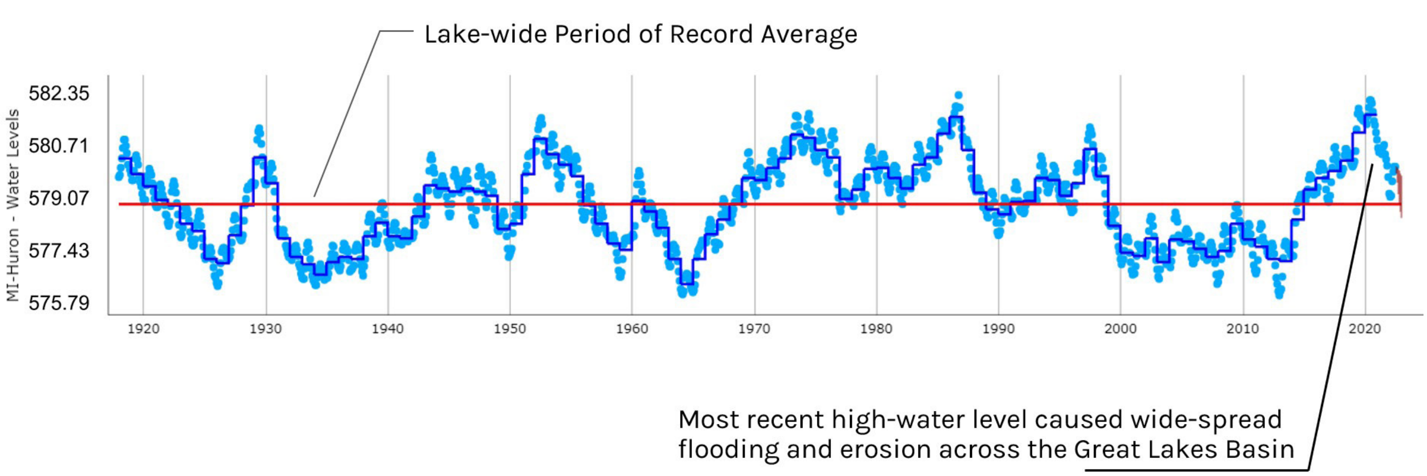


Figure B21: Lake Michigan Water Level Changes, 1917 to 2022.

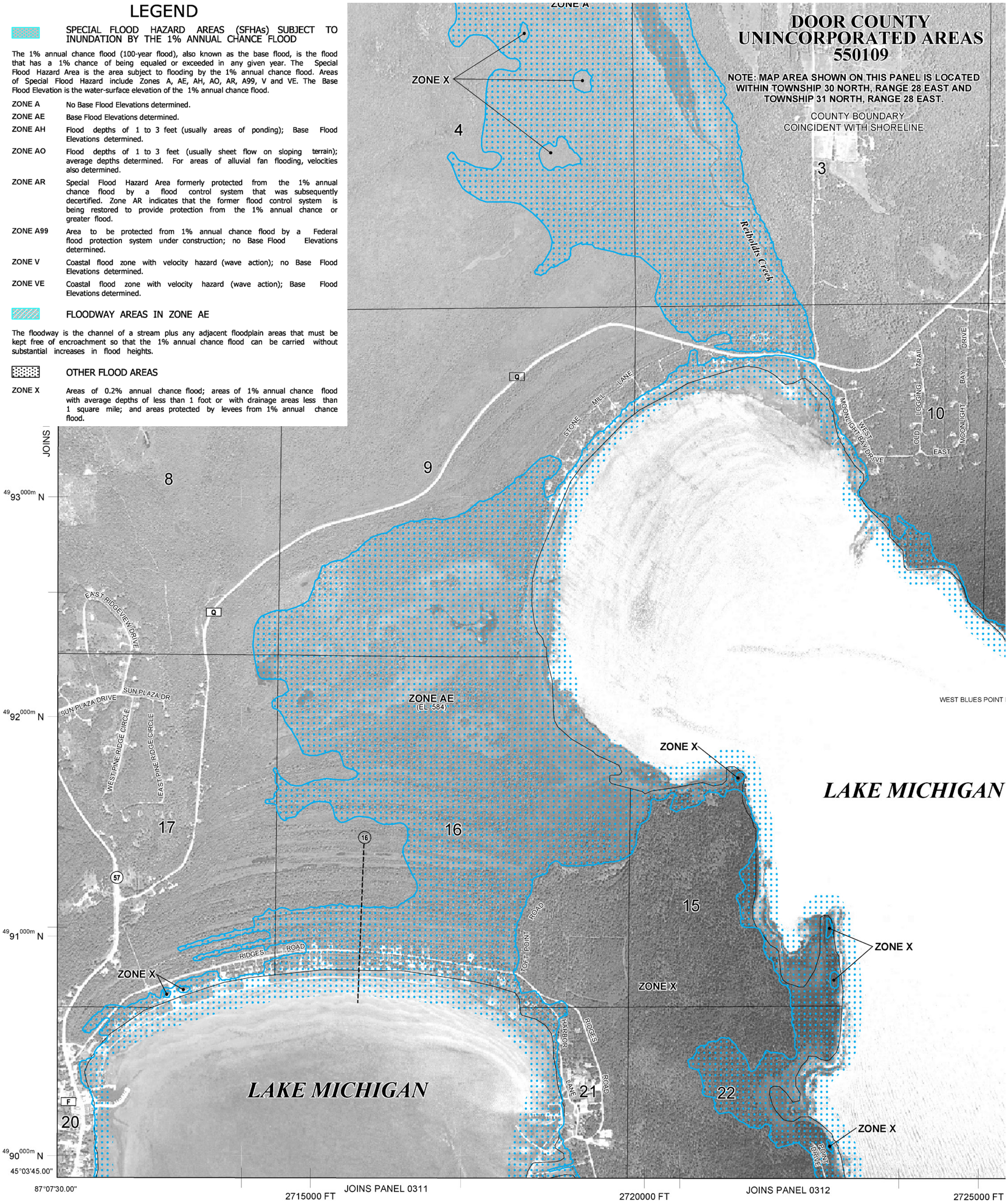


Figure B22: FEMA Flood Insurance Rate Map, Door County, Wisconsin, 2009. (Map Number 55029C0305C)

It is unknown when lake levels will rise again in the future, or if the lake will again exceed the recent record high. However, any increase in water levels above the record high would have a dramatic impact on TRS, as groundwater inundation tied to the elevation of the lake would flood substantial areas of the Sanctuary including inland swales. As noted by the Ridges News in November 1986 during that last period of record high water, "The swales are brimming and the roots of many Spruces, Tamaracks and Arborvitaes bordering the swales are being loosened. High winds coupled with a build-up of heavy wet snow on these trees this winter promises to topple hundreds of them."

Figure B23 based on available topographic information shows areas that would be inundated by lake water levels one-foot, two-feet, and three-feet above the record high. TRS needs to remain cognizant of rare plant populations within these areas that could be negatively affected by elevated water levels, and should develop plans for safe access to properties if flooding occurs.

Credit: *The Ridges Sanctuary by Roy Lukes, Photo by Roy Lukes*

Figure B24: Shore erosion and toppled trees along Baileys Harbor during high water of 1986.

Source: *2018 FEMA Lidar: WI 3 County (Door, Marquette, Outagamie Counties)*

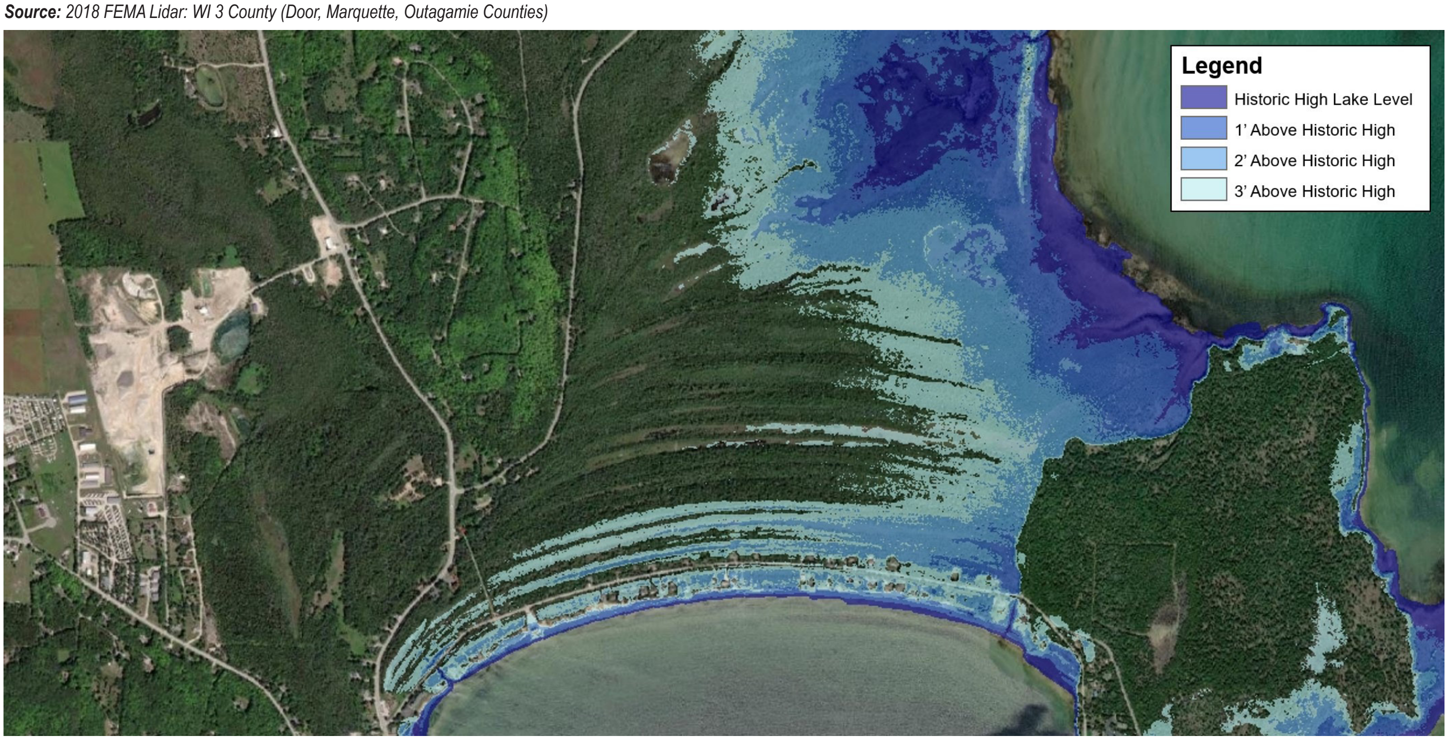


Figure B23: Areas within TRS that would be flooded by lake level rise.

4.4 HUMAN IMPACTS ON WETLAND WATER QUALITY

The wetlands within TRS are fed by both surface water runoff and groundwater flows from the surrounding watershed and recharge area. Human uses on this greater landscape can introduce excessive nutrients, road salt, septic system effluent, and other contaminants that alter wetland ecology and adversely impact native plant and animal communities. These stressors may allow invasive species to spread aggressively or potentially change the water chemistry in a way that no longer supports sensitive species. Sustaining the habitat within TRS' unique wetland habitats requires an understanding of the watersheds and groundwater aquifers feeding the system, to address potential contamination and implement protection efforts.

A study published in 2020 by the Wisconsin Geological and Natural History Survey and the Nature Conservancy sampled six representative sites on the Door County peninsula to document human impacts on groundwater discharging to wetlands.[19] The study was designed to document the current water quality of the springs feeding the wetland and to link contamination found to the upland land uses in the zone of contribution for the groundwater. TRS was one of the sites selected, with a water sampling location located east of the North Campus overflow parking lots off Highway Q and a stream gage installed on Hidden Brook at Ridges Road.

Water samples from TRS did show the presence of acesulfame, an artificial sweetener that is an effective tracer for human source pollution, but did not have any detectable traces of pesticides. TRS also had high chloride readings, with two samples above 15 mg/L. Phosphorus was also a concern, with one reading higher than 0.03 mg/L which is the standard for lakes to be considered eutrophic. These contaminants may be linked to the TRS site having the highest residential housing density of any of the wetland sites sampled in the study.

Figure B25: Protecting water quality in the swales is of utmost importance to maintain biodiversity.

Credit: *Hart et al., 2020, page 36.*

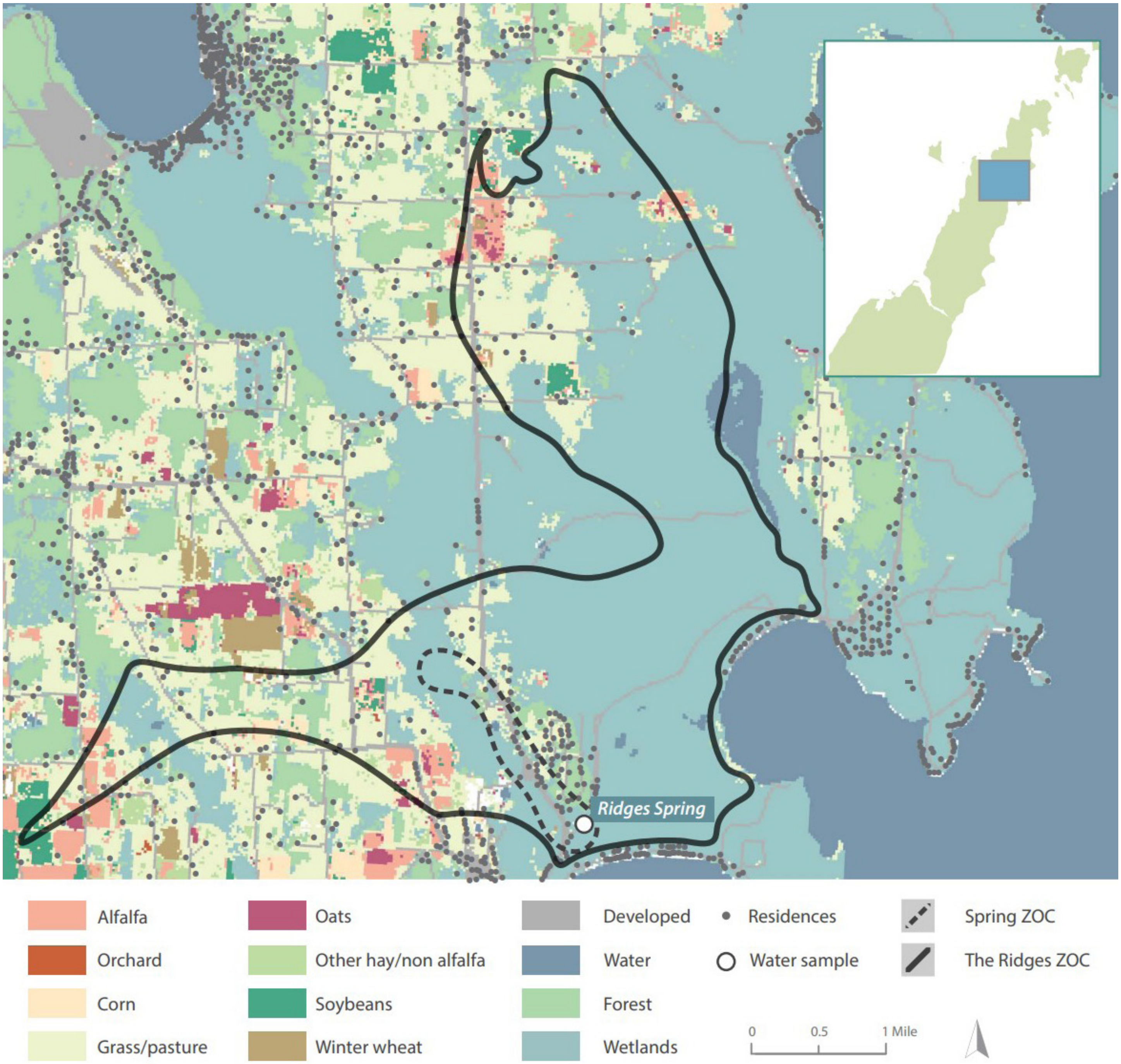


Figure B26: Zone of contribution, land use and residences for TRS wetlands, 2017.

4.5 CLIMATE MIGRATION

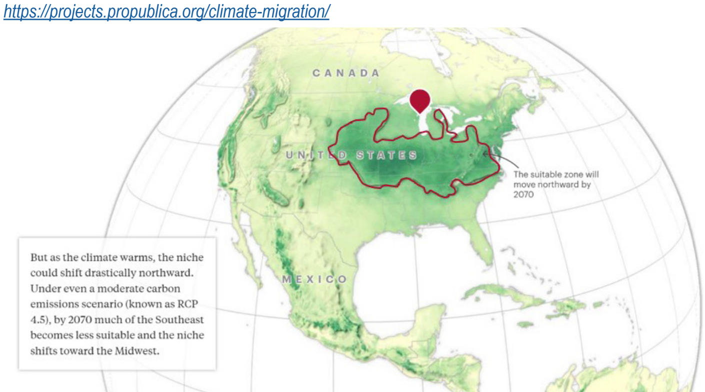
Human climate migration is another development pressure facing TRS and Door County. With rising temperatures, optimal human habitation and agricultural zones are shifting northward. Today, the most suitable zone in the U.S. for people to live based on temperature and precipitation is the south central states, stretching from Georgia to northern Texas, and north to Tennessee and Nebraska (see Figure B27). Under a low emissions scenario, this zone shifts north to the Midwest states, generally encompassing Iowa to Pennsylvania. Under the high emissions scenario, this zone shifts even further north, including the upper Midwest to southern Canada, including northern Wisconsin and Door County. This shift in comfort zones may encourage people to move north, resulting in additional pressures on the watersheds and coastlines surrounding TRS, as well as amplified local traffic volumes that can cause increased vehicular mortality of dragonflies, birds, and other animals.

4.6 HERBIVORY

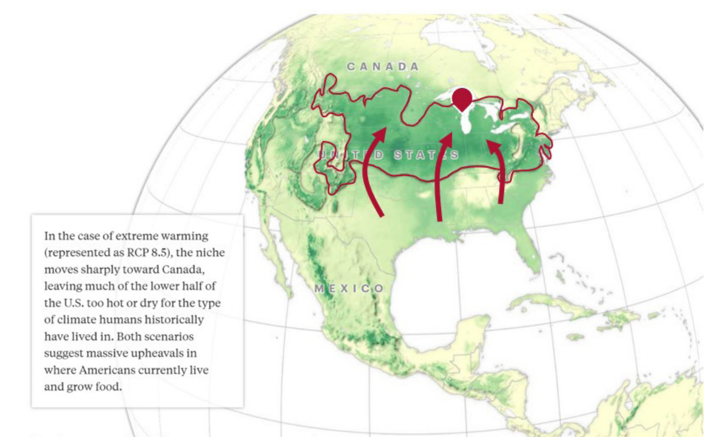
With climate change resulting in more mild winters and less snowpack, there will be less winter mortality and higher reproductive rates for Wisconsin's deer herd. According to the Wisconsin Department of Natural Resources (DNR) deer metrics system, Door County has almost twice as many deer as it did in 2010.[20] The DNR recently analyzed risks to forest regeneration in Door County, and found that whitetail deer populations are causing significant difficulty with regeneration of tree species. Forest regeneration monitoring from 2018-2020 found that 100% of recently harvested forest stands in Door County failed to meet density guidelines or height expectations for new growth.[21] Based on this information, the County Deer Advisory Council has set an objective to decrease the deer population within the Door County Deer Management Zone from 2021-2023. Deer are particularly fond of eating orchids, and TRS pollinator research plots must be fenced to prevent loss of seed heads.

Credit: *Shaw, A., et al. New Climate Maps Show a Transformed United States. ProPublica, Sept. 15, 2020.* *https://projects.propublica.org/climate-migration/*

Optimal Human Habitation Zones Today



Low Emissions Scenario



High Emissions Scenario

Figure B27: Optimal human habitation zones are shifting northward.

4.7 INVASIVE SPECIES

Invasive species are non-native plants, animals, invertebrates and diseases which spread quickly when introduced to an area free from the predators and competition that controlled their populations in their native range. Invasives crowd out native plants and create monoculture stands. By altering mycorrhizal relationship and soil chemistry, invasives can also impact forest regeneration and composition.

Invasive species benefit from climate change, as their aggressive traits allow them to exploit disturbance and canopy openings. These species often act in harmony with each other, such as Tree-of-Heaven acting as a host species for the Spotted Lanternfly. Canopy openings associated with the impacts of emerald ash borer, beech scale, and hemlock woolly adelgid provide prime targets for invasives to gain entry to TRS forests.

Cyclical patterns in lake levels as discussed above also opens beach areas for increased phragmites infestation during periods of low water. Woody vegetation and cattails have also been shown to cause impacts on adult dragonfly flight patterns. In addition, as temperatures warm, invasive species from the southern United States will migrate northward, including feral hogs and armadillos that are noted as severe threats to Hine's emerald dragonfly habitat in the southern limits of its range.[22] Statewide partnerships will be necessary to prevent these destructive invaders from reaching Door County.

Working with local partner organizations, TRS needs to use the Early Detection and Rapid Response strategy (EDRR) to deter establishment of invasive species. This management technique identifies pockets of invasive species previously undocumented in a natural area, and targets eradication while the population is still practical. Once an invader becomes established, control options become more limited to reducing impacts with less hope for eradication. New technologies such as remote sensing and drone-based analysis could assist in early detection and collection of herbaceous samples. Similar to drones being used to identify and protect threatened plants on inaccessible cliff faces in Hawaii, remote locations within TRS could be monitored via the air.[23]

Previous invasive control efforts at TRS have focused on treating phragmites, Japanese knotweed, teasel, crown vetch, black swallow wort, and Japanese barberry. Scots pine has also been documented, particularly in the open meadow areas at Appel's Bluff. Other species of particular concern to watch for that are not currently known to be present at TRS are creeping jenny, Asian jumping worms, European frog-bit, and hemlock woolly adelgid.

As another consideration, in the era of rapid climate change, a nature preserve like TRS takes on heightened importance as a nature refuge, a place for migrating native species to relocate and find hospitable conditions to reestablish themselves. This will strain the tension between human management and natural processes, as conservationists will need to consider to what extent a climate "refugee" species represents an invasive, or how aggressively migrating species need to be countered. In an example of how migration is already occurring, a 2022 study by UWGB of small mammals at Toft Point found that southern flying squirrels were present on the property, where only the northern species was documented in 1971. It is unclear whether the southern species is displacing the northern from its range, which will take further research to understand the dynamics.

Figure B28: Invasive Scots Pine seedling at Appel's Bluff.

5.0 MASTER PLAN SWOT ANALYSIS

As part of the Sustainable Citizens Symposium hosted by TRS in September 2022, the planning team conducted a SWOT analysis with symposium participants. A SWOT is a strategic planning exercise aimed at understanding participants' impressions of TRS' strengths and weaknesses as related to climate resiliency, as well as opportunities for positive change and threats to programs or facilities. Weaknesses are viewed as internal issues generally within an organization's control, while threats are better described as vulnerabilities to outside factors that may limit TRS' response to climate impacts. Overall, this tool helps analyze what TRS is doing well now, and identifies concerns that need to be addressed in developing future strategies targeted at climate resilience.

Participants were first asked the question, "From the perspective of regeneration and sustainability, if The Ridges did only one thing, what would it be?" Priorities from the responses were summarized in the following four buckets:

PROTECT

- Preserve the land
- Protect habitats
- Preserve biodiversity
- Preserve for future generations to enjoy

INSPIRE

- Current and future leaders
- Leverage nature
- Lead by example
- Inspire stewardship

EDUCATE

- Grow research
- Teach community about sustainable practices
- Gain knowledge

CONNECT

- Connect people to nature
- Inclusively connect to diverse communities
- Build partnerships to be more effective

Next, the group was asked to brainstorm the top pressures facing TRS:

CLIMATE CRISIS

- Impacts to habitat
- Invasive species
- Extreme events
- Water management

PEOPLE

- Crowds / human density
- Overuse
- Carrying capacity

DEVELOPMENT

- Loss of habitat
- Over-densification
- Strain on resources

FUNDING

- Financial resources
- Revenue
- Need for more staff to keep up with growth

ACCESSIBILITY

- Communication
- Address inequalities and lack of diversity
- Experience nature versus protect the resource

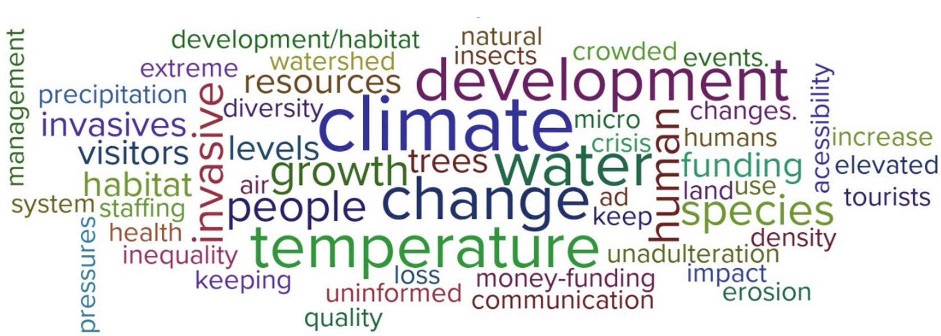


Figure B29: Word cloud with participants' responses for the top three pressures facing TRS.

After discussing these aspirations and stressors, participants engaged in the SWOT analysis. The following summarizes the results of the discussion, identifying strengths, combined weaknesses and threats, and opportunities for the future:

STRENGTHS

The Land
- Boreal Forests / Unique Habitats / Lake Michigan
- Carbon Sinks

Community
- Volunteers
- Passionate and Talented Staff
- Leadership and Funding

Culture and History
- Foundational Philosophy
- Respected Voice

Research and Education
- Interpretive Exhibits
- Social Media Presence
- Hands-on Science

Partnerships
- Collaboration with Conservation Groups
- Relationship with UW Green Bay

WEAKNESSES / THREATS

Funding
- Need more money, more staff, more time
- Potential weakening of existing funds

Growth (Overgrowth)
- Concern about over building
- Staff spread too thin
- More land, more to manage

Politics
- Political priorities shift
- Fear of taking a stand / alienating donors or locals

Knowledge Gaps / Communication
- Research gaps hinder acting appropriately and quickly
- Communicate better TRS' purpose

Consensus and Focus
- Fear of change
- Watering down the cause
- What is the message to share?

OPPORTUNITIES

Leadership (Walk the Talk)
- Be a model for sustainability
- Visitors leave with lessons they can apply at home
- Model green energy. Find a place for solar at TRS!
- Climate change resiliency leader

Advocate
- Have a clear position on climate action & be a stronger advocate
- Teach volunteers and the community to be better advocates and politically engaged

Protect Resources
- Prioritize boreal forest, healthy ecosystems and wildlife
- Maintain facilities to minimize need for future large projects
- Let some land be (closed to the public)
- Acquire key parcels

Outreach and Communication
- Welcome a more diverse range of visitors / stakeholders
- Expand messaging around climate change
- Expand virtual outreach and events

Expand Education and Research
- Leverage the Ridges Inn to expand outreach, research, and education
- Expand Citizen Science
- Be a destination for research
- Provide multi-day educational experiences
- Expand mission & programs beyond the Ridges Community

Partnerships
- Partner with other institutions supporting science-based research and action plans
- Partner for Lake Michigan protection

Fundraising
- Hire a dedicated grant writer
- Attract donors with aspirational sustainability
- Fund for Lake Michigan
- Endowment

6.0 RECOMMENDATIONS FOR TRS TO ADDRESS CLIMATE IMPACTS

6.1 FACILITIES AND BUILT SYSTEMS

TRS recently purchased the former Ridges Inn, strategically located on Highway 57 adjacent to existing Sanctuary land. The Master Plan identifies a strategy to repurpose the existing buildings on the Ridges Inn property to expand current program offerings and administrative support facilities. Other improvements are planned to construct new education support facilities at the North Campus and Family Discovery Trail and to renovate the Nature Center to accommodate a larger multipurpose community room. TRS is committed to reducing the climate impacts of these facility improvements through the strategies of adaptive reuse and regenerative design. Improvements will also make TRS more resilient to climate change, including adopting strategies that address potential loss of power from intense storm events and constructing facilities that support research for rare species survival.

ADAPTIVE REUSE

A major international report concluded that the buildings and construction sector accounted for 36% of total global energy use and 39% of energy and process-related carbon dioxide emissions in 2018. 11% of these emissions resulted from the manufacturing of building materials and products such as steel, cement and glass.[24] Thus, the design and construction industry needs to place greater urgency on avoiding waste, and recognize that the greenest building is one that already exists. Strategies to adaptively reuse existing buildings maximize the use of existing assets, reduce carbon emissions, and reduce the quantity of demolition waste sent to landfills. Adaptive reuse can also result in cost savings on building materials for new construction, which have dramatically risen in cost since the 2020 pandemic disrupted global supply chains.

Future design phases for TRS implementation projects will need to consider structural integrity issues, compliance with updated codes and regulations, energy conservation practices, and use of low carbon materials.

Source: *2018 Global Status Report, Global Alliance for Buildings and Construction.*

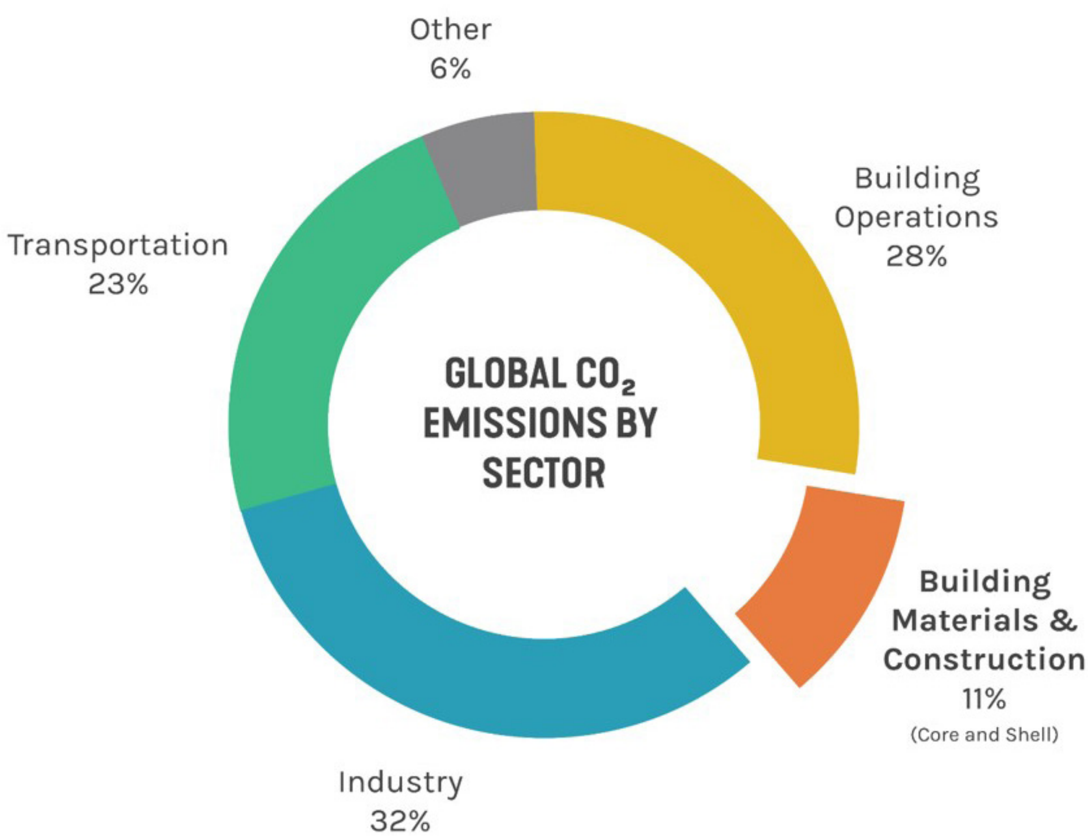


Figure B30: Global carbon dioxide emissions by sector of the economy. Note the high contribution from building materials and operations.

As noted in the graph below, the potential to reduce carbon is significantly higher in the design phase, where solutions can build less and build clever to optimize material usage.

Traditional cost estimating approaches and short-term economic timeframes defined by annualized budgets make it difficult to factor in the long-term return-on-investment for climate action. Applying cost-benefit analysis to the entire life cycle of a project can help reframe the conversation and clarify how higher upfront investment can translate into significant economic, environmental and social benefits in the future. During the early planning stages for future facility improvement projects, cost-benefit studies will help TRS understand that climate risk is financial risk that needs to be anticipated and managed, and make more informed, longer-term budgeting and investment decisions.

Source: *"Bringing embodied carbon upfront", World Green Building Council. Data Source: HM Treasury, Infrastructure Carbon Review, 2013*

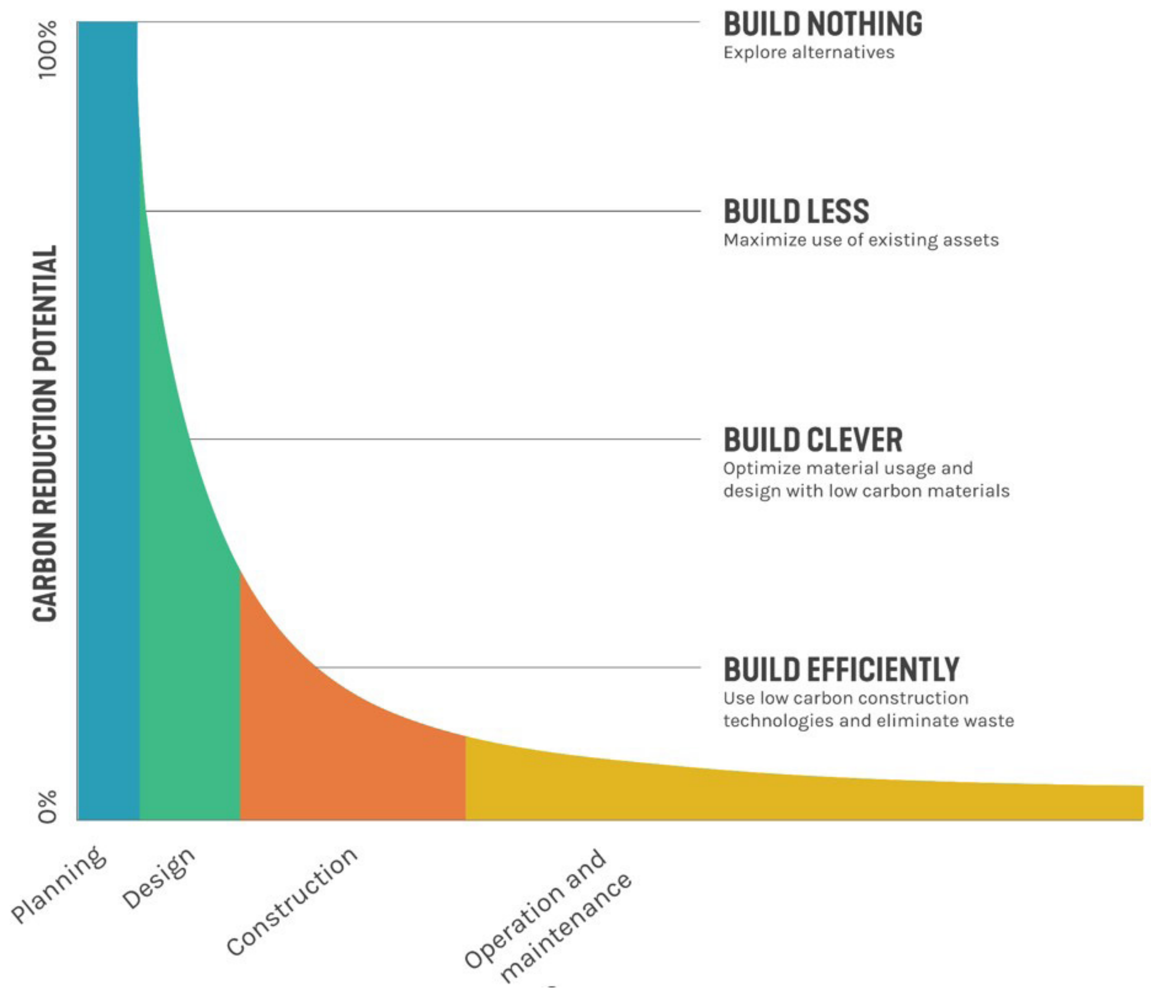


Figure B31: The greatest potential for carbon reduction is from reuse of existing structures.

Figure B32: The Nature Center can incorporate new technologies to increase sustainability.

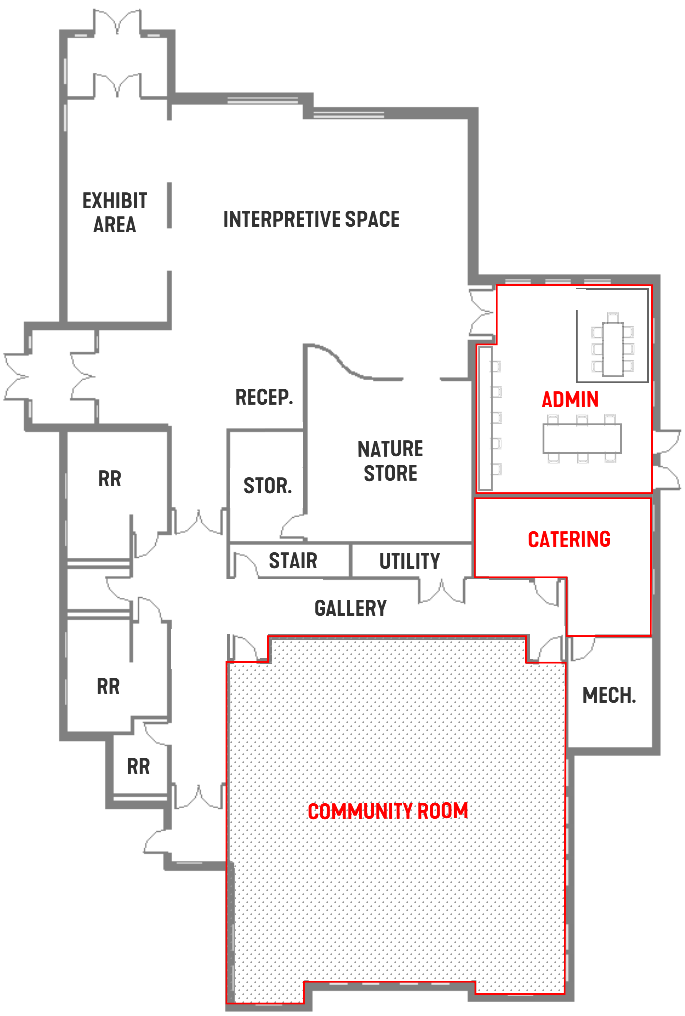


Figure B33: Proposed Nature Center floor plan with community room.

The master plan includes the following recommendations specific to adaptive reuse of TRS facilities:

- **Cook-Albert Fuller Nature Center** – The Nature Center is a wonderful facility and relatively recent addition to TRS that elevated the community presence and capabilities of the organization. As a LEED Gold certified building, it set a high bar in Door County for sustainable design that this plan applauds and attempts to build upon, as TRS aims even higher as an environmental leader and voice for regenerative design. Recommendations in the master plan do not scrap the Center's original design, rather they illustrate an informed approach after a decade of use data to make the building even more sustainable and effective at fulfilling its core community functions within its current footprint.

  A particular focus is adapting the building to accommodate a larger, more flexible version of the existing Discovery Room and gallery space to accommodate the wide range of programs and events to be hosted by TRS. The plan seeks to integrate this multipurpose space without impacting simultaneous educational, retail, or other daily functions, and avoid the frequent shut down of the Nature Center for larger events that occur in its current configuration. This is accomplished by relocating the majority of the administrative office space and other back-of-house functions to the Ridges Inn campus, renovating the existing office space into a larger community room, and reconfiguring the existing Discovery Room to provide limited office support and a catering kitchen.

- **The Ridges Inn** – A two-pronged adaptive reuse approach is planned at this property, creating a Research Campus and relocating existing buildings from the buffer along Hidden Brook. First, the Guest House will be remodeled to accommodate office space for the majority of TRS staff not associated with daily operation of the Nature Center. The existing Lodge building will be adapted to provide office, lab, and support space for a research field station, and cooperative research-in-residence programs with regional partners and institutions utilizing renovated, on-site lodging. A permanent base for citizen science will also be created in the Juniper-Birchwood Cabin. Renovating these existing buildings into new facilities to support research and citizen science programs is crucial from a climate resilience perspective in order to expand partnerships and develop strategies to assist the survival of the orchid and dragonfly species as further discussed below.

  Secondly, the plan recommends restoring Hidden Brook on the property and establishing a minimum 50-foot wide native vegetation buffer along the stream that is free from development. Existing structures currently located within the buffer zone are recommended to be relocated for reuse on other properties. A further study is necessary to determine if these buildings fulfill a need elsewhere in the Sanctuary such as the Finell property, or if they can be provided to another Door County partner or sold to a private end user.

- **Finell Property** – Further analysis is needed to determine the adaptive reuse potential of the existing Finell house and garage. Should their reuse potential be minimal, as preliminary study suggests due to structural and other impairments, this property could be a logical recipient of relocated Ridges Inn structures that could be adapted to meet lodging and other future programming outlined for this property. The garage on the Finell property may house the work truck and other power tools. Given the proximity of this site to the intersection of Highways 57 and Q and the short driveway, this location allows for easy access to this equipment in response to damage from storm events.

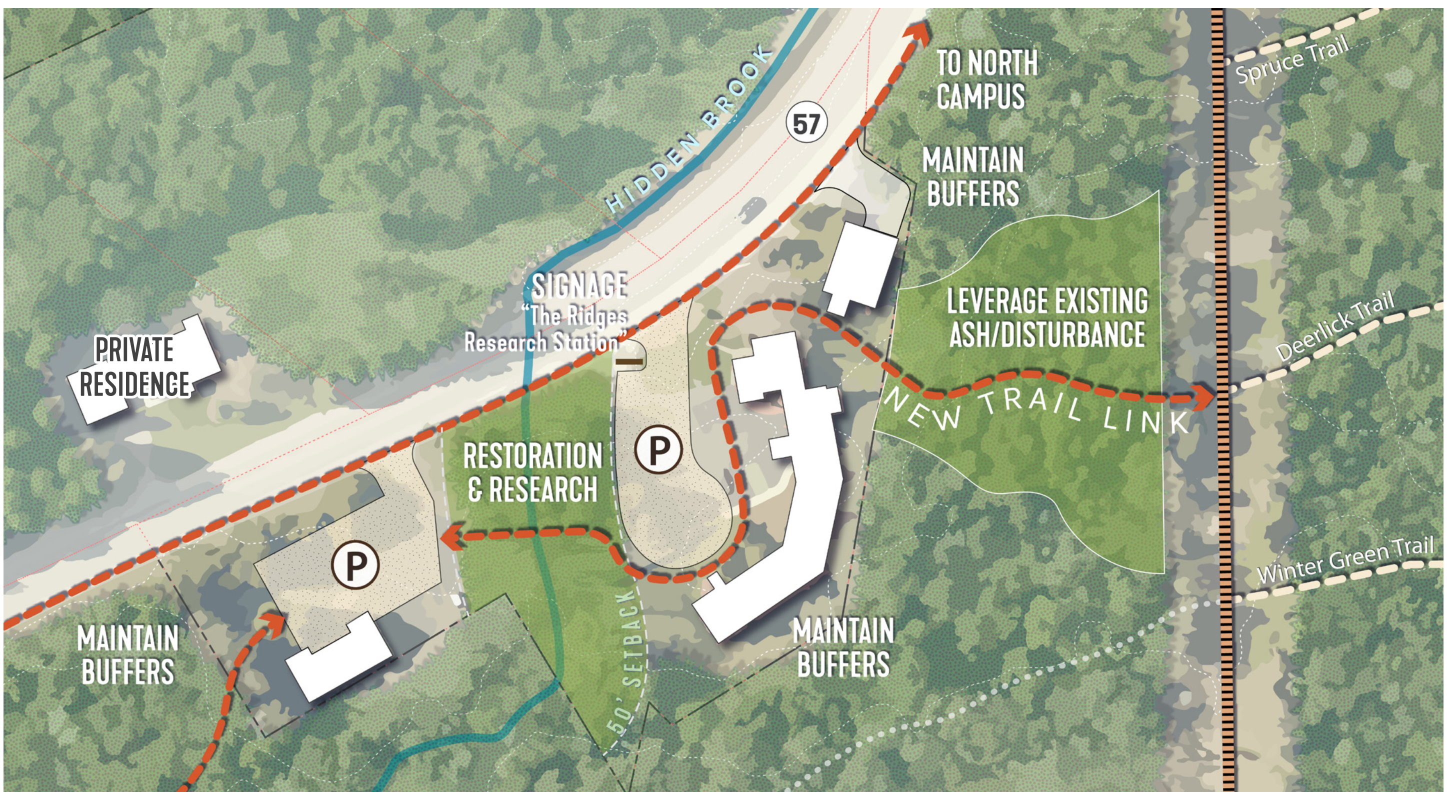


Figure B34: Proposed site plan for the Research Campus at the renovated Ridges Inn property.

LEGEND

Existing Trail   Proposed Trail

REGENERATIVE DESIGN

Regenerative design goes beyond doing less harm, instead crafting solutions that repair natural and human systems. The goal is to create restorative, net-positive impacts from architectural design that result in improved social and environmental conditions. Regenerative design sits at the intersection of human wellbeing, climate resilience, and environmental conservation, bringing together principles of social equity, indoor environmental quality, and passive survivability.

Some of the standards associated with regenerative design include:

- Meet entire energy needs through on-site renewable energy.
- Meet entire water needs through captured rainwater or wastewater.
- Treat all wastewater and stormwater onsite.
- Enhance human health.
- Enhance habitat and local ecology.

Advancements in technology are paving the way to reach the goal of net-zero energy building design. Photovoltaics and other renewable energy technologies have made great strides in the past decade, and aggressive energy conservation is possible using strategies such as highly insulated exterior envelopes, triple-glazed windows, exterior sun-shading, daylighting, natural ventilation, high-efficiency HVAC systems, and aggressive plug load management. Material ingredient disclosure and transparency are creating healthier and safer environments by requiring building materials manufacturers to openly communicate the ingredients of a product, so smart decisions can be made to avoid those ingredients understood to be hazardous where there are cleaner alternatives. In all, regenerative design focuses not only on the "footprints" of environmental and social impacts from our actions, but also "handprints" – those beneficial changes we can make to support and protect the processes that sustain life.

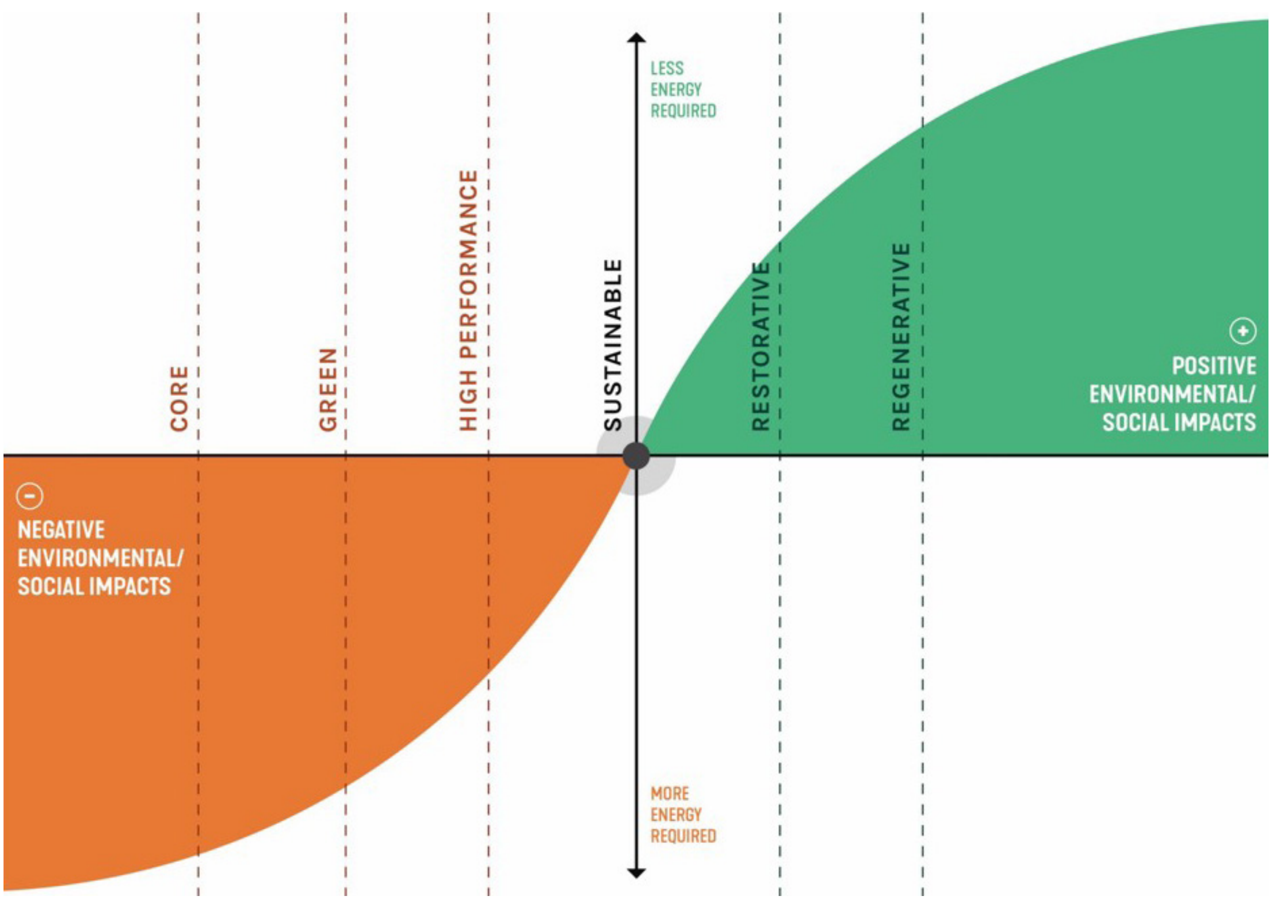


Figure B35: Regenerative design crafts solutions with positive environmental and social impacts.

In addition to reducing carbon emissions and impact on water resources, these technologies also increase the resilience of facilities in response to climate change. In case of power failures from intense storm events, daylighting allows for natural light, photovoltaics reduce reliance on the electrical grid, and natural ventilation and operable windows allow for airflow when HVAC systems are down. Onsite wastewater treatment prevents overwhelming municipal systems during flood events, and green infrastructure strategies limit impacts from development on sensitive streams and wetlands.

The following recommendations apply the strategies of regenerative design to TRS facilities:

- **The Ridges Inn and Other New Building Facilities** – The master plan establishes a goal for the renovation of the Ridges Inn property and all other planned new structures to meet the Living Building Challenge℠. According to Living Building Challenge 4.0, "The Living Building Challenge℠ is an attempt to dramatically raise the bar from a paradigm of doing less harm to one in which we view our role as a steward and creator of a true Living Future. The Challenge defines the most advanced measure of sustainability in the built environment today and acts to rapidly diminish the gap between current limits and the end-game positive solutions we seek. Projects that achieve Living Building® certification can claim to be the greenest anywhere, and serve as role models in their communities for redefining the future of the built environment."

  Living Buildings:

  - Connect occupants to light, air, food, nature, and community.
  - Remain within the resource limits of their site, by being self-sufficient for water and energy.
  - Create a positive impact on both human and natural systems that interact with them.

  The entire Ridges Inn facility will be reconfigured to be a model for regenerative design. Existing cabin structures within the brook buffer zone will be relocated to the Finell property or other off-site locations. This relocation will facilitate restoration of the existing brook, creating a more thriving, less disturbed ecosystem and habitat. East of the brook, the Ridges Inn will be transformed programmatically and renovated with high performance systems.

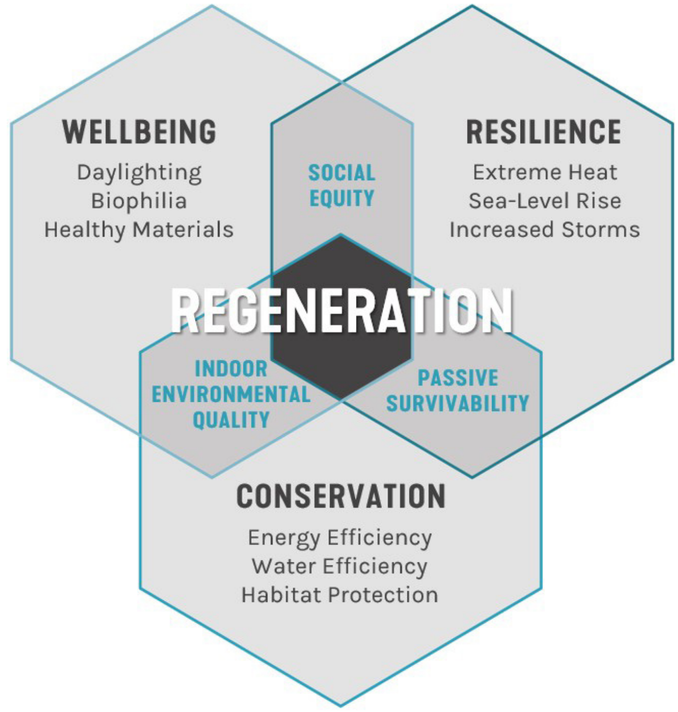


Figure B36: Regenerative design combines principles of wellbeing, resilience, and conservation.

Credit: *The Living Building Challenge, https://living-future.org/lbc*

LIVING BUILDING CHALLENGE

Figure B37: The renovated Ridges Inn is proposed to meet the Living Building challenge℠.

A geothermal well field under the new parking area will provide a heat sink and heat source to support ground source heat pumps. New triple-glazed windows, improvements to the thermal envelope, high-performance lighting with daylight controls, waste heat recovery, and other innovative systems should be used to drive down energy use. The site is heavily shaded, limiting options to provide photovoltaics to only the new entrance to the Ridges Inn. Net zero energy can be achieved at a campus scale by providing solar panels elsewhere, such as the North Campus.

Rainwater from the existing and new roofs will be collected and treated to meet all non-potable water demand while the existing well will serve potable water

Figure B38: Example of a solar canopy and deck that may inspire renovations at the Ridges Inn.

Figure B39: A rain chain directs roof runoff to a bioswale for treatment.

demand, thus achieving net zero water. Composting toilets might also be considered to treat all waste on site, using the municipal waste infrastructure as a back-up system. The new parking lot to serve the research campus should use permeable paving systems to reduce stormwater volumes, promote infiltration, and reduce the heat island impact.

West of the restored brook, the existing Guest House will be transformed and vertically expanded to provide administrative offices. A separate geothermal wellfield will be provided in the west parking area, again supporting ground source heat pumps. Vertical expansion of the structure allows for redesign of the roof to collect rainwater for reuse and potentially houses solar panels depending on shade from the tree canopy to the south. The roof design can also provide a thermal chimney, which is a roof dormer that enhances natural ventilation inside the building. Operable windows, open planning, and vertical connections between the first and second floor will also enhance natural ventilation. Like the main lodge, the administration building can use similar energy conservation strategies, composting toilets, and rainwater harvesting, resulting in a net-zero energy, water, and waste design.

New pavilions and restroom facilities are also planned for other destinations at TRS, including the Family Discovery Trail, the North Campus, and the County Beach. These structures will also incorporate sustainable strategies such as photovoltaics, rainwater harvesting, and onsite waste management with septic fields or composting toilets. New parking areas and drive aisles will use permeable paving systems wherever possible to reduce stormwater volumes, promote infiltration, and reduce the heat island impact.

- **Cook-Albert Fuller Nature Center** – The master plan highlights the following enhancements that could be made to the existing Nature Center to build upon its existing collection of sustainable strategies associated with its LEED Gold status, using regenerative design as a benchmark. Based on existing energy use patterns, a 55-kW photovoltaic array would generate enough power to allow the building to achieve net-zero energy. The highest roof form facing southeast is the best candidate for photovoltaic arrays and could provide two thirds of the required electrical output. An additional array on the new open-air pavilion envisioned west of the building would provide the remainder. The portion of the existing and new roofs to receive solar panels should be modified to a standing seam metal roof, allowing solar panels to be mounted directly to the metal standing seams and reducing roof penetrations. A metal roof would also support cleaner rainwater harvesting than asphalt shingles. To allow the existing building to provide natural ventilation, selective windows could be replaced with operable windows.

SITE AND LANDSCAPE DESIGN STRATEGIES

Redesign of the sites surrounding the renovated building facilities can equally support regeneration goals. Emerging technologies offer the potential to reduce emissions and store carbon, such as using low-carbon strategies for concrete construction, wood products that provide sequestration, and even potential new materials developed to capture carbon emissions. All materials being considered during site improvements should undergo a full life cycle assessment to understand embodied carbon from manufacturing, transportation, installation, maintenance, and disposal.

Incorporating stormwater management strategies reduces runoff and improves water quality from impervious surfaces, including roofs and parking lots. These green infrastructure strategies include, but are not limited to:

- Using permeable pavements such as unit paver systems and reinforced gravel.
- Harvesting roof drainage with cisterns for reuse in buildings or orchid shade houses.
- Incorporating bioswales to capture, treat, and infiltrate stormwater, with consideration given to how additional runoff is diverted in a 500-year storm event in order to minimize damage to any downstream ecosystems.
- Considering green roofs on future buildings where surfaces are not otherwise occupied with photovoltaic panels.
- Educating the public by making stormwater conveyance and treatment visible, using strategies such as rain chains and runnels.

Figure B40: Cisterns can be used to colllect roof water to meet non-potable water needs.

Figure B41: Bioswales treat runoff from hardscape surfaces.

Figure B42: Nature Center parking lot signage educates visitors about planting for pollinators.

Landscapes should only use native species which reduce water and fertilizer requirements, as well as provide shelter and food for wildlife and pollinators. Plans should strategize for overlapping bloom times within beds to support pollinators throughout the entire growing season, and vegetation should be retained through winter and early spring months to provide refuge for hibernating insects and animals. Trees and landscape features should also be sited to provide optimal shading to limit summer heat gain. Composted organic building waste may be used to improve soil health in landscape beds.

Several rating systems have been developed to measure and promote successful sustainable landscape design and construction. In particular, TRS may consider designing future projects to meet guidance under the Sustainable Site Initiative (SITES), a system developed in partnership between the American Society of Landscape Architects, the United States Botanic Garden, and The Ladybird Johnson Wildflower Center. The SITES rating system includes a range of strategies and recommendations that promote reducing carbon emissions and creating healthy landscapes, including:

- Using recycled, salvaged, or sustainably manufactured materials.
- Using regionally sourced materials to reduce transportation impacts and promote local economies.
- Designing for deconstruction and reuse.
- Using renewable sources for energy needs.
- Reducing outdoor energy consumption, including the use of energy efficient lighting.

6.2 NATURAL RESOURCES

Climate adaptation recommendations for the Sanctuary's natural resources focus on management implications for the Ram's Head Lady Slipper Orchid and the Hine's Emerald Dragonfly. Planning for these two critical species will have symbiotic implications for water resources, pollinators, soil health, and other species, and can be used as a model for future additional planning efforts to assist vulnerable species to adapt to rapidly changing conditions.

For both these species, leveraging internal TRS expertise with external partnerships is key to strategizing climate adaptations. Multiple organizations are performing research in this field, and collaborative efforts are crucial to understanding threats to natural resources and developing adaptive management techniques to address climate impacts. Local partners include Door County, Crossroads at Big Creek, the Nature Conservancy, the Door County Land Trust, the Wisconsin Department of Natural Resources, the U.S. Fish and Wildlife Service, and University of Wisconsin-Green Bay's Cofrin Center for Biodiversity and Toft Point Research Field Station.

In particular, the designation of a large area of northern Door County as a RAMSAR Wetland of International Importance brings together many of these agencies in a working group to protect sensitive habitats. Other regional research partners include, but are not limited to, the Wisconsin Wetlands Association, the North American Orchid Conservation Center (based at the Smithsonian Environmental Research Center), Illinois College, the Minnesota Landscape Arboretum, the Chicago Botanic Garden, the Great Lakes Coastal Wetland Monitoring Program, the Wisconsin Geological and Natural History Survey, and the University of South Dakota-Vermillion. TRS will have capacity to host all these partner groups at the renovated Ridges Inn research field station, with opportunities for researcher-in-residence collaboration through lodging.

RAM'S HEAD LADY SLIPPER ORCHID

TRS' unique habitats allow for an incredible diversity of orchid species to be represented in a concentrated area. The original plant survey conducted by Albert Fuller in 1935 documented 26 orchid species present at TRS of the 49 species native to Wisconsin. Unfortunately, it appears that some species may have recently disappeared from the landscape and others are declining in numbers.

Continued research is critical to the survival of the Ram's Head Lady's Slipper. As climate change and development continue to threaten our natural areas, research efforts can inform best practices to protect and preserve habitat and foster species survival. TRS' nationally recognized orchid restoration project provides essential information that can be used to sustain the Ram's Head and other native orchid species. The goals of TRS's orchid research are to inventory current populations, understand specific environmental conditions and germination techniques of each species, establish a seed bank, and identify threats such as habitat loss and deer herbivory. Important factors being considered include identifying pollinator relationships, understanding mycorrhizal fungal associations, and microclimate factors such as shade, water availability, and temperature.

Credit: *The Ridges Sanctuary.*

Figure B43: Research is essential to understanding climate change impacts for species survival.

Phenological monitoring may be critically important to evaluating impacts of climate change. For example, a New England study comparing Henry David Thoreau's journals to the seasonal distribution of tree leaf-out found that earlier canopy coverage negatively impacts the sunlight available for ephemeral wildflower energy reserves.[25] TRS is currently embarking on a study along the Range Light corridor easement to better understand the effects of canopy thinning on the herbaceous ground layer.

Even if Door County warms significantly and TRS' boreal forest declines, the advancements TRS is leading through orchid research will likely help ensure species survival and human-assisted migration as the boreal forest moves further north of its current range and ideal conditions for orchids deteriorate at TRS. A Belgium study on climate change impacts on orchids concluded that milder winters and wetter springs had a positive impact on European orchid populations at the northern edge of their ranges, but recognized that limitations on the ability of mycorrhizal fungi to shift in distribution may limit the orchid population migration.[26] Seeding potential relocation sites with the appropriate mycorrhizal fungi identified through research could assist migration of orchid species beyond their current northern range limits, and may also have symbiotic effects on tree species moving north.

Proactive management and stewardship actions will likely be required within TRS, as evaluated and guided by the organization's Land Committee. To conserve a species that would otherwise be lost, TRS needs to directly assist in the regenerative process. As research shows which microclimates are ideal for survival of orchid species, consideration should be given both to transplanting vulnerable plants or to propagating and planting certain species into more desirable locations as a species survival strategy. Manipulating light conditions may include constructing shade structures or performing tree canopy management, either by thinning or replanting to replace tree losses from invasive insects and disease. Rainwater catchment or drip irrigation systems may be necessary to assist populations of rare species through periods of severe drought.

Similarly, intervention is critical to relocate plants if high lake levels threaten to raise groundwater and cause long-duration flooding in linked swales and large areas of the Sanctuary. In areas of saturated soils caused by flooding, trails will need to be closed to prevent further damage to the natural resource. Finally, monitoring for invasive species using the EDRR strategy must deter establishment of invasives that are not yet present at TRS to prevent adverse impacts on the remaining orchid habitat.

Credit: *https://homesteadlifestyle.com/diy-rain-water-catchment-system/*

Figure B44: Rainwater catchment can occur in remote areas.

Figure B45: Yellow Lady's Slipper Orchid in the Heart of The Ridges.

HINE'S EMERALD DRAGONFLY

According to the U.S. Fish and Wildlife Service, the Hine's emerald dragonfly is one of the most endangered dragonfly species in the U.S. The dragonfly relies on groundwater fed wetlands with slowly flowing water dominated by grass-like plants, with adjacent forest edges and uplands. Its aquatic egg and larval life stages last from 2 to 4 years, before emerging as an adult that lives from 14 days to 6 weeks. The dragonfly also have been known to rely on crayfish burrows to increase survival during times of drought, as subsurface burrows retain water when wetlands dry up.[27] Inventories of crayfish populations may help researchers understand if this symbiotic relationship between dragonflies and crayfish exists at TRS. Creation of similar but artificial burrows may also increase dragonfly survivability in periods of drought.

Major threats to the Hine's emerald in the Northern Recovery Unit include habitat loss and alteration, changes in water flow, contamination, vehicle mortality, and invasive species. For TRS, protecting the watershed and groundwater recharge areas is a critical strategy to prevent leaching of harmful contaminants into critical habitat areas. The Land Management Plan (Appendix A of the Master Plan) identifies priority parcels to be considered for future acquisition to protect recharge zones, which would limit additional impervious surfaces and septic systems associated with development.

TRS should also hold discussions with the County and Township to consider alternatives to road salt for highways within the watershed to reduce observed chloride contamination. In addition, TRS can capitalize on its position as a leader in environmental education to provide outreach on limiting pesticide, herbicide, and fertilizer use within the surrounding agricultural and residential land uses. Mitigating pesticide use would also help sustain pollinators, which in turn benefits not only native orchids and other vegetation, but also the local cherry and apple crops. TRS could sponsor pilot programs with farmers and orchards to explore alternatives to herbicide and pesticide use, and advocate for policy change through regional water quality partnerships.

The above efforts will not only benefit overall water quality, but the associated decrease in nutrient loading will allow native wetland vegetation to better resist invasive species such as phragmites and narrow leaf cattail, which have proven negative impacts on crayfish populations and adult dragonfly flight behaviors. TRS should also closely monitor the impacts of invasive animals. As noted earlier, invasive species from the southern United States are migrating northward with the warming climate, including feral hogs which are already present in Wisconsin and armadillos that have been observed in the state but are not yet known to have a breeding population. Every effort should be made to keep these invaders out of Door County, as their digging behavior is destructive to wetland habitats.

***Credit:** The Ridges Sanctuary.*

Figure B46: Stream monitoring for macroinvertebrates at TRS.

***Credit:** Missouri Department of Conservation.*

Figure B47: Hine's emerald dragonfly.

7.0 CONCLUSION

Without universal urgent action to both mitigate and adapt to the impacts of climate change, the unique species and ecosystems found at The Ridges Sanctuary will be lost. Traditional philosophies of protection, preservation, and restoration in land management are being upended by climate change impacts and the risks and vulnerabilities they pose. Nature will need a helping hand as conditions change and The Ridges' climate becomes less hospitable for the species who have inhabited it for the past 500 years. This shift will require a more active role – a more broadly connected and collaborative role – than the preservation mindset that has guided the organization since 1937. Leveraging partnerships through the new Ridges Inn field station can advance research programs to provide data and assess adaptive management strategies to prevent habitat loss and assist climate migration of rare species. Through this research, combined with education highlighting TRS' integration of regenerative facility improvements and climate change mitigation efforts, TRS will advocate by example, providing climate leadership to the Door County community, Great Lakes region, and beyond. As a next step, this plan will serve as a guide for the development of an action plan to implement recommendations.

Credit: *The Ridges Sanctuary.*

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